The density of mobile electrons in copper metal is 8.4 × 10^{28} m^{-3}. Suppose that i = 4.2 × 10^{18} electrons/s are drifting through a copper wire. (This is a typical value for a simple circuit.) The diameter of the wire is 3.6 mm. In this case, about how many minutes would it take for a single electron in the electron sea to drift from one end to the other end of a wire 34 cm long?

minutes

$$I = nA\bar{v}$$

$$I = nAv_{drift}$$

$$v_{drift} = \frac{I}{nA}$$

$$v_{drift} = \frac{d}{t}$$

$$t = \frac{d}{v_{drift}}$$

$$t = \frac{d}{\frac{I}{nA}}$$

$$= \frac{dnA}{I}$$

$$= 69.215e3 \text{ s}$$

$$= 1.154e3 \text{ m}$$

In the previous chapter you calculated the drift speed in a copper wire to be 2.00 × 10^{-5} m/s for a typical electron current. Calculate the magnitude of the electric field E inside the copper wire. The mobility of mobile electrons in copper is shown below.

$$u = 4.5 \text{ x } 10^{-3} \frac{\frac{m}{s}}{\frac{N}{C}}$$

(Note that though the electric field in the wire is very small, it is adequate to push a sizeable electron current through the copper wire.)

E = N/C

$$E = \frac{v}{u}$$

$$= 0.00444 \text{ N/C}$$

Suppose a wire leads into another, thinner wire of the same material which has only half the cross sectional area. In the "steady state," the number of electrons per second flowing through the thick wire must be equal to the number of electrons per second flowing through the thin wire.

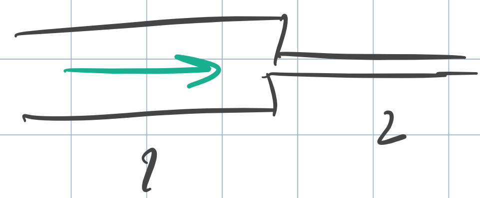
(a) If the drift speed $\bar{v}_1$ in the thick wire is 9×10^{-5} m/s, what is the drift speed $\bar{v}_2$ in the thinner wire?

$\bar{v}_2$ = ____ m/s

(b) If the electric field E_1 in the thick wire is 6×10^{-3} N/C, what is the electric field E_2 in the thinner wire?

E_2 = ____ N/C

Part One



$$I_2 = I_1$$

$$n_1 A_1 V_{drift\ 1} = n_2 A_2 V_{drift\ 2}$$

$$n_1 = n_2$$

$$A_2 = \frac{1}{2} A_1$$

$$\cancel{n_1} \cancel{A_1} V_{drift\ 1} = \cancel{n_1} \frac{1}{2} \cancel{A_1} V_{drift\ 2}$$

$$V_{drift\ 1} = \frac{1}{2} V_{drift\ 2}$$

$$V_{drift\ 2} = 2 V_{drift\ 1}$$

$$= 18e{-5}\ m/s$$

Part Two

$$V_{drift\ 2} = 2 V_{drift\ 1}$$

$$\cancel{u} E_2 = 2 \cancel{u} E_1$$

$E_2 = 2E_1$

$= 12e{-3}\ N/C$

Suppose wire A and wire B are made of different metals, and are subjected to the same electric field in two *different* circuits. Wire B has 5 times the cross-sectional area, 1.2 times as many mobile electrons per cubic centimeter, and 2 times the mobility of wire A. In the steady state, 3×10^{18} electrons enter wire A every second. How many electrons enter wire B every second?

electrons/second

$I_A = u A_A n_A E$

$I_B = u A_B n_B E$

$E = \dfrac{I_A}{A_A n_A u_A}$

$E = \dfrac{I_B}{A_B n_B u_B}$

$\dfrac{I_A}{A_A n_A u_A} = \dfrac{I_B}{A_B n_B u_B}$

$A_B = 5A_A$

$n_B = 1.2 n_A$

$u_B = 2u_A$

$A_B n_B u_B I_A = I_B A_A n_A u_A$

$(5\cancel{A_A})(1.2\cancel{n_A})(2\cancel{u_A}) I_A = I_B \cancel{A_A}\cancel{n_A}\cancel{u_A}$

$I_B = 12\ I_A$

$I_B = 3.6e19\ e^-/sec$