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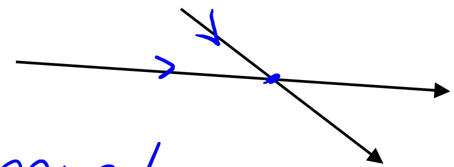
6.2 Kirchhoff's Laws

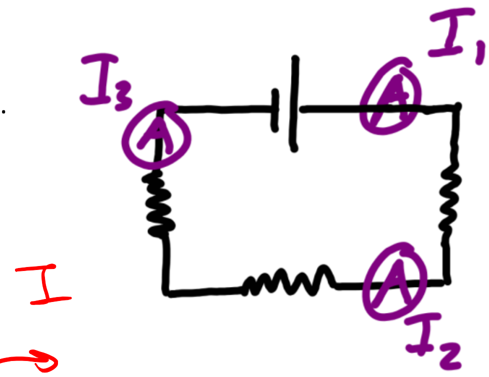
Question for the day: why does our circuit fuse blow up?



We'll need to consider Kirchhoff's Laws first.

Kirchhoff's Current Law states that the total amount of current entering a junction equal the total amount of current leaving the junction.

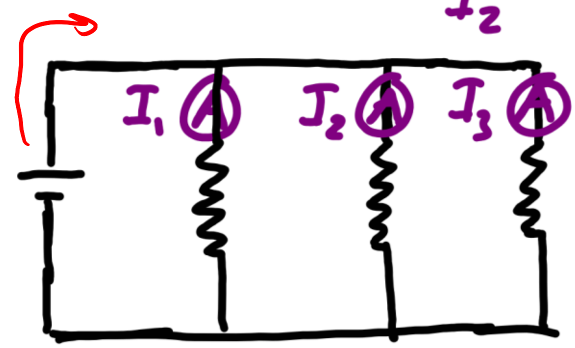
For resistors in **series**, there is only one pathway, so no junctions.



That means the current is the same everywhere in the circuit.

$I_{Total} = I_3 = I_2 = I_1$

For resistors in **parallel**, your current branches off into multiple pathways. At each junction, the current either splits off or combines. Therefore, the current of each branch, must equal up to the total current.



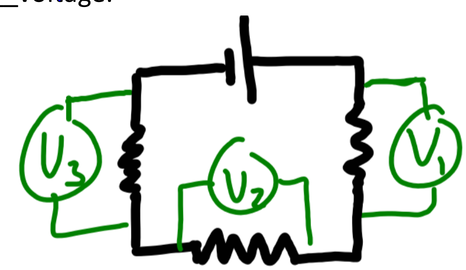
$I_{Total} = I_1 + I_2 + I_3$

Kirchhoff's Voltage Law states that the sum of the potential differences in a circuit must add up to zero.

Otherwise, energy would not be conserved, breaking the law of conservation of energy.

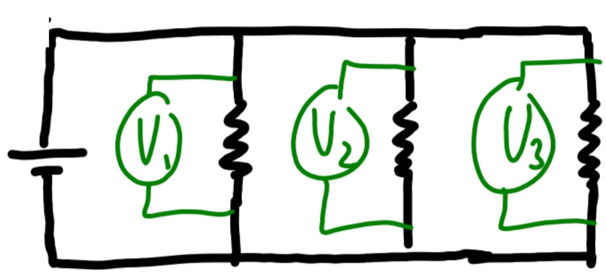
Across a resistor following the direction of the current, you would get a voltage drop. Across a battery/cell following the direction of the current, you would increase voltage.

For resistors in **series**, the potential drop going around the circuit should equal the total voltage (V_T across the battery)



$V_{Total} = V_1 + V_2 + V_3$

For resistors in **parallel**, since the potential difference drop happens at the same location in your circuit, the potential different across each resistor is the same.



$V_{Total} = V_1 = V_2 = V_3$

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So, how do we calculate the total resistance in a circuit?

$$V_T = I_T R_T$$

For resistors in **series:**

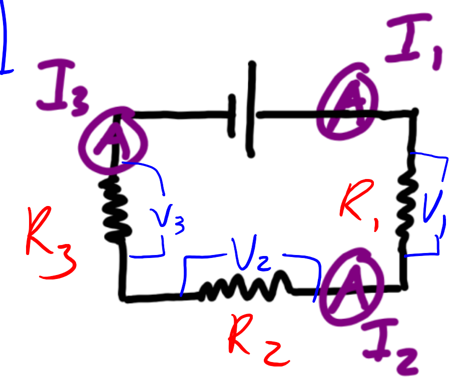
$V_T = V_1 + V_2 + V_3$, since $V = IR$

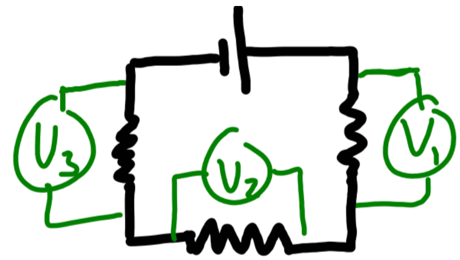
$I_T R_T = I_1 R_1 + I_2 R_2 + I_3 R_3$

$I_T = I_1 = I_2 = I_3$ ∴ all I's cancel

$R_T = R_1 + R_2 + R_3$

$$R_T = R_1 + R_2 + R_3$$





Think of it this way, more resistance in your circuit is like adding more roadblocks while you're driving (ex. More cares in traffic). As a result, you'll have to drive slower.

For resistors in **parallel**:

$$V_T = I_T R_T$$

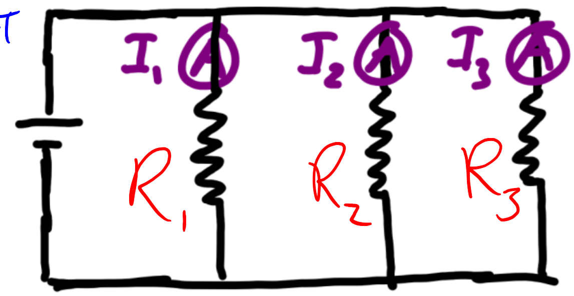
$I_T = I_1 + I_2 + I_3$, since $I = \frac{V}{R}$

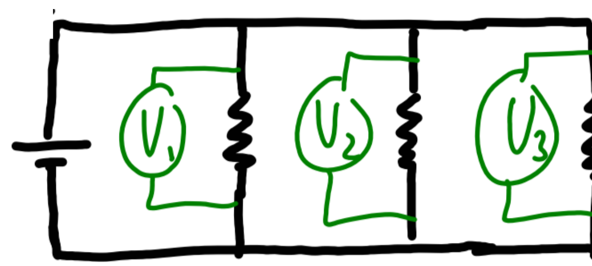
$\frac{V_T}{R_T} = \frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}$

$V_T = V_1 = V_2 = V_3$ ∴ all V's cancel

$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$





In fact, your home electric outlets use a parallel system. Thus, every time you hook something to your outlet, you're adding another resistor (load) in a parallel circuit.

Try this -> What happens to your total resistance as you add more and more resistors in parallel? Use some made up numbers yourself! $R_1 = 1\,\Omega$ $R_2 = 2\,\Omega$ $R_3 = 3\,\Omega$

Why? Compare parallel pathways to the residential roads you cut through just to skip traffic. The more alternative pathways there are, the less traffic you'd have to fight. What happens to the traffic flow (current)?

HW: Worksheet 6.2 In class examples, Circuitry Package #5, 6, 10, 11, 20, 21, 22, 25, 26, 27, 28, 31, 32, 33 MC questions