For a single resistor: $V = IR$

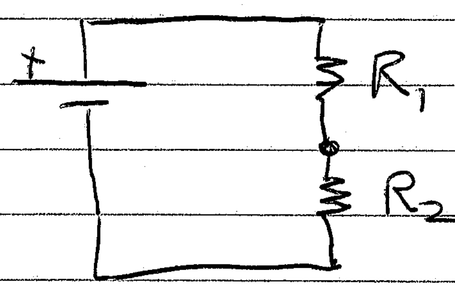
$P = IV$

In simple circuit, $V = \mathcal{E}$.
- └ Battery voltage
- └ Device voltage

With multiple loads, the configuration is important.

__Series Configuration__

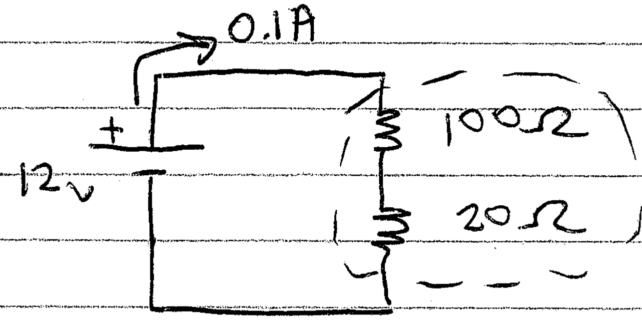
- The current from one device is forced into the next device.



$I_1 = I_2 = I$

$V_1 + V_2 = V_{net}$

- In series, devices have the __same__ current
- In series, an individual charge loses its energy a bit at a time, eventually losing all.



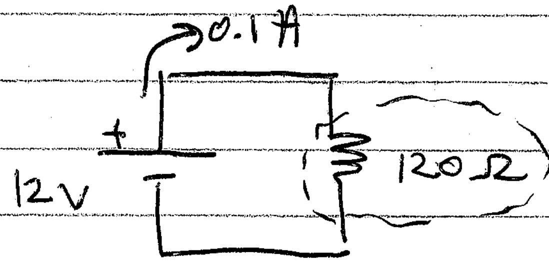
$$V_1 + V_2 = V_{net}$$

$$I(100\Omega) + I(20\Omega) = (12\,v)$$

$$I(120) = 12$$

$$I = 0.1\ A$$

looks like Ohm's Law



Equivalent Circuit

In general:

$$V_1 + V_2 + \dots = V_{net}$$

$$IR_1 + IR_2 + \dots = IR_{net}$$

$$R_1 + R_2 + \dots = R_{net}$$

Notes:

- Inserting $R_3 = 0$ does nothing
  - ↳ "good" wire
- Inserting $R_3 = \infty$ blocks the current
  - ↳ "broken" wire
- An ammeter in series:
  - measures the <u>same</u> current as your device
  - has $R = 0$ to avoid affecting the result.

Internal Resistance - resistance built in to a battery that acts like it's in series.

- Adds to R_{net}.
- "Drops" some voltage.

$$V_{net} = V_1 + V_2$$

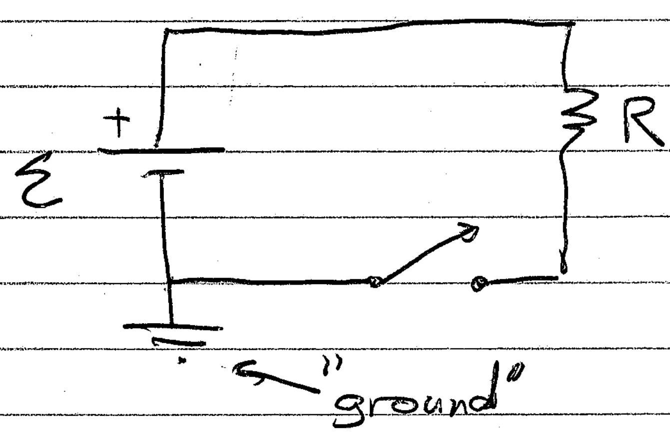
$$\mathcal{E} = V_{int} + V_{ext}$$

$$\mathcal{E} = IR_{int} + V_{ext}$$

$$\mathcal{E} - IR_{int} = V_{ext}$$

Ex: Lights dim when microwave runs.

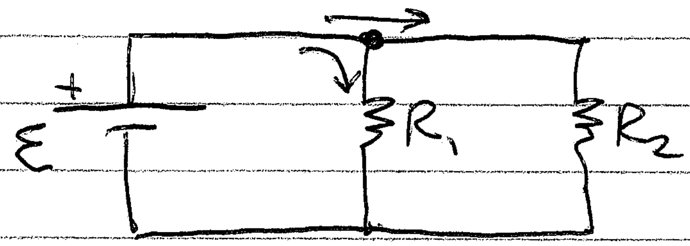
- I increases
- More voltage is lost.
- Less V_{ext} ⟹ dim lights



$$\mathcal{E} = V_R + V_{switch}$$

(V_R ↑ 0; V_{switch} ↑ $\mathcal{E}$)

Parallel Configuration - Circuit has <u>branches</u> where current must choose a path. For true parallel, current <u>splits</u> and <u>merges</u>.



$$I_1 + I_2 = I_{net}$$

$$V_1 = V_2 = V$$

- The current splits, and the branch currents add up to the total.
- Any one charge loses the same voltage regardless of which branch it chooses.

$(I = \rho v A)$

$$I_1 + I_2 = I_{net}$$

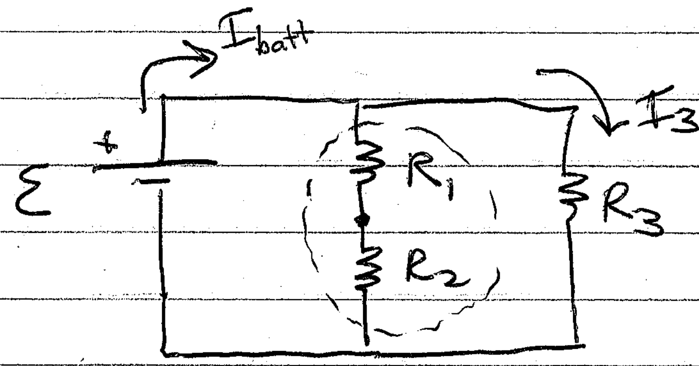
$$\frac{V}{R_1} + \frac{V}{R_2} = \frac{V}{R_{net}}$$

$$\frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{R_{net}}$$

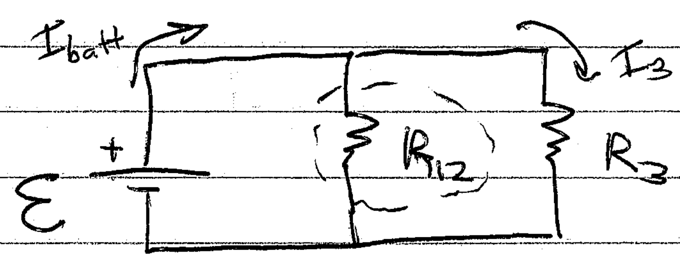
Inverse resistances add in parallel. Similar to pythagorean theorem. Inverse is (-1) power.

Combination Circuit - can analyze **many** (not all) circuits with equivalents

Ex:



Find some series or parallel part.



$R_{12} = R_1 + R_2$

What details are the same?

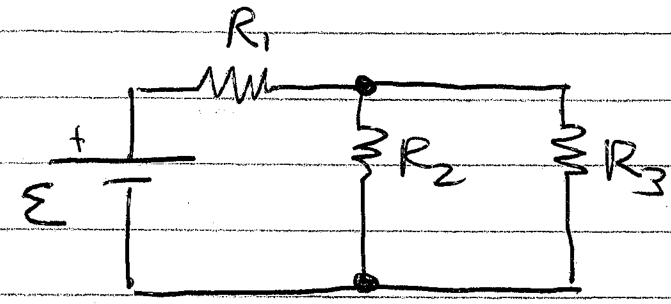
I_{batt} | $\mathcal{E}$

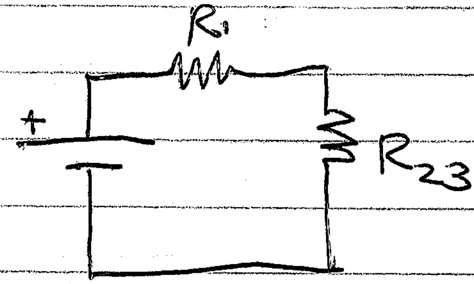
I_3 | V_3

$I_1 = I_2 = I_{12}$ | $V_1 + V_2 = V_{12}$

Note: V_{12} doesn't really transfer.

Ex:





$$= \left(\frac{1}{R_2} + \frac{1}{R_3}\right)^{-1}$$

What transfers from easy to complicated version?

I_{batt} $\qquad$ ε

I_1 $\qquad$ V_1

$I_2 + I_3 = I_{23}$ $\qquad$ $V_2 = V_3 = V_{23}$