

Exercise walk-through

11.1

Electric Current

AP Physics C: Electricity and Magnetism

Electric current and Ohm's law

Rate of charge flow

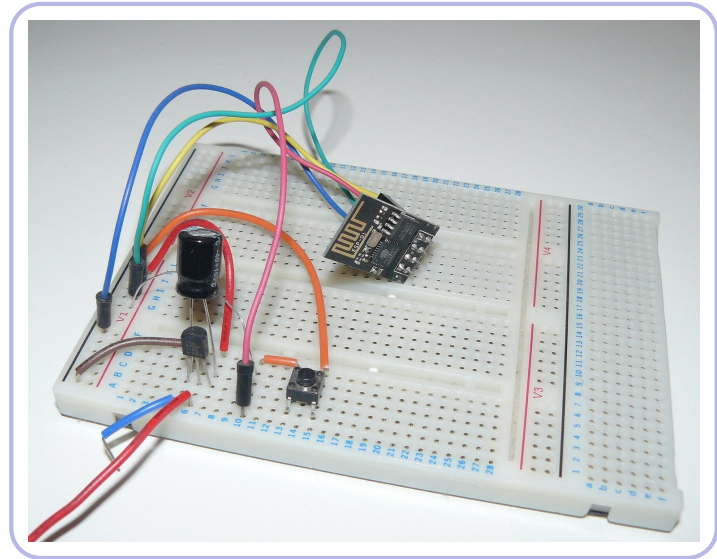
$$I = \frac{dQ}{dt}$$

Conventional current is opposite to the electron **drift**.

Ohm's law

$$V = IR, \quad R = \frac{\rho L}{A}$$

Resistivity ρ is a material property; R is the object's.



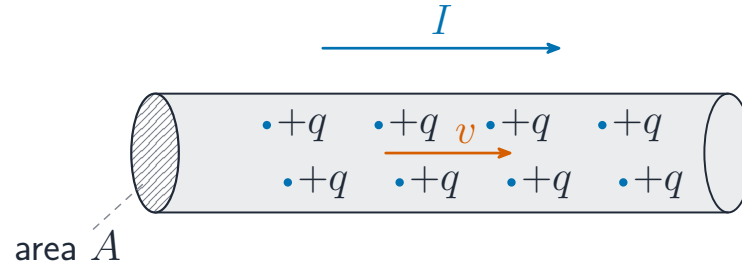
Breadboard

What a circuit is, and what Ohm's law claims

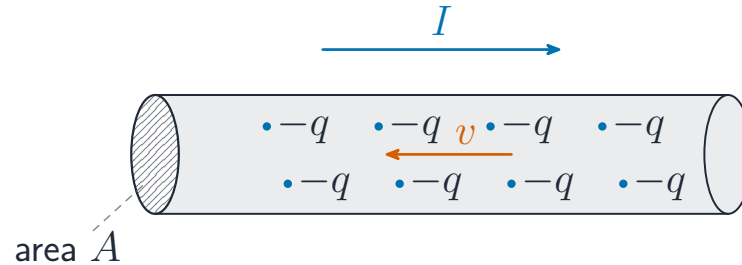
a circuit	closed loops of wires, batteries, resistors, bulbs, capacitors, inductors, switches and meters – charge flows only around a closed loop
steady state	current the same everywhere along one branch; nothing accumulates
Ohm's law	$I = \frac{\Delta V}{R}$ for an ohmic element – one whose R does not change with I
resistance	$R = \frac{\rho \ell}{A}$: material through ρ , and geometry through ℓ and A
ideal battery	maintains a fixed emf with zero internal resistance; a real one has r in series

Current is a **scalar** with a chosen direction, not a vector. Conventional current runs the way **positive** charge would move.

Electric Current



(a) positive carriers drift with I



(b) electrons drift against I

Charge carriers drift slowly through a conductor to make a current

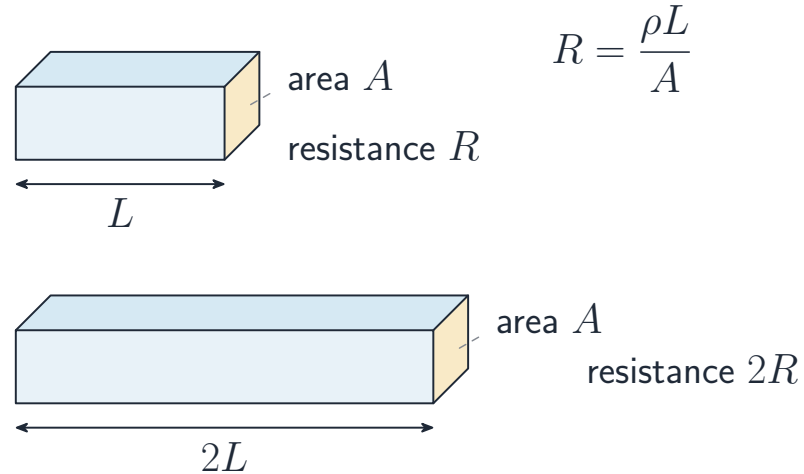
Worked example – how slowly electrons actually drift

A copper wire of area $1.0 \times 10^{-6} \text{ m}^2$ with $n = 8.5 \times 10^{28} \text{ m}^{-3}$ carries 1.7 A. Find the drift velocity .

- $v_d = \frac{I}{nqA}$
- $= \frac{1.7}{(8.5 \times 10^{28})(1.6 \times 10^{-19})(1.0 \times 10^{-6})}$
- $= 1.3 \times 10^{-4} \text{ m/s}$ – about 0.5 m per hour

The *signal* travels near light speed; the electrons crawl. **Current density** $\vec{J} = nq\vec{v}_d$ is the same idea per unit **cross-sectional area**, tied to the field by $\vec{E} = \rho\vec{J}$, with $I = \int \vec{J} \cdot d\vec{A}$ in general.

Resistance, Resistivity, and Ohm's Law



twice the length $\Rightarrow$ twice the resistance

A longer conductor has more resistance; a wider one has less

Exercises 2.1-2.3

2.1 A charge of 15 C flows past a point in 3.0 s. Find the current. [2]

2.2 State the direction of conventional current relative to the electron flow. [1]

2.3 State what drives a current through a conductor. [1]

Exercises 2.1-2.3

2.1 A charge of 15 C flows past a point in 3.0 s. Find the current. [2]

2.1

- $I = \frac{\Delta Q}{\Delta t} = \frac{15}{3.0} = 5.0 \text{ A}$

2.2 State the direction of conventional current relative to the electron flow. [1]

2.2

- opposite to the electron flow

2.3 State what drives a current through a conductor. [1]

2.3

- a potential difference across it

Exercises 3.1-3.2

3.1 Electric current is defined as

[1]

☐

A Q/V

B $\frac{dQ}{dt}$

C It

D V/R

3.2 Conventional current flows in the direction of

[1]

☐

A electron flow

B positive charge flow

C neutron flow

D no charge

Exercises 3.1-3.2

3.1 Electric current is defined as

[1]

☐

A Q/V

B $\frac{dQ}{dt}$

C It

D V/R

3.1 B

- $\frac{dQ}{dt}$.

3.2 Conventional current flows in the direction of

[1]

☐

A electron flow

B positive charge flow

C neutron flow

D no charge

3.2 B

- positive charge flow.

Exercise 3.3 (a)

3.3 A wire carries a steady current of 3.0 A.

(a) Find the charge that passes in 20 s.

[2]

Exercise 3.3 (a)

3.3 A wire carries a steady current of 3.0 A.

(a) Find the charge that passes in 20 s.

[2]

(a)

- $\Delta Q = I \Delta t = 3.0 \times 20 = 60 \text{ C}$

Exercise 3.3 (b)

3.3 A wire carries a steady current of 3.0 A.

(b) State the conservation law obeyed by a steady current.

[1]

Exercise 3.3 (b)

3.3 A wire carries a steady current of 3.0 A.

(b) State the conservation law obeyed by a steady current.

[1]

(b)

- conservation of charge