Current (continuing)

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

microscopic		macroscopic	
Electric field	$\vec{E}$	voltage	V
current density	$\vec{J}$	current	I
resistivity	ρ	resistance	R

Ohm's law

$\vec{J} = \frac{\vec{E}}{\rho} \iff I = \frac{V}{R}$

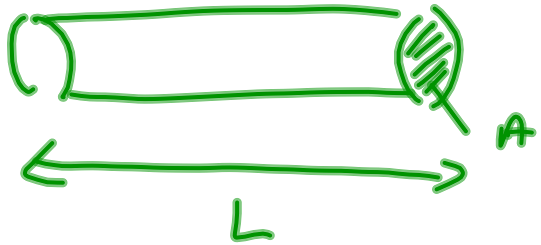
$$J = \frac{E}{\rho} \qquad (*)\ I = \frac{V}{R}$$

$$I = J \cdot A$$

A surface area

$$I = \frac{E}{\rho} \cdot A$$

$$(*)\ R = \rho \frac{L}{A}$$



$$\rho = \frac{RA}{L}$$

$$I = \frac{E \cdot L}{R \cancel{A}} \cdot \cancel{A} = \frac{E \cdot L}{R} = \frac{V}{R}$$

Example of R (light bulb)

R resistance [Ω] Ohm

$I = \frac{V}{R}$ or $V = I \cdot R$ or $R = \frac{V}{I}$ Ohm's law

Electric power

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

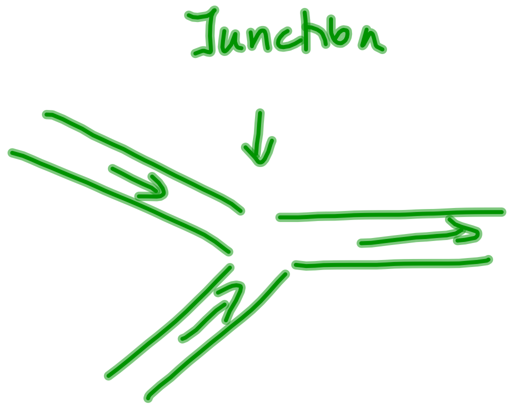
$$= I^2 R \quad [W]$$

Conservation of current / charge

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

conservation of mass

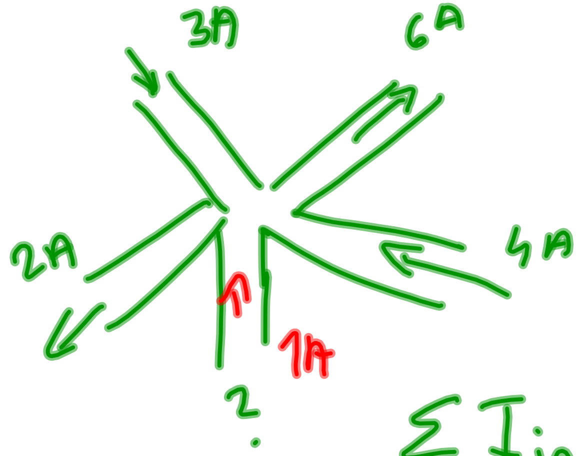
$$flow_{in} = flow_{out}$$



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

Kirchhoff's junction law

The sum of the currents into a junction must equal to the sum of the currents leaving the junction. (cons. of current / charge)



A point where a wire branches is called a junction.

$\Sigma I_{in} = 7A$

$\Sigma I_{out} = 8A$

2 ways to decrease current – decrease the amount of charge

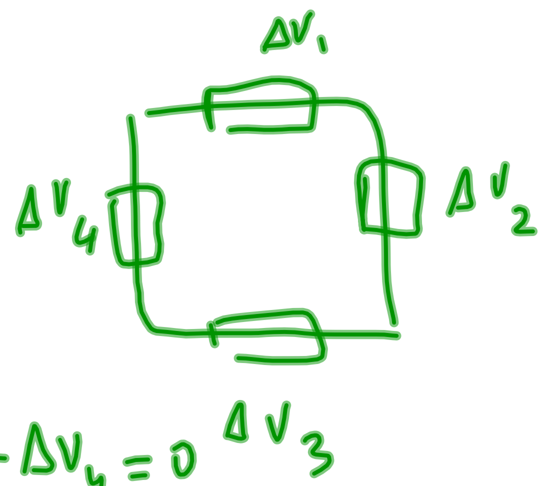
$$I = \frac{\Delta Q}{\Delta t}$$

– decrease the speed (v_d)

Resistors don't change current, but use energy.

Kirchhoff's loop law

The sum of all the potential differences encountered while moving around a loop or closed path is zero.



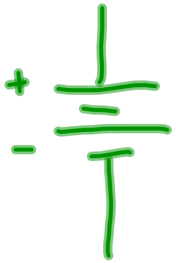
$$\Delta V_{loop} = \sum_i (\Delta V)_i = 0$$

conservation of energy

$$\Delta V_1 + \Delta V_2 + \Delta V_3 + \Delta V_4 = 0$$

Circuit elements

Battery

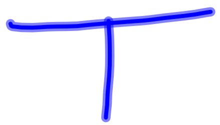


ε

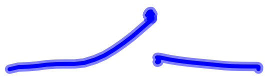
Resistor

Wire

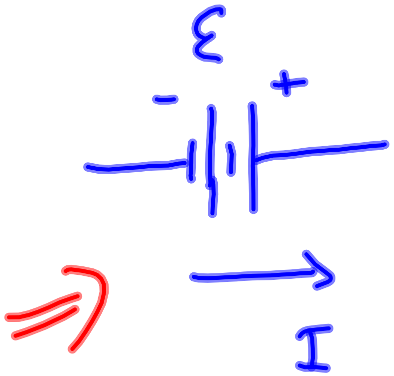
Junction



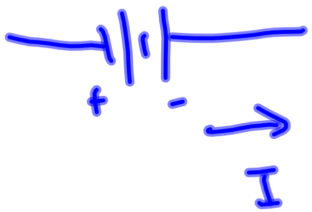
Switch



$$\Delta V = V_{downstream} - V_{upstream}$$

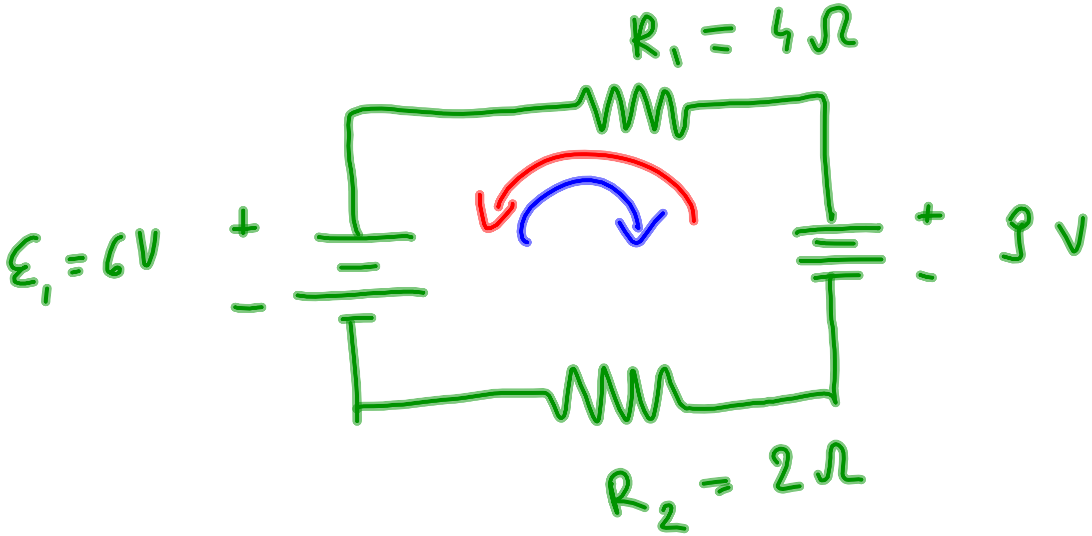


$\Delta V_{bat} = +\,\mathcal{E}$ potential increases



$\Delta V_{bat} = -\,\mathcal{E}$ potential decreases

$9V - IR_1 - 6V - IR_2 = 0$ $\quad I = 0.5A$



Find the current & potential across each resistor.

Remember $V = I \cdot R$

$$\Sigma(\Delta V)_L = 0$$

$$6V - IR_1 - 9V - IR_2 = 0$$

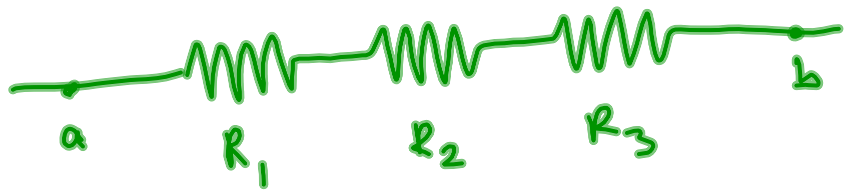
$$-3V = I(6\Omega) \Rightarrow \boxed{I = -0.5A}$$

$$\Delta V_1 = -IR_1 = -2V$$

$$\Delta V_2 = -IR_2 = -1V$$

Resistors in series & parallel

in series



- no junctions
- I is the same

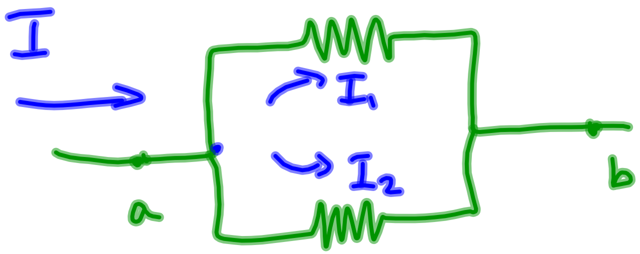
$$\Delta V_{ab} = \Delta V_1 + \Delta V_2 + \Delta V_3$$
$$= IR_1 + IR_2 + IR_3$$
$$= I(R_1 + R_2 + R_3)$$

$R_{eq} = R_1 + R_2 + R_3 + \dots$ in series

Ammeters - device that measures the current in a circuit

- (A)
- must be placed in series with a device that it measures

Parallel resistors



junction !

$I = I_1 + I_2$

$\Delta V_{ab} = \Delta V_1 = \Delta V_2$

the same potential difference

$I = \frac{\Delta V_1}{R_1} + \frac{\Delta V_2}{R_2}$

$= \Delta V_{ab}\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$

$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$

Voltmeter - in parallel

$I = 4A$ confirm

ΔV, I through each resistor?

$I = \frac{V}{R}$ $\quad I_1 = \frac{9}{15}$ A

$I = \Sigma I$ $\quad I_2 = \frac{9}{4}$ A

$I_3 = \frac{9}{8}$ A

$$I = \frac{9}{15} + \frac{9}{4} + \frac{9}{8} = 4A$$

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$I = \frac{V}{R_{eq}}$$