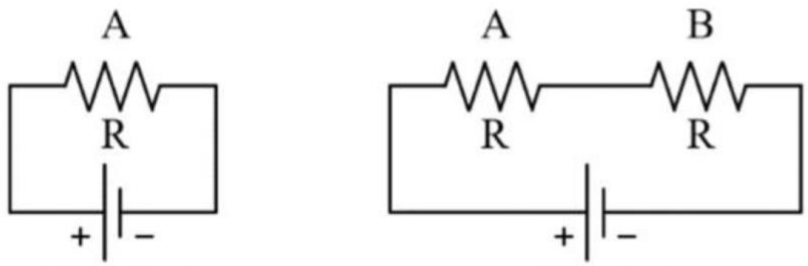


Circuit 1 Circuit 2

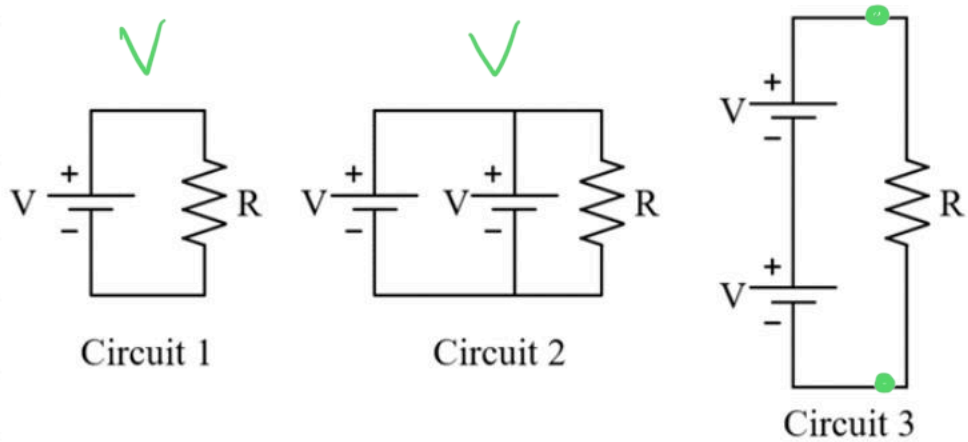
How does the power dissipated by resistor A change when resistor B is added, as shown in circuits 1 and 2 respectively?

- ○ increases
- ● decreases
- ○ stays the same

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

why do we care?

- high powered resistors are expensive!



In which circuit(s) does the resistor dissipate the least power?

- ○ Circuit 1
- ○ Circuit 2
- ○ Circuit 3
- ● Circuits 1 and 2
- ○ Circuits 1 and 3
- ○ Circuits 2 and 3

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

why do we care?

- less current is drawn so battery will last longer

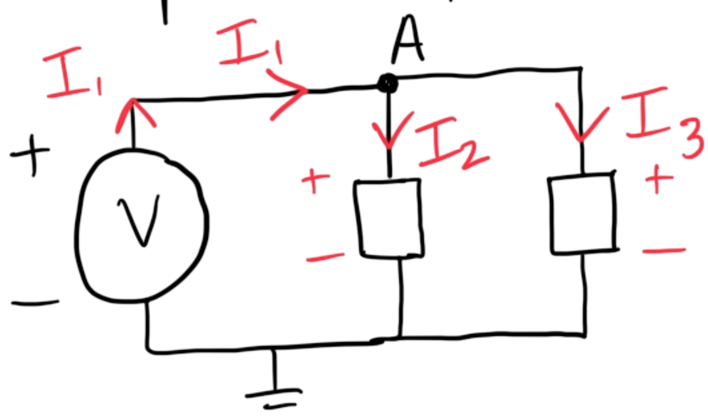
Kirchoff's laws

Kirchoff's current law (KCL)

The sum of currents at a node or junction is zero.

$$\sum_{n=1}^{N} I_n = 0$$

convention: Define currents entering nodes as positive, leaving as negative.

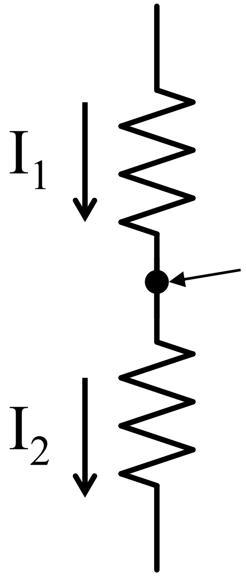


KCL at A: $\sum_{n=1}^{3} I_n = 0$

$$I_1 + (-I_2) + (-I_3) = 0$$

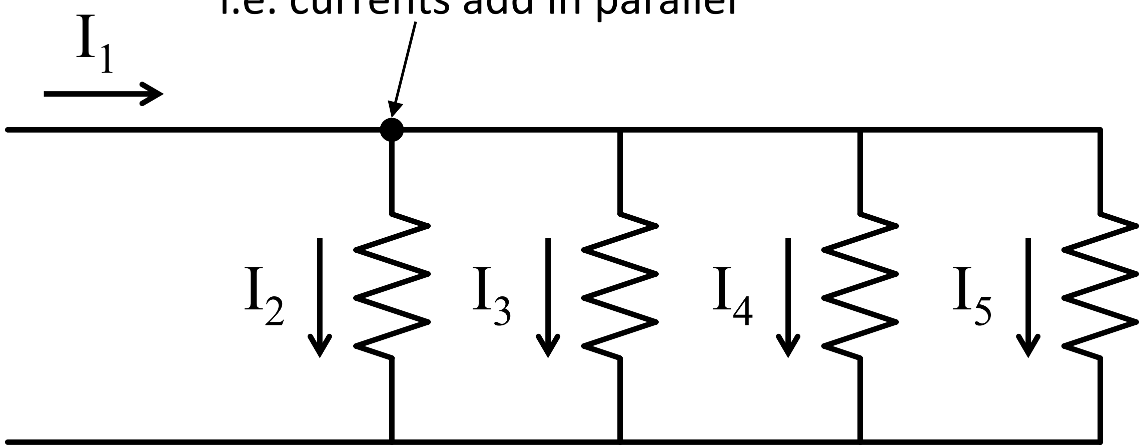
$$I_1 = I_2 + I_3$$

Another way of thinking about it: currents are the same in series, currents add in parallel



KCL at this node gives $I_1 = I_2$ (or $I_1 - I_2 = 0$), i.e. currents are the same in series

The current "splits" at this node, so $I_1 = I_2 + I_3 + I_4 + I_5$, i.e. currents add in parallel



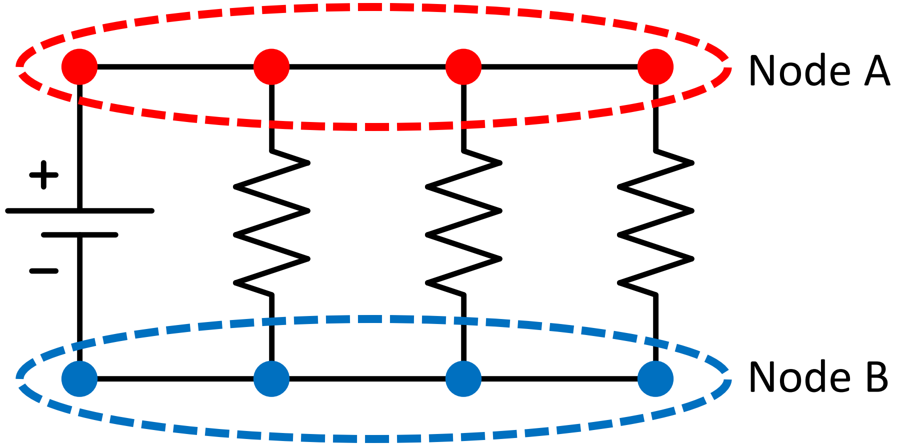
If you are confused about what exactly counts as a node in this diagram, see the next slide….

courtesy of Dr. Ben Finio

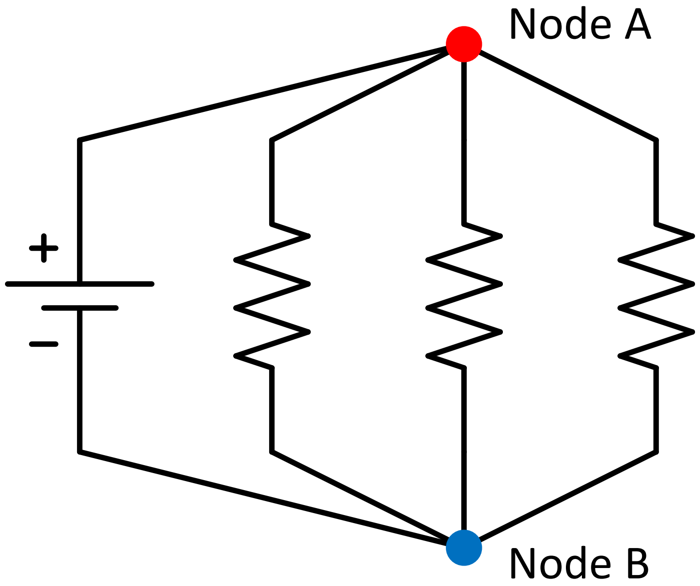
Wait a minute…what is a node?

- A node is any connection between two or more parts in a circuit
- Important: points in a circuit directly connected by a wire are part of the **same node**.

In this circuit, the red dots are **not** four separate nodes. The same applies to the blue dots.



The circuit on the left is equivalent to drawing this:



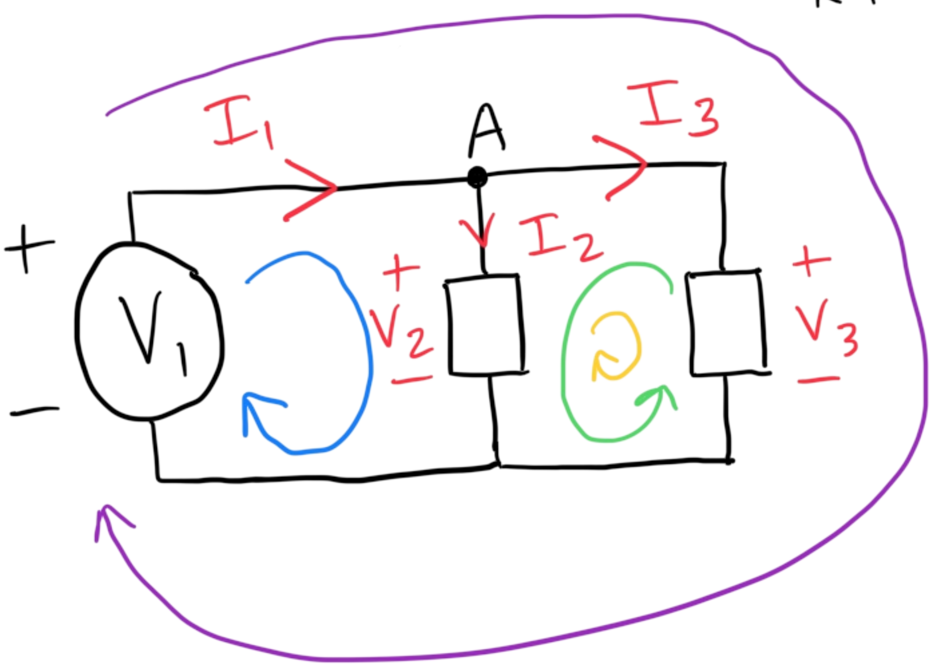
The circuit on the left looks "neater" so that's how we usually draw things. But you don't need to apply KCL eight times to analyze the circuit! (Actually, in the circuit on the right, you still only need to do it once – you will get the same equation for nodes A and B).

courtesy of Dr. Ben Finio

Kirchoff's voltage law (KVL)

The sum of voltages around a closed loop is zero.

$$\sum_{K=1}^{K} V_K = 0$$



$-V_1 + V_2 = 0$

$V_2 - V_3 = 0$

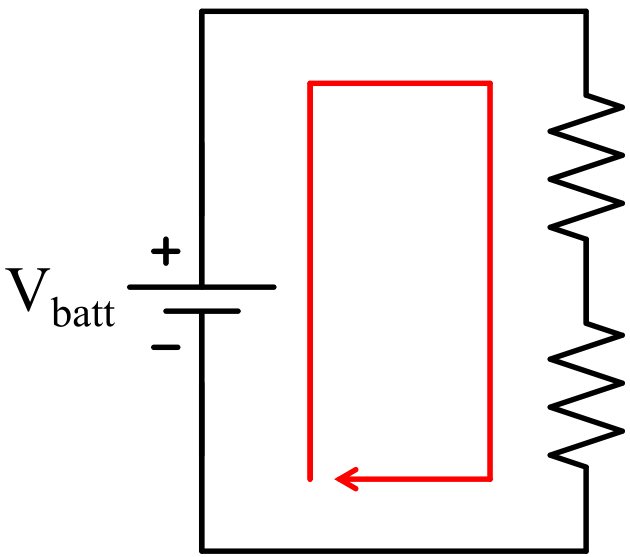
$-V_2 + V_3 = 0$

$-V_1 + V_3 = 0$

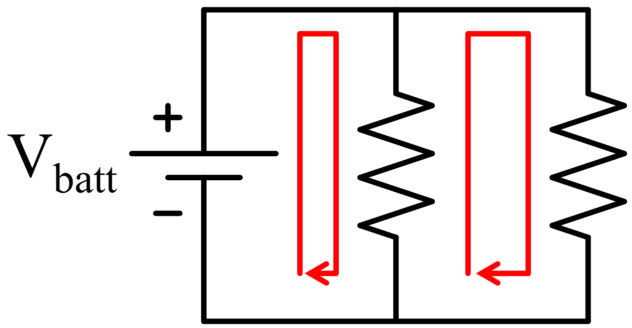
$V_1 = V_2 = V_3$

Alternatively: voltage drop between any 2 points is the same, regardless of path

Another way to think about it: voltages add in series, voltages are the same in parallel



Voltage drops across these two resistors add up to equal the battery voltage

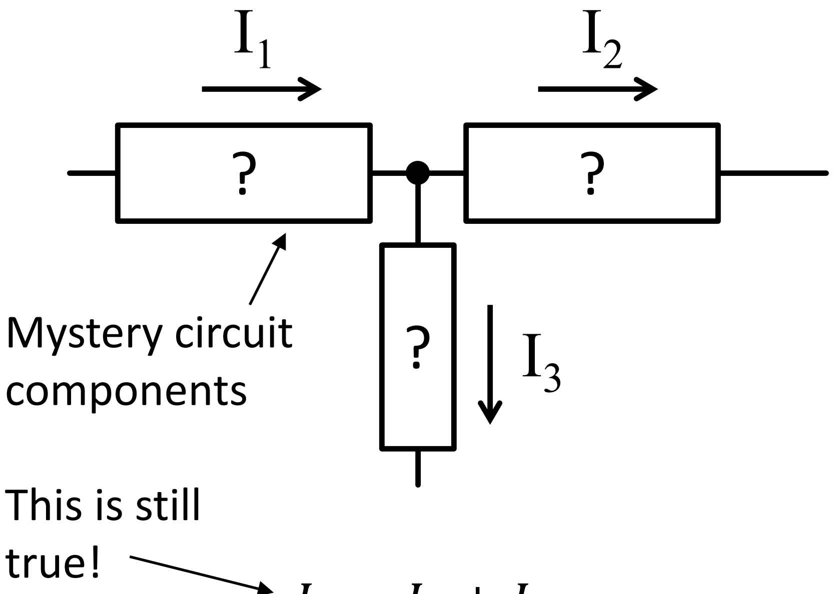


Two parts in parallel form their own loop – their voltages must be equal

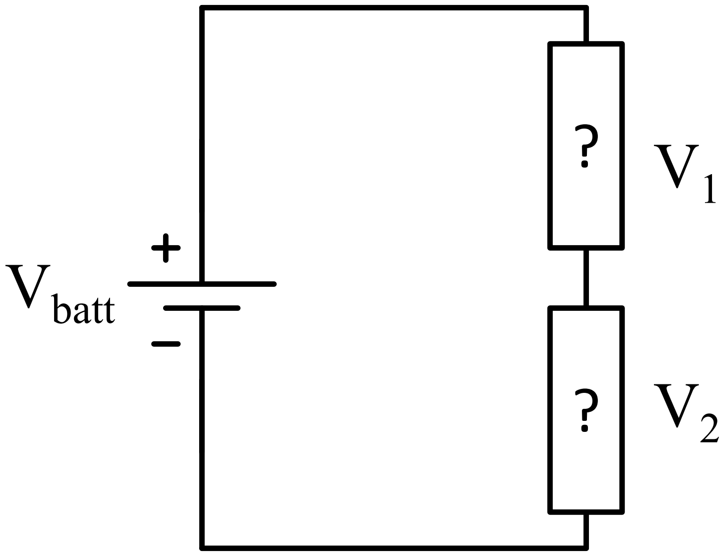
courtesy of Dr. Ben Finio

An Important Note About KCL & KVL

- Unlike Ohm's Law, which only applies to resistors, KCL and KVL are **always true**
- This means they apply to capacitors, inductors, diodes, etc., or more generally, any "black box" circuit component



$I_1 = I_2 + I_3$



$V_{batt} = V_1 + V_2$

courtesy of Dr. Ben Finio