

drift speed, Ohm's law, resistors, resistivity, emf and Kirchhoff's rules

Current and drift speed

- current $I = \frac{q}{t}$ for steady flow, or $I = \lim_{\Delta t \rightarrow 0} \frac{\Delta q}{\Delta t}$, unit ampere
- conventional current runs the way positive charge would move, **opposite** to electron flow in a metal
- no field: free electrons move randomly at $\sim 10^6 \text{ m s}^{-1}$, no net drift
- field applied: electrons drift opposite E at only 10^{-4} to 10^{-5} m s^{-1} , ten orders slower



electrons drift the other way

electrons drift one way through the wire while conventional current I is marked the other

Q. A wire of diameter 0.02 m has 10^{28} free electrons per m^3 and carries 100 A. Find the drift speed.

$$1) A = \pi r^2 = \pi (0.01)^2 = 3.14 \times 10^{-4} \text{ m}^2$$

$$2) v_d = \frac{I}{nAe} = \frac{100}{10^{28} \times 3.14 \times 10^{-4} \times 1.6 \times 10^{-19}}$$

$$3) \text{denominator} = 10^{28} \times 3.14 \times 10^{-4} \times 1.6 \times 10^{-19} \approx 5.02 \times 10^5$$



electrons drift the other way

the same wire in the example: electrons one way, conventional I the other

Answer $v_d \approx 1.99 \times 10^{-4} \text{ m s}^{-1}$

100 A still crawls at a fifth of a millimetre per second, since n is enormous

learn these

Current, drift speed and current density

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charge in a length L , n electrons per unit volume

$$q = nALe$$

current in terms of drift speed

$$I = nAv_d e$$

current density

$$J = \frac{I}{A} = nev_d$$



thicker thinner: faster
same current through both

the same I through a thick then a thin section: same charge, faster where it's thin, $J = I/A$ rises

A is the wire's cross-section. I is the same at every cross-section in series, so where A narrows, $J = I/A$ rises

Ohm's law

statement, physical state unchanged

$$I \propto V$$

resistance

$$V = IR, R = \frac{V}{I}$$

conductance

$$C = \frac{I}{R}$$

unit of R is ohm, Ω : $1 \Omega = \frac{1 \text{ V}}{1 \text{ A}}$. ohmic gives a

straight I - V line through the origin; non-ohmic (diode, thermistor, electrolyte) does not, resistance

there is $\frac{dV}{dI}$, not fixed

