Answer on Question #65469-Physics - Electric Circuits

A power line carries a current of 1.25×103 A over a distance of 2.50×102 km. The line is made of copper (Copper: Cu, atomic weight 63.5, density of 8.920 g/cm3, assumed to have one free electron per every copper atom) and has a diameter of 2.00 cm. How long does it take an individual electron to travel the entire length of the power line?

Solution

The current

$$I = \frac{q}{t}.$$

Thus the time of traveling

$$t = \frac{q}{I}.$$

The charge

$$q = eN = e\frac{mN_A}{\mu} = \frac{e\rho VN_A}{\mu} = \frac{e\rho LSN_A}{\mu} = \frac{e\rho L\pi d^2 N_A}{4\mu}.$$

Finally

$$t = \frac{e\rho LSN_A}{4I\mu} = \frac{1.6\times10^{-19}\times8.92\times10^{3}\times2.5\times10^{5}\times3.14\times4\times10^{-4}\times6.02\times10^{23}}{4\times63.5\times10^{-3}\times1.25\times10^{3}}$$
$$\approx 8.5\times10^{8}\text{ s}.$$

Answer $t = 8.5\times10^{8}$ s.