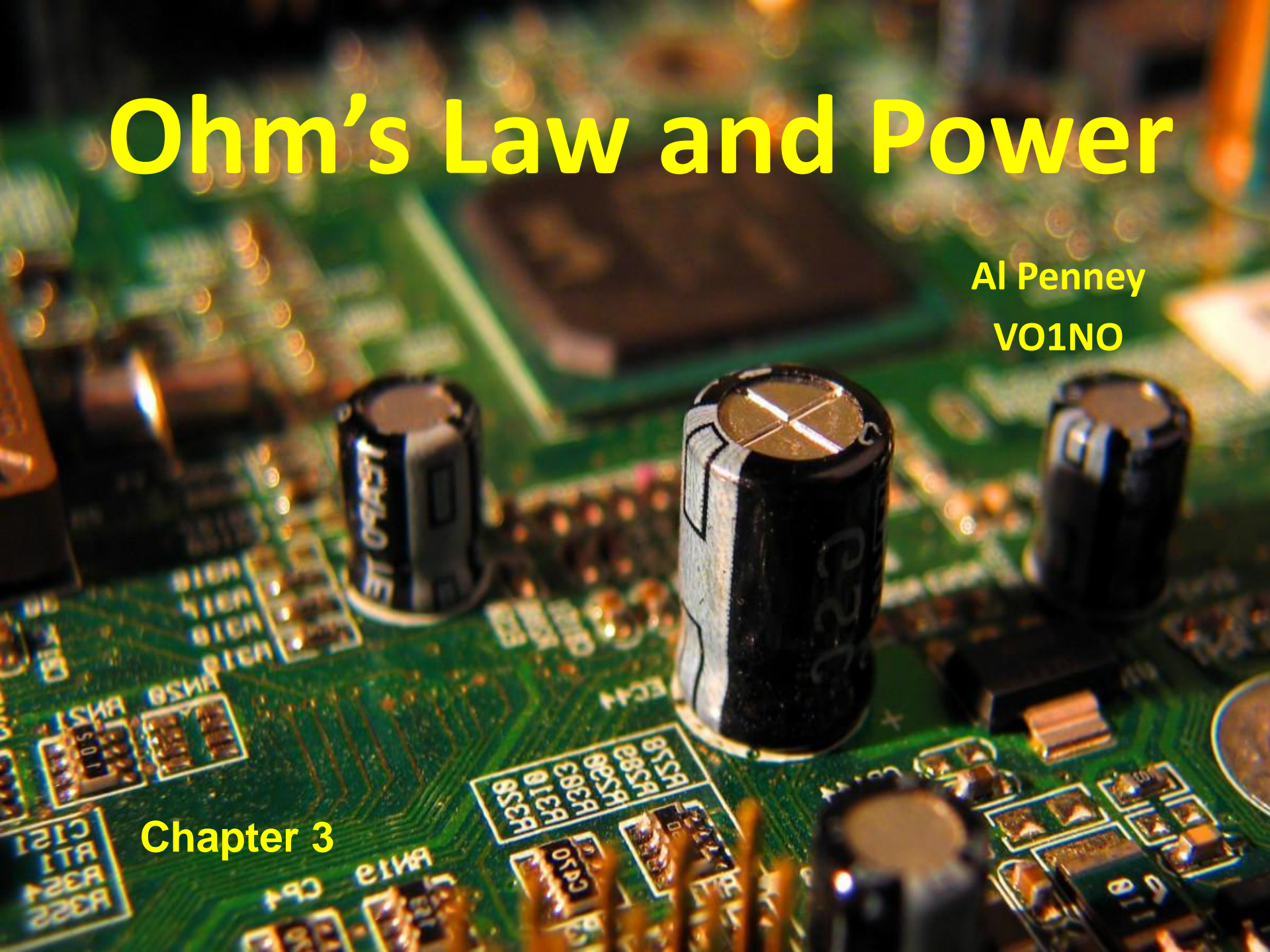


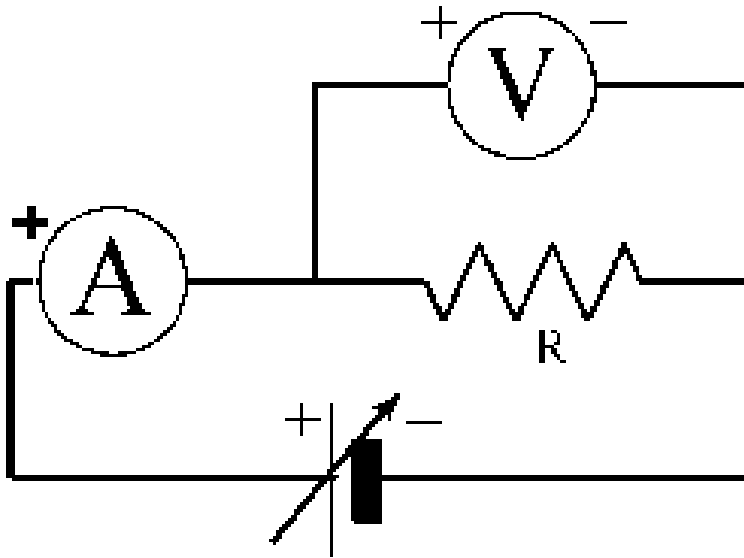
Ohm's Law and Power

Al Penney
VO1NO

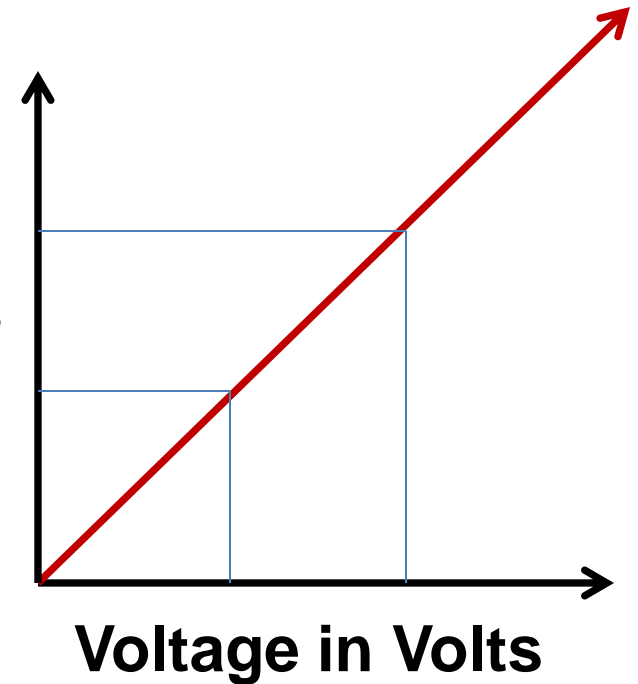
Chapter 3



Voltage and Current



Current
In Amps



As Voltage is increased, Current also increases.

Ohm's Law

- Relationship between Voltage, Current and Resistance can be expressed mathematically as:

$$E = I \times R$$

Where

E is measured in Volts;

I is measured in Amps; and

R is measured in Ohms.

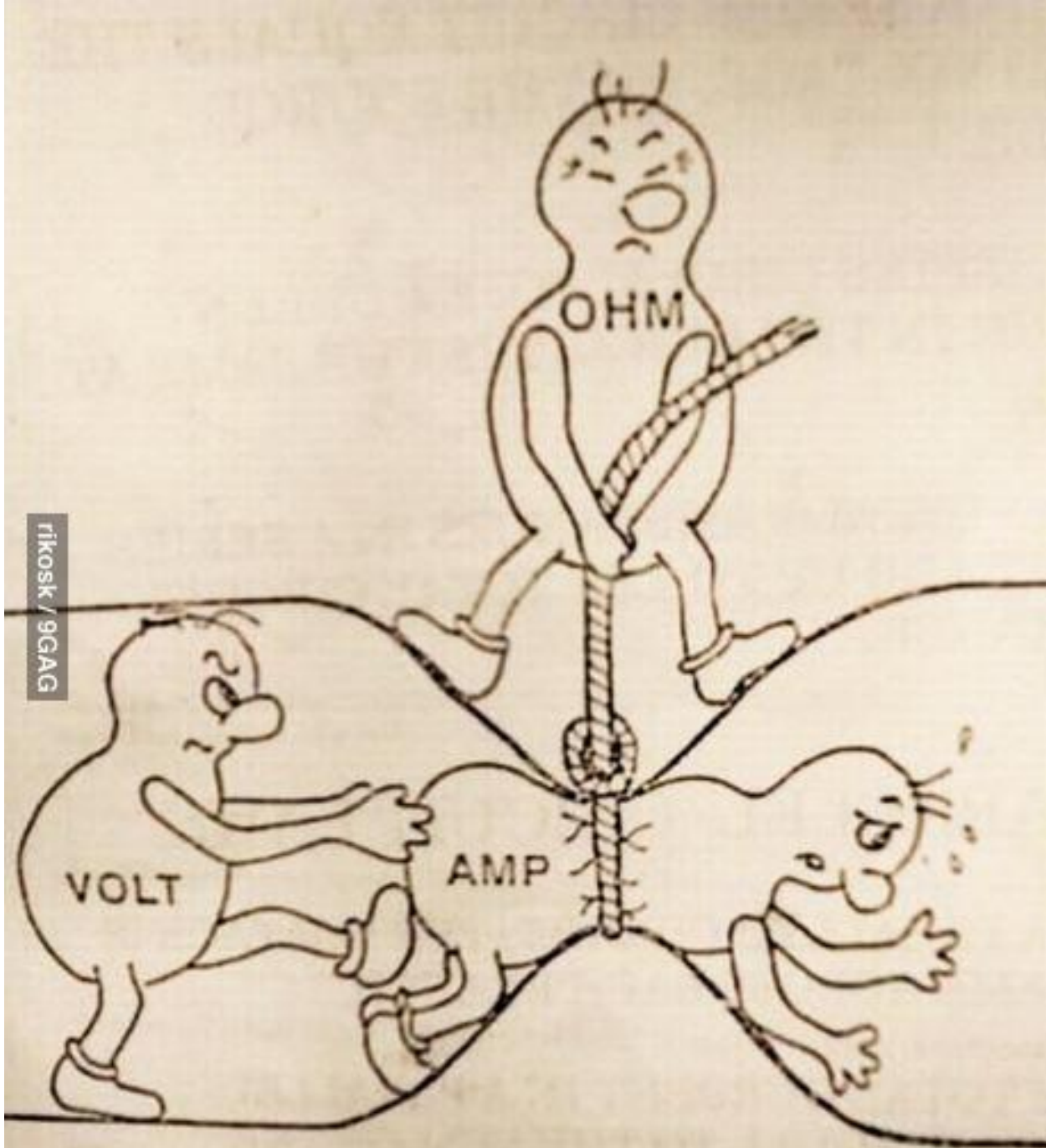
Ohm's Law

The equation can be re-written to determine any of the 3 variables if the other two are known:

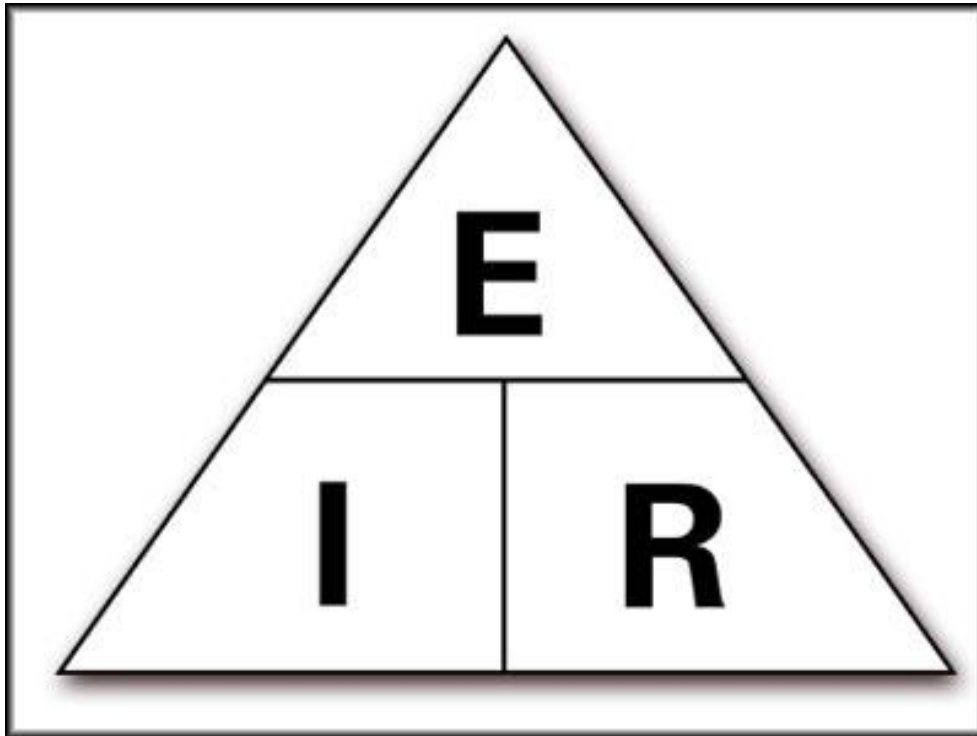
$$I = E / R$$

And

$$R = E / I$$



Ohms Law Triangle

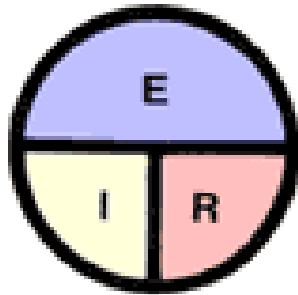


Remember the Units:

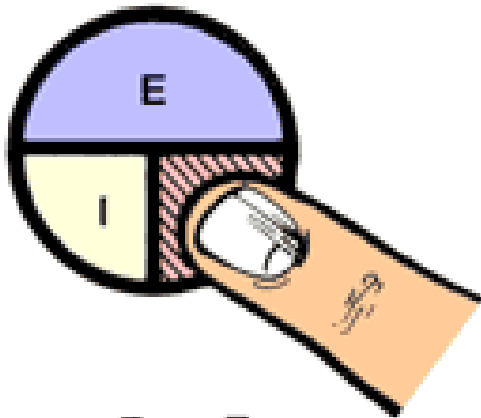
- E is measured in **VOLTS**
- I is measured in **AMPS**
- R is measured in **OHMS**

Ohms Law Triangle

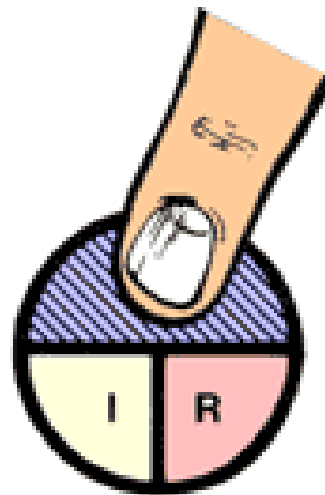
(Okay – Circle!)



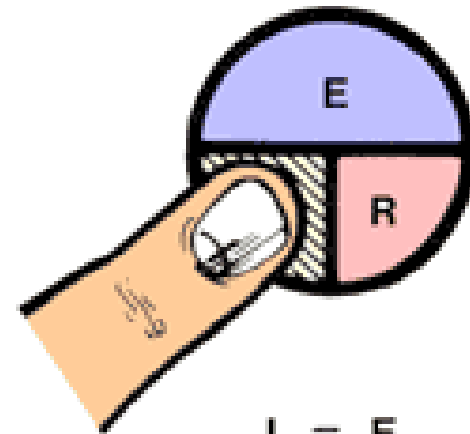
I = AMPERES (CURRENT)
R = OHMS (RESISTANCE)
E = VOLTS (ELECTROMOTIVE FORCE)



$$R = \frac{E}{I}$$



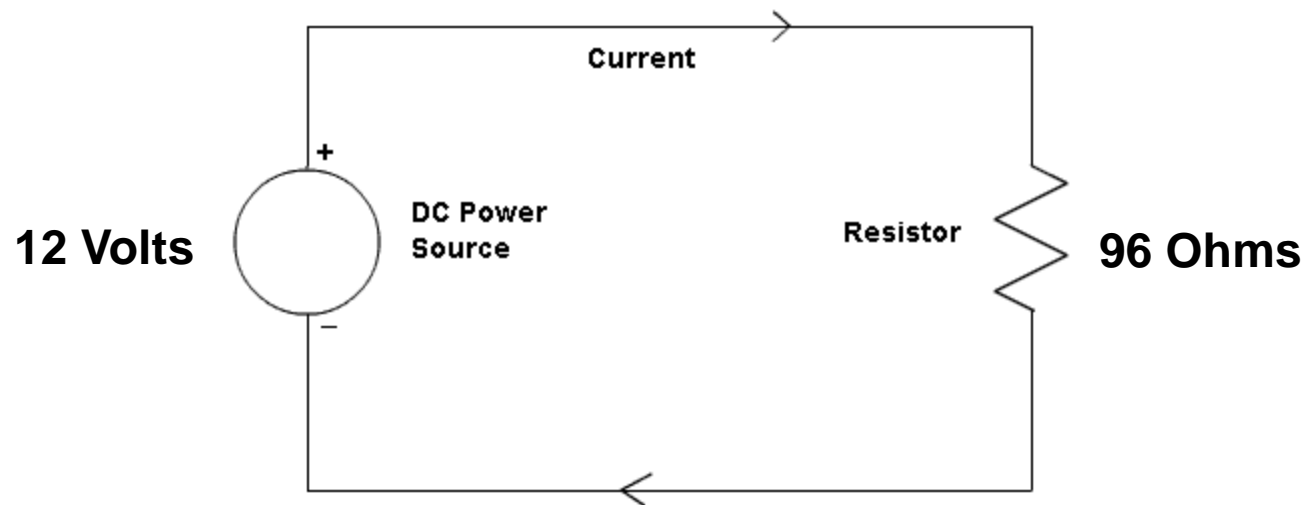
$$E = I \times R$$



$$I = \frac{E}{R}$$

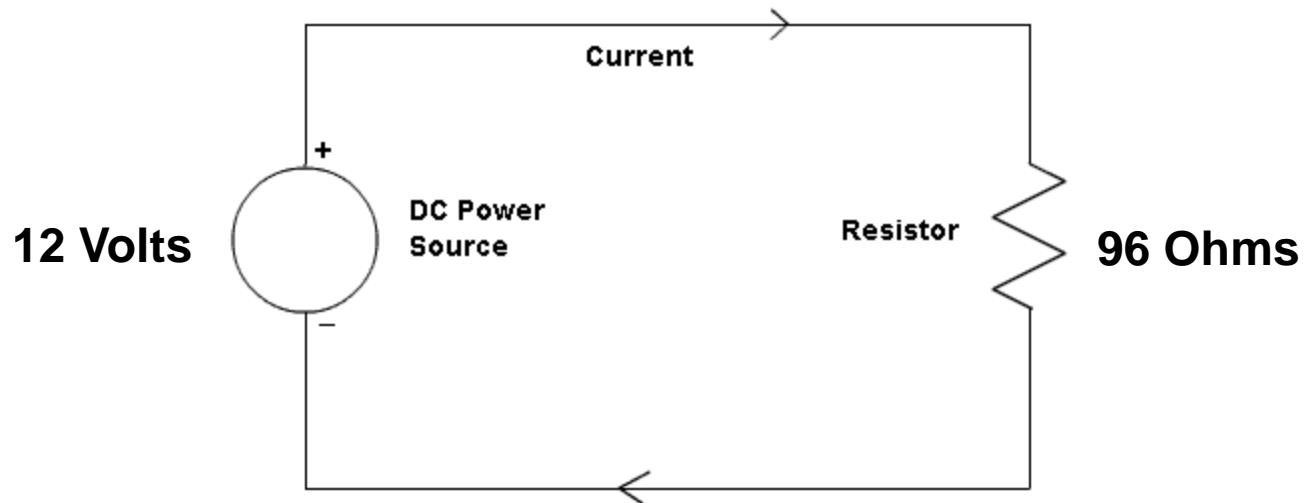
Ohms Law Problem #1

What is the current?

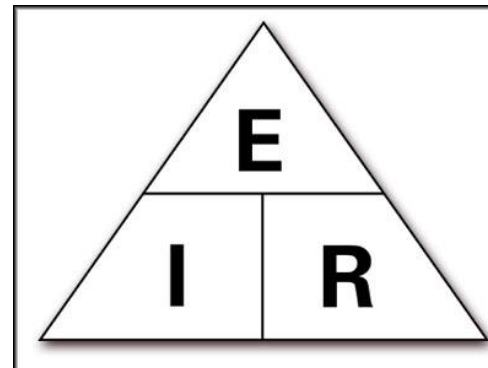


Ohms Law Problem #1

What is the current?

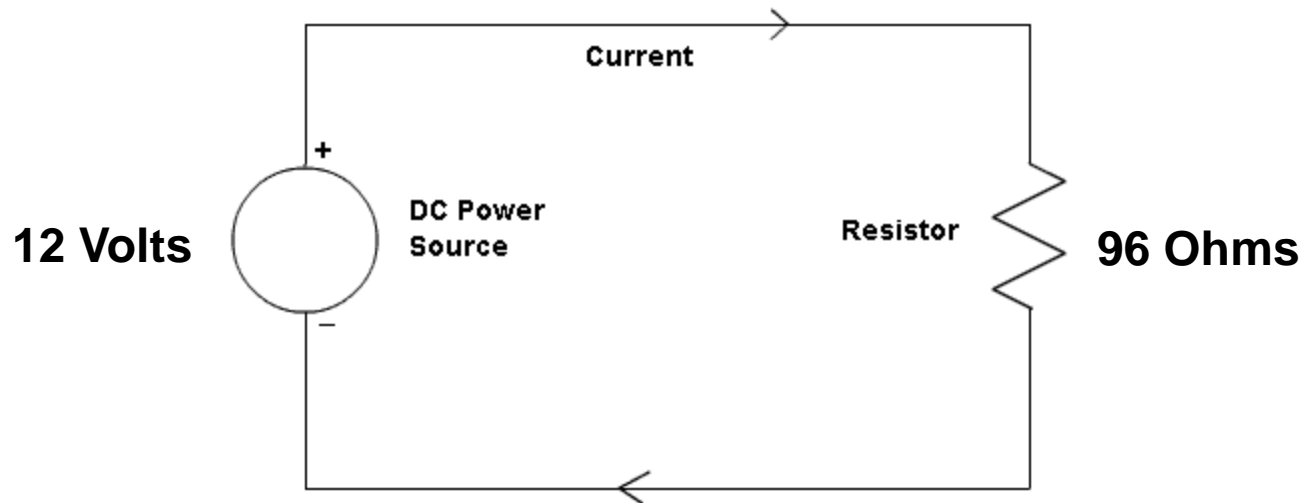


Consult the Ohms Law Triangle:

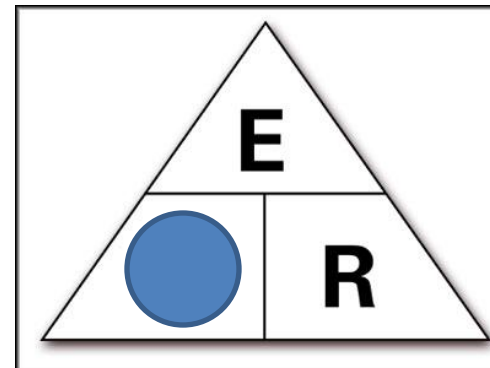


Ohms Law Problem #1

What is the current?



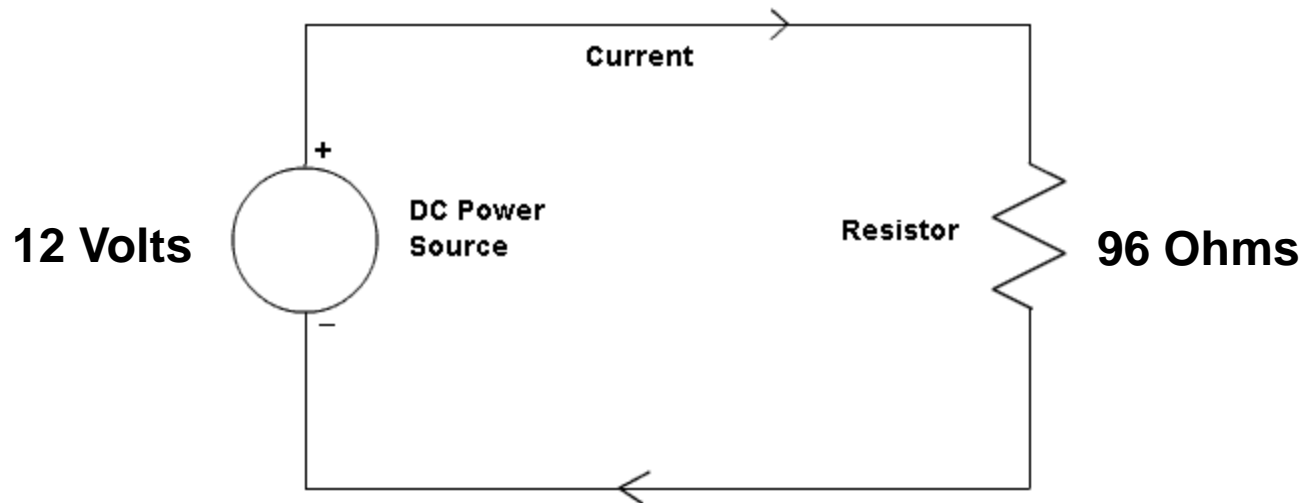
Consult the Ohms Law Triangle:



$$I = E / R$$

Ohms Law Problem #1

What is the current?



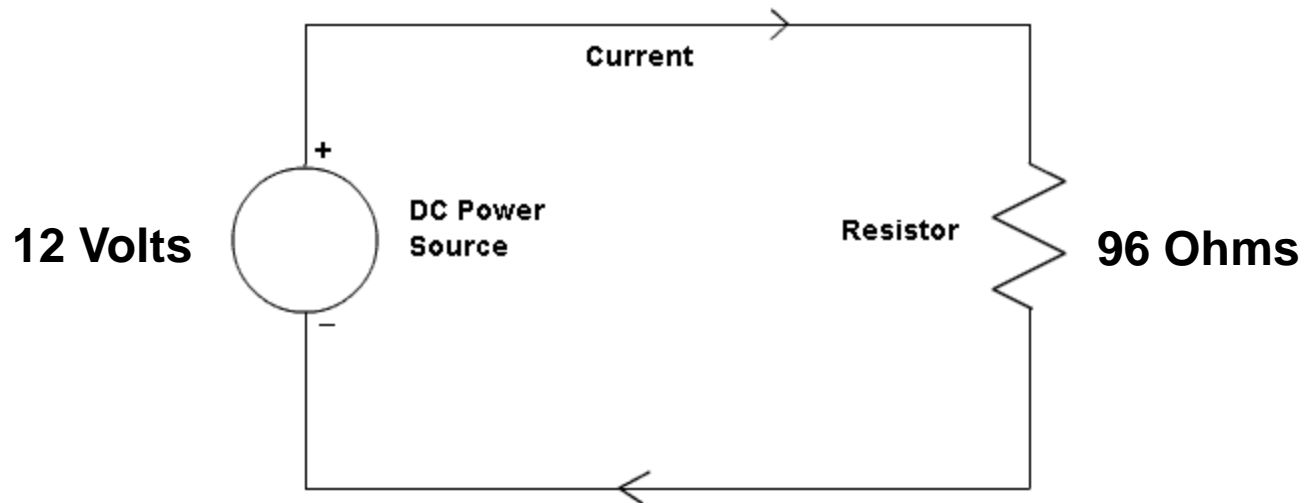
$$I = E / R$$

$$I = 12 \text{ Volts} / 96 \text{ Ohms}$$

$$I =$$

Ohms Law Problem #1

What is the current?



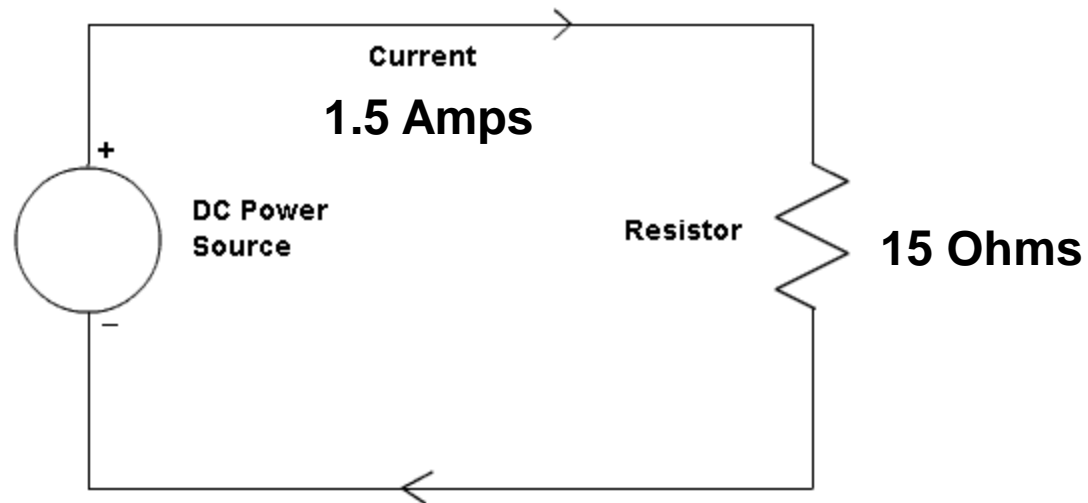
$$I = E / R$$

$$I = 12 \text{ Volts} / 96 \text{ Ohms}$$

$$I = 0.125 \text{ Amps}$$

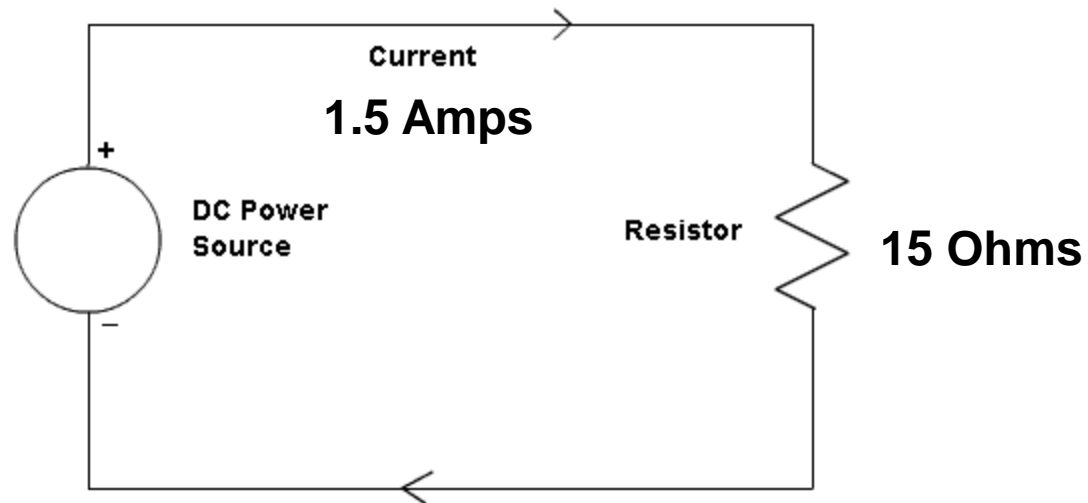
Ohms Law Problem #2

What is the voltage?

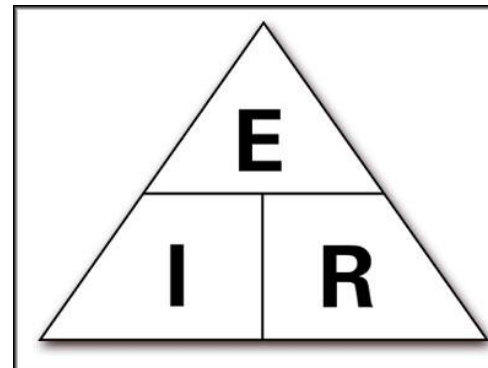


Ohms Law Problem #2

What is the voltage?

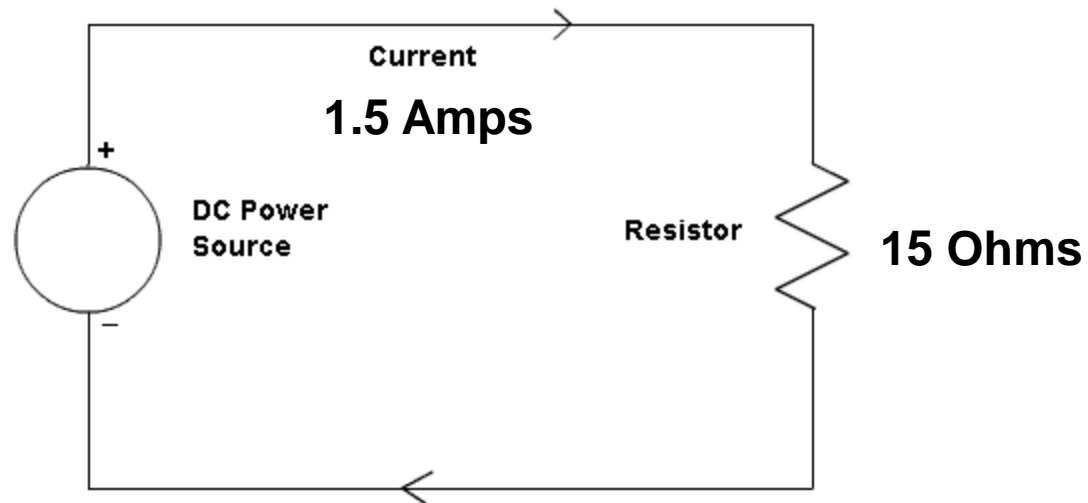


Consult the Ohms Law Triangle:

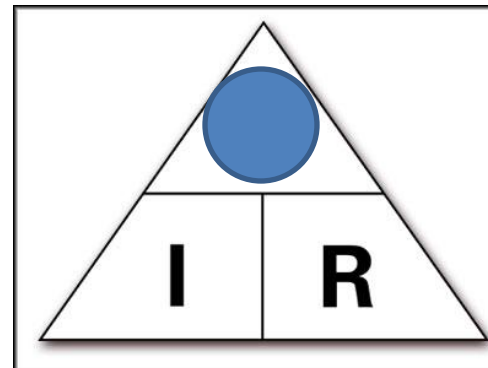


Ohms Law Problem #2

What is the voltage?



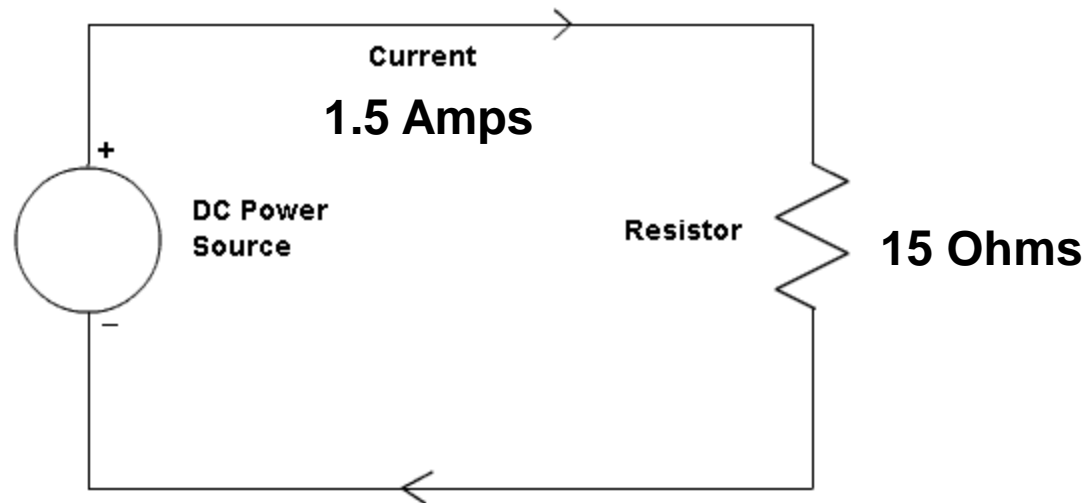
Consult the Ohms Law Triangle:



$$E = I \times R$$

Ohms Law Problem #2

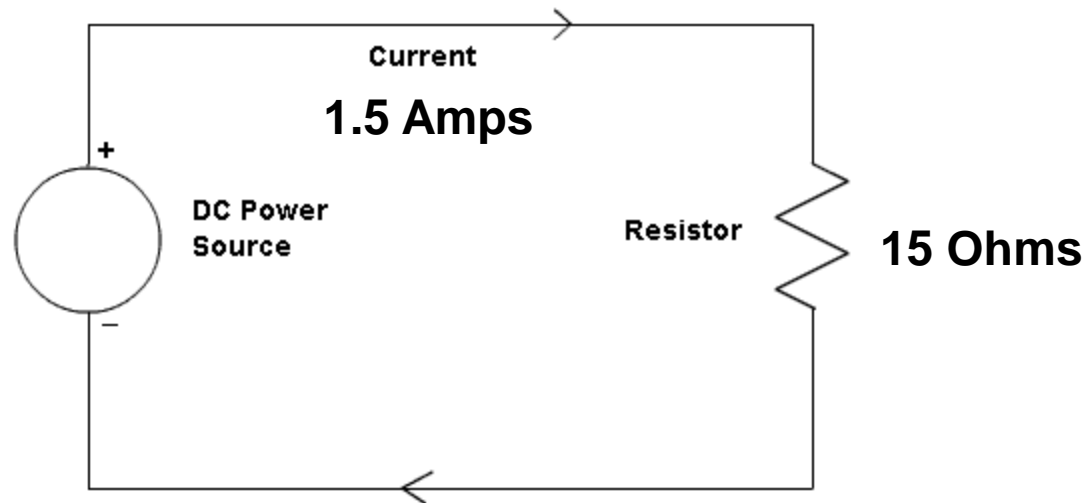
What is the voltage?



$$\begin{aligned} E &= I \times R \\ &= 1.5 \text{ Amps} \times 15 \text{ Ohms} \end{aligned}$$

Ohms Law Problem #2

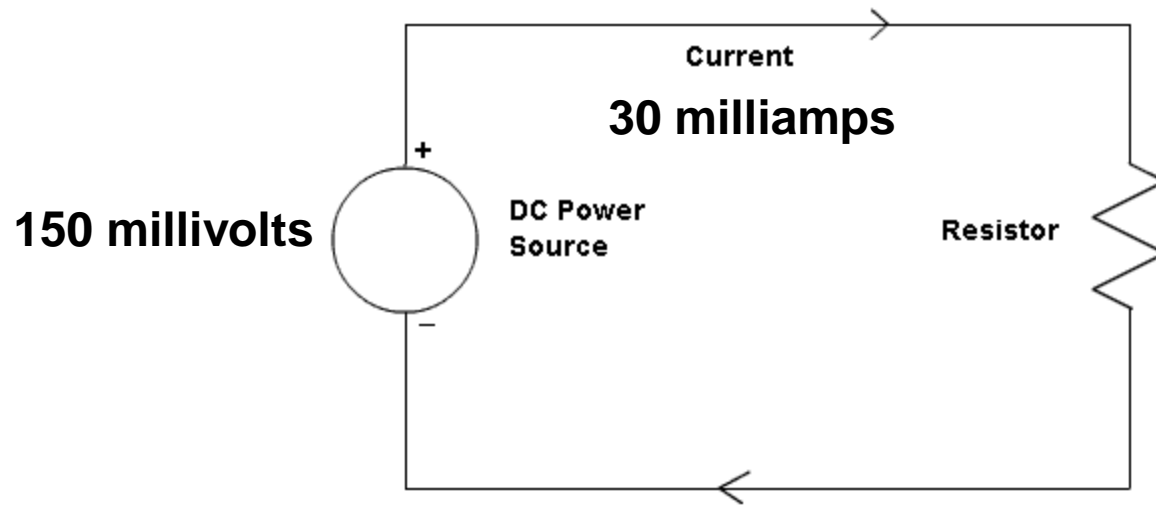
What is the voltage?



$$\begin{aligned} E &= I \times R \\ &= 1.5 \text{ Amps} \times 15 \text{ Ohms} \\ &= 22.5 \text{ Volts} \end{aligned}$$

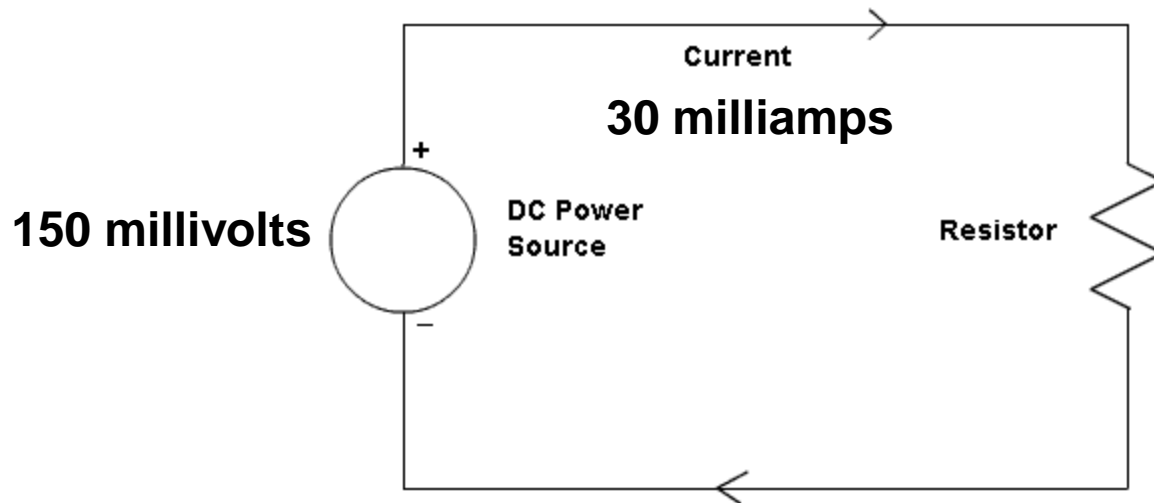
Ohms Law Problem #3

What is the resistance?

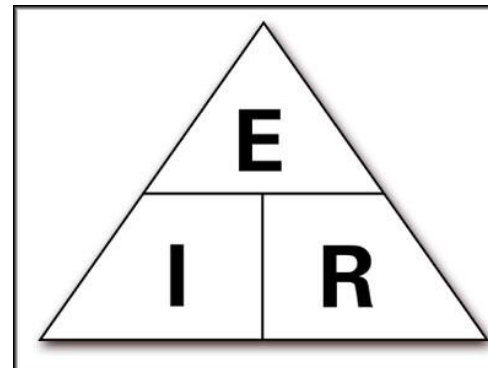


Ohms Law Problem #3

What is the resistance?

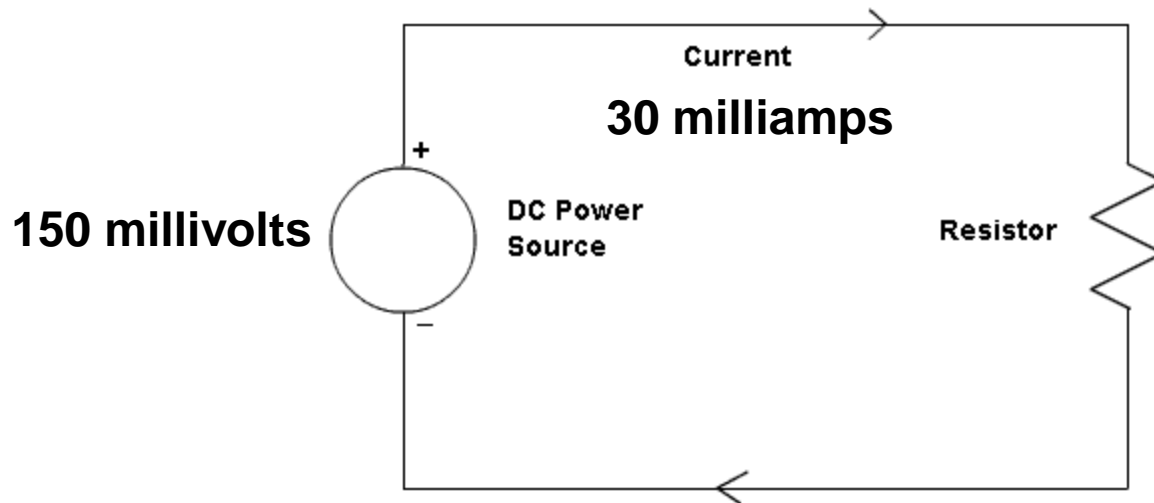


Consult the Ohms Law Triangle:

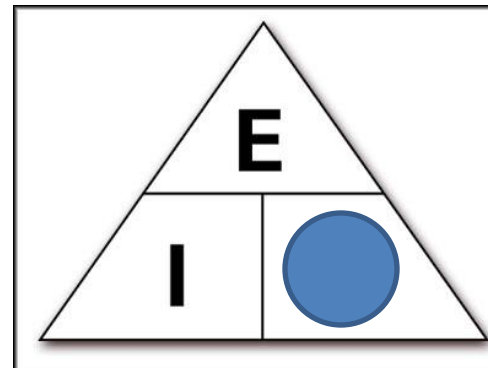


Ohms Law Problem #3

What is the resistance?



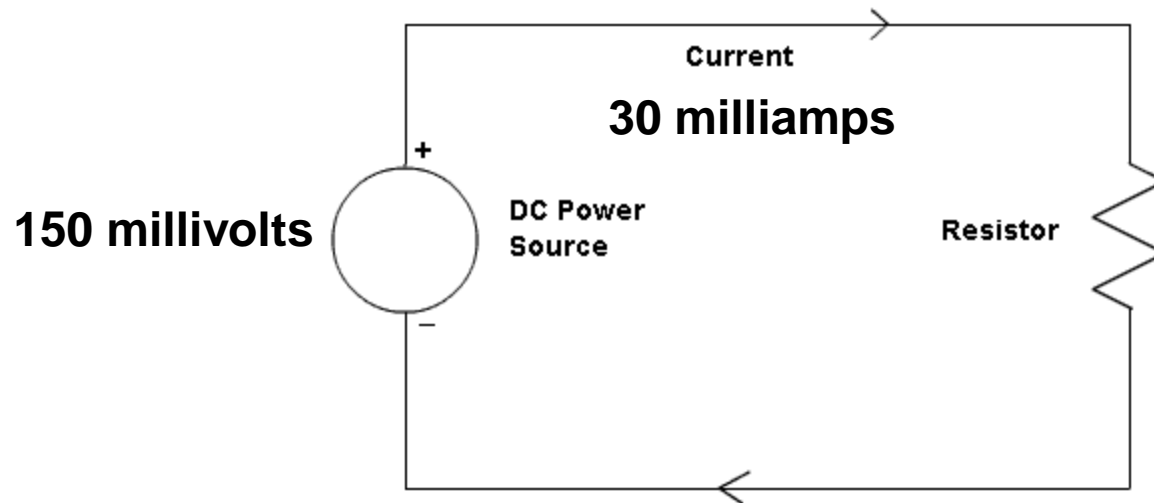
Consult the Ohms Law Triangle:



$$R = E / I$$

Ohms Law Problem #3

What is the resistance?



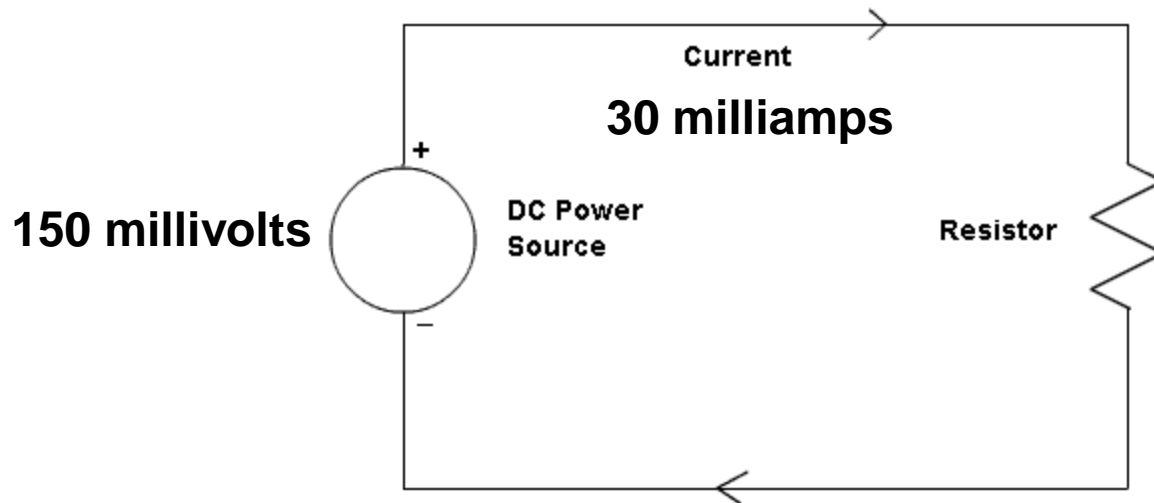
$$R = E / I$$
$$= 150 \text{ millivolts} / 30 \text{ milliamps}$$

Ohms Law Problem #3

- **REMEMBER the UNITS!**
 - 150 millivolts = $150 / 1000$ volts = 0.15 volts
 - 30 milliamps = $30 / 1000$ amps = 0.03 amps

Ohms Law Problem #3

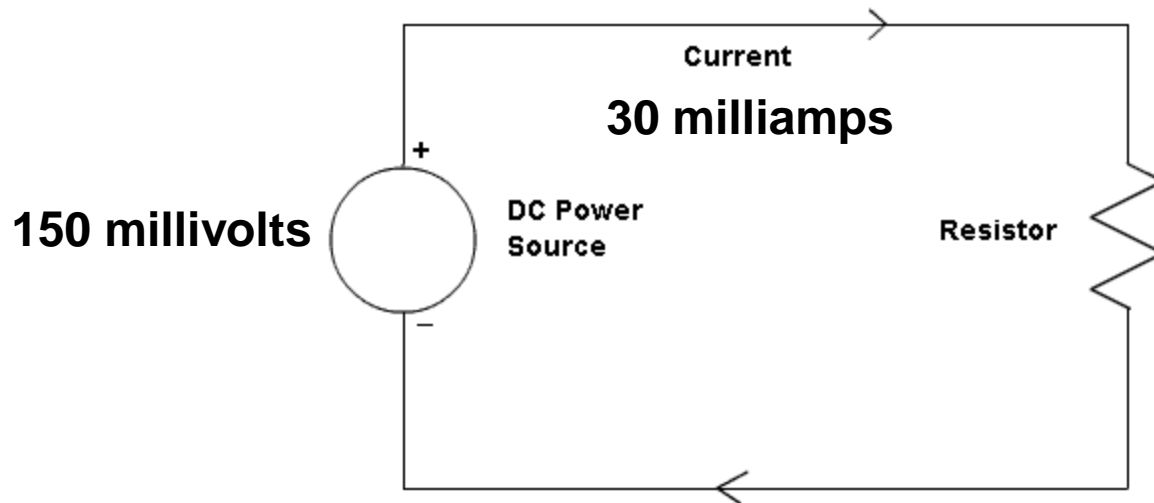
What is the resistance?



$$\begin{aligned} R &= E / I \\ &= 150 \text{ millivolts} / 30 \text{ milliamps} \\ &= 0.15 \text{ Volts} / 0.03 \text{ Amps} \end{aligned}$$

Ohms Law Problem #3

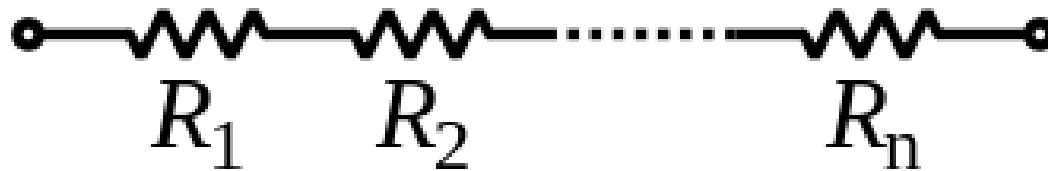
What is the resistance?



$$\begin{aligned} R &= E / I \\ &= 150 \text{ millivolts} / 30 \text{ milliamps} \\ &= 0.15 \text{ Volts} / 0.03 \text{ Amps} \\ &= 5 \text{ Ohms} \end{aligned}$$

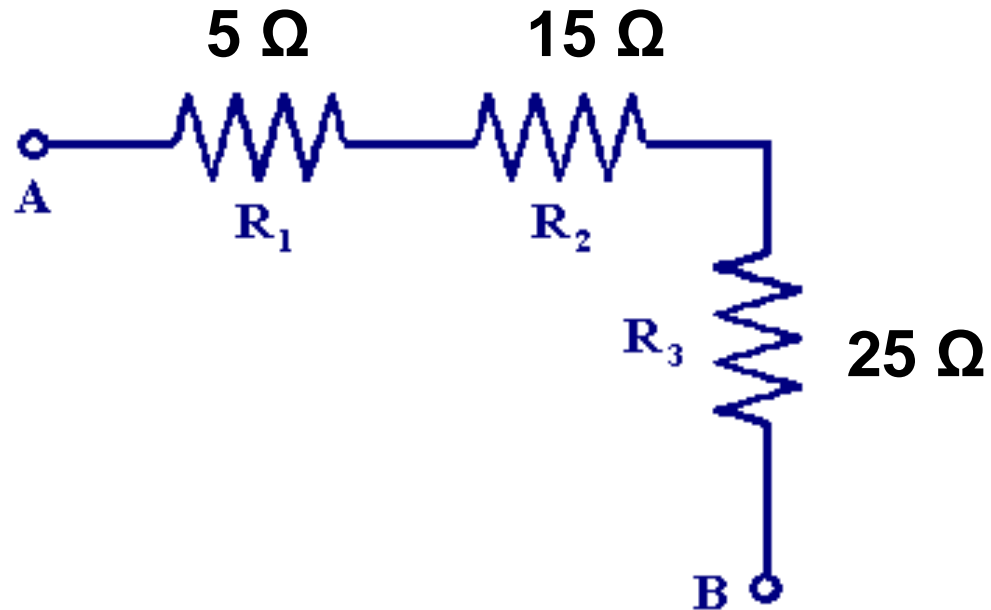
Resistors in Series

- When resistors are in **SERIES**, the total resistance is the **SUM** of the individual resistances.

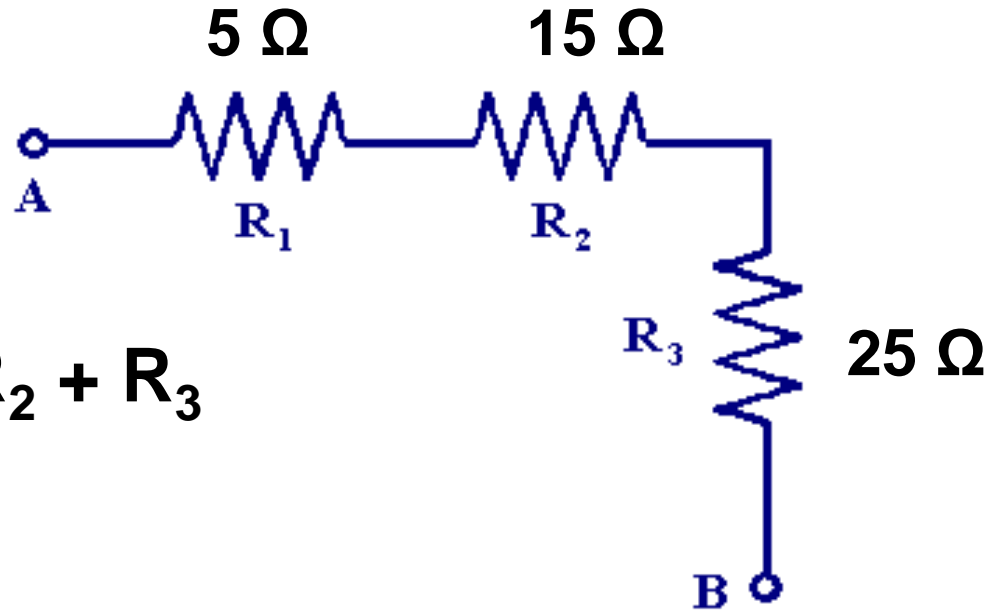


$$R_{\text{Total}} = R_1 + R_2 + R_3 + \dots + R_N$$

Resistors in Series

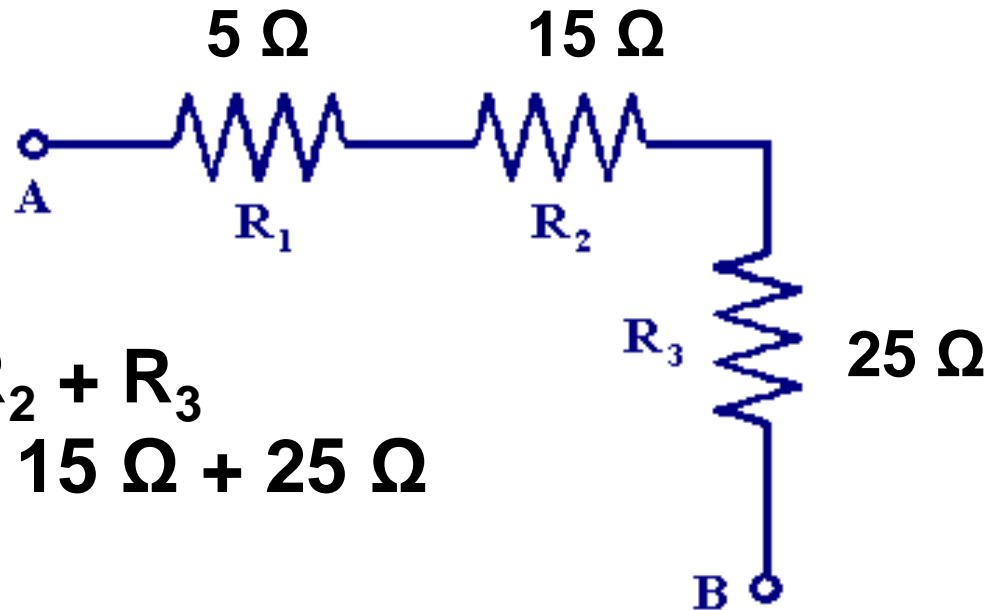


Resistors in Series



$$R_{\text{Total}} = R_1 + R_2 + R_3$$

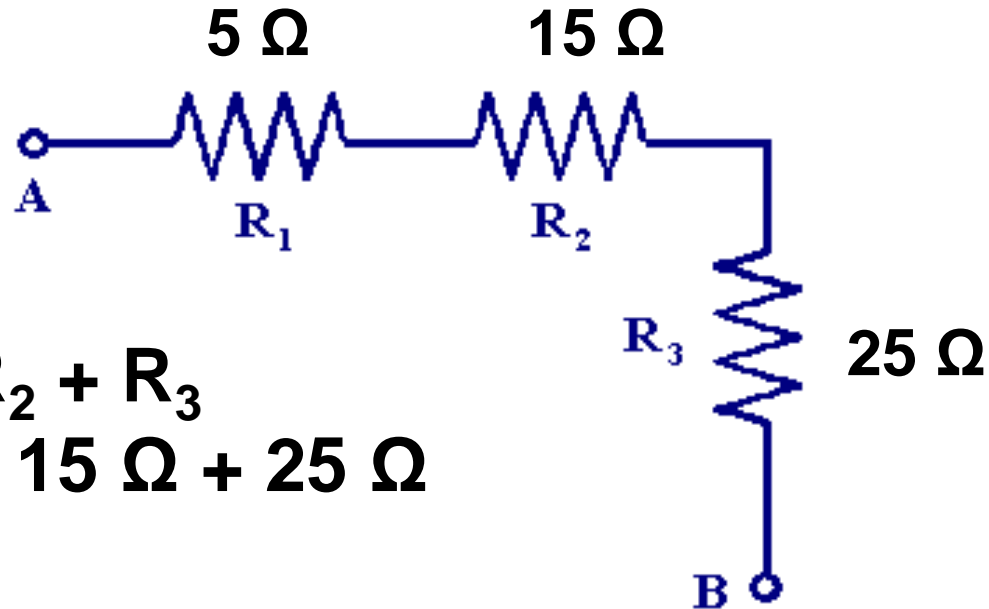
Resistors in Series



$$R_{\text{Total}} = R_1 + R_2 + R_3$$

$$R_{\text{Total}} = 5\ \Omega + 15\ \Omega + 25\ \Omega$$

Resistors in Series



$$R_{\text{Total}} = R_1 + R_2 + R_3$$

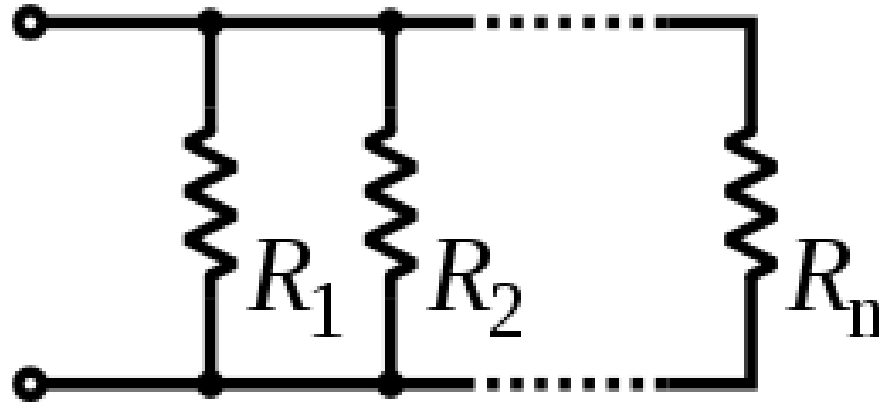
$$R_{\text{Total}} = 5\ \Omega + 15\ \Omega + 25\ \Omega$$

$$R_{\text{Total}} = 45\ \Omega$$

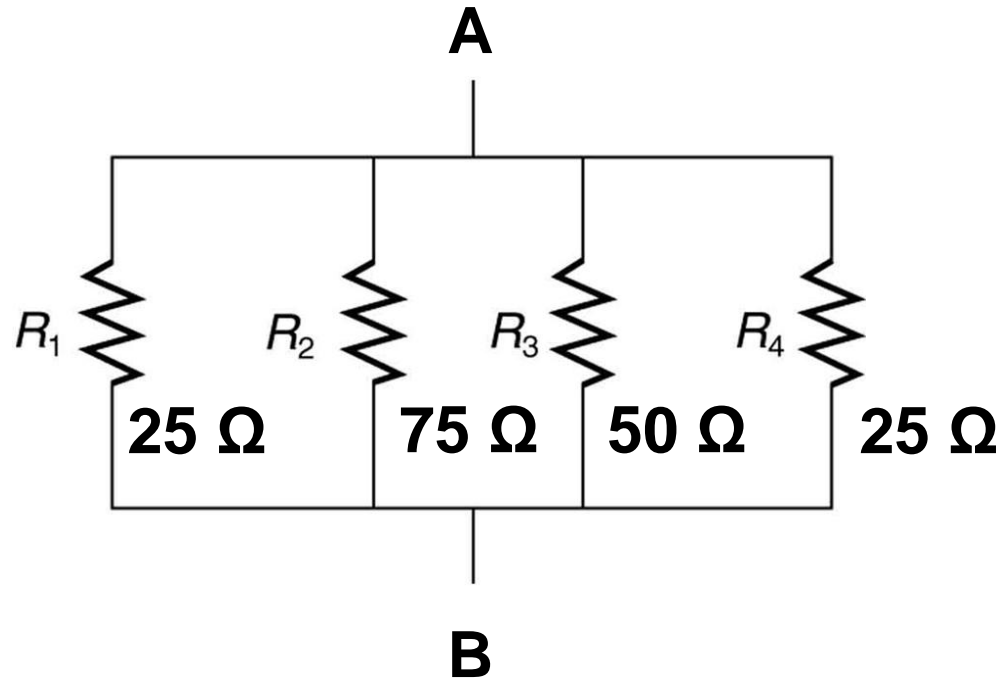
Resistors in Parallel

- When resistors are in Parallel, the total resistance is given by the following equation:

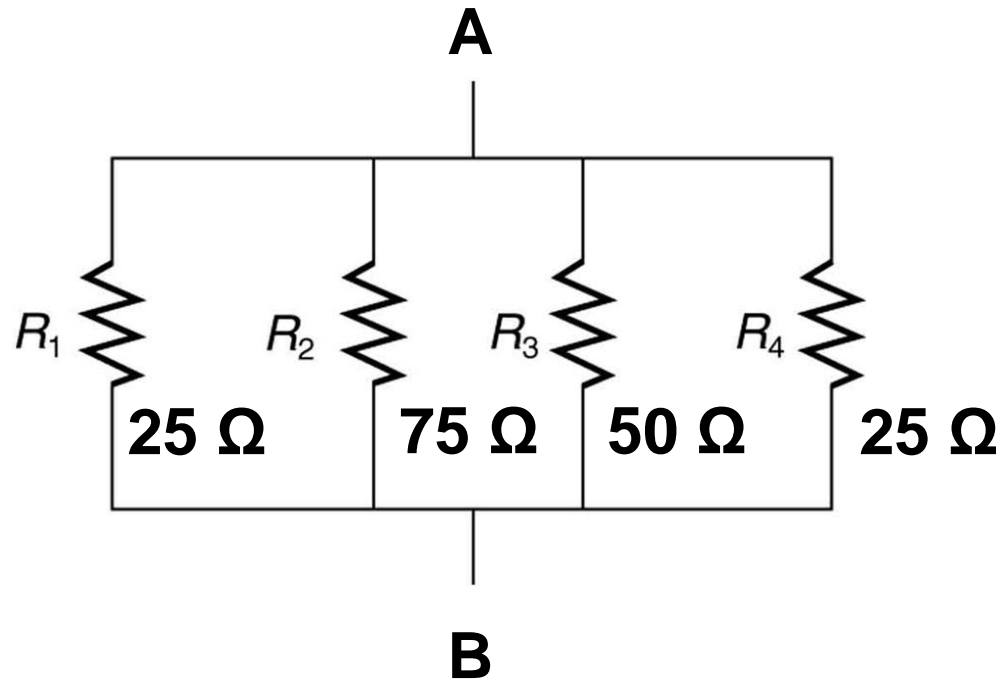
$$\frac{1}{R_{\text{Total}}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots + \frac{1}{R_N}$$



Resistors in Parallel

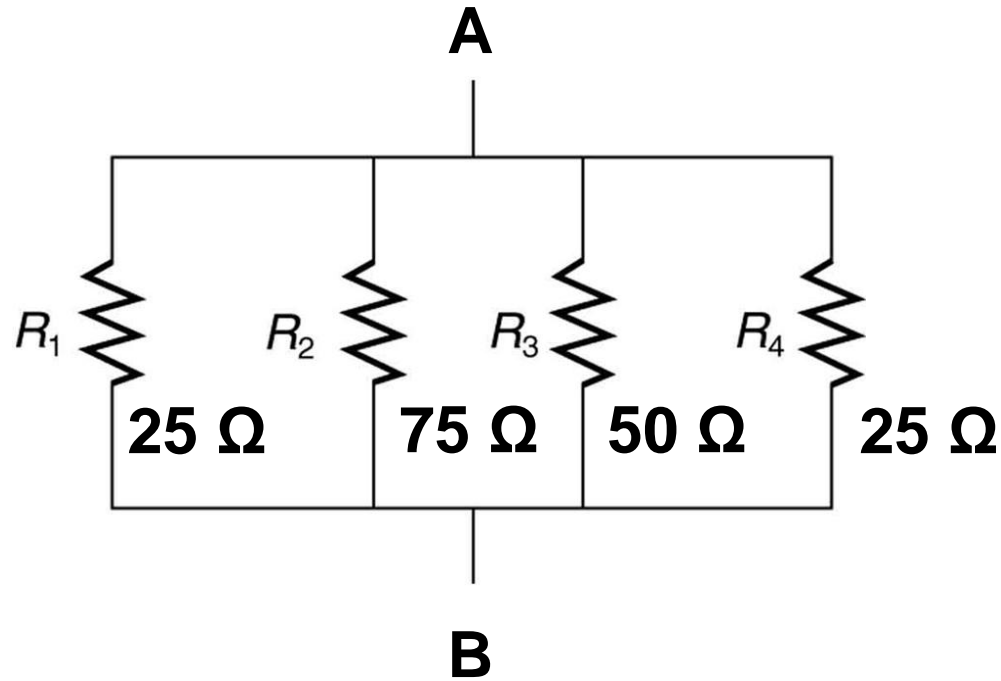


Resistors in Parallel



$$\frac{1}{R_{\text{Total}}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}$$

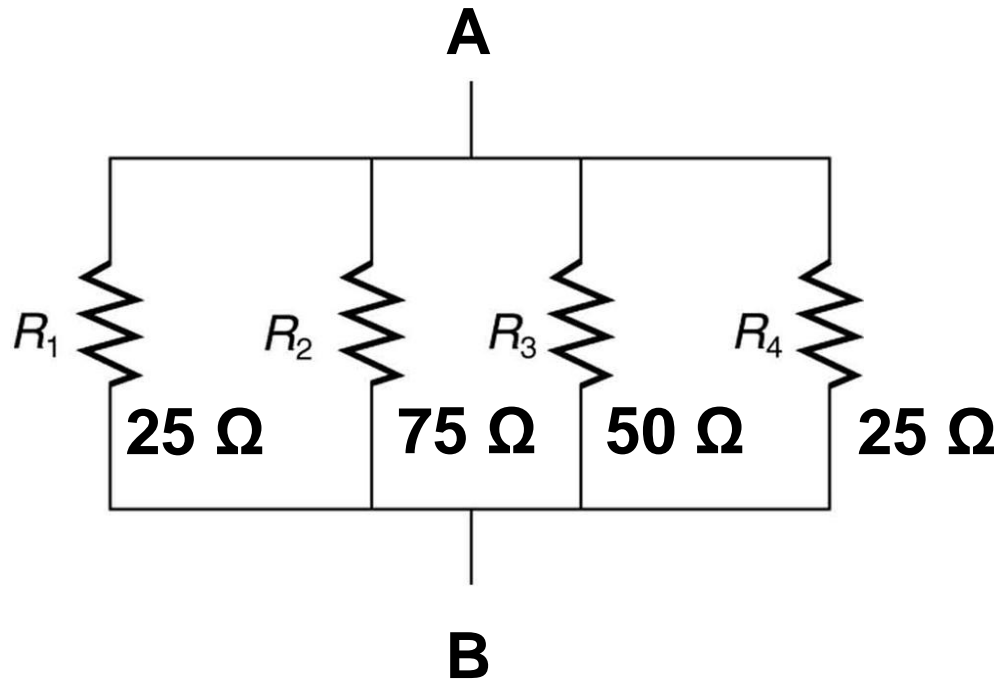
Resistors in Parallel



$$\frac{1}{R_{\text{Total}}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}$$

$$\frac{1}{R_{\text{Total}}} = \frac{1}{25} + \frac{1}{75} + \frac{1}{50} + \frac{1}{25}$$

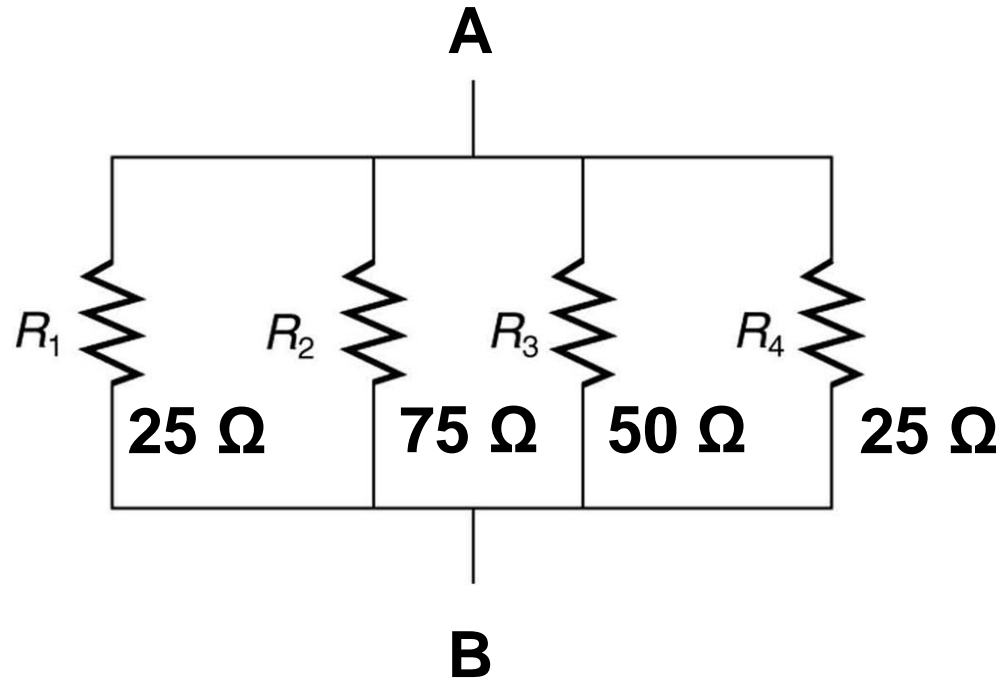
Resistors in Parallel



$$\frac{1}{R_{\text{Total}}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}$$

$$\frac{1}{R_{\text{Total}}} = \frac{1}{25} + \frac{1}{75} + \frac{1}{50} + \frac{1}{25} = \frac{6}{150} + \frac{2}{150} + \frac{3}{150} + \frac{6}{150}$$

Resistors in Parallel

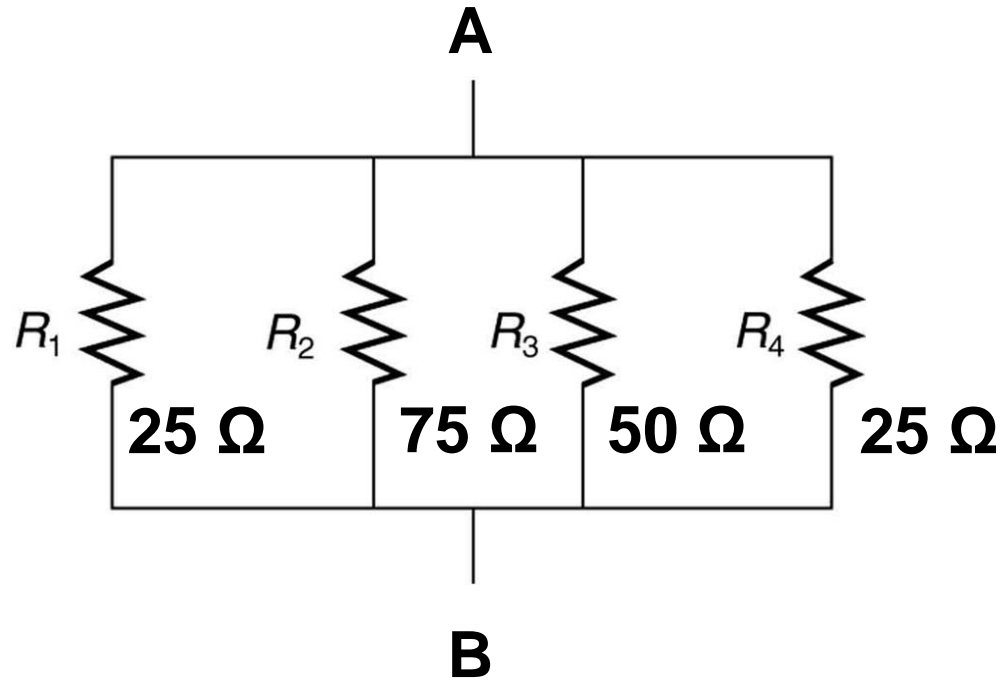


$$1/R_{\text{Total}} = 1/R_1 + 1/R_2 + 1/R_3 + 1/R_4$$

$$1/R_{\text{Total}} = 1/25 + 1/75 + 1/50 + 1/25 = 6/150 + 2/150 + 3/150 + 6/150$$

$$1/R_{\text{Total}} = 17/150 \Omega$$

Resistors in Parallel



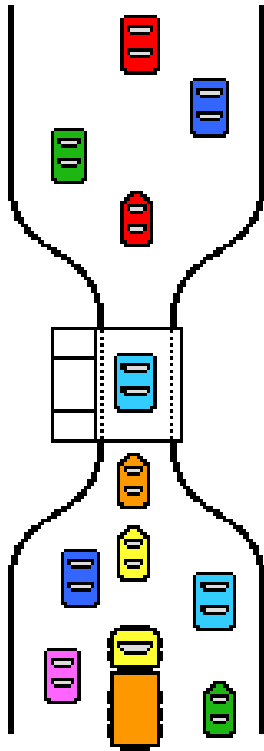
$$1/R_{\text{Total}} = 1/R_1 + 1/R_2 + 1/R_3 + 1/R_4$$

$$1/R_{\text{Total}} = 1/25 + 1/75 + 1/50 + 1/25 = 6/150 + 2/150 + 3/150 + 6/150$$

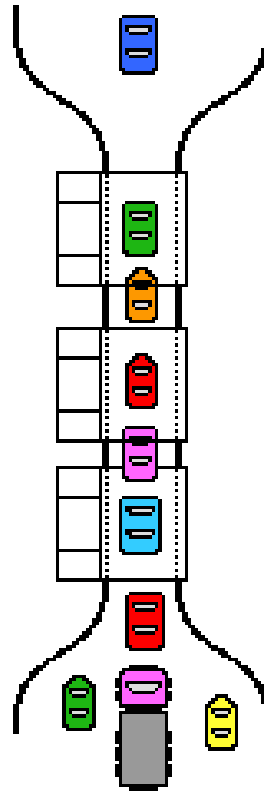
$$1/R_{\text{Total}} = 17/150\ \Omega$$

$$R_{\text{Total}} = 150/17\ \Omega = 8.82\ \Omega$$

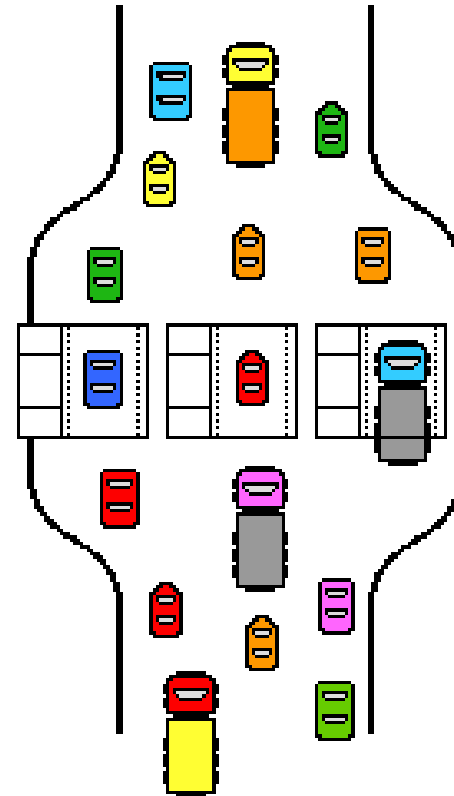
Influencing the Flow Rate on a Tollway



A Single Resistor



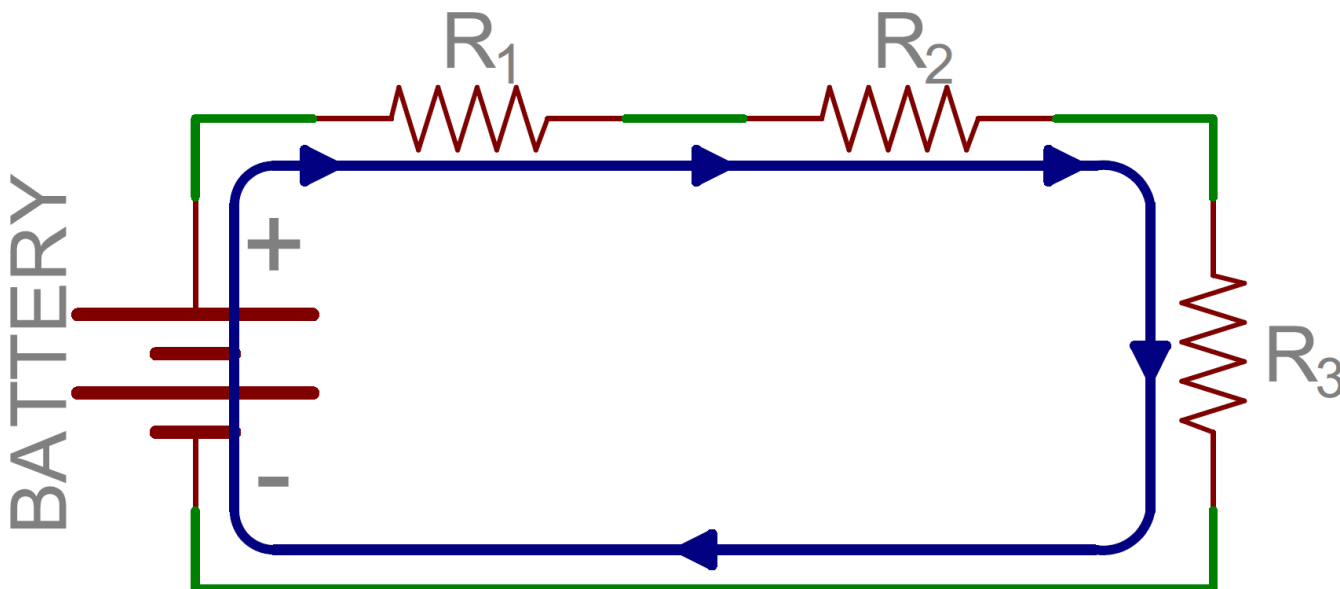
**Three Resistors
Placed in Series**



**Three Resistors
Placed in Parallel**

Current in a Series Circuit

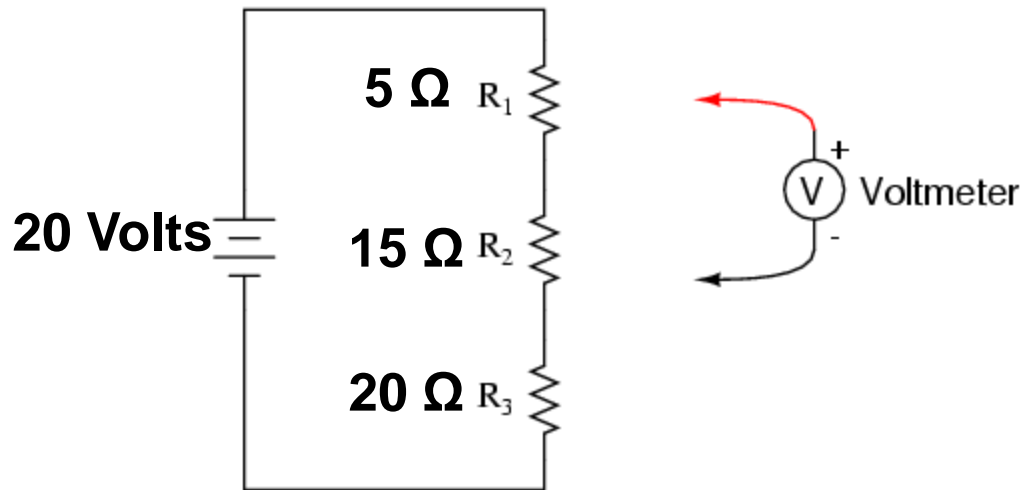
- The current through each resistor in a Series Circuit is identical.



$$I_{\text{Total}} = I_{R1} = I_{R2} = I_{R3}$$

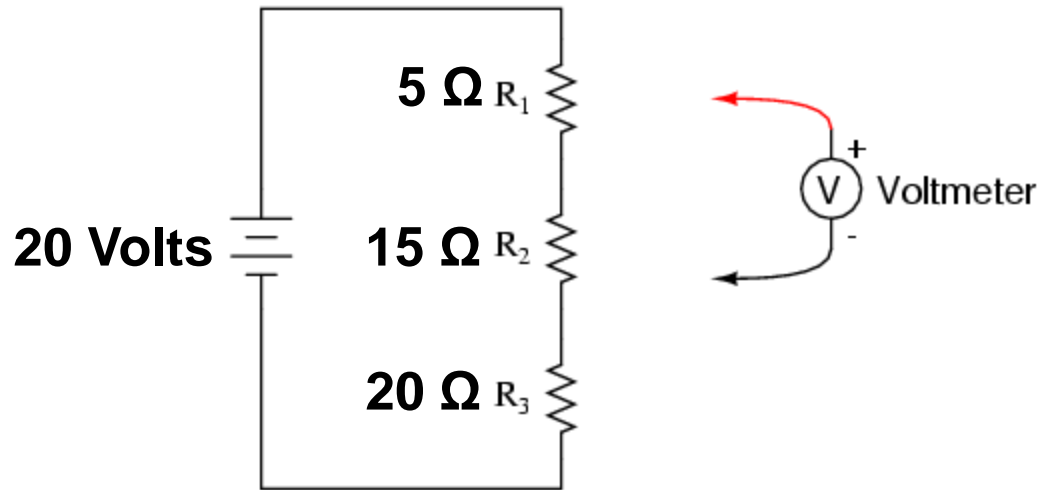
Voltage in Series Circuits

- The sum of all the voltages across each resistor in a Series Circuit will equal the source voltage.

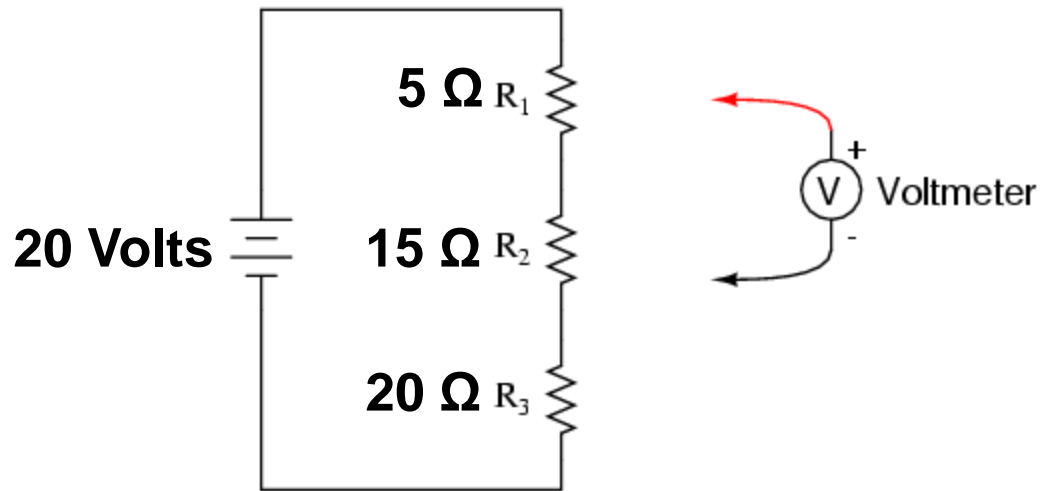


$$E_{\text{source}} = E_{R1} + E_{R2} + E_{R3}$$

To Calculate Voltage Drop...



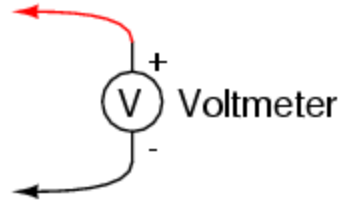
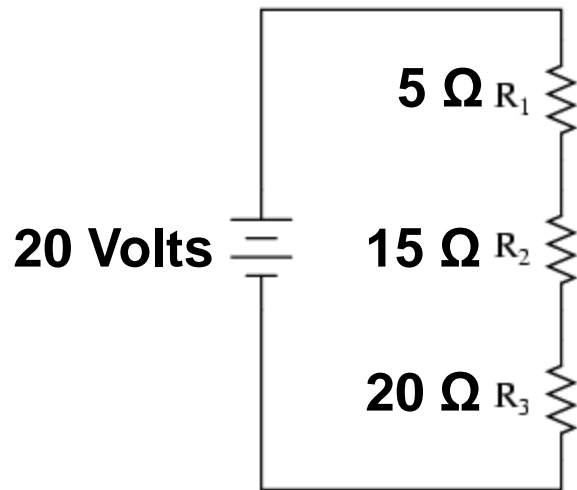
1. Determine Total Resistance



$$R_{\text{Total}} = R_1 + R_2 + R_3$$

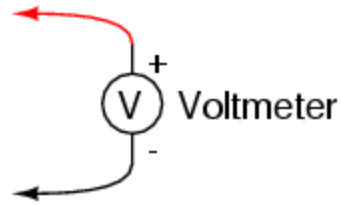
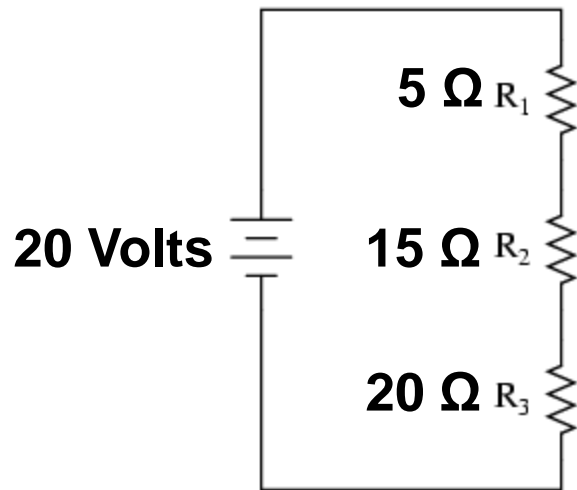
$$R_{\text{Total}} =$$

1. Determine Total Resistance



$$\begin{aligned}R_{\text{Total}} &= R_1 + R_2 + R_3 \\R_{\text{Total}} &= 5\ \Omega + 15\ \Omega + 20\ \Omega \\R_{\text{Total}} &= 40\ \Omega\end{aligned}$$

2. Determine Current

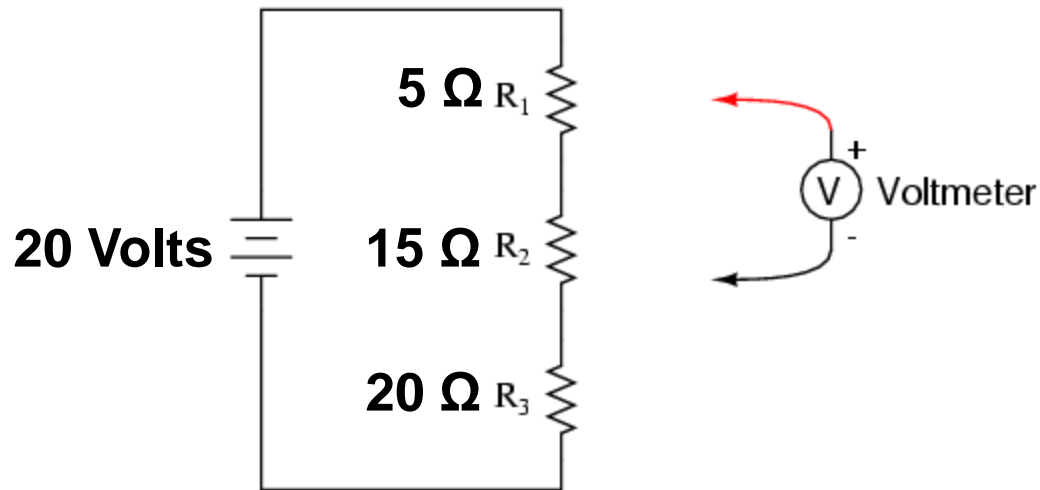


$$R_{\text{Total}} = R_1 + R_2 + R_3$$
$$R_{\text{Total}} = 5\ \Omega + 15\ \Omega + 20\ \Omega$$
$$R_{\text{Total}} = 40\ \Omega$$

$$I = E / R$$

$$I =$$

2. Determine Current



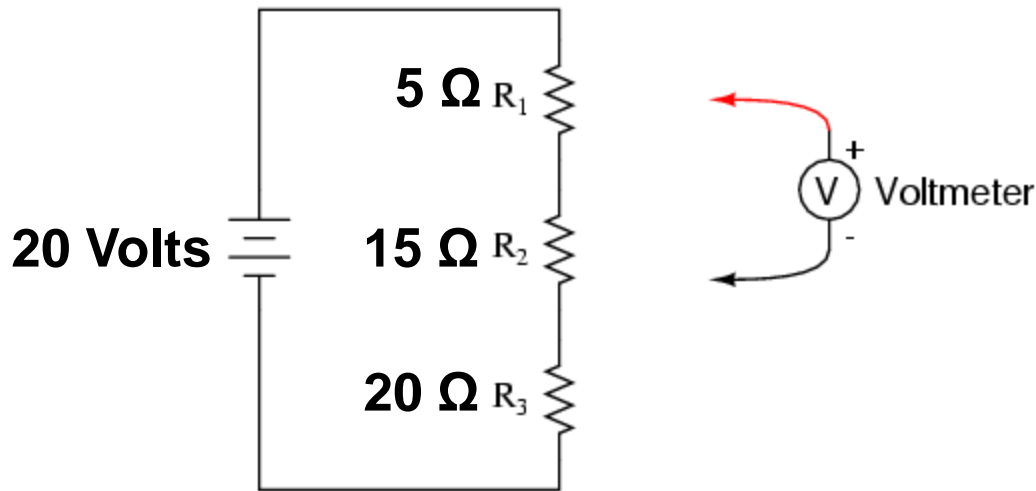
$$R_{\text{Total}} = R_1 + R_2 + R_3$$
$$R_{\text{Total}} = 5 \Omega + 15 \Omega + 20 \Omega$$
$$R_{\text{Total}} = 40 \Omega$$

$$I = E / R$$

$$I = 20 \text{ Volts} / 40 \text{ Ohms}$$

$$I = 0.5 \text{ Amps}$$

3. Determine Voltage Drops



$$R_{\text{Total}} = R_1 + R_2 + R_3$$
$$R_{\text{Total}} = 5 \Omega + 15 \Omega + 20 \Omega$$
$$R_{\text{Total}} = 40 \Omega$$

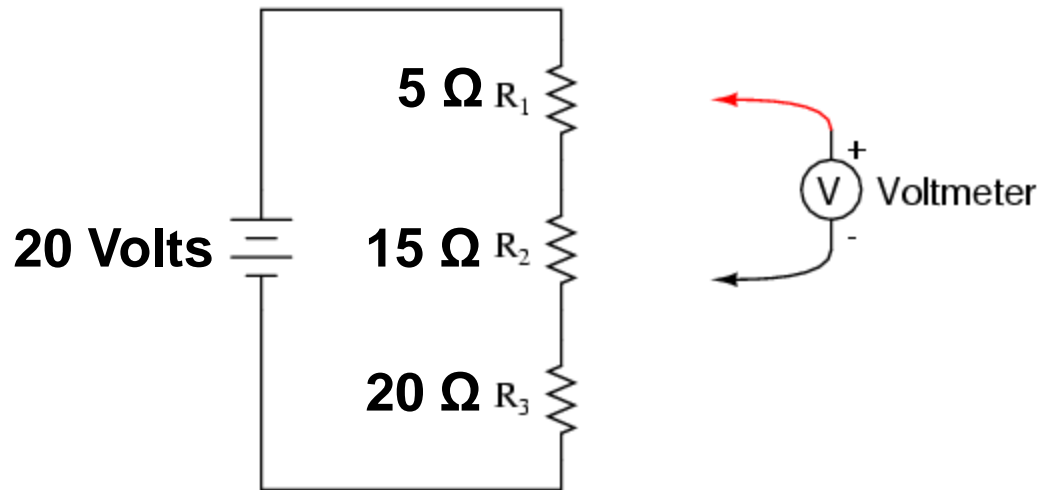
$$I = E / R$$
$$I = 20 \text{ Volts} / 40 \text{ Ohms}$$
$$I = 0.5 \text{ Amps}$$

$$E_{R1} = I \times R_1$$
$$E_{R1} =$$

$$E_{R2} = I \times R_2$$
$$E_{R2} =$$

$$E_{R3} = I \times R_3$$
$$E_{R3} =$$

3. Determine Voltage Drops



$$R_{\text{Total}} = R_1 + R_2 + R_3$$
$$R_{\text{Total}} = 5 \Omega + 15 \Omega + 20 \Omega$$
$$R_{\text{Total}} = 40 \Omega$$

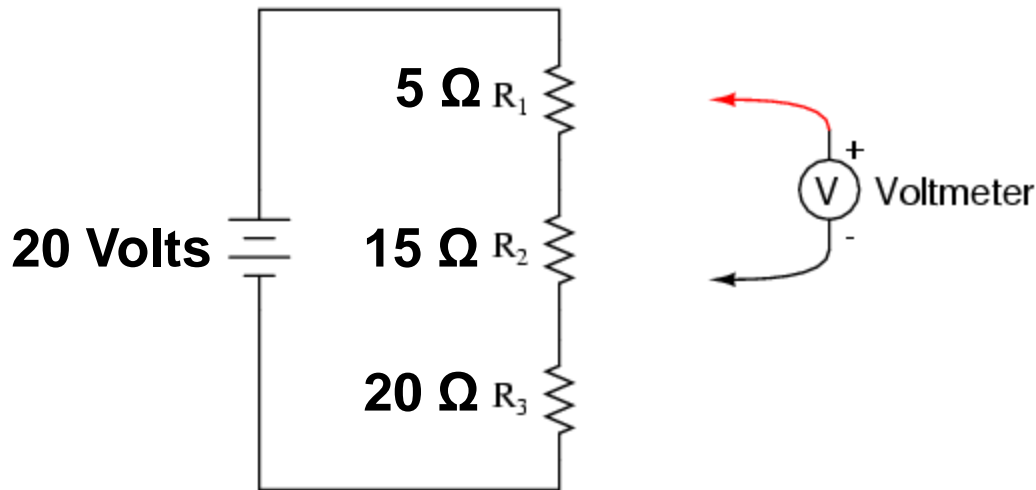
$$I = E / R$$
$$I = 20 \text{ Volts} / 40 \text{ Ohms}$$
$$I = 0.5 \text{ Amps}$$

$$E_{R1} = I \times R_1$$
$$E_{R1} = 0.5 \text{ Amps} \times 5 \Omega$$
$$E_{R1} = 2.5 \text{ Volts}$$

$$E_{R2} = I \times R_2$$
$$E_{R2} = 0.5 \text{ Amps} \times 15 \Omega$$
$$E_{R2} = 7.5 \text{ Volts}$$

$$E_{R3} = I \times R_3$$
$$E_{R3} = 0.5 \text{ Amps} \times 20 \Omega$$
$$E_{R3} = 10 \text{ Volts}$$

4. Check Your Results!



$$R_{\text{Total}} = R_1 + R_2 + R_3$$
$$R_{\text{Total}} = 5 \Omega + 15 \Omega + 20 \Omega$$
$$R_{\text{Total}} = 40 \Omega$$

$$I = E / R$$
$$I = 20 \text{ Volts} / 40 \text{ Ohms}$$
$$I = 0.5 \text{ Amps}$$

$$E_{R1} = I \times R_1$$
$$E_{R1} = 0.5 \text{ Amps} \times 5 \Omega$$
$$E_{R1} = 2.5 \text{ Volts}$$

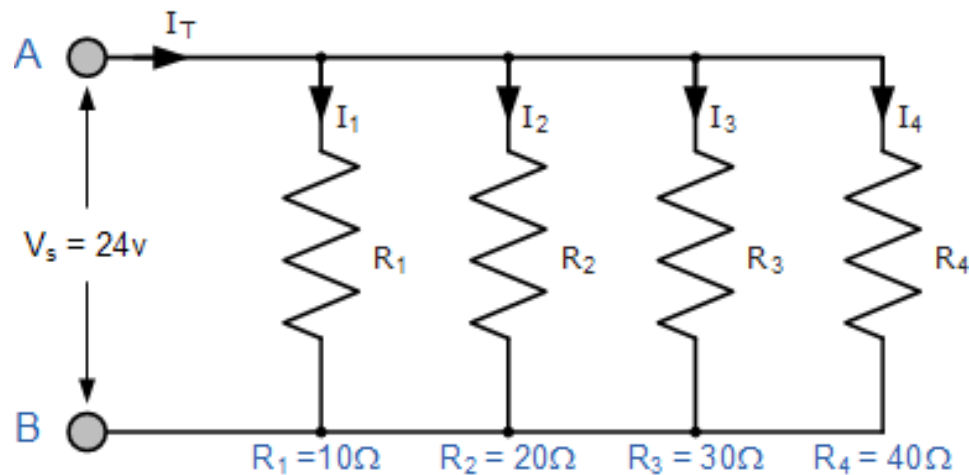
$$E_{R2} = I \times R_2$$
$$E_{R2} = 0.5 \text{ Amps} \times 15 \Omega$$
$$E_{R2} = 7.5 \text{ Volts}$$

$$E_{R3} = I \times R_3$$
$$E_{R3} = 0.5 \text{ Amps} \times 20 \Omega$$
$$E_{R3} = 10 \text{ Volts}$$

$$E_{\text{source}} = E_{R1} + E_{R2} + E_{R3}$$
$$E_{\text{source}} = 2.5V + 7.5V + 10V = 20V$$

Voltage in Parallel Circuits

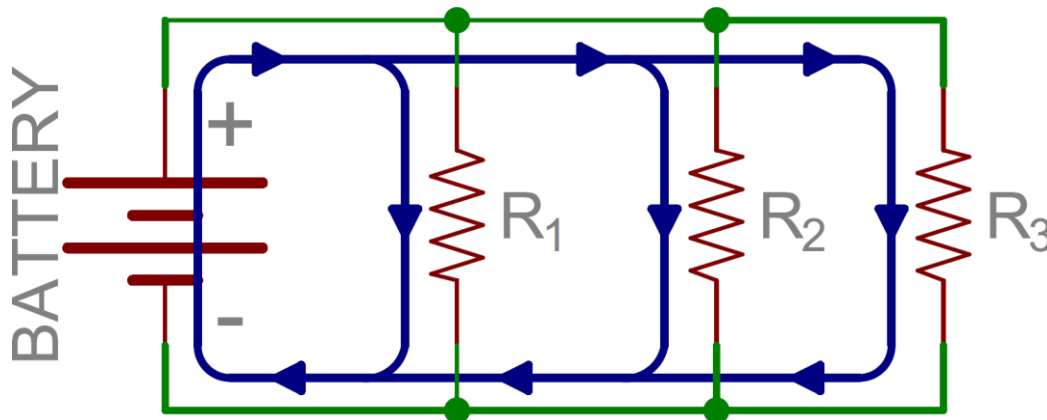
- The voltage applied to each resistor in a Parallel Circuit is the same as the source voltage.



$$E_{\text{source}} = E_{R1} = E_{R2} = E_{R3} = E_{R4}$$

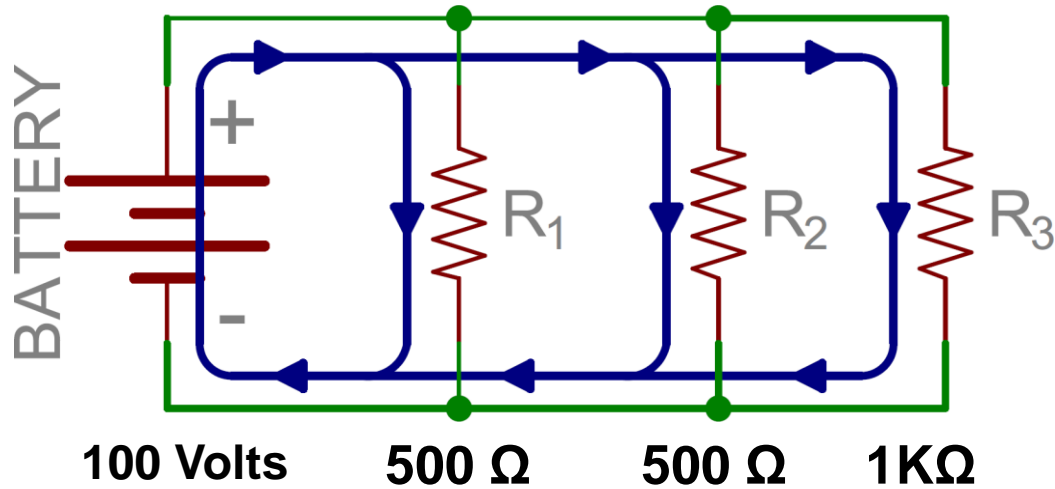
Current in a Parallel Circuit

- The total current in a Parallel Circuit is divided among the resistors.
- The sum of the currents through each resistor equals the total current.

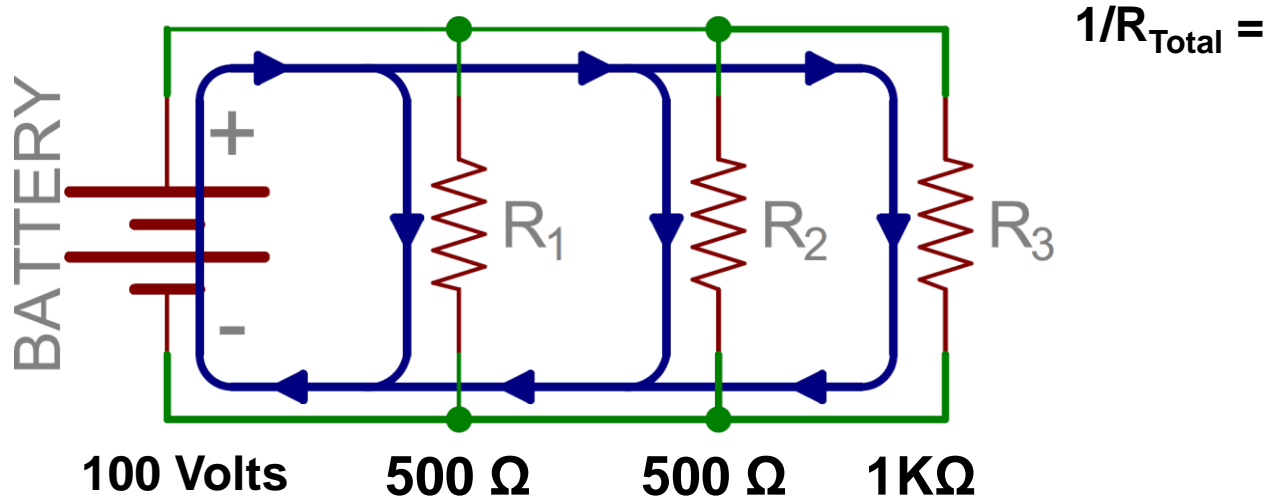


$$I_{\text{Total}} = I_{R1} + I_{R2} + I_{R3}$$

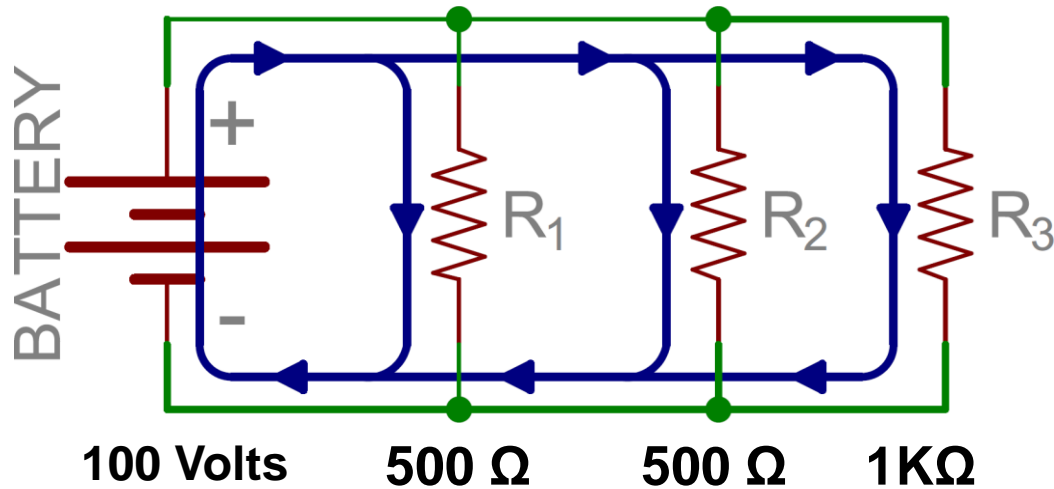
To Calculate Currents...



Determine Equivalent Resistance

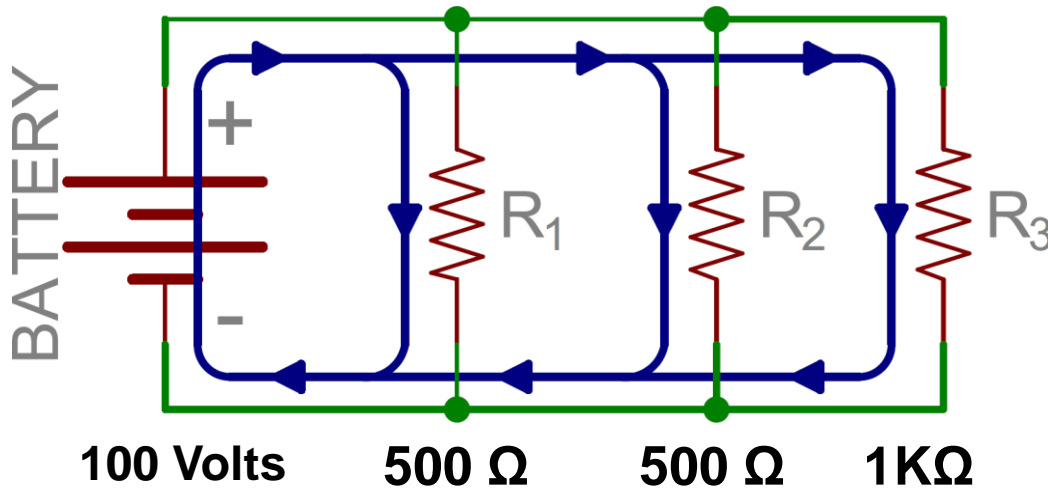


Determine Equivalent Resistance



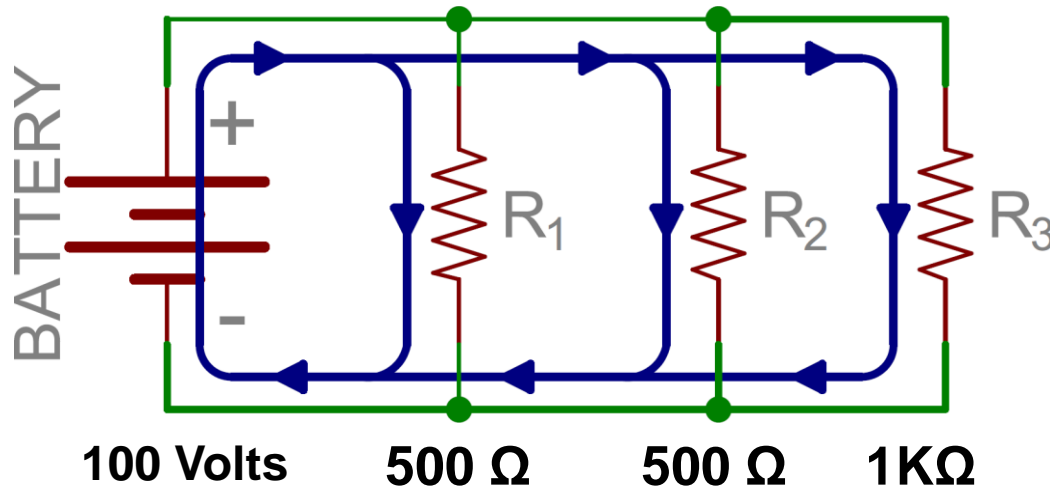
$$\frac{1}{R_{\text{Total}}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$
$$\frac{1}{R_{\text{Total}}} = \frac{1}{500} + \frac{1}{500} + \frac{1}{1K}$$

Determine Equivalent Resistance



$$\begin{aligned} 1/R_{\text{Total}} &= 1/R_1 + 1/R_2 + 1/R_3 \\ 1/R_{\text{Total}} &= 1/500 + 1/500 + 1/1K \\ 1/R_{\text{Total}} &= 2/1000 + 2/1000 + 1/1000 \\ 1/R_{\text{Total}} &= 5/1000 \end{aligned}$$

Determine Equivalent Resistance



$$1/R_{\text{Total}} = 1/R_1 + 1/R_2 + 1/R_3$$

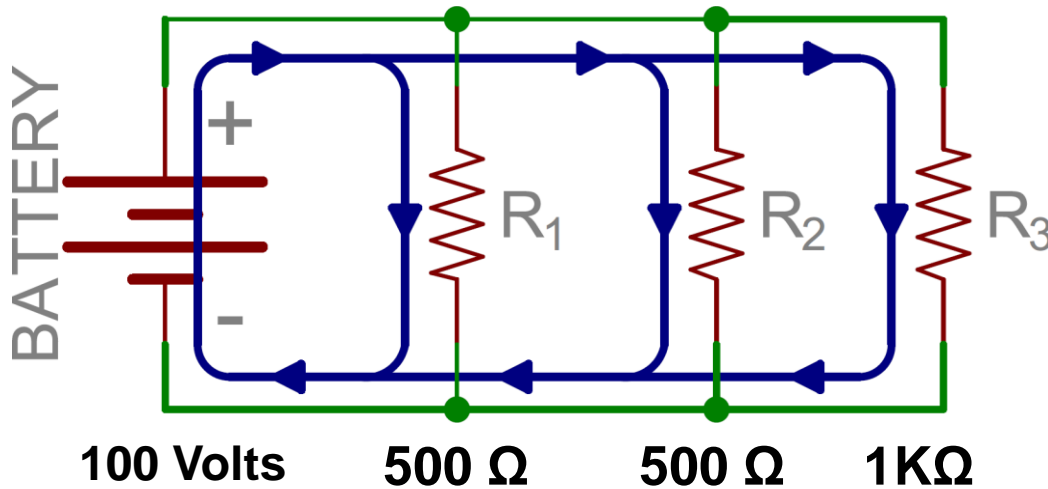
$$1/R_{\text{Total}} = 1/500 + 1/500 + 1/1K$$

$$1/R_{\text{Total}} = 2/1000 + 2/1000 + 1/1000$$

$$1/R_{\text{Total}} = 5/1000$$

$$R_{\text{Total}} = 1000/5 = 200 \Omega$$

Determine Overall Current

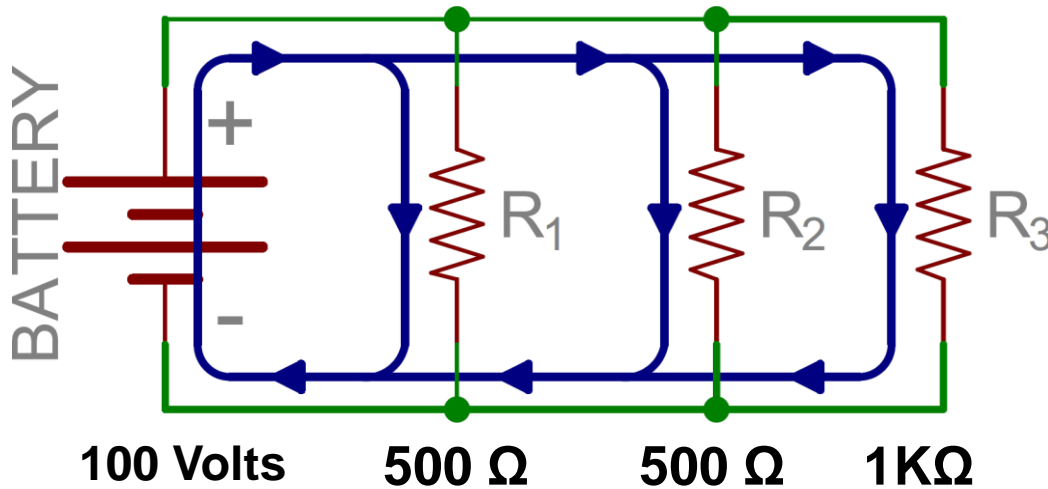


$$\begin{aligned}1/R_{\text{Total}} &= 1/R_1 + 1/R_2 + 1/R_3 \\1/R_{\text{Total}} &= 1/500 + 1/500 + 1/1\text{K} \\1/R_{\text{Total}} &= 2/1000 + 2/1000 + 1/1000 \\1/R_{\text{Total}} &= 5/1000\end{aligned}$$

$$R_{\text{Total}} = 1000/5 = 200 \Omega$$

I =

Determine Overall Current



$$1/R_{\text{Total}} = 1/R_1 + 1/R_2 + 1/R_3$$

$$1/R_{\text{Total}} = 1/500 + 1/500 + 1/1K$$

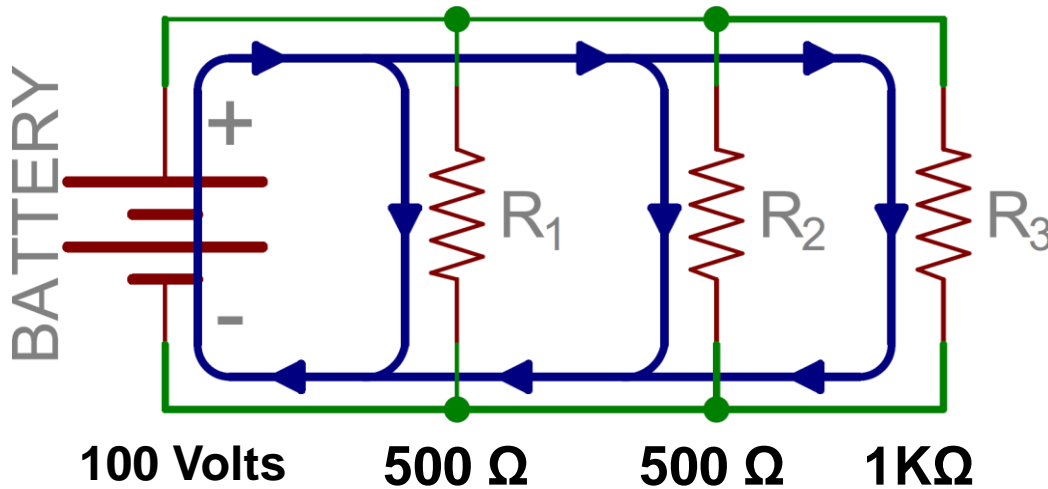
$$1/R_{\text{Total}} = 2/1000 + 2/1000 + 1/1000$$

$$1/R_{\text{Total}} = 5/1000$$

$$R_{\text{Total}} = 1000/5 = 200 \Omega$$

$$I = E / R$$

Determine Overall Current



$$1/R_{\text{Total}} = 1/R_1 + 1/R_2 + 1/R_3$$

$$1/R_{\text{Total}} = 1/500 + 1/500 + 1/1K$$

$$1/R_{\text{Total}} = 2/1000 + 2/1000 + 1/1000$$

$$1/R_{\text{Total}} = 5/1000$$

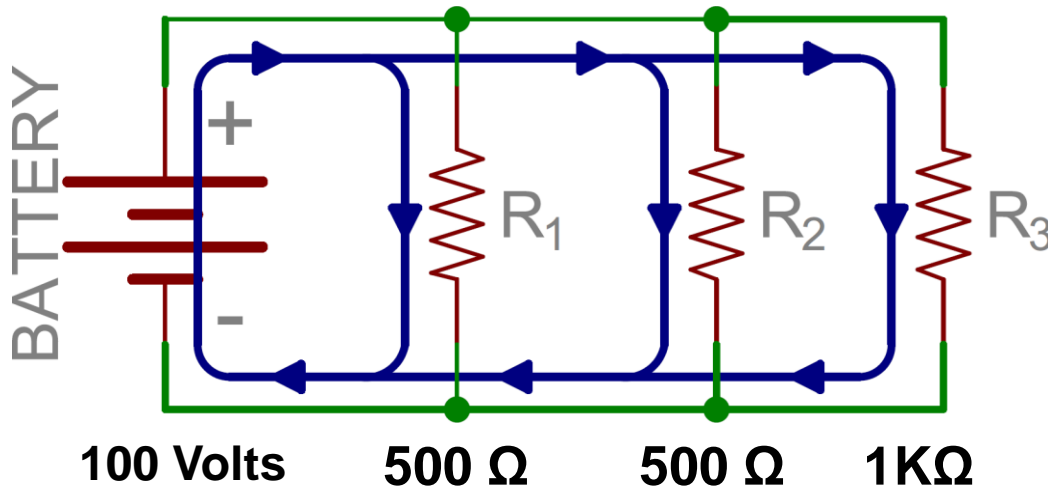
$$R_{\text{Total}} = 1000/5 = 200 \Omega$$

$$I = E / R$$

$$I = 100 \text{ V} / 200 \Omega$$

$$I = 0.5 \text{ Amps}$$

Determine Individual Currents



$$\begin{aligned} 1/R_{\text{Total}} &= 1/R_1 + 1/R_2 + 1/R_3 \\ 1/R_{\text{Total}} &= 1/500 + 1/500 + 1/1K \\ 1/R_{\text{Total}} &= 2/1000 + 2/1000 + 1/1000 \\ 1/R_{\text{Total}} &= 5/1000 \end{aligned}$$

$$R_{\text{Total}} = 1000/5 = 200 \Omega$$

$$I = E / R$$

$$I = 100 \text{ V} / 200 \Omega$$

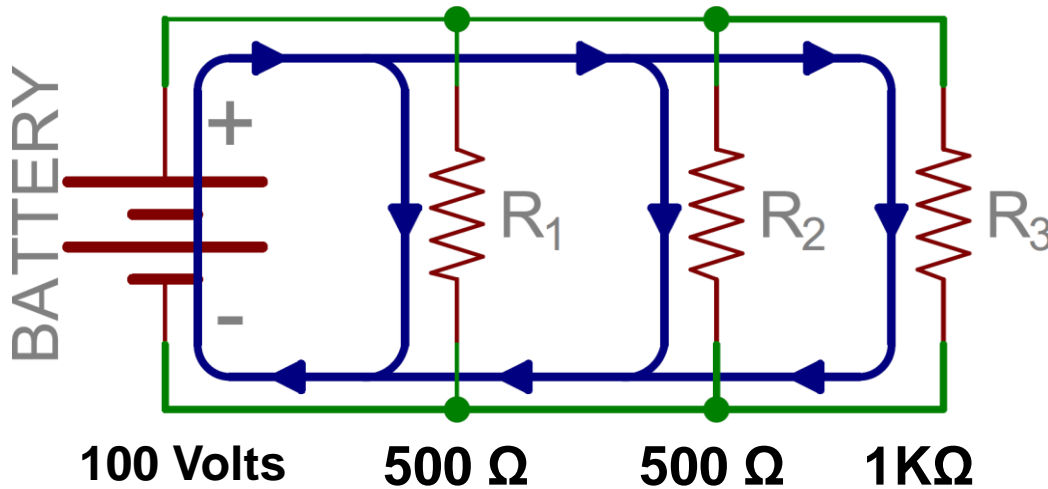
$$I = 0.5 \text{ Amps}$$

$$I_{R1} =$$

$$I_{R2} =$$

$$I_{R3} =$$

Determine Individual Currents



$$\begin{aligned}1/R_{\text{Total}} &= 1/R_1 + 1/R_2 + 1/R_3 \\1/R_{\text{Total}} &= 1/500 + 1/500 + 1/1\text{K} \\1/R_{\text{Total}} &= 2/1000 + 2/1000 + 1/1000 \\1/R_{\text{Total}} &= 5/1000\end{aligned}$$

$$R_{\text{Total}} = 1000/5 = 200\ \Omega$$

$$I = E / R$$

$$I = 100\ \text{V} / 200\ \Omega$$

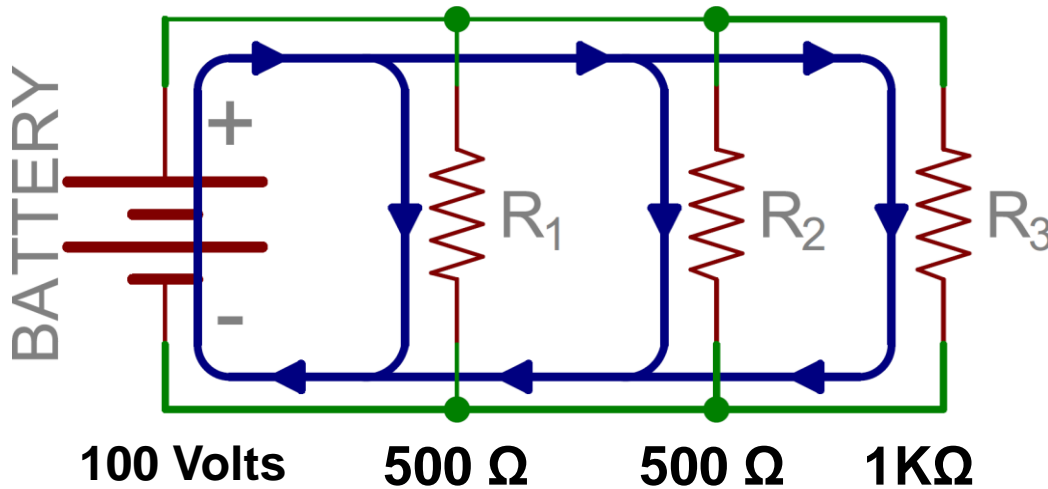
$$I = 0.5\ \text{Amps}$$

$$I_{R1} = E / R_1$$

$$I_{R2} = E / R_2$$

$$I_{R3} = E / R_3$$

Determine Individual Currents



$$\begin{aligned}1/R_{\text{Total}} &= 1/R_1 + 1/R_2 + 1/R_3 \\1/R_{\text{Total}} &= 1/500 + 1/500 + 1/1K \\1/R_{\text{Total}} &= 2/1000 + 2/1000 + 1/1000 \\1/R_{\text{Total}} &= 5/1000\end{aligned}$$

$$R_{\text{Total}} = 1000/5 = 200 \Omega$$

$$I = E / R$$

$$I = 100 \text{ V} / 200 \Omega$$

$$I = 0.5 \text{ Amps}$$

$$I_{R1} = E / R_1$$

$$I_{R1} = 100 \text{ V} / 500 \Omega$$

$$I_{R1} =$$

$$I_{R2} = E / R_2$$

$$I_{R2} = 100 \text{ V} / 500 \Omega$$

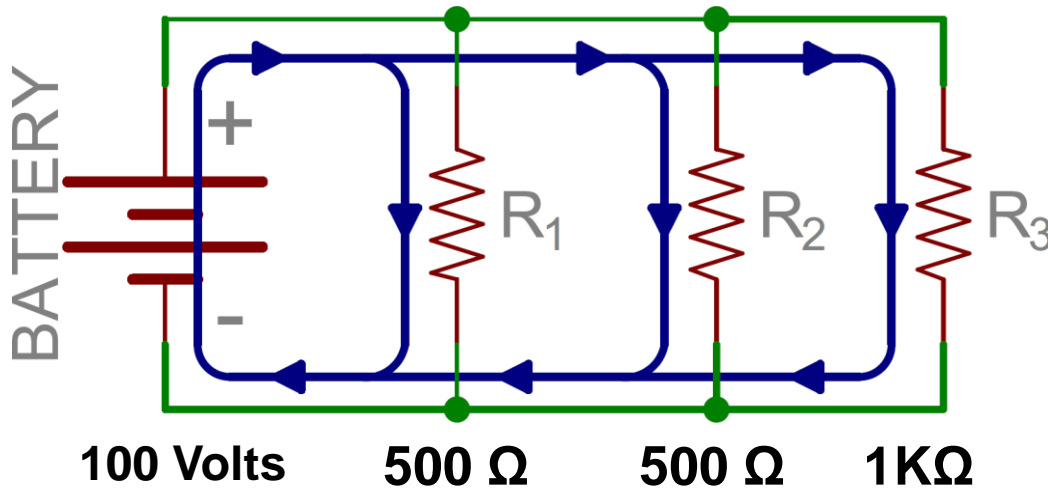
$$I_{R2} =$$

$$I_{R3} = E / R_3$$

$$I_{R3} = 100 \text{ V} / 1000 \Omega$$

$$I_{R3} =$$

Determine Individual Currents



$$\begin{aligned}1/R_{\text{Total}} &= 1/R_1 + 1/R_2 + 1/R_3 \\1/R_{\text{Total}} &= 1/500 + 1/500 + 1/1K \\1/R_{\text{Total}} &= 2/1000 + 2/1000 + 1/1000 \\1/R_{\text{Total}} &= 5/1000\end{aligned}$$

$$R_{\text{Total}} = 1000/5 = 200 \Omega$$

$$I = E / R$$

$$I = 100 \text{ V} / 200 \Omega$$

$$I = 0.5 \text{ Amps}$$

$$I_{R1} = E / R_1$$

$$I_{R1} = 100 \text{ V} / 500 \Omega$$

$$I_{R1} = 0.2 \text{ Amps}$$

$$I_{R2} = E / R_2$$

$$I_{R2} = 100 \text{ V} / 500 \Omega$$

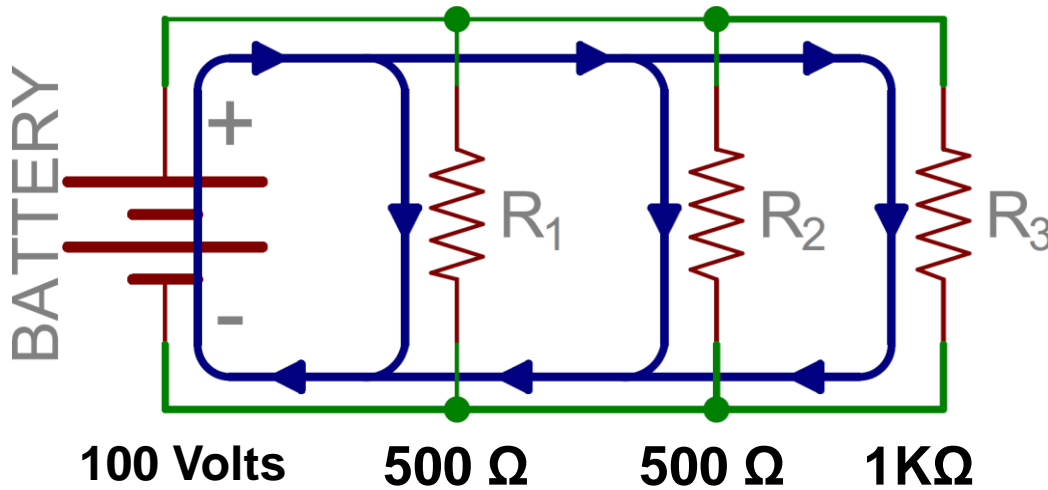
$$I_{R2} = 0.2 \text{ Amps}$$

$$I_{R3} = E / R_3$$

$$I_{R3} = 100 \text{ V} / 1000 \Omega$$

$$I_{R3} = 0.1 \text{ Amps}$$

Check your Answer!



$$\begin{aligned} 1/R_{\text{Total}} &= 1/R_1 + 1/R_2 + 1/R_3 \\ 1/R_{\text{Total}} &= 1/500 + 1/500 + 1/1\text{K} \\ 1/R_{\text{Total}} &= 2/1000 + 2/1000 + 1/1000 \\ 1/R_{\text{Total}} &= 5/1000 \end{aligned}$$

$$R_{\text{Total}} = 1000/5 = 200 \Omega$$

$$I = E / R$$

$$I = 100 \text{ V} / 200 \Omega$$

$$I = 0.5 \text{ Amps}$$

$$I_{R1} = E / R_1$$

$$I_{R1} = 100 \text{ V} / 500 \Omega$$

$$I_{R1} = 0.2 \text{ Amps}$$

$$I_{R2} = E / R_2$$

$$I_{R2} = 100 \text{ V} / 500 \Omega$$

$$I_{R2} = 0.2 \text{ Amps}$$

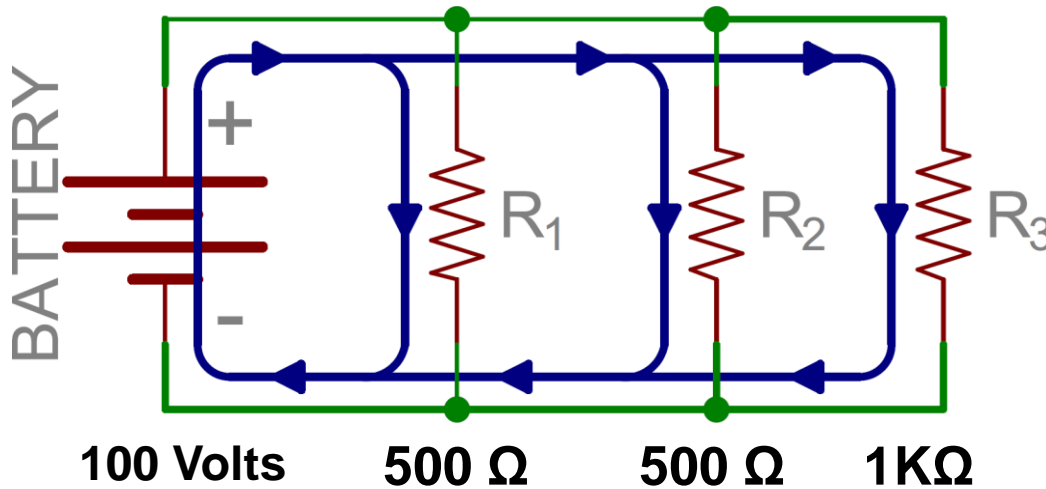
$$I_{R3} = E / R_3$$

$$I_{R3} = 100 \text{ V} / 1000 \Omega$$

$$I_{R3} = 0.1 \text{ Amps}$$

$$I_{\text{Total}} =$$

Check your Answer!



$$\begin{aligned}1/R_{\text{Total}} &= 1/R_1 + 1/R_2 + 1/R_3 \\1/R_{\text{Total}} &= 1/500 + 1/500 + 1/1K \\1/R_{\text{Total}} &= 2/1000 + 2/1000 + 1/1000 \\1/R_{\text{Total}} &= 5/1000\end{aligned}$$

$$R_{\text{Total}} = 1000/5 = 200 \Omega$$

$$I = E / R$$

$$I = 100 \text{ V} / 200 \Omega$$

$$I = 0.5 \text{ Amps}$$

$$I_{R1} = E / R_1$$

$$I_{R1} = 100 \text{ V} / 500 \Omega$$

$$I_{R1} = 0.2 \text{ Amps}$$

$$I_{R2} = E / R_2$$

$$I_{R2} = 100 \text{ V} / 500 \Omega$$

$$I_{R2} = 0.2 \text{ Amps}$$

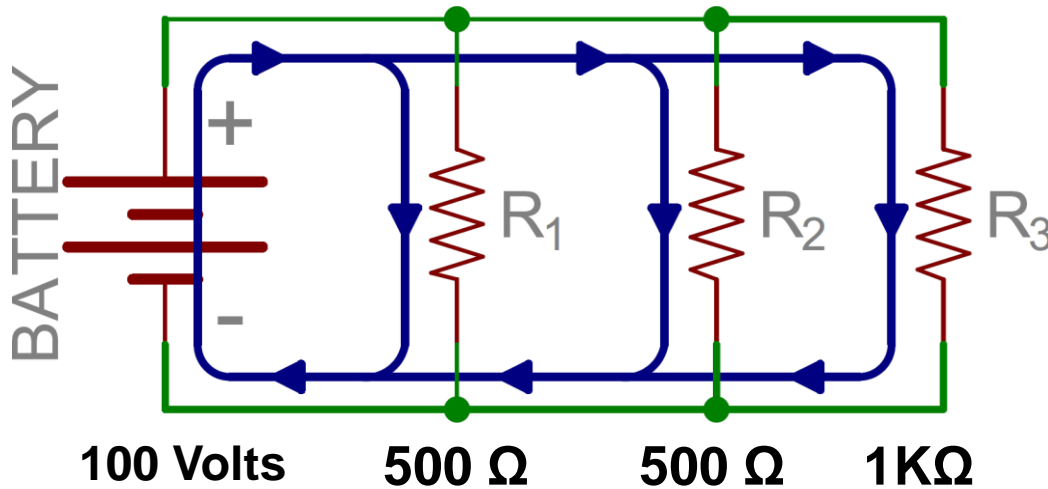
$$I_{R3} = E / R_3$$

$$I_{R3} = 100 \text{ V} / 1000 \Omega$$

$$I_{R3} = 0.1 \text{ Amps}$$

$$I_{\text{Total}} = I_{R1} + I_{R2} + I_{R3} =$$

Check your Answer!



$$\begin{aligned}1/R_{\text{Total}} &= 1/R_1 + 1/R_2 + 1/R_3 \\1/R_{\text{Total}} &= 1/500 + 1/500 + 1/1K \\1/R_{\text{Total}} &= 2/1000 + 2/1000 + 1/1000 \\1/R_{\text{Total}} &= 5/1000\end{aligned}$$

$$R_{\text{Total}} = 1000/5 = 200 \Omega$$

$$I = E / R$$

$$I = 100 \text{ V} / 200 \Omega$$

$$I = 0.5 \text{ Amps}$$

$$I_{R1} = E / R_1$$

$$I_{R1} = 100 \text{ V} / 500 \Omega$$

$$I_{R1} = 0.2 \text{ Amps}$$

$$I_{R2} = E / R_2$$

$$I_{R2} = 100 \text{ V} / 500 \Omega$$

$$I_{R2} = 0.2 \text{ Amps}$$

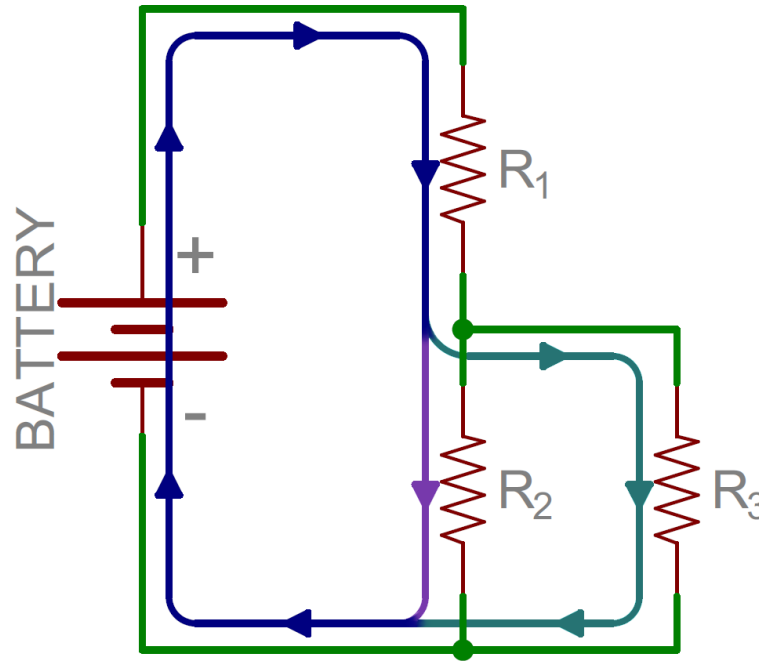
$$I_{R3} = E / R_3$$

$$I_{R3} = 100 \text{ V} / 1000 \Omega$$

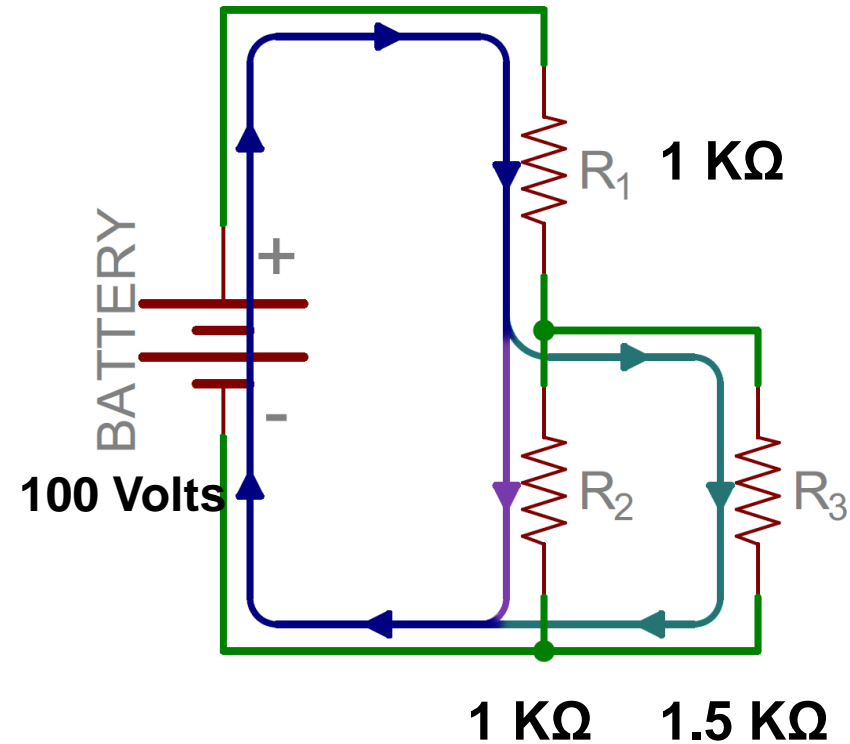
$$I_{R3} = 0.1 \text{ Amps}$$

$$I_{\text{Total}} = I_{R1} + I_{R2} + I_{R3} = 0.2 + 0.2 + 0.1 = 0.5 \text{ Amp}$$

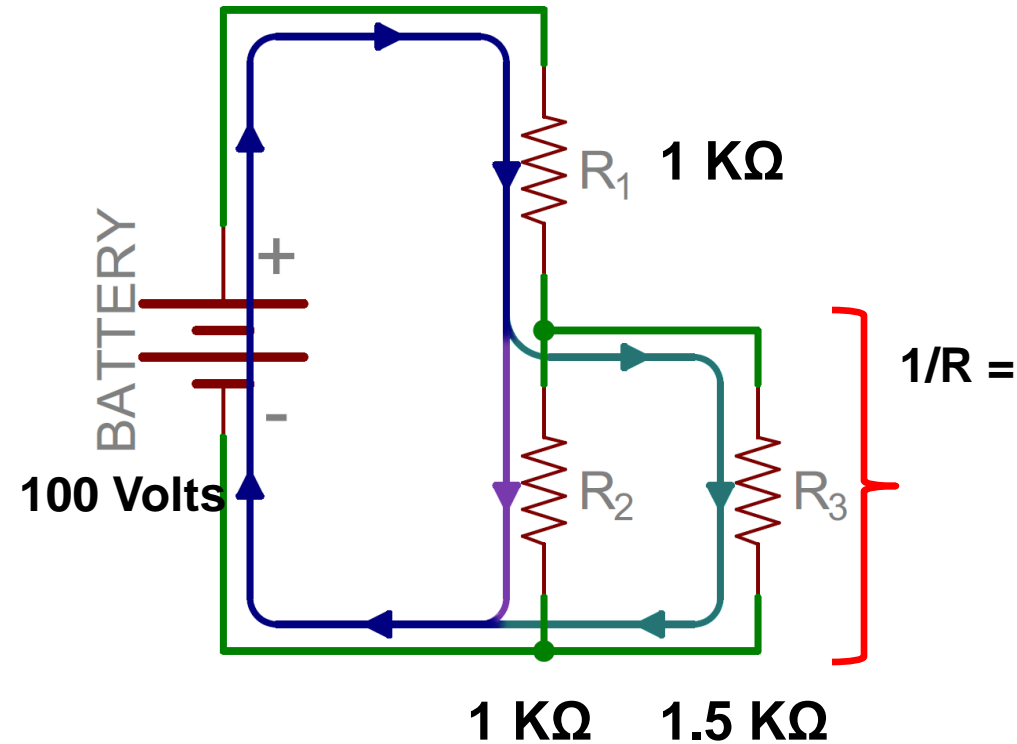
Series Parallel Combinations



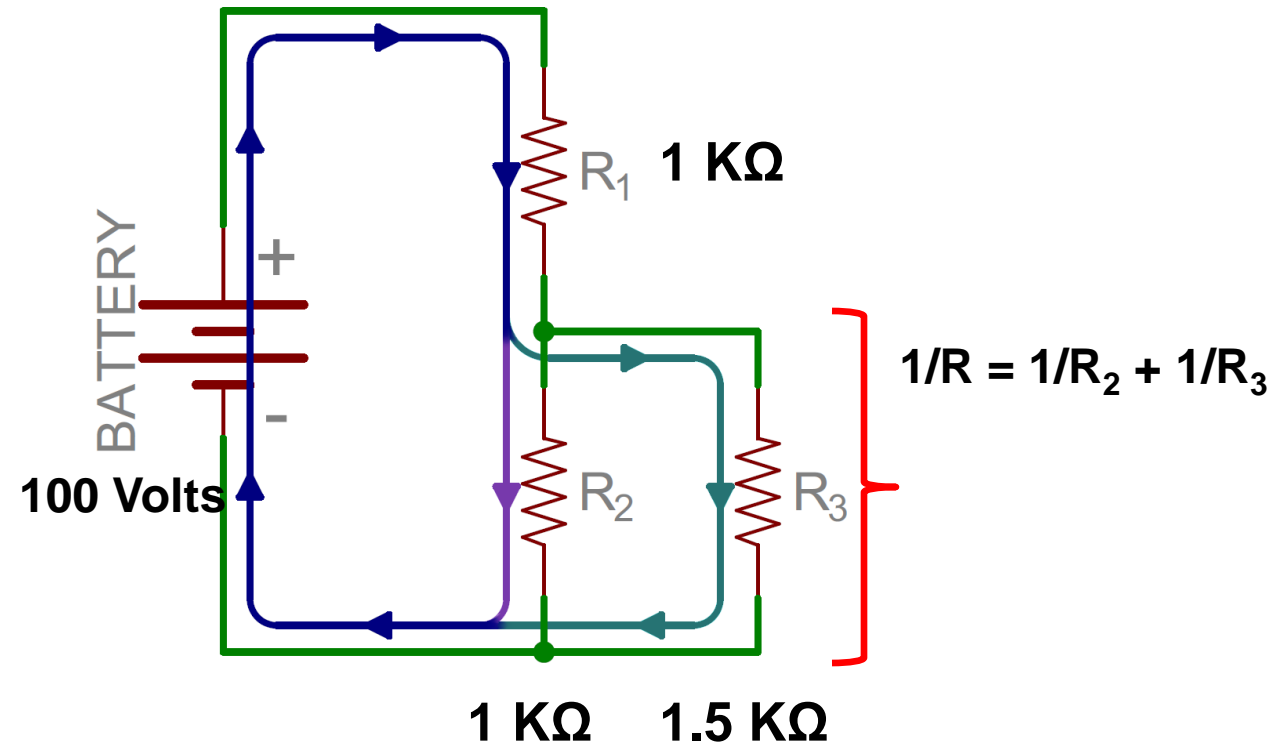
Series Parallel Combinations



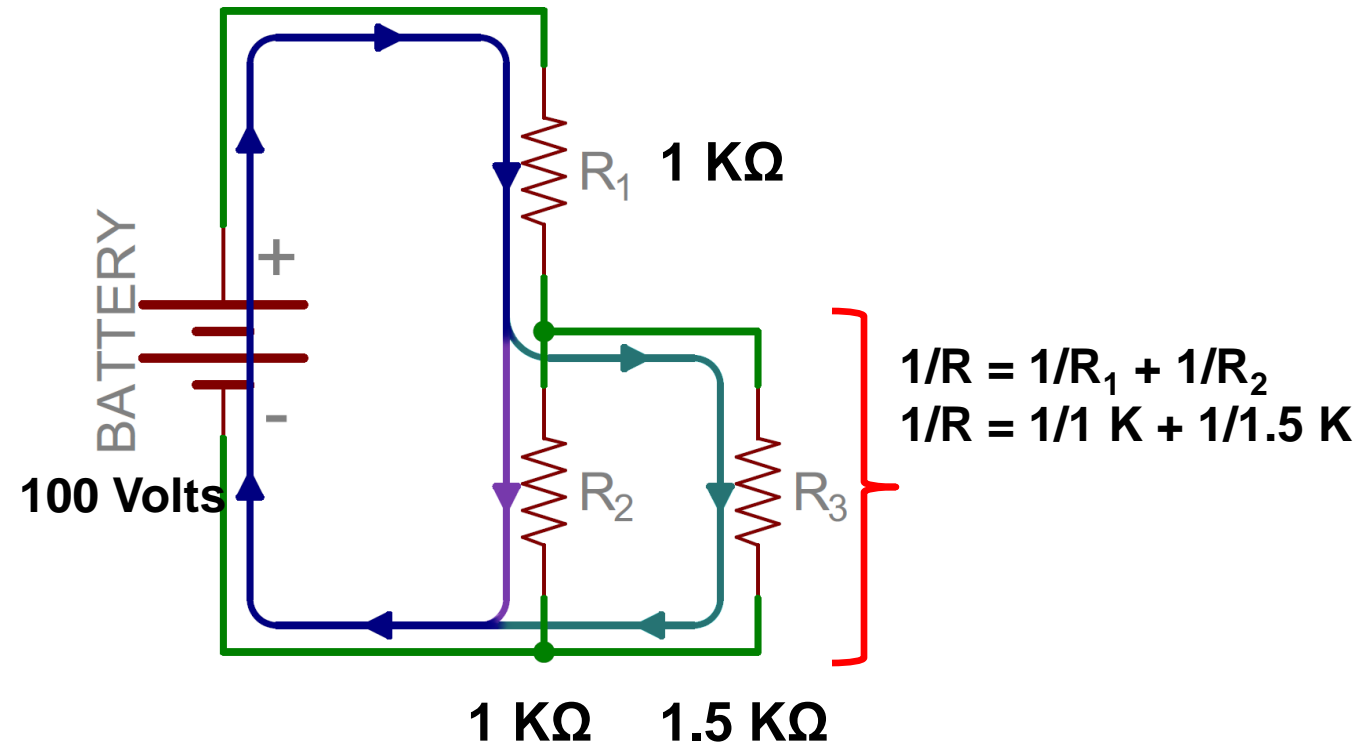
Series Parallel Combinations



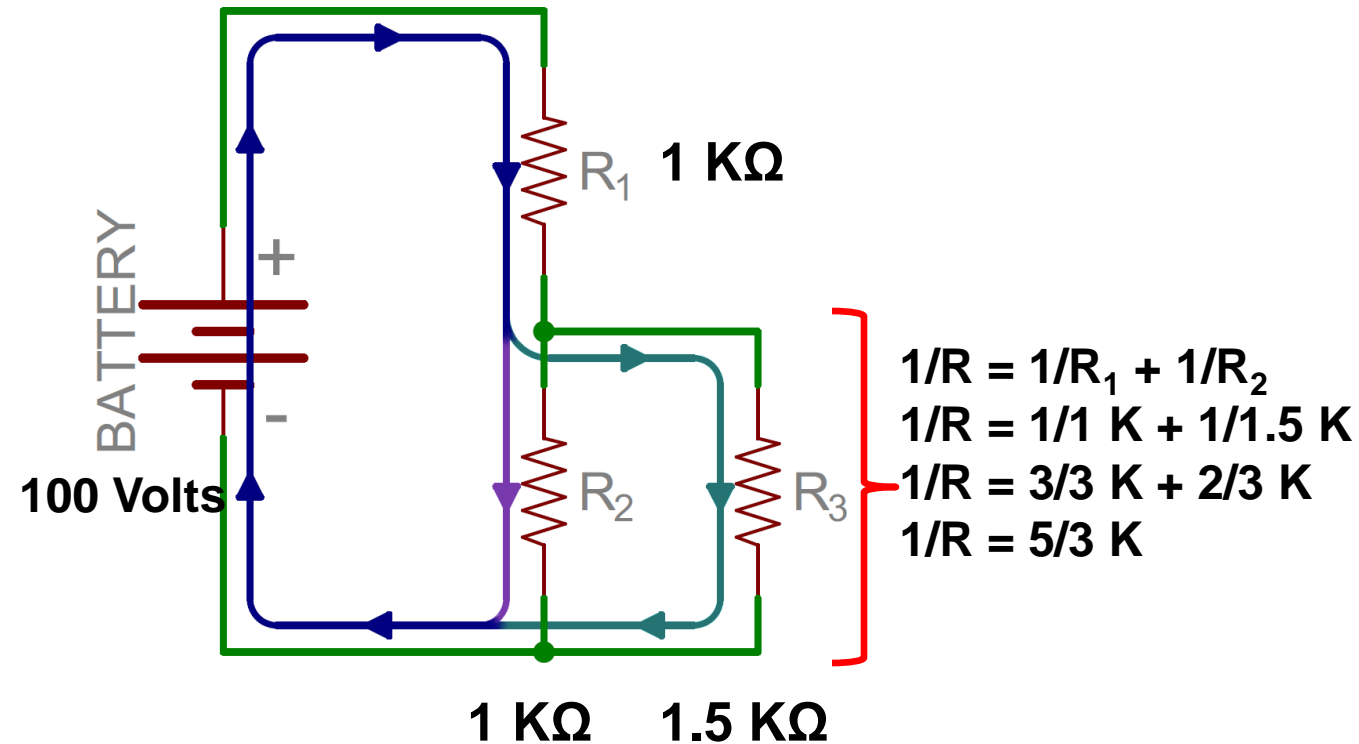
Series Parallel Combinations



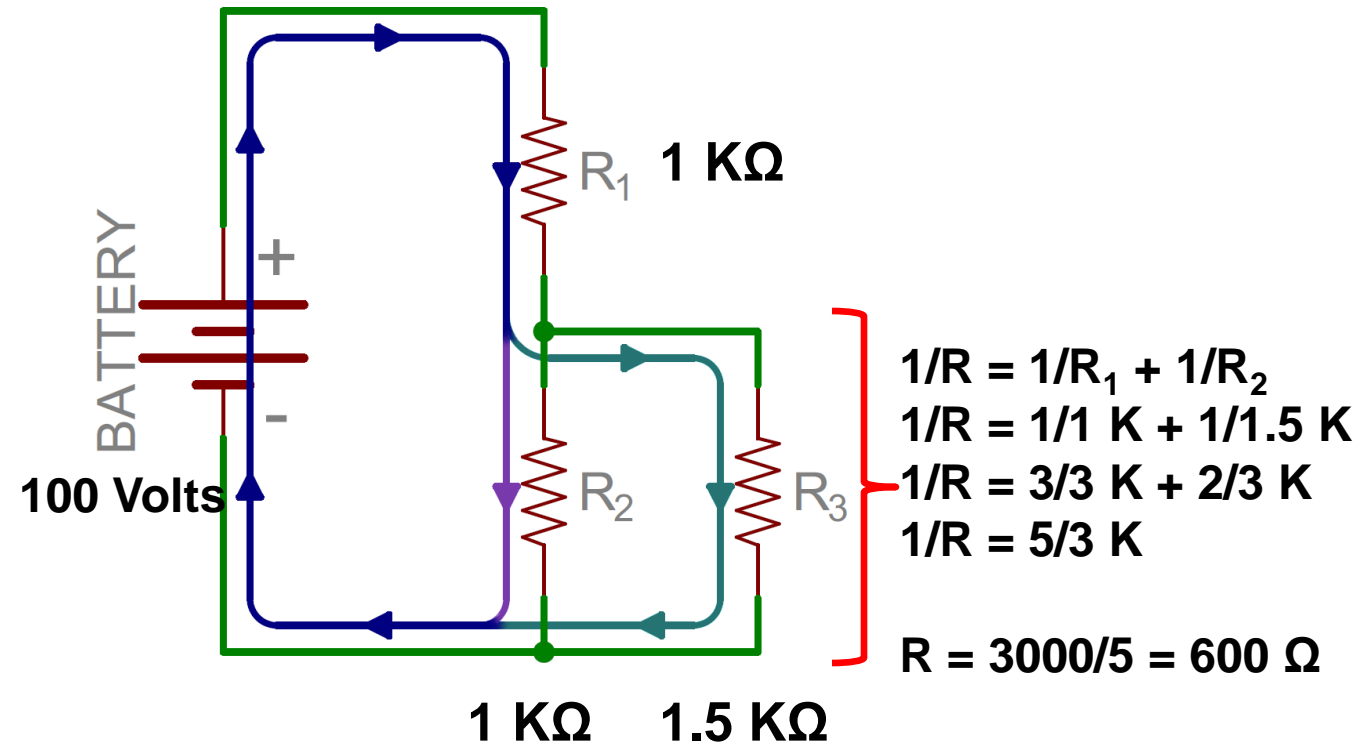
Series Parallel Combinations



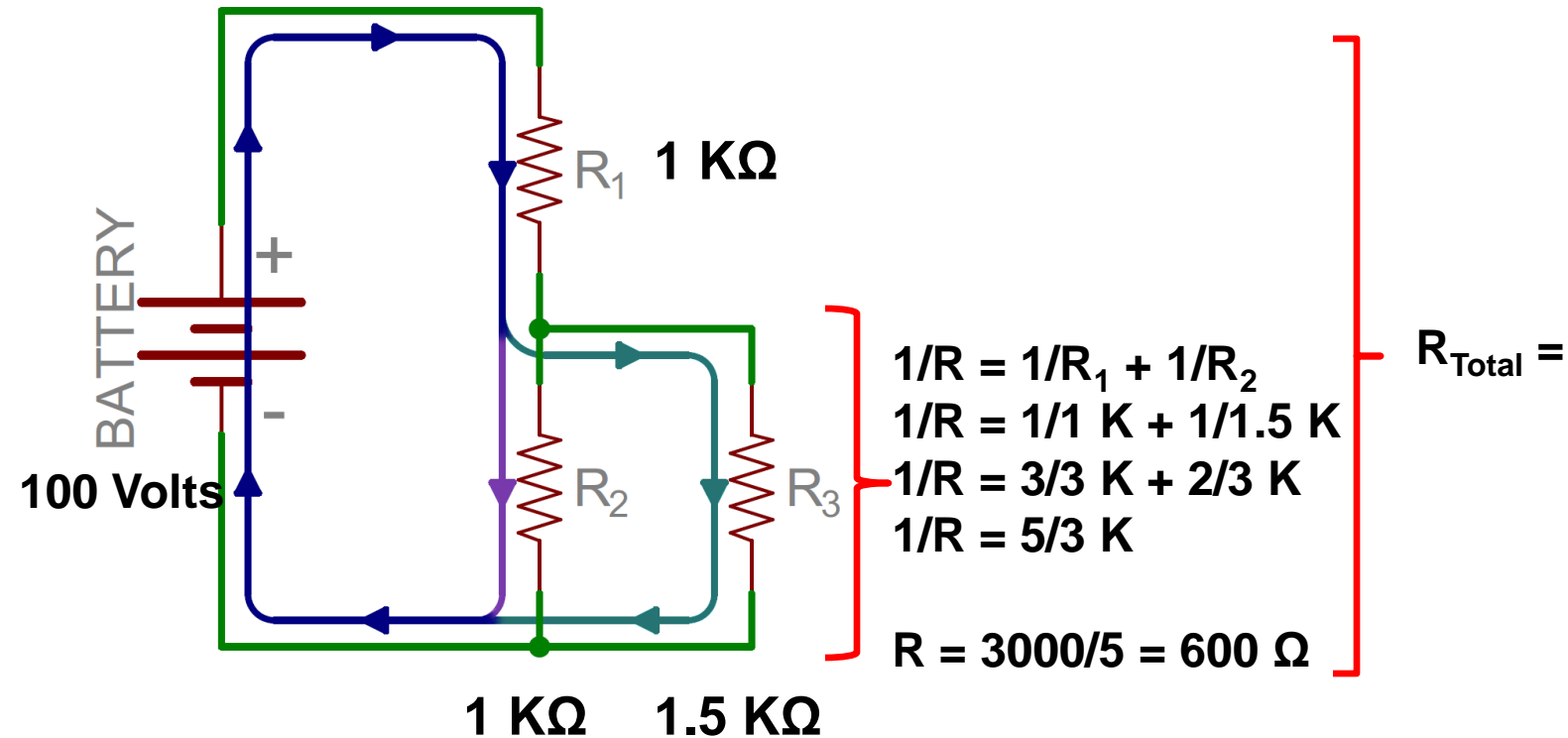
Series Parallel Combinations



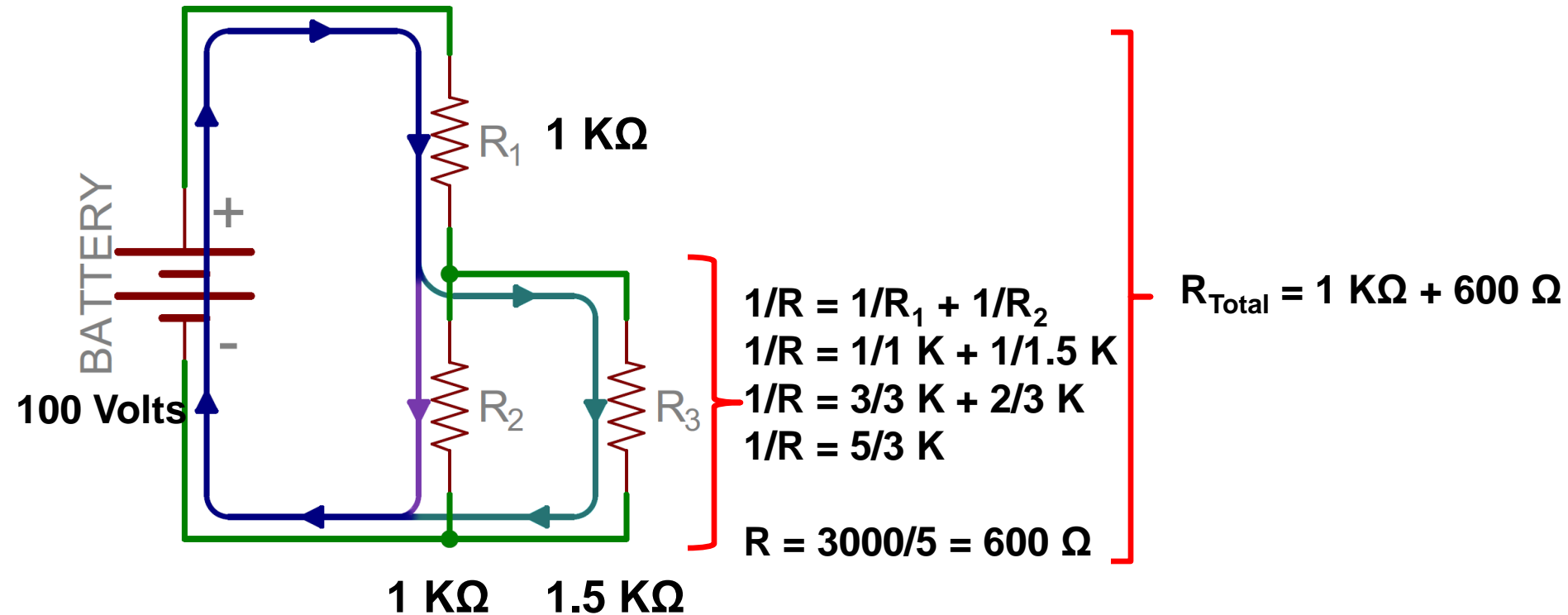
Series Parallel Combinations



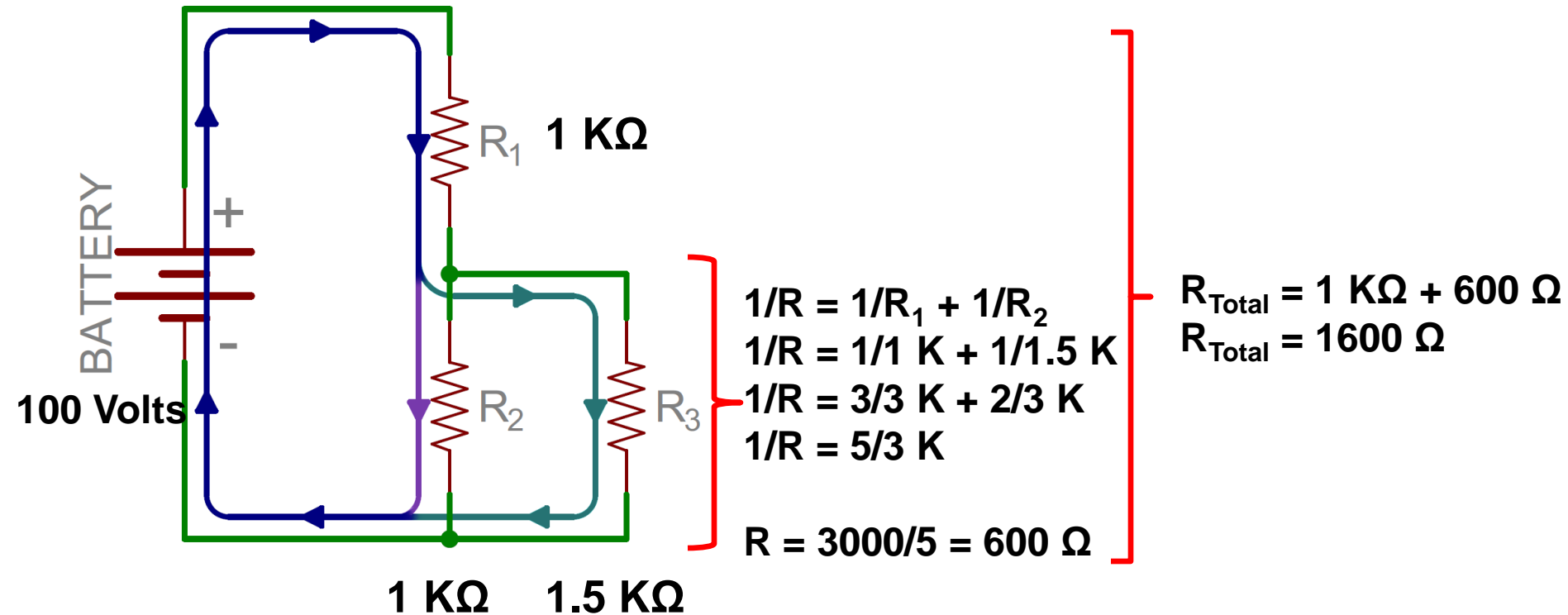
Series Parallel Combinations



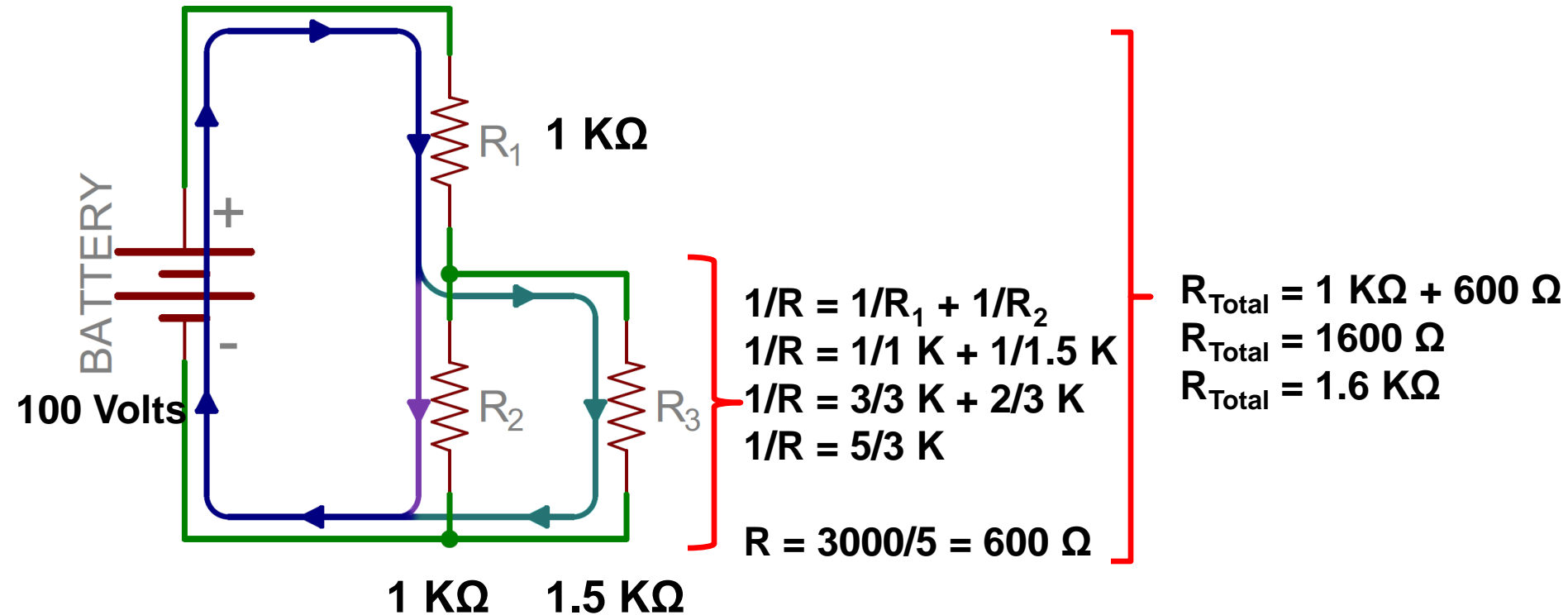
Series Parallel Combinations



Series Parallel Combinations



Series Parallel Combinations



Energy and Power

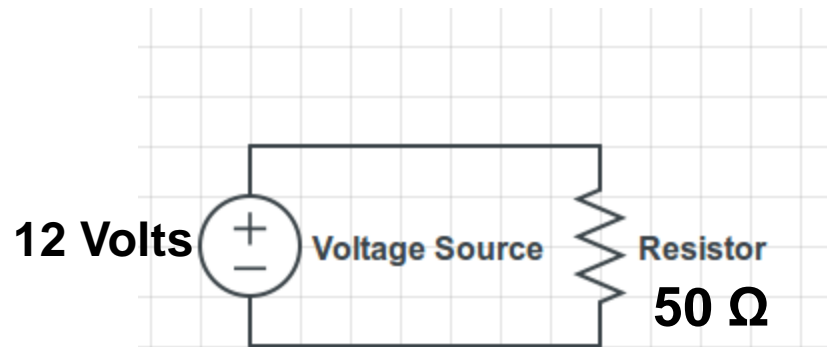
- Energy is the ability to do work.
- Two types: Kinetic and Potential
- A cell has Potential Energy – it stores chemical energy that can be released to do work.
- When electrons move against a resistance, work is done.
- The rate at which work is done is called Power

Power

- Basic unit of Power is the Watt, abbreviated W.
- In electrical systems, we can calculate power if we know any two of
 - Voltage;
 - Current; or
 - Resistance.

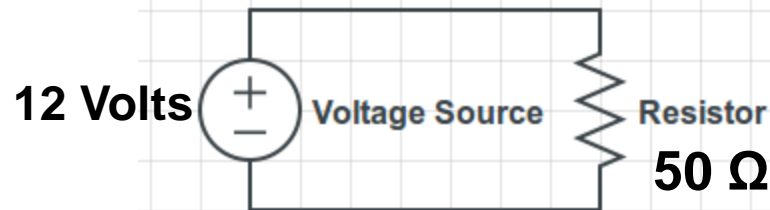
$$P = E \times I = E^2 / R = I^2 \times R$$

Calculating Power #1



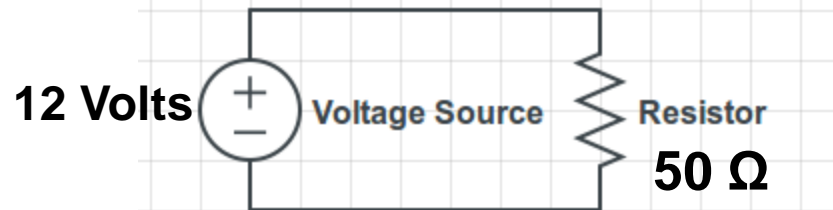
$$P = E \times I = E^2 / R = I^2 \times R$$

Calculating Power #1



$$P = E \times I = E^2 / R = I^2 \times R$$
$$P = E^2 / R$$

Calculating Power #1



$$P = E \times I = E^2 / R = I^2 \times R$$

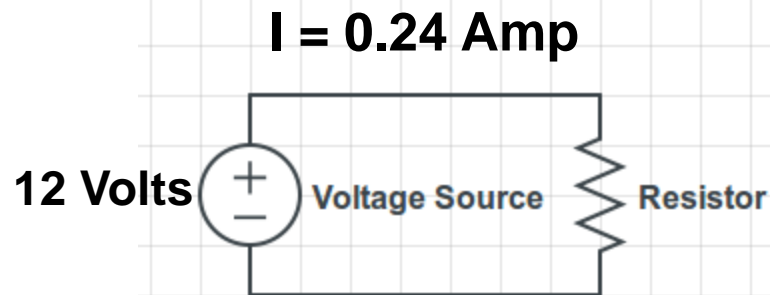
$$P = E^2 / R$$

$$P = 12^2 / 50$$

$$P = 144 / 50$$

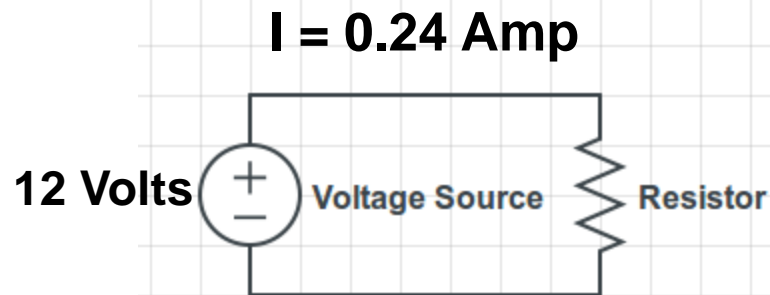
$$P = 2.88 \text{ Watts}$$

Calculating Power #2



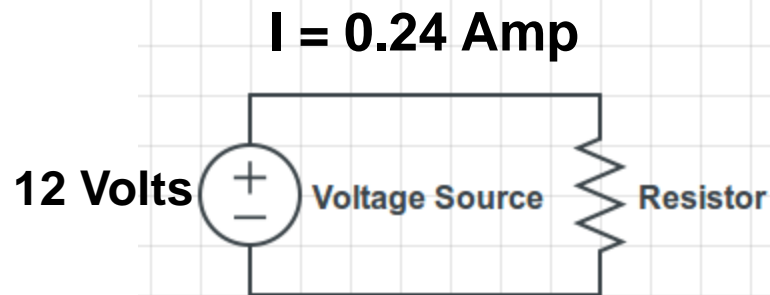
$$P = E \times I = E^2 / R = I^2 \times R$$

Calculating Power #2



$$P = E \times I = E^2 / R = I^2 \times R$$
$$P = E \times I$$

Calculating Power #2



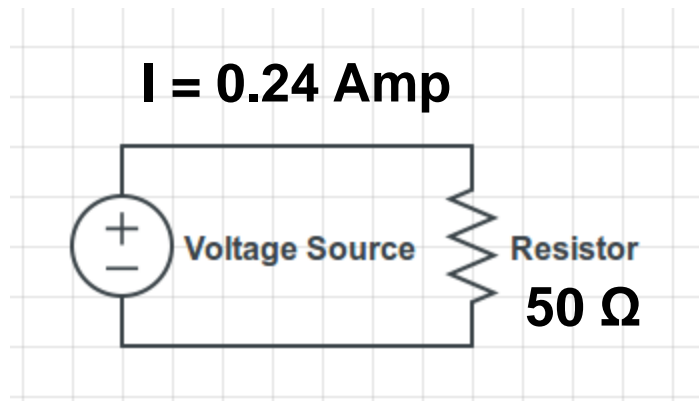
$$P = E \times I = E^2 / R = I^2 \times R$$

$$P = E \times I$$

$$P = 12 \times 0.24$$

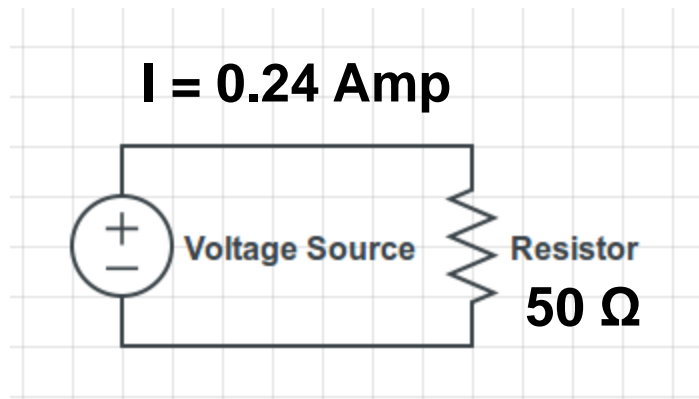
$$P = 2.88 \text{ Watts}$$

Calculating Power #3



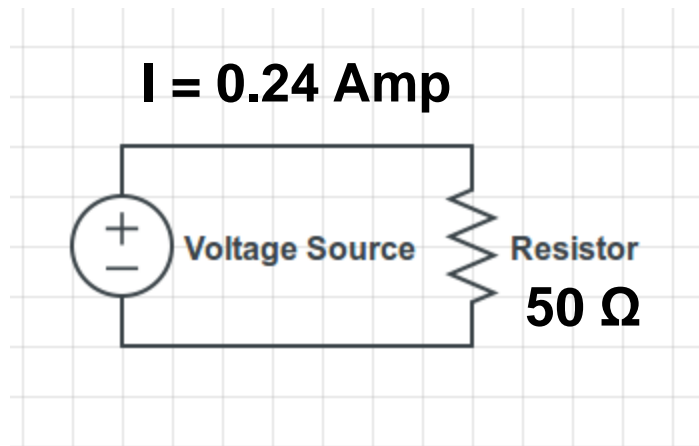
$$P = E \times I = E^2 / R = I^2 \times R$$

Calculating Power #3



$$P = E \times I = E^2 / R = I^2 \times R$$
$$P = I^2 \times R$$

Calculating Power #3



$$P = E \times I = E^2 / R = I^2 \times R$$

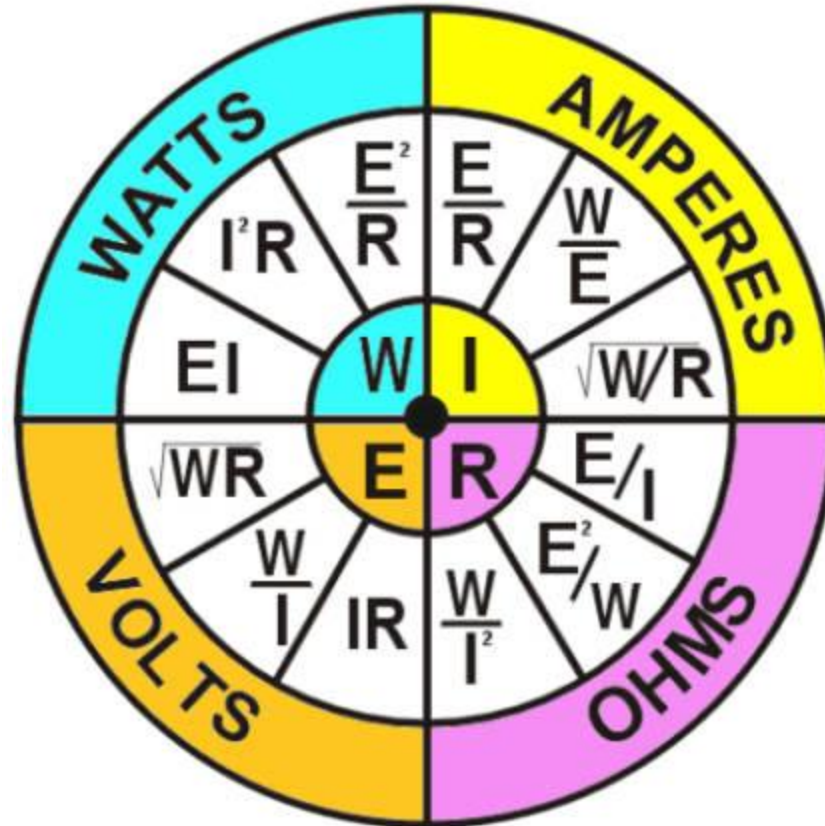
$$P = I^2 \times R$$

$$P = 0.24^2 \times 50$$

$$P = 0.0576 \times 50$$

$$P = 2.88 \text{ Watts}$$

Circuit Calculator



Remember the Units – Ohms, Volts, Amps, Watts!!

Questions?