Answer on Question #45821 – Physics – Other

Question.

A current flows in a wire of circular cross-section with the free electrons travelling with a mean drift velocity v. If an equal current flows in a wire of the same material but of twice the radius, what is the new mean drift velocity?

$v/4$
$v/2$
$2v$
$4v$

Solution.

By definition the drift velocity is the average velocity that a particle attains due to an electric field. Drift velocity is expressed in the following equations:

$$J = \rho v_{avg}, \text{ where}$$

J is the current density;

ρ is charge density;

v_{avg} is the drift velocity.

As we know, the current density is defined the following:

$$J = \frac{I}{S}, where$$

I is the electric current through the wire;

S is the cross-sectional area.

We have the circular cross-section. Therefore, $S = \pi r^2$, where r is the radius of wire.

So,

$$\frac{I}{\pi r^2} = \rho v_{avg} \rightarrow v_{avg} \sim \frac{1}{r^2} \rightarrow v_{avg} r^2 = const$$

We have $v_{avg\ 0}$ for r_0. Therefore, for $r = 2r_0$ we will have:

$$v_{avg} r^2 = v_{avg\ 0} r_0^2 \rightarrow v_{avg} = v_{avg\ 0} \left(\frac{r_0}{r}\right)^2 = \frac{1}{4} v_{avg\ 0}$$

Answer.

$v/4$