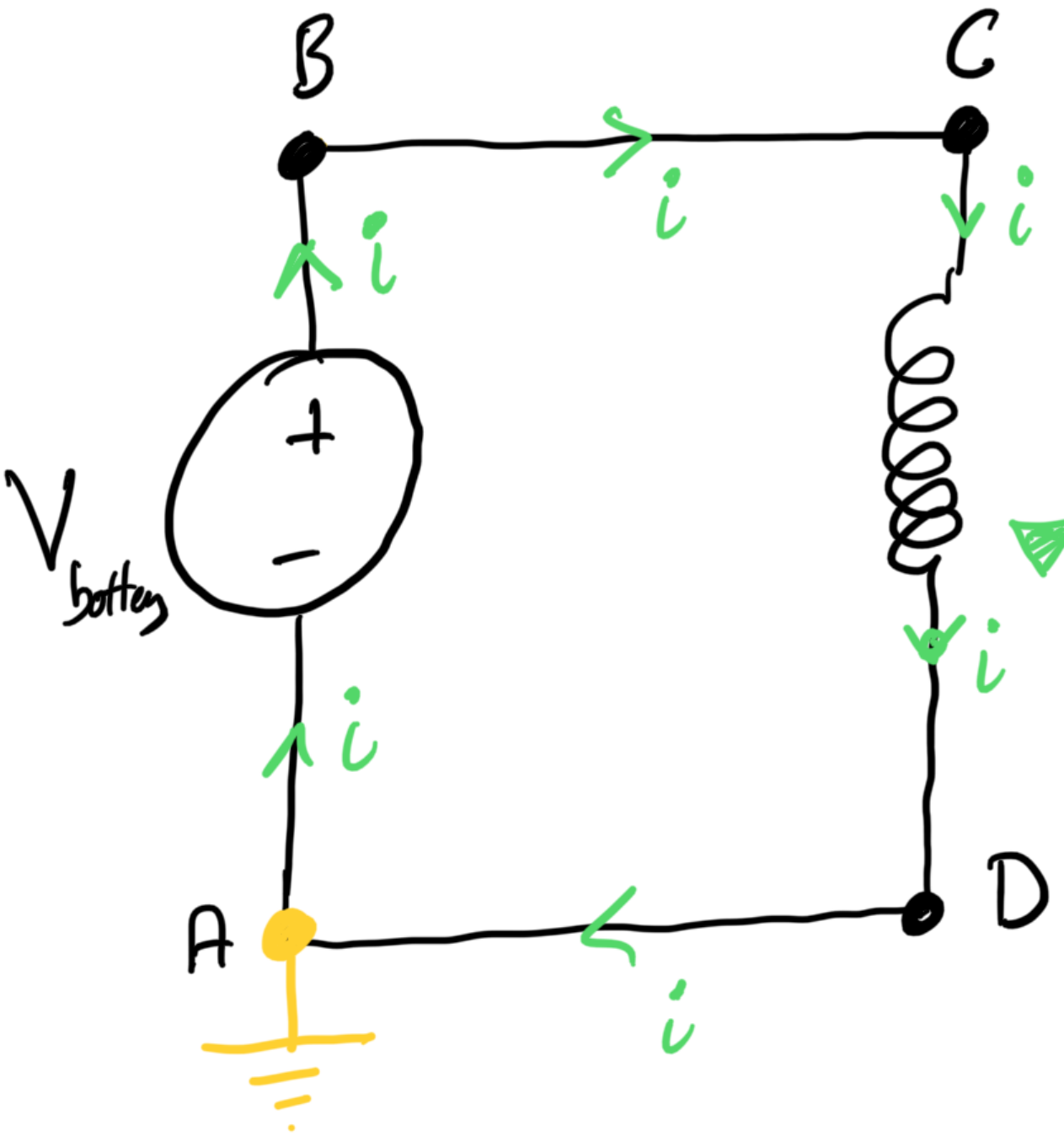
Electric Circuits



Notes:

① Batteries pump charge
i.e. electric current

② $V_A = 0$, by convention
→ grounded.

③ $V_B = V_{battery}$

④ $V_C = V_B$ (assume "wires" are perfect!)

⑤ $V_D = V_A = 0$ (same)

V_D

$\therefore \quad \Delta V_{\text{light bulb}} = V_C - V_D = V_{\text{battery}}$

Question: What is i? How is it related to $\Delta V_{\text{light bulb}}$?

Answer: For a lot of circuit elements,

$$i \propto \Delta V$$

Ohm's Law

(The bigger the battery, the larger the current!! Makes sense)

Mathematically, we write this as:

$$\Delta V_{\text{element}} = i_{\text{element}} \cdot R$$

$\Delta V_{\text{element}}$: voltage Difference

R: resistance

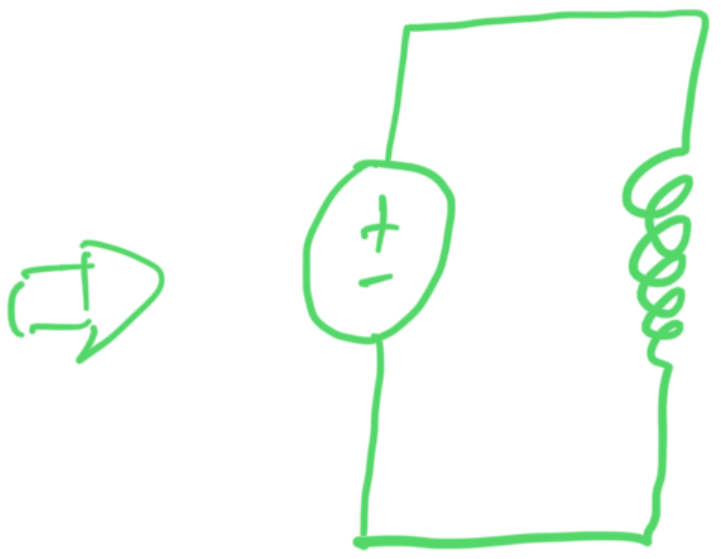
across element of the circuit

current through element

Note: $R = \frac{\Delta V}{i} \Rightarrow [R] = \frac{V}{A} \equiv \text{Ohm}$

!! Ω

Example: Flashlight



$V_{Battery} = 3.0\,V$ (two AA in series, each 1.5 V)

What is $R_{lightbulb}$? I have no idea!!!

What is i? I have no idea!!!

The only thing I know about light bulbs is their power ratings, in Watts!!

I looked it up: $P = 2.7\ W$

So, for good reason, it turns out that:

$$P_{element} \equiv i_{element} \cdot \Delta V_{elem.}$$

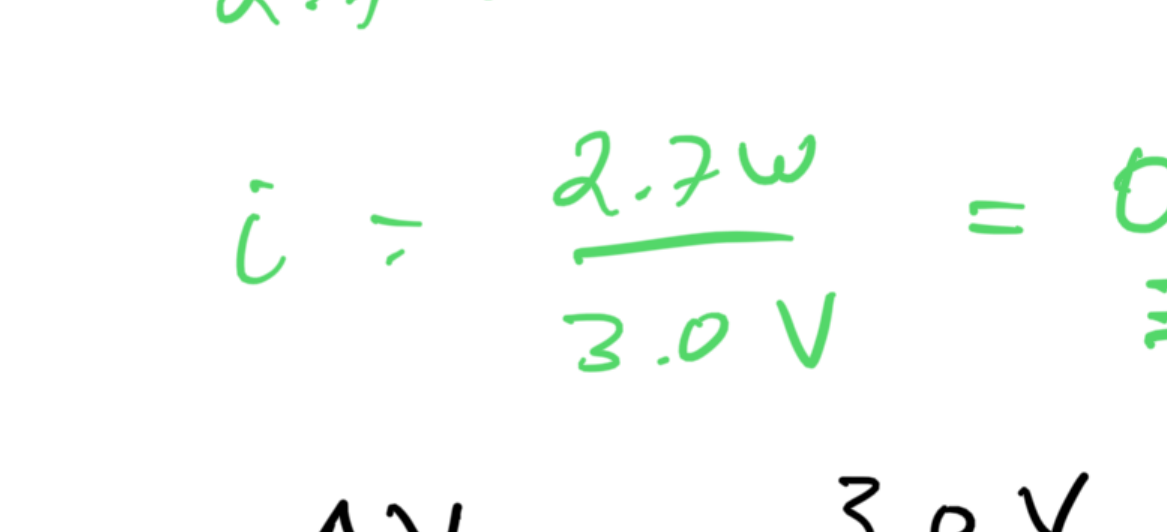
So, for our flashlight:

$$2.7\ W = i\,(3.0\ V)$$

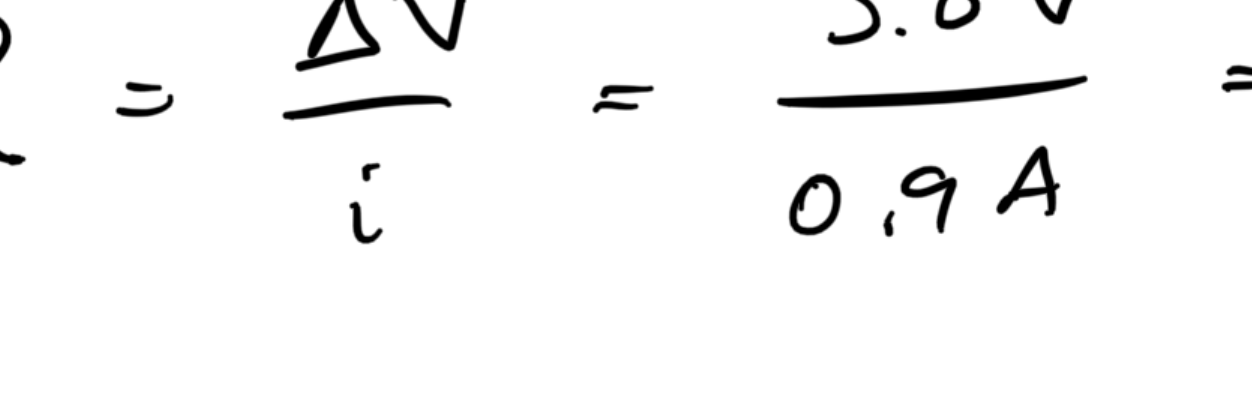
$$i = \frac{2.7\ W}{3.0\ V} = 0.9\ A$$

$$\therefore R = \frac{\Delta V}{i} = \frac{3.0\ V}{0.9\ A} = 3.33\ \Omega$$

What does a lightbulb filament look like?



It turns out that:



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

(like a garden hose!)

A ← cross-sectional area.

$\rho \equiv$ resistivity = property of material.

$$\rho_{tungsten} = 5.6 \times 10^{-8}\ \Omega \cdot m \quad \text{at } 20^\circ C$$

What is l? Flashlight ~ 1cm = 0.01m

$$R = \rho \frac{l}{A} \quad \therefore \quad A = \frac{\rho l}{R} = \frac{(5.6 \times 10^{-8})(.01)}{3.33}$$

$$= 1.68 \times 10^{-10}\ m^2$$

$A = \pi r^2$

$$\pi r^2 = 1.68 \times 10^{-10}$$

$$r = 7.3 \times 10^{-6}\ m$$

$r = 7.3\ \mu m$!!! Super-thin !!!