The electron current

Currents - controlled motion of charges

- eletrons are charge carriers in metals

$I = \frac{\Delta Q}{\Delta t}$ steady current [A]

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

* because currents were known before what charge carriers are (negative), the direction of current is defined to be the direction in which positive charges seem to move (opposite of what electrons do)

$$I = \frac{\Delta Q}{\Delta t}$$

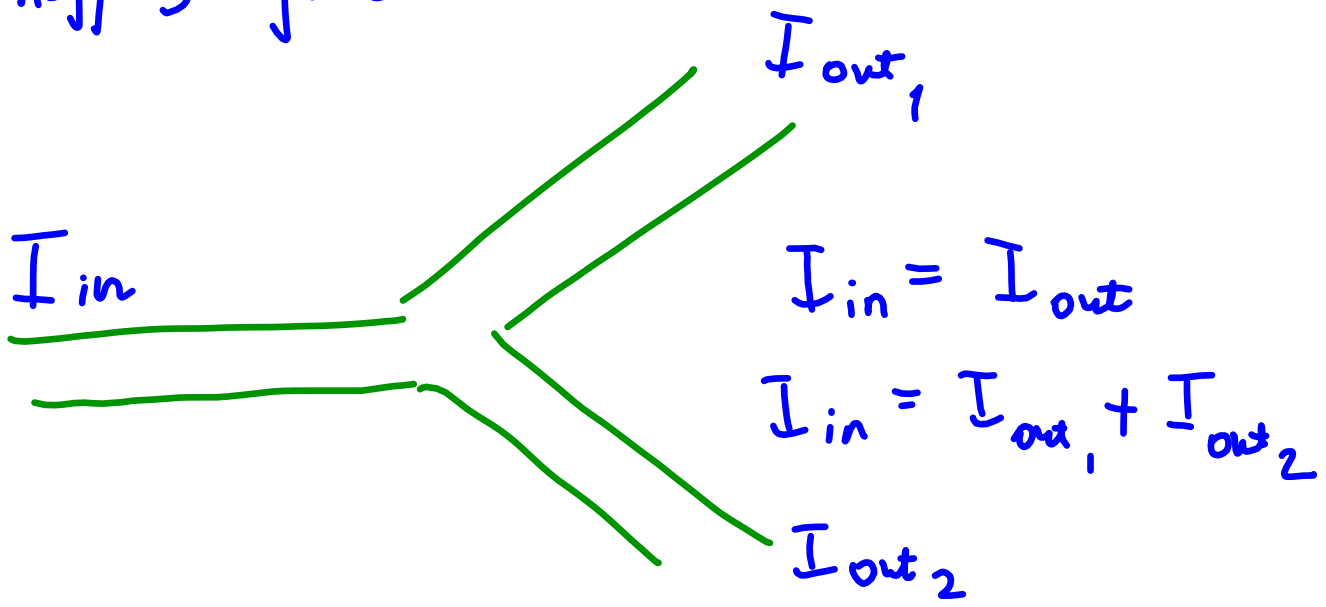
The current is the same at all points in a current-carrying wire

We cannot destroy electrons

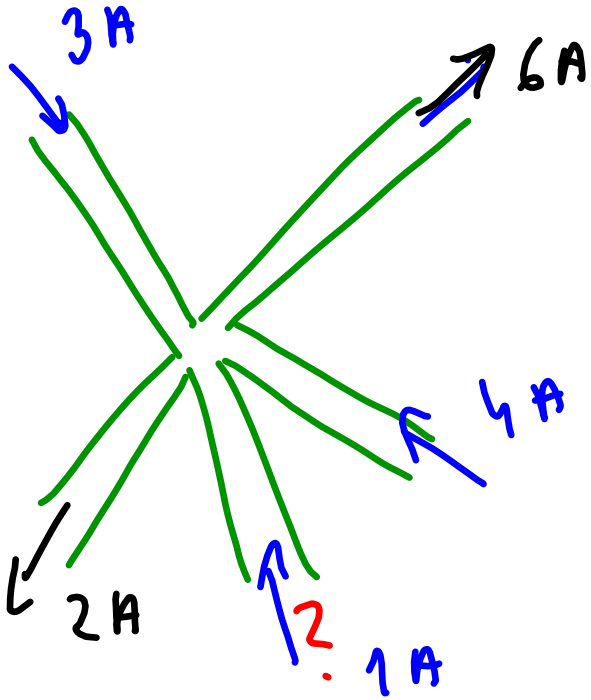
The rate of electrons entering the light bulb or any other device is exactly the same as the rate of electrons leaving it.

Conservation of current (charge)

- Kirchhoff's junction law



$$\Sigma I_{in} = \Sigma I_{out}$$



$7A \neq 8A$

$8A = 8A$

Conductivity & Resistivity

σ — ρ

different materials have different conductivity

$$\rho = \frac{1}{\sigma}$$

$J = \frac{I}{A}$ current density $J = \sigma E$

A: surface area

Current is caused by an electric field exerting forces on the charge carriers

Resistance & Ohm's law

Resistance [R] is a property of a specific conductor, it depends on conductor's length, diameter & resistivity [ρ] of the material.

[Ω] Ohm

$$R = \frac{\rho L}{A}$$

L length

A area ($r^2\pi$)

Ex part (1) Copper wire of 0.5 cm in diameter & 70 cm long connects your car's battery to the starter motor. What is the resistance?

$$R = \rho \frac{L}{A} \quad \begin{matrix} [m] \\ [\Omega m] \quad [m^2] \end{matrix} \qquad = 0.6\ m\Omega$$

$$A = r^2 \pi$$

$r = 0.25\ cm$

$L = 70\ cm$

$\rho = 1.68 \cdot 10^{-8}\ \Omega m$

Resistance & Ohm's law

- how much current does it take to run this hair dryer?

Answer will depend on 2 things - voltage V
- resistance R

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

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

2 extreme cases - ① open circuit $R \to \infty$

- no current $I \to 0$
- switch in off position

real situations are in between

exception ~ superconductors

② Short circuit $R = 0$

Current of any magnitude is possible

Ex part 2

If the starter motor draws a current of 170 A, what is the potential difference across the wire?

$R = 0.6\ m\Omega$

$I = 170\ A$

$V = I \cdot R = 0.1\ V$

Electric power $\quad (V = I \cdot R)$

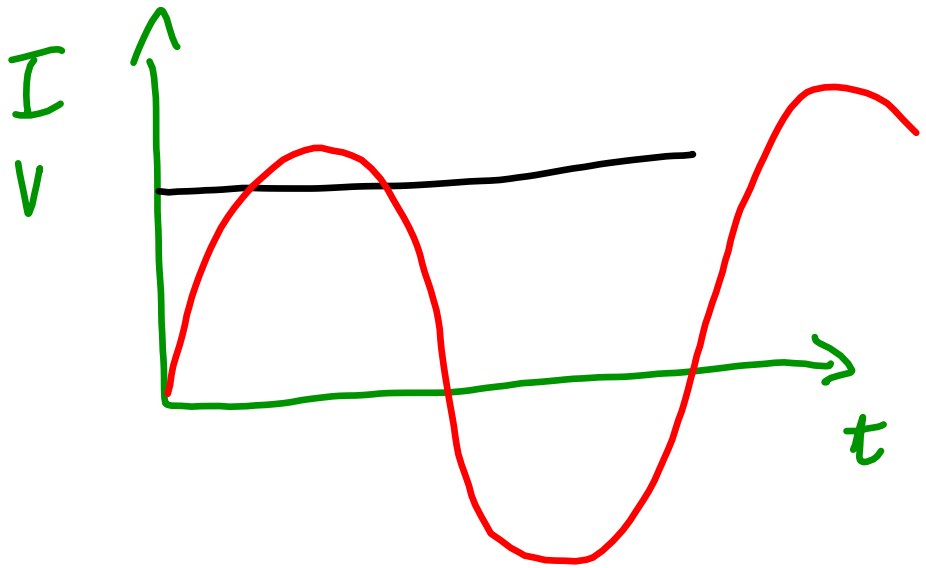
$$P = I \cdot V = I^2 R = \frac{V^2}{R}$$

$$I = \frac{\Delta Q}{\Delta t}$$

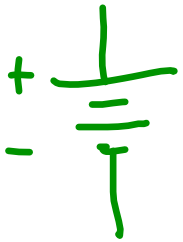
AC / DC

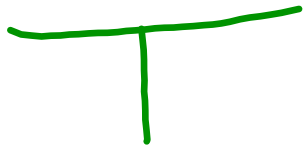
alternating current

direct current



Circuit elements & diagrams

Battery 

Junction 

Wire 

Capacitor 

Resistor 

switch 

Bulb 

1) $\Sigma I_{in} = \Sigma I_{out}$

2) Sum of potential differences around any loop or closed path is zero.

(This is a statement of energy conservation)

(W_u - running to prof. office & back)

$$\Delta V_{loop} = \sum_i (\Delta V)_i = 0$$

Kirchoff's loop law