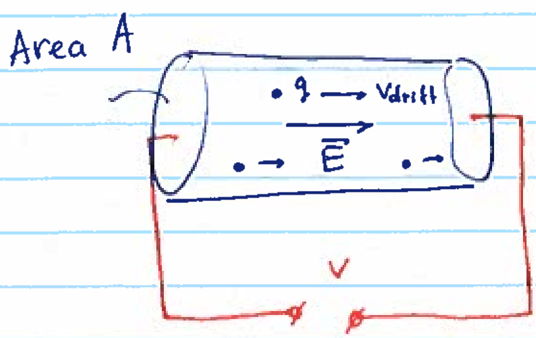
Electric current I (measured in Ampere)

Electric current is the amount of positive charge passing through a wire in a given time

(yes, the current flows officially in the opposite direction of moving electrons)



$$I = \frac{dQ}{dt} = q \cdot A \cdot n_q \cdot \langle V_q \rangle$$

q – unit charge "positive electron"

n_q – density of free carriers

$\langle V_q \rangle = V_{drift}$ – common velocity of charges in electric field

$\langle V_q \rangle \propto E$

$V = E \cdot l$

$$I = A \cdot \sigma \cdot E$$

σ – conductivity, depends on the material

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

$$V = \frac{I}{A \cdot \sigma} \cdot l = \frac{l}{\sigma \cdot A} \cdot I = \boxed{\frac{l \rho}{A}} \cdot I$$

R – resistance

$V = R \cdot I$ – Ohm's law $\quad R = \frac{V}{I} \quad [R] = \text{Ohm}$, Ω

For a uniform wire / piece of conductor

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

$R \uparrow$ if area is smaller

$R \uparrow$ if the ~~wat~~ wire is longer

Power dissipated at a resister

$$P = \frac{dU}{dt} = \frac{V\,dQ}{dt} = V \cdot I = V^2/R = I^2 R$$

Thick wires are better to use for high current, since they loose less energy (and are less likely to melt)

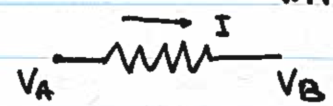
Electric circuits

DC (direct current) — constant current

AC (alternating current) [we'll get ~~the~~ to them soon]

Common elements

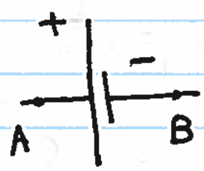
- wires — & when assumed ideal (default), connect points of equal potential $\Delta V_{wire} = 0$
- R resistors $V_A - V_B = \Delta V_R = I \cdot R$



- Batteries: sources of constant potential difference

Ideal battery is a source of <u>electromotive force</u> (emf): $\mathcal{E}$ — max voltage a battery can produce.
Real batteries have some internal resistance, so their actual output voltage can be less than their emf — we'll discuss it later.

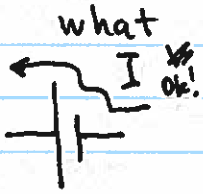
Notation:



$V_A - V_B = \mathcal{E}$

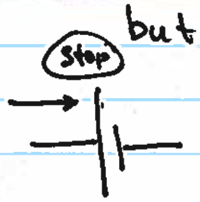
My favorite mnemonics | → break in half ¦ → + combine

In what direction battery would push the current?



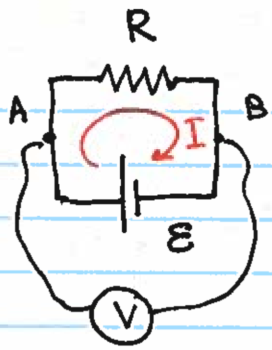
easy to get over, taking the steps

but



hard to get through, with high fence

Simplest circuit



$V_A - V_B = \mathcal{E}$

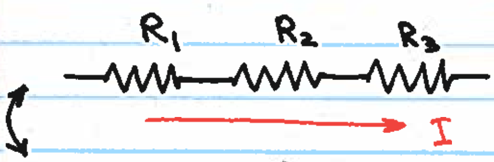
$V_A - IR = V_B$

$V_A - V_B = IR$

$\mathcal{E} = IR$

$I = \mathcal{E}/R$

Series connection



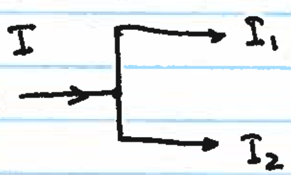
equivalent

Same current flows through each resistor for connection in series (since all the charges must get from one end to another)

Total voltage drop $IR_1 + IR_2 + IR_3 = V_{tot}$

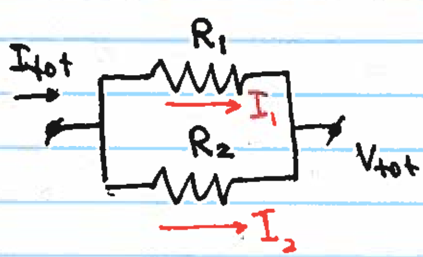
Effective resistance $R_{eff} = \dfrac{V_{tot}}{I} = R_1 + R_2 + R_3$

Parallel connection



$I = I_1 + I_2$ original flow of charges splits in two (or more) streams, but their total current stays the same

Parallel resistor connection



$I_{tot} = I_1 + I_2$

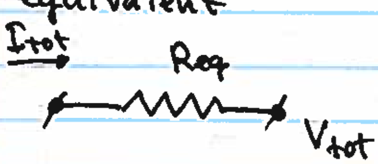
$V_1 = V_2 = V_{tot}$

$V_1 = I_1 R_1 \quad V_2 = I_2 R_2$

⇓

$I_1 = \dfrac{V_1}{R_1} = \dfrac{V_{tot}}{R_1} \quad I_2 = \dfrac{V_2}{R_2} = \dfrac{V_{tot}}{R_2}$

equivalent



$I_{tot} = \dfrac{V_{tot}}{R_{eq}} = \dfrac{V_{tot}}{R_1} + \dfrac{V_{tot}}{R_2}$

$\dfrac{1}{R_{eq}} = \dfrac{1}{R_1} + \dfrac{1}{R_2} \qquad R_{eq} = \dfrac{R_1 R_2}{R_1 + R_2}$