Answer on Question #69441-Physics / Electromagnetism

A copper wire ($\rho = 1{,}75 \times 10^{-8}\ \Omega \cdot \text{m}$, the electron density in copper is 8.49×10^{28} electrons/m^3) of diameter $d = 1$ mm and length $l = 30$ m is connected across a battery of $V = 2$ V. calculate the current density in the wire and drift velocity of electrons.

Solution:

In terms of a Ohm's law

$$I = \frac{V}{R}, \qquad R = \rho\frac{l}{A}, \qquad I = \frac{VA}{\rho l}.$$

The current density is given by

$$j = \frac{I}{A} = \frac{V}{\rho l} = \frac{2}{1.75\times10^{-8}\times30} = 3.8\times10^{6}\ \frac{\text{A}}{\text{m}^2}.$$

The drift velocity

$$v = \frac{j}{en} = \frac{3.8\times10^{6}}{1.6\times10^{-19}\times8.49\times10^{28}} = 2.8\times10^{-4}\ \frac{\text{m}}{\text{s}}.$$

Answer: $j = 3.8\times10^{6}\ \frac{\text{A}}{\text{m}^2}$, $v = 2.8\times10^{-4}\ \frac{\text{m}}{\text{s}}$.