

Answer on Question #46001– Physics – Electromagnetism

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?

Solution: current density (electric current per unit area of cross section) is proportional to the mean drift velocity of the electrons

$$j = \frac{I}{S} = env,$$

where e is the charge of one electron and n is the concentration of the free electrons in the wire. Since the currents flowing in the wires are the same in both cases, we can write

$$env \cdot S = env_{new} \cdot S_{new}.$$

Therefore the new mean drift velocity is

$$v_{new} = v \cdot \frac{S}{S_{new}} = v \cdot \frac{\pi r^2}{\pi r_{new}^2}$$

But the new radius is $r_{new} = 2r$, thus the new mean drift velocity is

$$v_{new} = v \cdot \frac{r^2}{(2r)^2} = \frac{v}{4}.$$

Answer:

$$v_{new} = \frac{v}{4}.$$