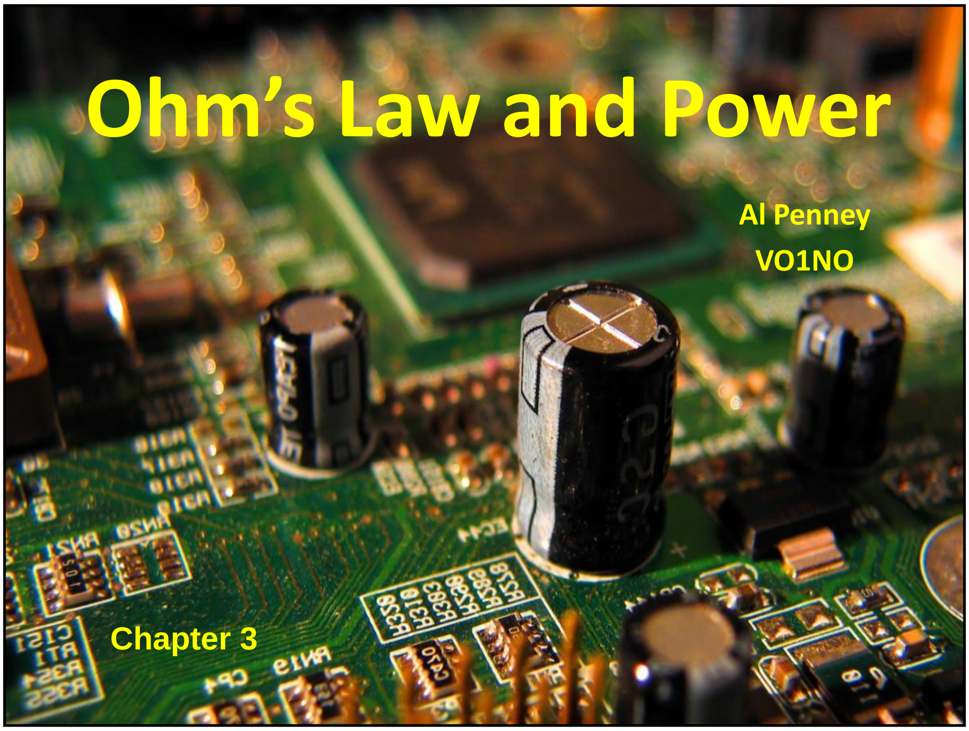
Ohm’s Law and Power
Al Penney
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Chapter 3

Objective

- Define Ohm's law;
- Make simple calculations using Ohm's law; and
- Understand the concept of power and the formula for its calculation.

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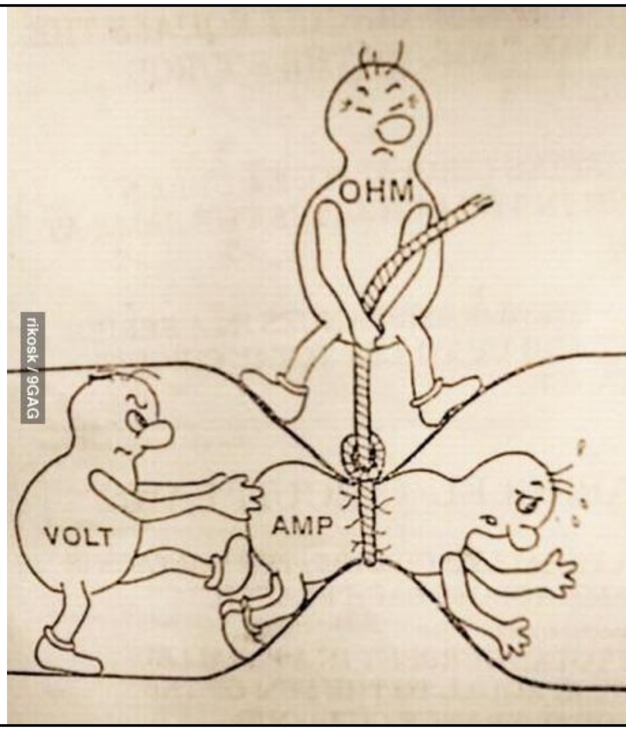

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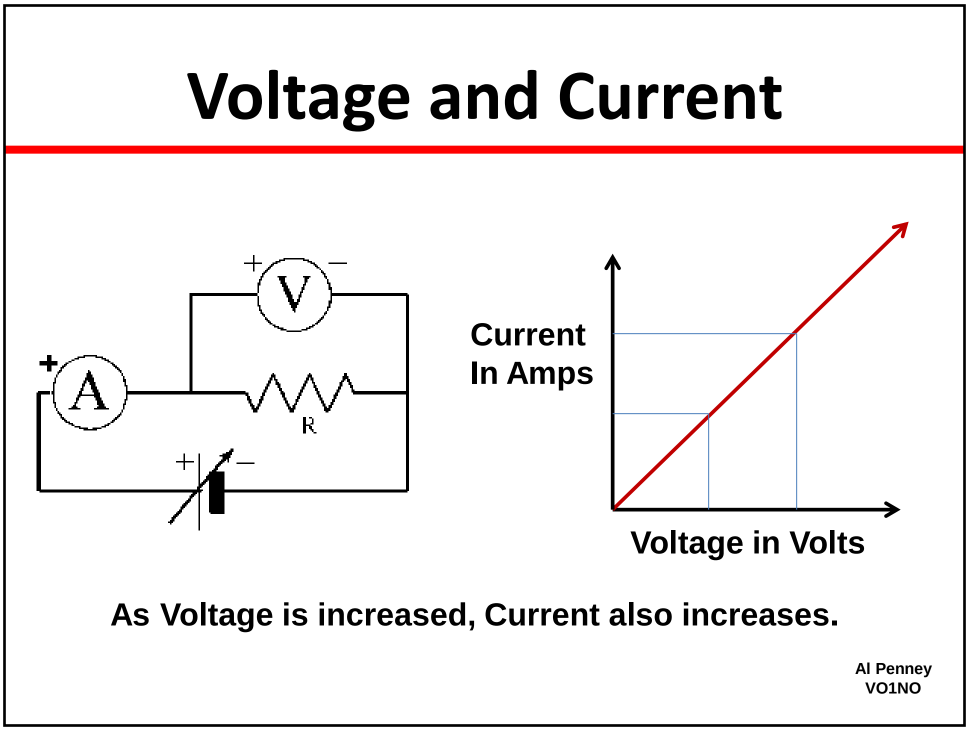

Ohm's law states that the current through a conductor between two points is directly proportional to the potential difference across the two points. Introducing the constant of proportionality, the resistance, one arrives at the usual mathematical equation that describes this relationship:

$$\mathbf{E = I \times R}$$

where *I* is the current through the conductor in units of amperes, *V* is the potential difference measured *across* the conductor in units of volts, and *R* is the resistance of the conductor in units of ohms. More specifically, Ohm's law states that the *R* in this relation is constant, independent of the current.
The law was named after the German physicist Georg Ohm, who, in a treatise published in 1827, described measurements of applied voltage and current through simple electrical circuits containing various lengths of wire. He presented a slightly more complex equation than the one above to explain his experimental results. The above equation is the modern form of Ohm's law.

Georg Simon Ohm (16 March 1789 – 6 July 1854) was a German physicist and mathematician. As a school teacher, Ohm began his research with the new electrochemical cell, invented by Italian scientist Alessandro Volta. Using equipment of his own creation, Ohm found that there is a direct proportionality between the potential difference (voltage) applied across a conductor and the resultant electric current. This relationship is known as Ohm's law, and the ohm, the standard unit of electrical resistance, is named after him.

Ohm's law, that electric current is proportional to a potential difference, was first discovered by Henry Cavendish, but Cavendish did not publish his electrical discoveries in his lifetime and they did not become known until 1879, long after Ohm had independently made the discovery and published himself. Thus the law came to bear the name of Ohm.

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.

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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

$$R = E / I$$

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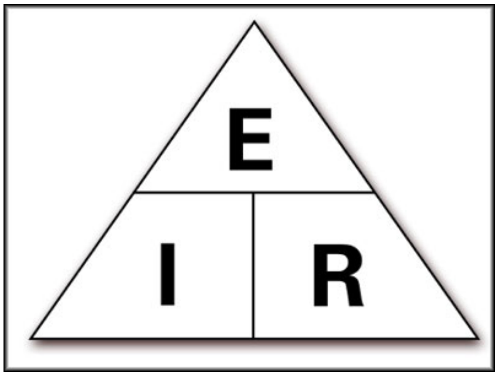
Ohm’s Law Triangle



Remember the Units:
- E is measured in **VOLTS**
- I is measured in **AMPS**
- R is measured in **OHMS**

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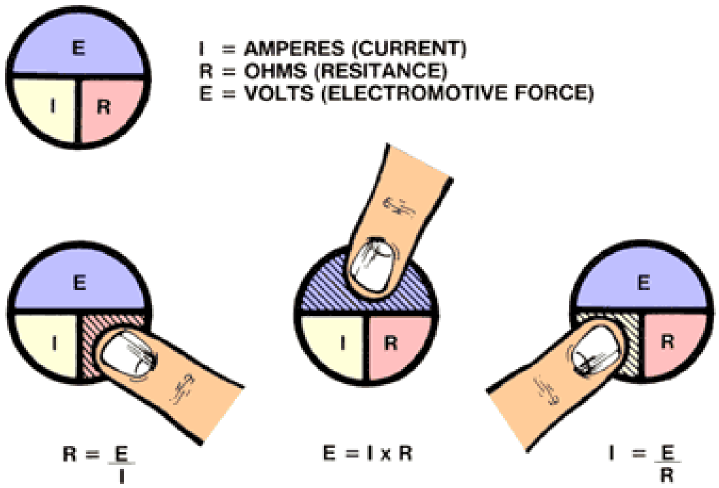
To help remember the formula it is possible to use a triangle with one side horizontal and the peak at the top like a pyramid. This is sometimes known as the Ohm's law triangle.

In the top corner of the Ohms law triangle is the letter E, in the left hand corner, the letter I, and in the right hand bottom corner, R.

To use the triangle cover up the unknown quantity and then and then calculate it from the other two. If they are in line they are multiplied, but if one is on top of the other then they should be divided. In other words if current has to be calculated the voltage is divided by the resistance i.e. E/R and so forth.

Ohm's Law Triangle

(Okay – Circle!)



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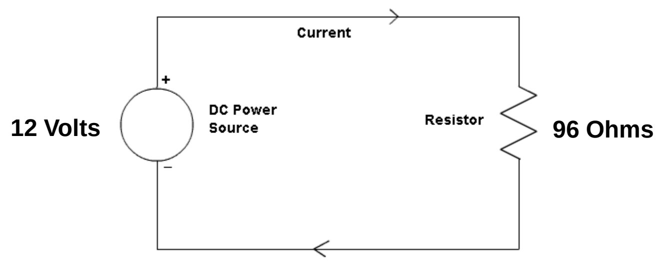
Ohm's Law Problem #1

What is the current?



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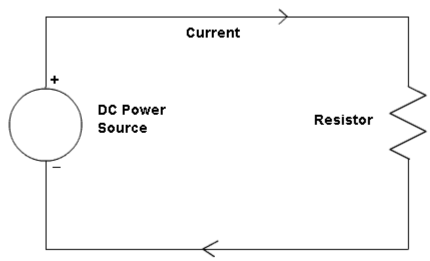
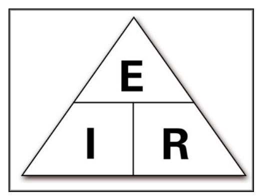
Ohm’s Law Problem #1

What is the current?



12 Volts **96 Ohms**

Consult the Ohms Law Triangle:



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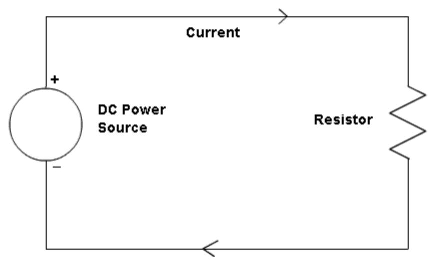
Ohm's Law Problem #1

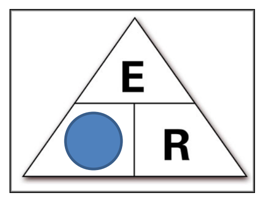
What is the current?

12 Volts



96 Ohms

Consult the Ohms Law Triangle:



I = E / R

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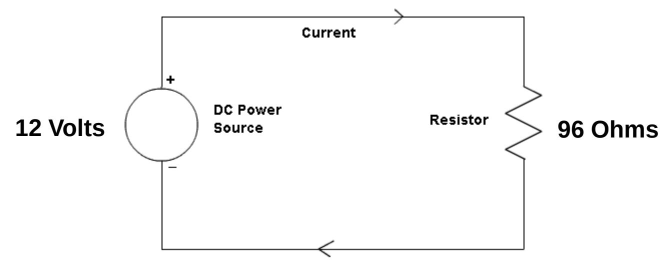
Ohm's Law Problem #1

What is the current?



I = E / R
I = 12 Volts / 96 Ohms
I =

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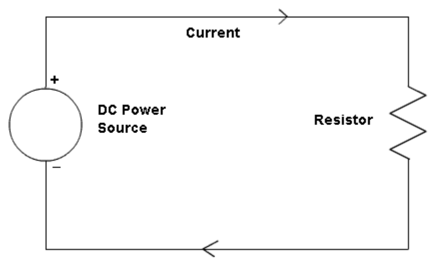
Ohm’s Law Problem #1

What is the current?



12 Volts **96 Ohms**

I = E / R
I = 12 Volts / 96 Ohms
I = 0.125 Amps

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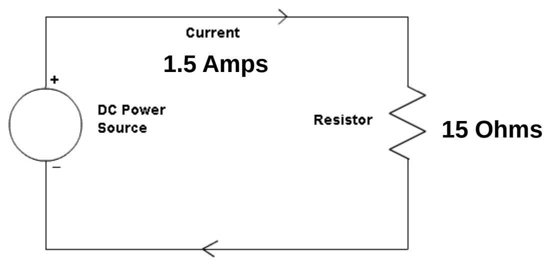
Ohm’s Law Problem #2

What is the voltage?



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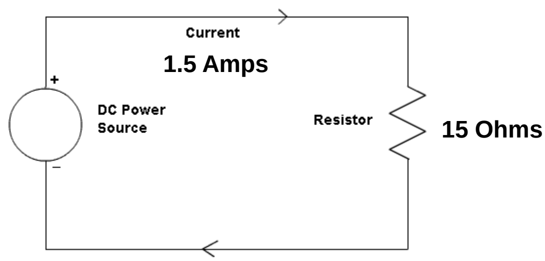
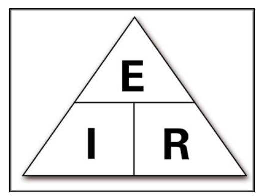
Ohm's Law Problem #2

What is the voltage?



Consult the Ohms Law Triangle:



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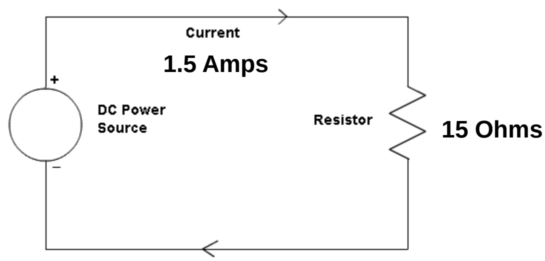
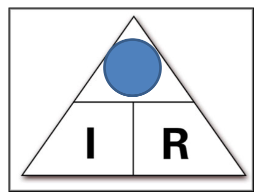
Ohm's Law Problem #2

What is the voltage?



Consult the Ohms Law Triangle:



E = I x R

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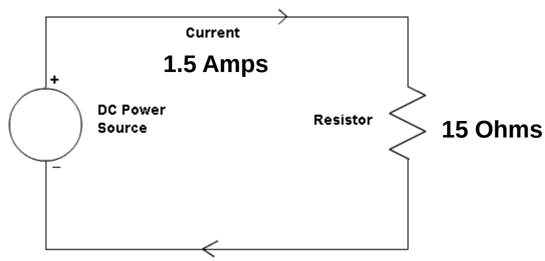
Ohm's Law Problem #2

What is the voltage?



E = I x R

= 1.5 Amps x 15 Ohms

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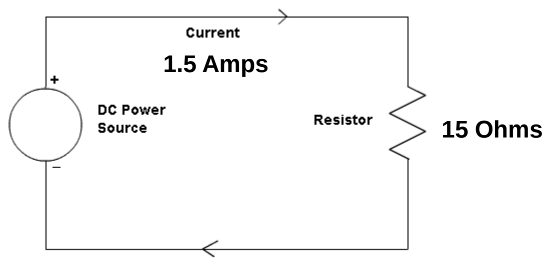
Ohm's Law Problem #2

What is the voltage?



E = I x R

= 1.5 Amps x 15 Ohms

= 22.5 Volts

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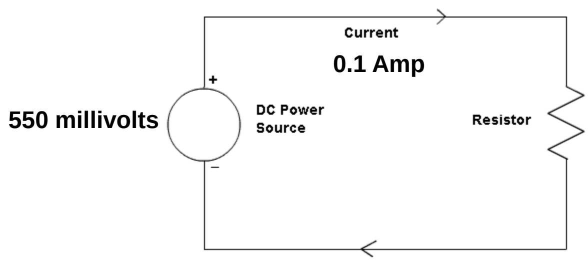
Ohm's Law Problem #3

What is the resistance?



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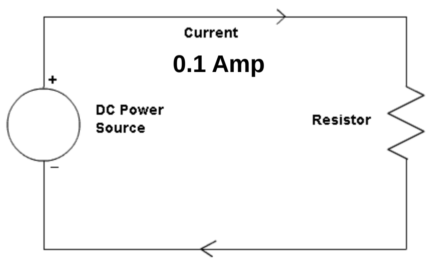
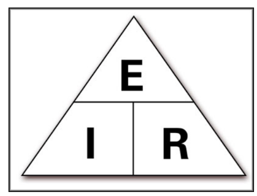
Ohm’s Law Problem #3

What is the resistance?

550 millivolts



Consult the Ohms Law Triangle:



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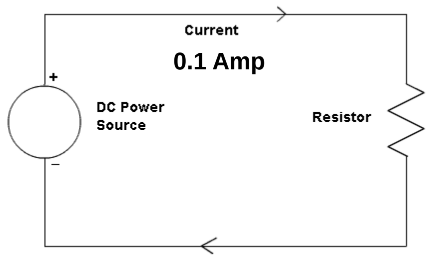
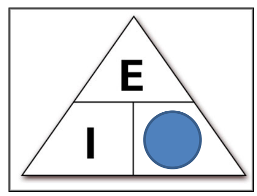
Ohm's Law Problem #3

What is the resistance?



Consult the Ohms Law Triangle:



R = E / I

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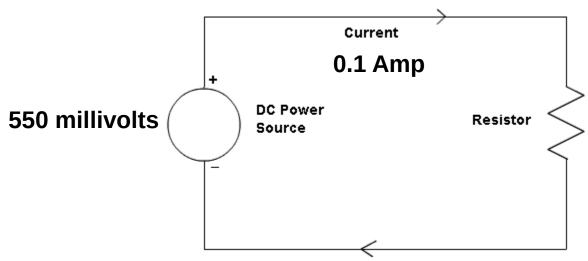
Ohm's Law Problem #3

What is the resistance?



R = E / I

= 550 millivolts / 0.1 Amp

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Ohm’s Law Problem #3

- **REMEMBER the UNITS!**
  - 550 **millivolts** = 550 / 1000 volts = 0.55 **volts**

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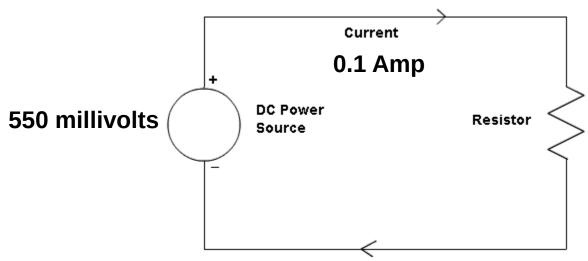
Ohm's Law Problem #3

What is the resistance?



R = E / I

= 550 millivolts / 0.1 Amp

= 0.55 Volts / 0.1 Amp

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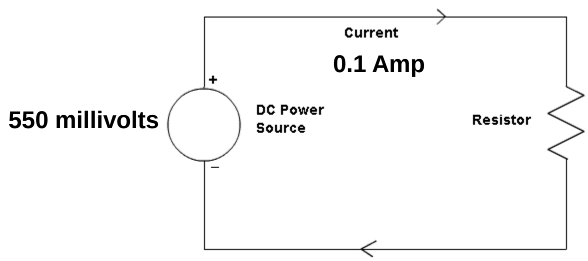
Ohm's Law Problem #3

What is the resistance?



R = E / I
= 550 millivolts / 0.1 Amp
= 0.55 Volts / 0.1 Amp
= 5.5 Ohms

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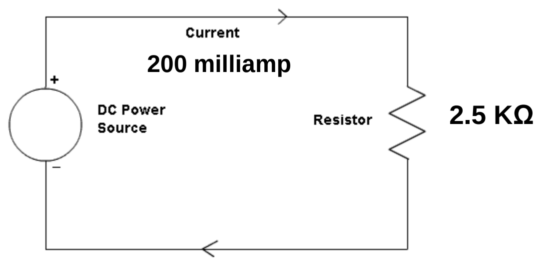
Ohm's Law Problem #4

What is the voltage?



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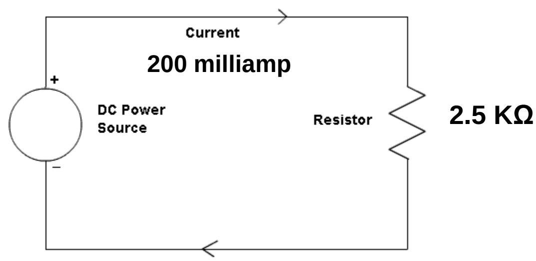
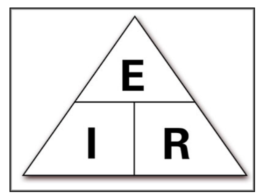
Ohm’s Law Problem #4

What is the voltage?



Consult the Ohms Law Triangle:



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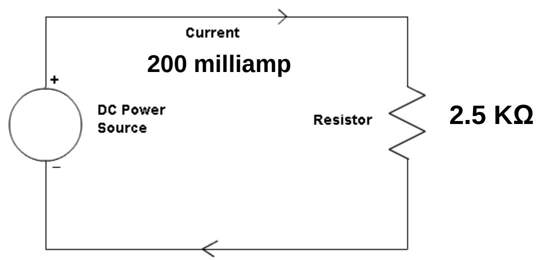
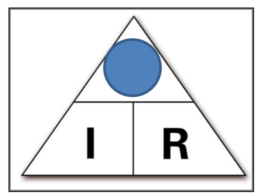
Ohm's Law Problem #4

What is the voltage?



Consult the Ohms Law Triangle:



E = I x R

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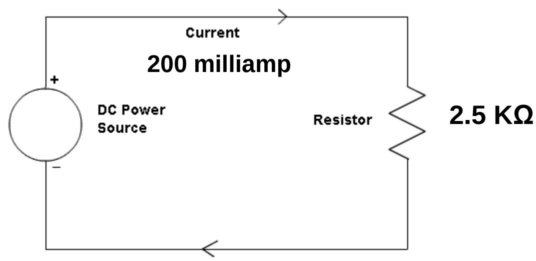
Ohm's Law Problem #4

What is the voltage?



E = I x R

= 200 milliamps x 2.5 Kilo Ohms

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Ohm’s Law Problem #3

- **REMEMBER the UNITS!**
  - 200 **milliamps** = 200 / 1000 Amps = 0.2 Amps
  - 2.5 **Kilo Ohms =** 2.5 x 1000 Ohms = 2500 Ohms

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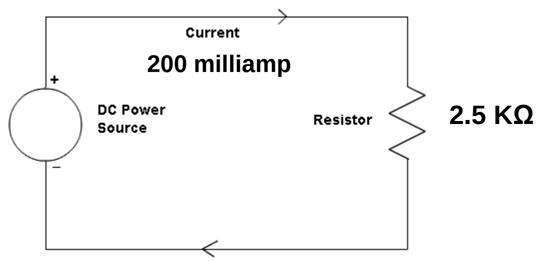
Ohm's Law Problem #4

What is the voltage?



E = I x R

= 200 milliamps x 2.5 Kilo Ohms

= 0.2 Amps x 2500 Ohms

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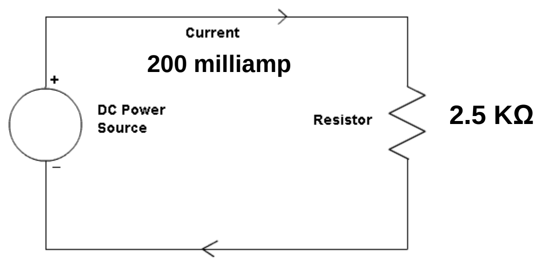
Ohm's Law Problem #4

What is the voltage?



E = I x R
= 200 milliamps x 2.5 Kilo Ohms
= 0.2 Amps x 2500 Ohms
= 500 Volts

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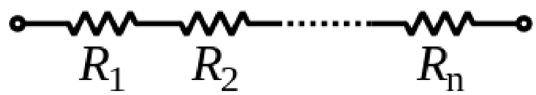
Resistors in Series

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



$$R_{Total} = R_1 + R_2 + R_3 + ... + R_N$$

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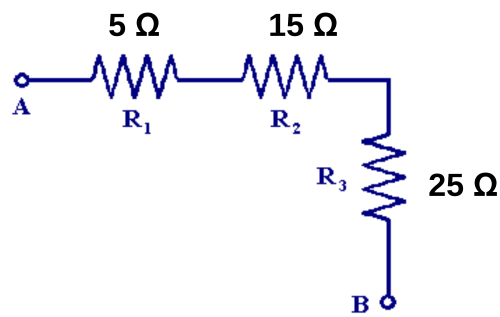
Resistors in Series



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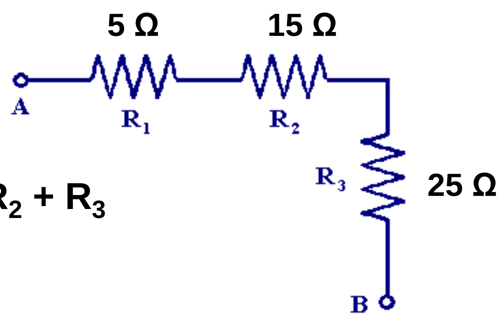
Resistors in Series



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

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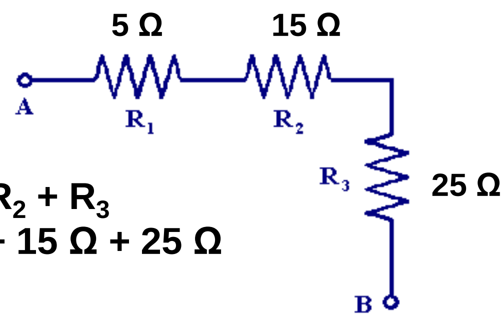
Resistors in Series



$R_{Total} = R_1 + R_2 + R_3$
$R_{Total} = 5\ \Omega + 15\ \Omega + 25\ \Omega$

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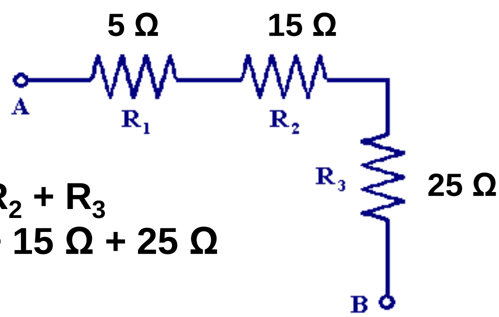
Resistors in Series



$R_{Total} = R_1 + R_2 + R_3$
$R_{Total} = 5\ \Omega + 15\ \Omega + 25\ \Omega$
$R_{Total} = 45\ \Omega$

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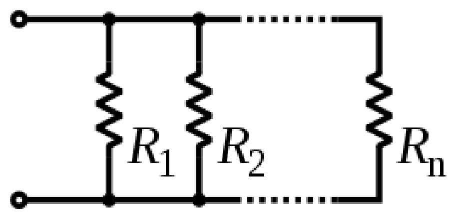
Resistors in Parallel

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

$1/R_{Total} = 1/R_1 + 1/R_2 + 1/R_3 + ... + 1/R_N$



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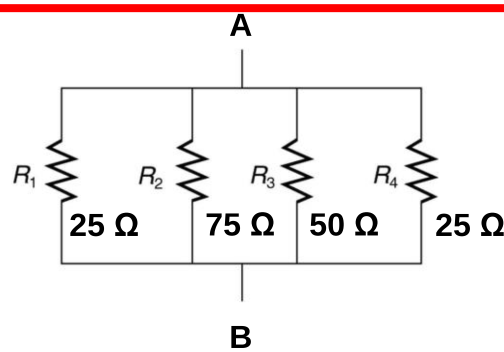
Resistors in Parallel



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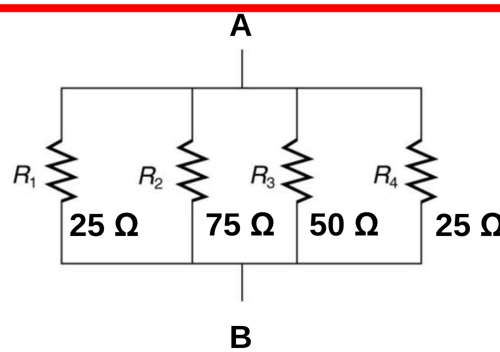
Resistors in Parallel



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

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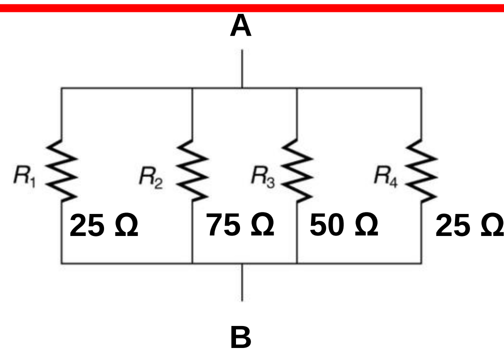
Resistors in Parallel



$1/R_{Total} = 1/R_1 + 1/R_2 + 1/R_3 + 1/R_4$
$1/R_{Total} = 1/25 + 1/75 + 1/50 + 1/25$

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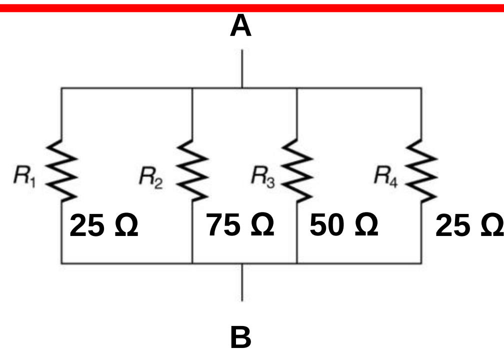
Resistors in Parallel



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

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

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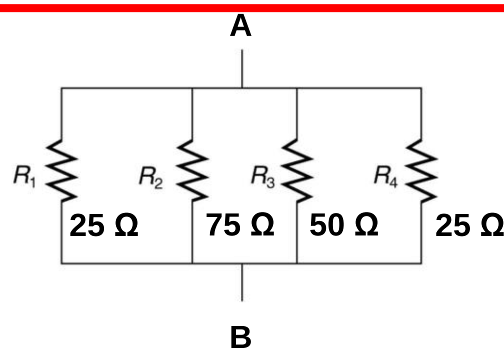
Resistors in Parallel



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

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

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

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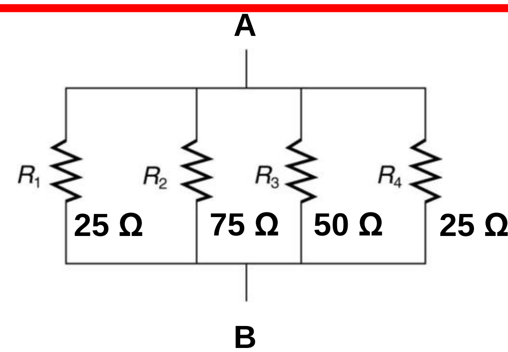
Resistors in Parallel



$1/R_{Total} = 1/R_1 + 1/R_2 + 1/R_3 + 1/R_4$
$1/R_{Total} = 1/25 + 1/75 + 1/50 + 1/25 = 6/150 + 2/150 + 3/150 + 6/150$
$1/R_{Total} = 17/150\ \Omega$

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

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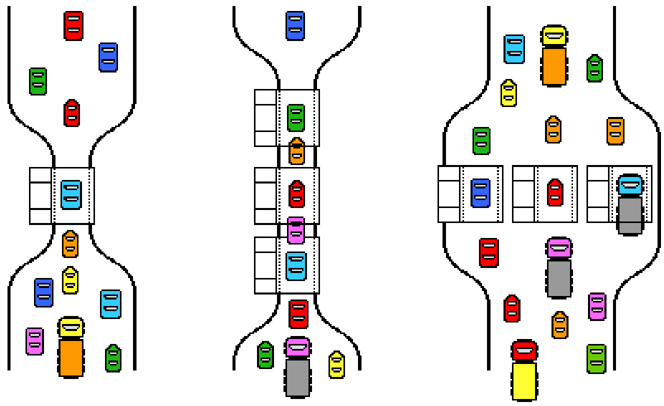
Influencing the Flow Rate on a Tollway



A Single Resistor

Three Resistors Placed in Series

Three Resistors Placed in Parallel

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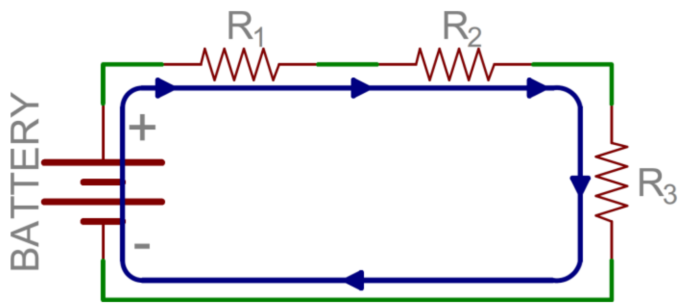
Current in a Series Circuit

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



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

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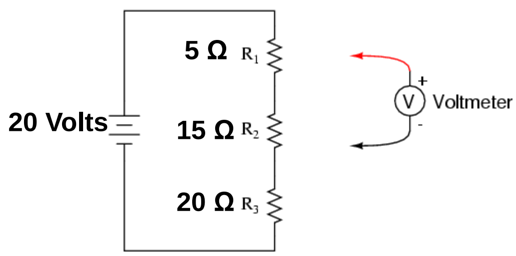
Voltage in Series Circuits

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



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

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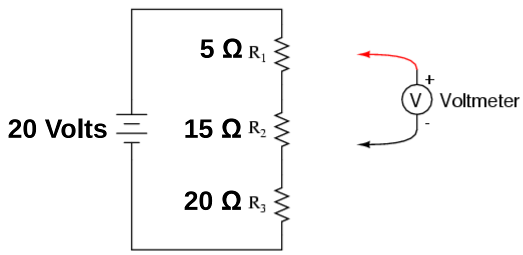
Voltage drop is the decrease of electrical potential along the path of a current flowing in an electrical circuit. Voltage drops in the internal resistance of the source, across conductors, across contacts, and across connectors are undesirable because some of the energy supplied is dissipated. The voltage drop across the electrical load is proportional to the power available to be converted in that load to some other useful form of energy.

Voltage drop is the loss of voltage caused by the flow of current flow through a resistance. The greater the resistance the greater the VD. To check the VD, use a voltmeter connected between the point where the VD is to be measured. In DC circuits and AC resistive circuits the total of all the voltage drops across series-connected loads should add up to the voltage applied to the circuit

To Calculate Voltage Drop…



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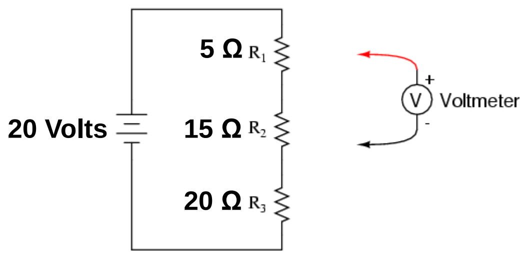
1. Determine Total Resistance



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

$R_{Total} =$

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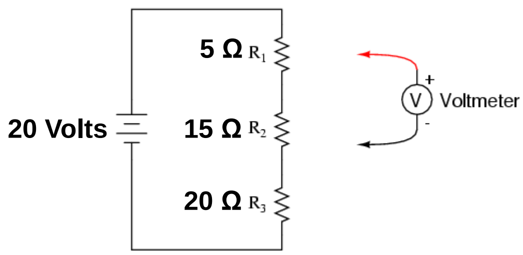
1. Determine Total Resistance



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

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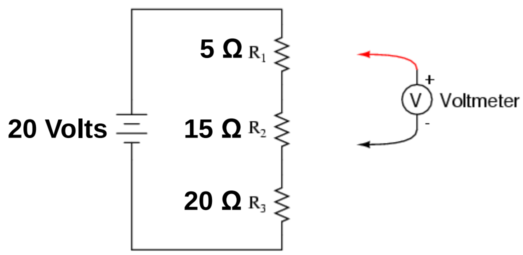
2. Determine Current



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

I = E / R
I =

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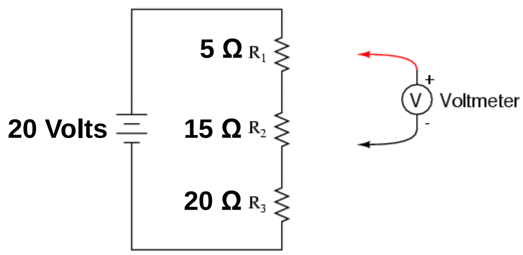
2. Determine Current



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

I = E / R
I = 20 Volts / 40 Ohms
I = 0.5 Amps

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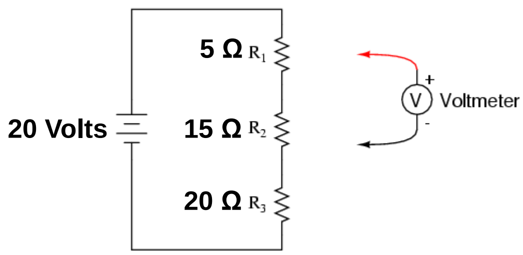
3. Determine Voltage Drops



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

I = E / R
I = 20 Volts / 40 Ohms
I = 0.5 Amps

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

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

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

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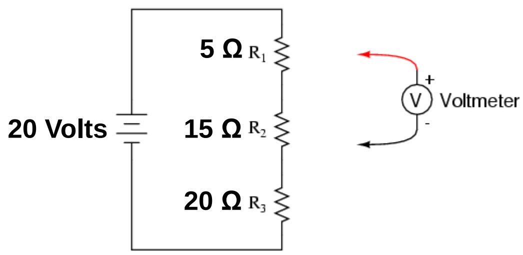
3. Determine Voltage Drops



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

$I = E / R$
$I = 20$ Volts / 40 Ohms
$I = 0.5$ Amps

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

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

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

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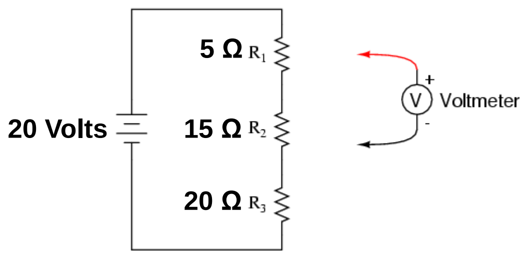
4. Check Your Results!



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

I = E / R
I = 20 Volts / 40 Ohms
I = 0.5 Amps

$E_{R1} = I \times R_1$
$E_{R1} = 0.5$ Amps x 5 Ω
$E_{R1} = 2.5$ Volts

$E_{R2} = I \times R_2$
$E_{R2} = 0.5$ Amps x 15 Ω
$E_{R2} = 7.5$ Volts

$E_{R3} = I \times R_3$
$E_{R3} = 0.5$ Amps x 20 Ω
$E_{R3} = 10$ Volts

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

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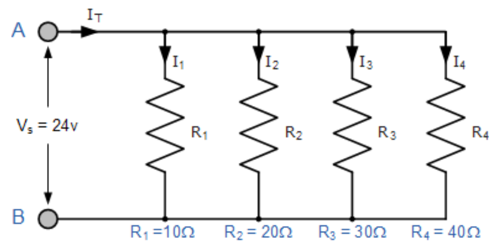
Voltage in Parallel Circuits

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



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

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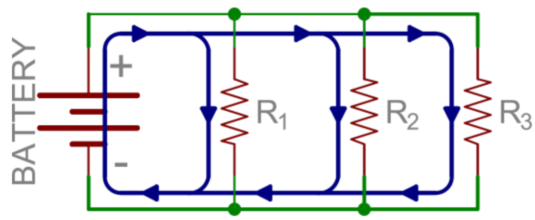
Current in a Parallel Circuit

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



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

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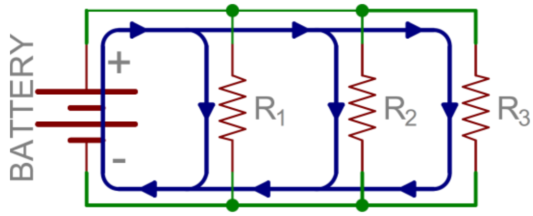
To Calculate Currents…



100 Volts 500 Ω 500 Ω 1KΩ

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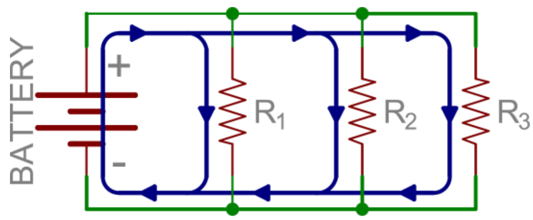
Determine Equivalent Resistance



100 Volts 500 Ω 500 Ω 1KΩ

$1/R_{Total}$ =

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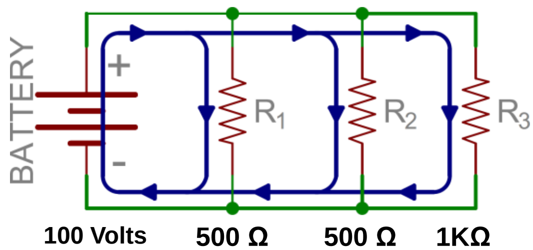
Determine Equivalent Resistance



$1/R_{Total} = 1/R_1 + 1/R_2 + 1/R_3$
$1/R_{Total} = 1/500 + 1/500 + 1/1K$

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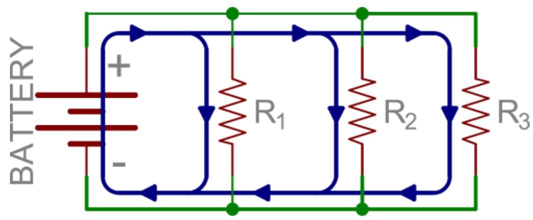
Determine Equivalent Resistance



100 Volts 500 Ω 500 Ω 1KΩ

$1/R_{Total} = 1/R_1 + 1/R_2 + 1/R_3$
$1/R_{Total} = 1/500 + 1/500 + 1/1K$
$1/R_{Total} = 2/1000 + 2/1000 + 1/1000$
$1/R_{Total} = 5/1000$

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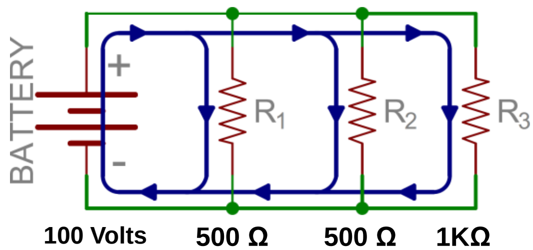
Determine Equivalent Resistance



$1/R_{Total} = 1/R_1 + 1/R_2 + 1/R_3$
$1/R_{Total} = 1/500 + 1/500 + 1/1K$
$1/R_{Total} = 2/1000 + 2/1000 + 1/1000$
$1/R_{Total} = 5/1000$

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

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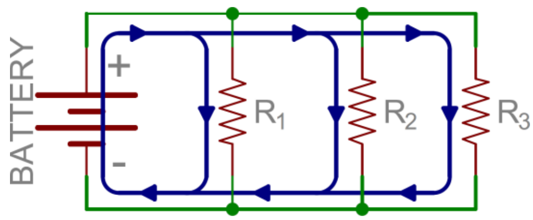
Determine Overall Current



100 Volts 500 Ω 500 Ω 1KΩ

$1/R_{Total} = 1/R_1 + 1/R_2 + 1/R_3$
$1/R_{Total} = 1/500 + 1/500 + 1/1K$
$1/R_{Total} = 2/1000 + 2/1000 + 1/1000$
$1/R_{Total} = 5/1000$

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

I =

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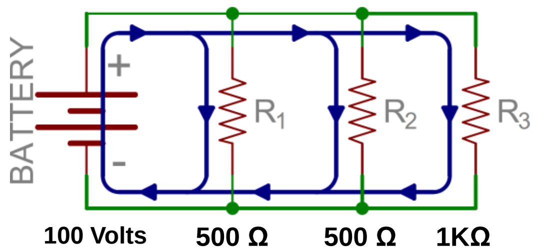
Determine Overall Current



$1/R_{Total} = 1/R_1 + 1/R_2 + 1/R_3$
$1/R_{Total} = 1/500 + 1/500 + 1/1K$
$1/R_{Total} = 2/1000 + 2/1000 + 1/1000$
$1/R_{Total} = 5/1000$

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

$I = E / R$

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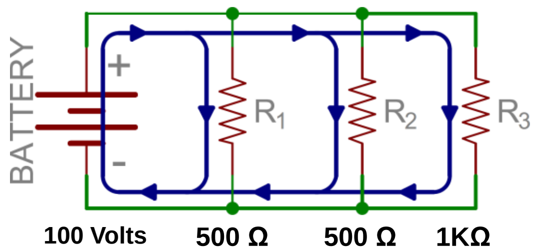
Determine Overall Current



$1/R_{Total} = 1/R_1 + 1/R_2 + 1/R_3$
$1/R_{Total} = 1/500 + 1/500 + 1/1K$
$1/R_{Total} = 2/1000 + 2/1000 + 1/1000$
$1/R_{Total} = 5/1000$

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

I = E / R
I = 100 V / 200 Ω
I = 0.5 Amps

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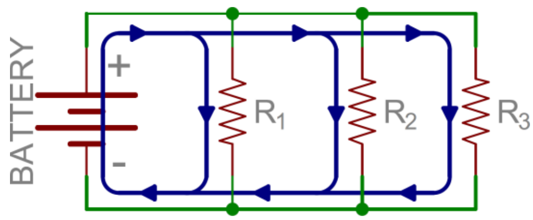
Determine Individual Currents



100 Volts 500 Ω 500 Ω 1KΩ

$1/R_{Total} = 1/R_1 + 1/R_2 + 1/R_3$
$1/R_{Total} = 1/500 + 1/500 + 1/1K$
$1/R_{Total} = 2/1000 + 2/1000 + 1/1000$
$1/R_{Total} = 5/1000$

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

$I = E / R$
$I = 100\ V / 200\ \Omega$
$I = 0.5$ Amps

$I_{R1} =$ $I_{R2} =$ $I_{R3} =$

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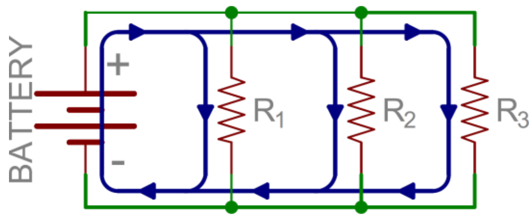
Determine Individual Currents



100 Volts 500 Ω 500 Ω 1KΩ

$1/R_{Total} = 1/R_1 + 1/R_2 + 1/R_3$
$1/R_{Total} = 1/500 + 1/500 + 1/1K$
$1/R_{Total} = 2/1000 + 2/1000 + 1/1000$
$1/R_{Total} = 5/1000$

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

$I = E / R$
$I = 100\ V / 200\ \Omega$
$I = 0.5$ Amps

$I_{R1} = E / R_1$ $I_{R2} = E / R_2$ $I_{R3} = E / R_3$

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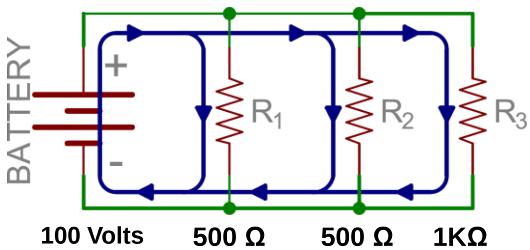
Determine Individual Currents



$1/R_{Total} = 1/R_1 + 1/R_2 + 1/R_3$
$1/R_{Total} = 1/500 + 1/500 + 1/1K$
$1/R_{Total} = 2/1000 + 2/1000 + 1/1000$
$1/R_{Total} = 5/1000$

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

$I = E / R$
$I = 100\ V / 200\ \Omega$
$I = 0.5$ Amps

$I_{R1} = E / R_1$
$I_{R1} = 100\ V / 500\ \Omega$
$I_{R1} =$

$I_{R2} = E / R_2$
$I_{R2} = 100\ V / 500\ \Omega$
$I_{R2} =$

$I_{R3} = E / R_3$
$I_{R3} = 100\ V / 1000\ \Omega$
$I_{R3} =$

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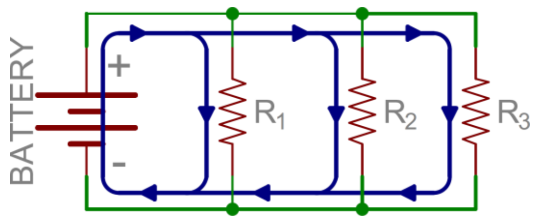
Determine Individual Currents



$1/R_{Total} = 1/R_1 + 1/R_2 + 1/R_3$
$1/R_{Total} = 1/500 + 1/500 + 1/1K$
$1/R_{Total} = 2/1000 + 2/1000 + 1/1000$
$1/R_{Total} = 5/1000$

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

I = E / R
I = 100 V / 200 Ω
I = 0.5 Amps

$I_{R1} = E / R_1$
$I_{R1} = 100\ V / 500\ \Omega$
$I_{R1} = 0.2$ Amps

$I_{R2} = E / R_2$
$I_{R2} = 100\ V / 500\ \Omega$
$I_{R2} = 0.2$ Amps

$I_{R3} = E / R_3$
$I_{R3} = 100\ V / 1000\ \Omega$
$I_{R3} = 0.1$ Amps

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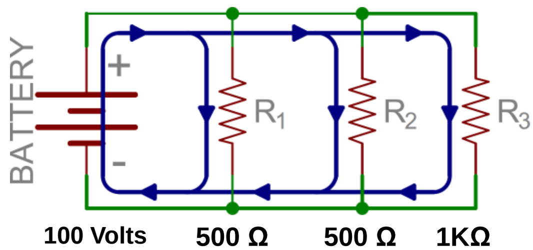
Check your Answer!



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

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

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

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

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

$I = E / R$

$I = 100\ V / 200\ \Omega$

$I = 0.5$ Amps

$I_{R1} = E / R_1$

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

$I_{R1} = 0.2$ Amps

$I_{R2} = E / R_2$

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

$I_{R2} = 0.2$ Amps

$I_{R3} = E / R_3$

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

$I_{R3} = 0.1$ Amps

$I_{Total} =$

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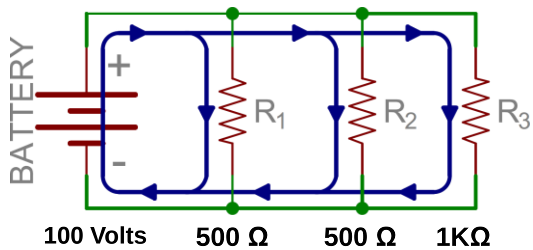
Check your Answer!



$1/R_{Total} = 1/R_1 + 1/R_2 + 1/R_3$
$1/R_{Total} = 1/500 + 1/500 + 1/1K$
$1/R_{Total} = 2/1000 + 2/1000 + 1/1000$
$1/R_{Total} = 5/1000$

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

$I = E / R$
$I = 100\ V / 200\ \Omega$
$I = 0.5$ Amps

$I_{R1} = E / R_1$
$I_{R1} = 100\ V / 500\ \Omega$
$I_{R1} = 0.2$ Amps

$I_{R2} = E / R_2$
$I_{R2} = 100\ V / 500\ \Omega$
$I_{R2} = 0.2$ Amps

$I_{R3} = E / R_3$
$I_{R3} = 100\ V / 1000\ \Omega$
$I_{R3} = 0.1$ Amps

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

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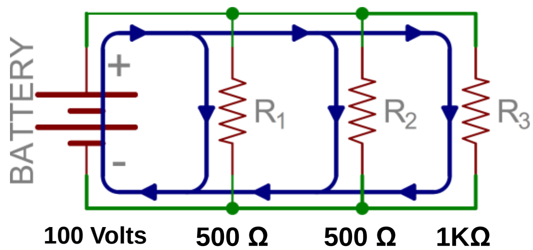
Check your Answer!



$1/R_{Total} = 1/R_1 + 1/R_2 + 1/R_3$
$1/R_{Total} = 1/500 + 1/500 + 1/1K$
$1/R_{Total} = 2/1000 + 2/1000 + 1/1000$
$1/R_{Total} = 5/1000$

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

$I = E / R$
$I = 100\ V / 200\ \Omega$
$I = 0.5$ Amps

$I_{R1} = E / R_1$
$I_{R1} = 100\ V / 500\ \Omega$
$I_{R1} = 0.2$ Amps

$I_{R2} = E / R_2$
$I_{R2} = 100\ V / 500\ \Omega$
$I_{R2} = 0.2$ Amps

$I_{R3} = E / R_3$
$I_{R3} = 100\ V / 1000\ \Omega$
$I_{R3} = 0.1$ Amps

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

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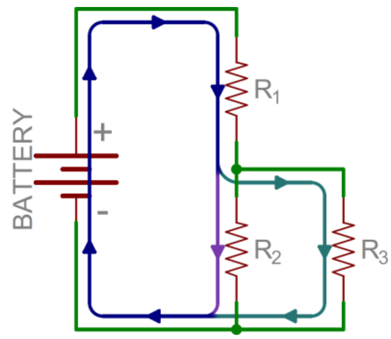
Series Parallel Combinations



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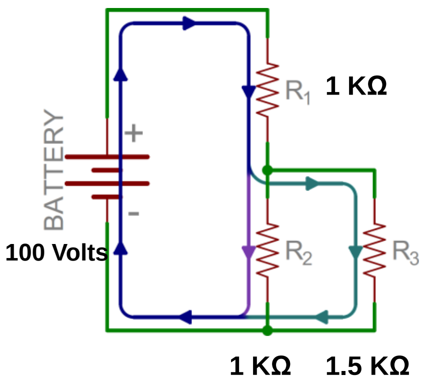
Series Parallel Combinations



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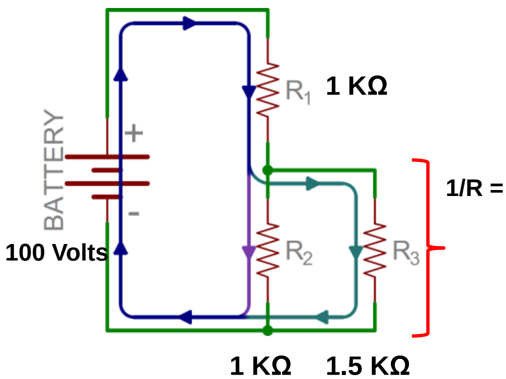
Series Parallel Combinations



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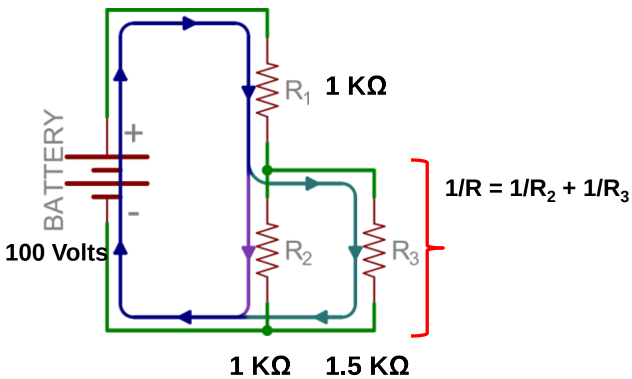
Series Parallel Combinations



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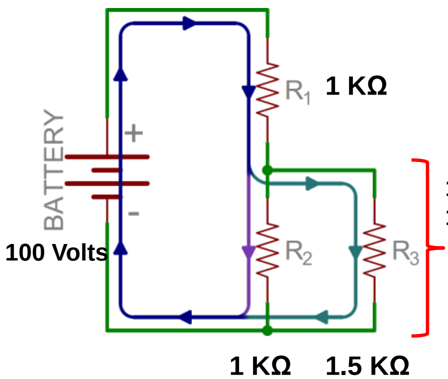
Series Parallel Combinations



$1/R = 1/R_2 + 1/R_3$
$1/R = 1/1\ K + 1/1.5\ K$

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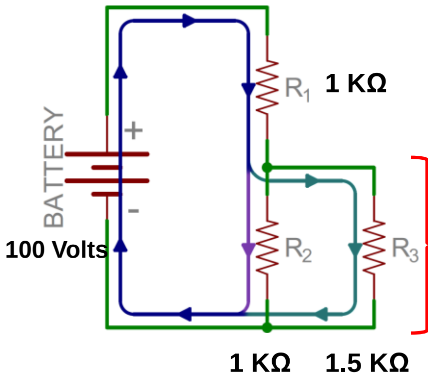
Series Parallel Combinations



$1/R = 1/R_2 + 1/R_3$
$1/R = 1/1\ K + 1/1.5\ K$
$1/R = 3/3\ K + 2/3\ K$
$1/R = 5/3\ K$

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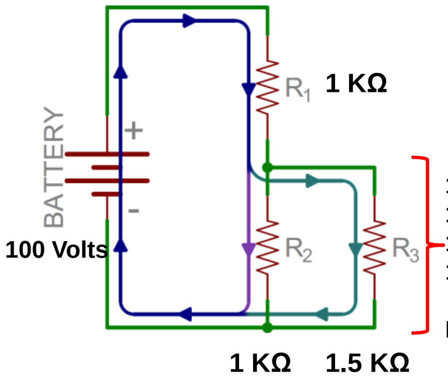
Series Parallel Combinations



$1/R = 1/R_2 + 1/R_3$
$1/R = 1/1\ K + 1/1.5\ K$
$1/R = 3/3\ K + 2/3\ K$
$1/R = 5/3\ K$

$R = 3000/5 = 600\ \Omega$

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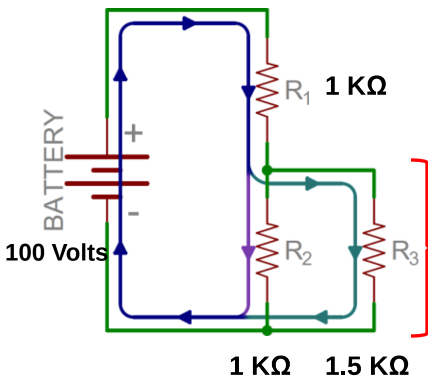
Series Parallel Combinations



$1/R = 1/R_2 + 1/R_3$
$1/R = 1/1\ K + 1/1.5\ K$
$1/R = 3/3\ K + 2/3\ K$
$1/R = 5/3\ K$

$R = 3000/5 = 600\ \Omega$

$R_{Total} =$

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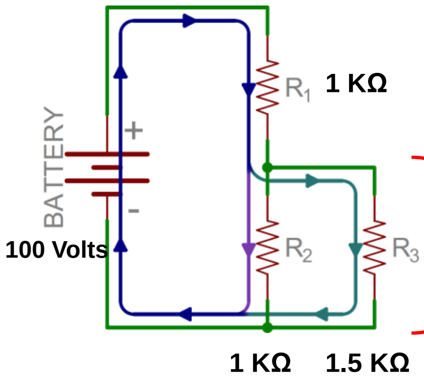
Series Parallel Combinations



$1/R = 1/R_2 + 1/R_3$

$1/R = 1/1\ K + 1/1.5\ K$

$1/R = 3/3\ K + 2/3\ K$

$1/R = 5/3\ K$

$R = 3000/5 = 600\ \Omega$

$R_{Total} = 1\ K\Omega + 600\ \Omega$

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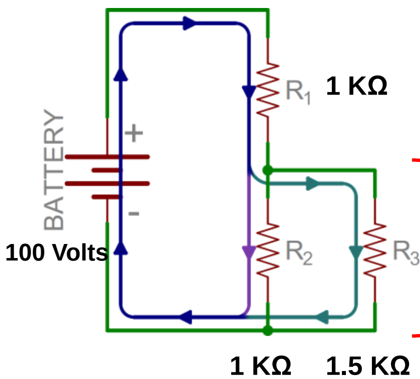
Series Parallel Combinations



$1/R = 1/R_2 + 1/R_3$
$1/R = 1/1\ K + 1/1.5\ K$
$1/R = 3/3\ K + 2/3\ K$
$1/R = 5/3\ K$

$R = 3000/5 = 600\ \Omega$

$R_{Total} = 1\ K\Omega + 600\ \Omega$
$R_{Total} = 1600\ \Omega$

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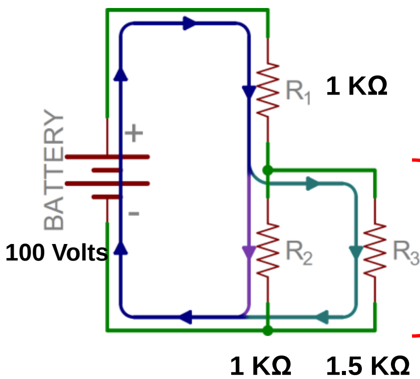
Series Parallel Combinations



$1/R = 1/R_2 + 1/R_3$

$1/R = 1/1\ K + 1/1.5\ K$

$1/R = 3/3\ K + 2/3\ K$

$1/R = 5/3\ K$

$R = 3000/5 = 600\ \Omega$

$R_{Total} = 1\ K\Omega + 600\ \Omega$

$R_{Total} = 1600\ \Omega$

$R_{Total} = 1.6\ K\Omega$

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Energy and Power

- Energy is the ability to do work.
- Some common types include **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**.

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An important aspect of any electrical or electronic circuit is the power associated with it. It is found that when a current flows through a resistor, electrical energy is converted into heat. This fact is used by electrical heaters which consist of a resistor through which current flows. Light bulbs use the same principle, heating the element up so that it glows white hot and produces light. At other times much smaller resistors and very much smaller currents are used. Here the amount of heat generated may be very small. However if some current flows then some heat is generated. In this instance the heat generated represents the amount of electrical power being dissipated.

Definition of power

Whether power is used in a mechanical environment or an electrical environment, the definition of power is still the same. The way in which it may be discussed may be slightly different, but nevertheless the definition and actuality of it is exactly the same.

Electric power definition:

Electric power is the rate, per unit time, at which electrical energy is transferred by an electric circuit. It is the rate of doing work.

In physics, **energy** is the quantitative property that must be transferred to an object in order to perform work on, or to heat, the object. Energy is a conserved quantity; the law of conservation of energy states that energy can be converted in form, but not created or destroyed. The SI unit of energy is the joule, which is the energy transferred to an object by the work of moving it a distance of 1 metre against a force of 1 newton.

Common forms of energy include the kinetic energy of a moving object, the potential energy stored by an object's position in a force field (gravitational, electric or magnetic), the elastic energy stored by stretching solid objects, the chemical energy released when a fuel burns, the radiant energy carried by light, and the thermal energy due to an object's temperature.

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.

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

(Mnemonic PIE)

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Definition of the watt:

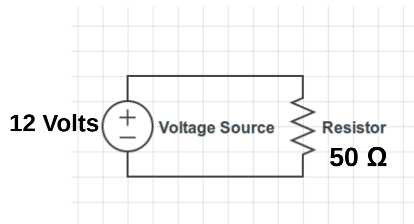
The watt is the SI unit of power defining the rate of energy conversion and it is equivalent to one joule per second.

The watt can be defined according to the application:

•***Electrical definition of the watt:*** one watt is the rate at which work is done when a current of one ampere, I of current flows through a network which has an electrical potential difference of one volt, V. W = V I

The **joule** (symbol: **J**) is a derived unit of energy in the International System of Units. It is equal to the energy transferred to (or work done on) an object when a force of one newton acts on that object in the direction of the force's motion through a distance of one metre (1 newton metre or N·m). It is also the energy dissipated as heat when an electric current of one ampere passes through a resistance of one ohm for one second. It is named after the English physicist James Prescott Joule (1818–1889)

Calculating Power #1



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

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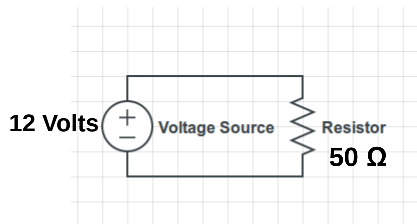
Calculating Power #1



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

$P = E^2 / R$

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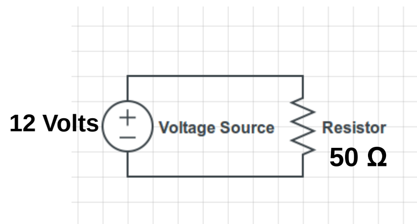
Calculating Power #1



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

$P = E^2 / R$

$P = 12^2 / 50$

$P = 144 / 50$

$P = 2.88$ Watts

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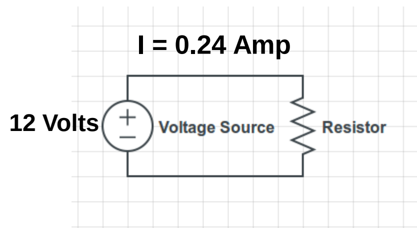
Calculating Power #2



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

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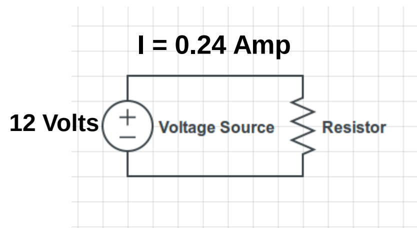
Calculating Power #2



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

$P = E \times I$

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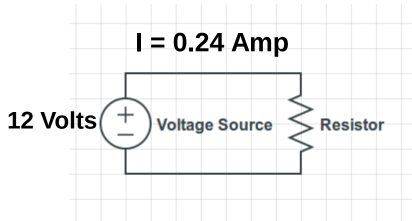
Calculating Power #2



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

$P = E \times I$

$P = 12 \times 0.24$

P = 2.88 Watts

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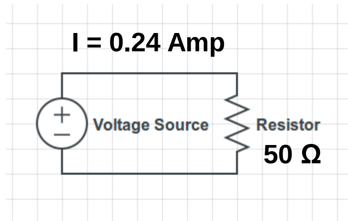
Calculating Power #3



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

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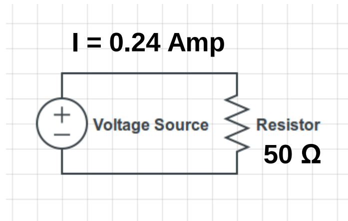
Calculating Power #3



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

$P = I^2 \times R$

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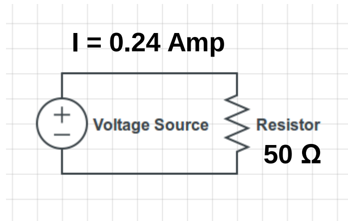
Calculating Power #3



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

$P = I^2 \times R$

$P = 0.24^2 \times 50$

$P = 0.0576 \times 50$

$P = 2.88$ Watts

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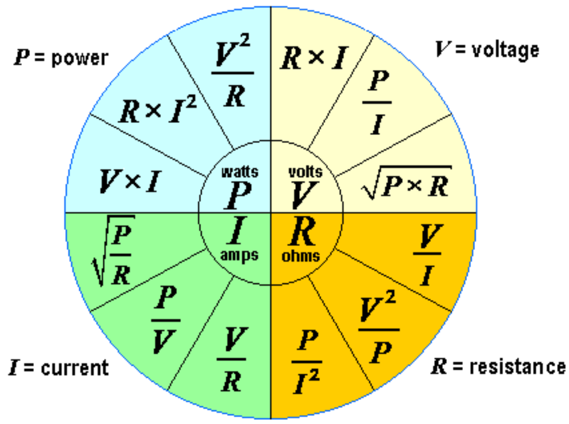
Circuit Calculator



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

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Power and Resistors

- Resistors rated not just by resistance, but also **amount of heat (power)** they can **safely dissipate.**
- Measured in **Watts**.
- In general, bigger resistors can dissipate more heat than smaller resistors.
- Use 50% to 100% safety margin in selecting components.

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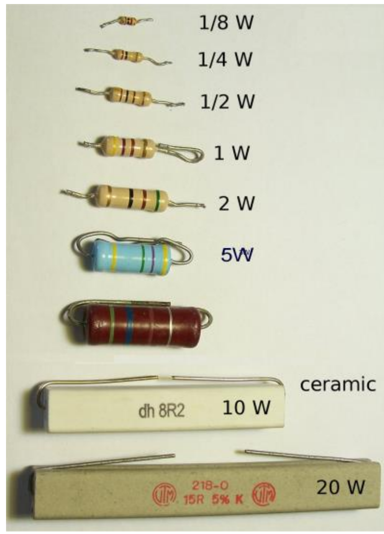
Power and Resistors



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Power Ratings in Circuits

- **Series Circuits**
  - Same current through all resistors.
  - Calculate power dissipated by each separately (**Power = I^2 x R**).
  - Lowest wattage component sets max rating of the overall circuit.

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Power Ratings in Circuits

- **Parallel Circuits**
  - Same voltage applied to all resistors.
  - Calculate power dissipated by each separately **(Power = E^2 / R).**
  - Do not exceed current and power ratings of any resistor in the group.
  - For greater heat dissipation, replace a single resistor with two resistors of twice the resistance (assuming same wattage).

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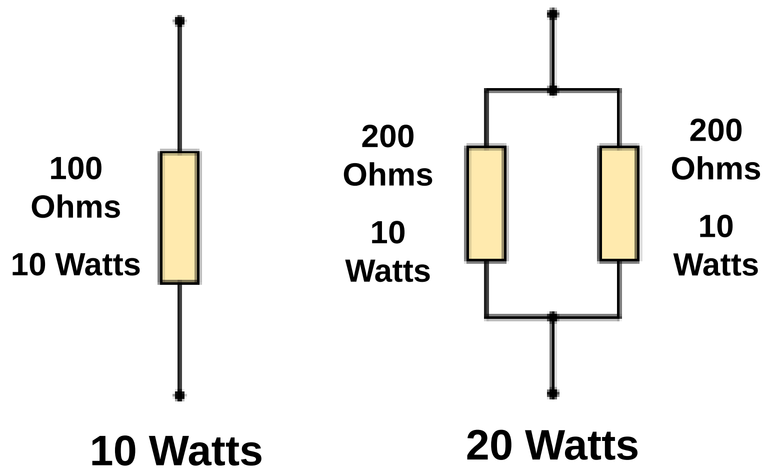
Heat – Parallel Resistors



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Questions?

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Review Question 1

If you have light bulbs marked 40 watts, 60 watts and 100 watts, which one will use electrical energy the fastest?

- The 40 watt bulb
- The 60 watt bulb
- The 100 watt bulb
- They will all be the same

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Review Question 1

If you have light bulbs marked 40 watts, 60 watts and 100 watts, which one will use electrical energy the fastest?

- The 40 watt bulb
- The 60 watt bulb
- The 100 watt bulb
- They will all be the same

< The 100 watt bulb >

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Review Question 2

Which electrical circuit will have no current?

- A short circuit
- A complete circuit
- A closed circuit
- An open circuit

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Review Question 2

Which electrical circuit will have no current?

- A short circuit
- A complete circuit
- A closed circuit
- An open circuit

< An open circuit >

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Review Question 3

Which two electrical units multiplied together give the unit "watts"?

- Amperes and henrys
- Volts and amperes
- Volts and farads
- Farads and henrys

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Review Question 3

Which two electrical units multiplied together give the unit "watts"?

- Amperes and henrys
- Volts and amperes
- Volts and farads
- Farads and henrys

< Volts and amperes >

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Review Question 4

How is the resistance in a DC circuit calculated when the voltage and current are known?

- Resistance equals current multiplied by voltage
- Resistance equals voltage divided by current
- Resistance equals power divided by voltage
- Resistance equals current divided by voltage

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Review Question 4

How is the resistance in a DC circuit calculated when the voltage and current are known?

- Resistance equals current multiplied by voltage
- Resistance equals voltage divided by current
- Resistance equals power divided by voltage
- Resistance equals current divided by voltage

< Resistance equals voltage divided by current >

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Review Question 5

The voltage required to force a current of 4.4 amperes through a resistance of 50 ohms is:

- 220 volts
- 2220 volts
- 22.0 volts
- 0.220 volt

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Review Question 5

The voltage required to force a current of 4.4 amperes through a resistance of 50 ohms is:

- 220 volts
- 2220 volts
- 22.0 volts
- 0.220 volt

< 220 volts >

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Review Question 6

What voltage would be needed to supply a current of 200 milliamperes, to operate an electric lamp which has a resistance of 25 ohms?

- 5 volts
- 8 volts
- 175 volts
- 225 volts

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Review Question 6

What voltage would be needed to supply a current of 200 milliamperes, to operate an electric lamp which has a resistance of 25 ohms?

- 5 volts
- 8 volts
- 175 volts
- 225 volts

< 5 volts >

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Review Question 7

Total resistance in a parallel circuit:

- is always less than the smallest resistance
- depends upon the voltage drop across each branch
- could be equal to the resistance of one branch
- depends upon the applied voltage

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Review Question 7

Total resistance in a parallel circuit:

• is always less than the smallest resistance

• depends upon the voltage drop across each branch

• could be equal to the resistance of one branch

• depends upon the applied voltage

< is always less than the smallest resistance >

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Review Question 8

One advantage of replacing a 50 ohm resistor with a parallel combination of two similarly rated 100 ohm resistors is that the parallel combination will have:

- lesser resistance and similar power rating
- the same resistance but greater power rating
- the same resistance but lesser power rating
- greater resistance and similar power rating

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Review Question 8

One advantage of replacing a 50 ohm resistor with a parallel combination of two similarly rated 100 ohm resistors is that the parallel combination will have:

- lesser resistance and similar power rating
- the same resistance but greater power rating
- the same resistance but lesser power rating
- greater resistance and similar power rating

< the same resistance but greater power rating >

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For Next Class:

- Review Chapter 3 of Basic Study Guide;
- Read Chapter 4 of Basic Study Guide; and
- Read RBR-4:
  - https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf10650.html

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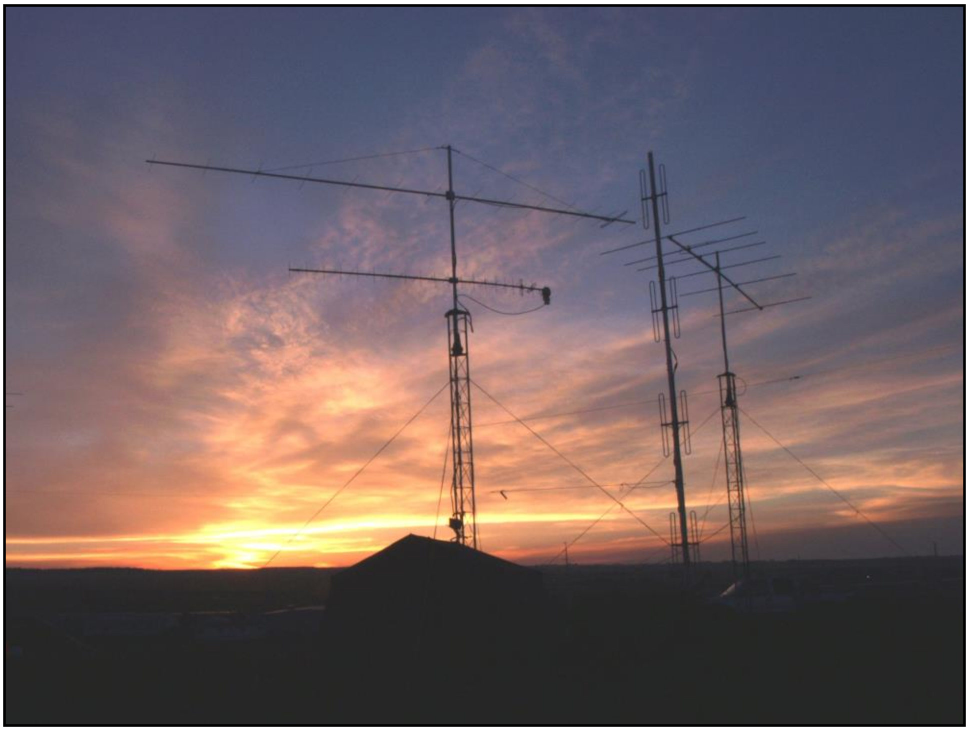
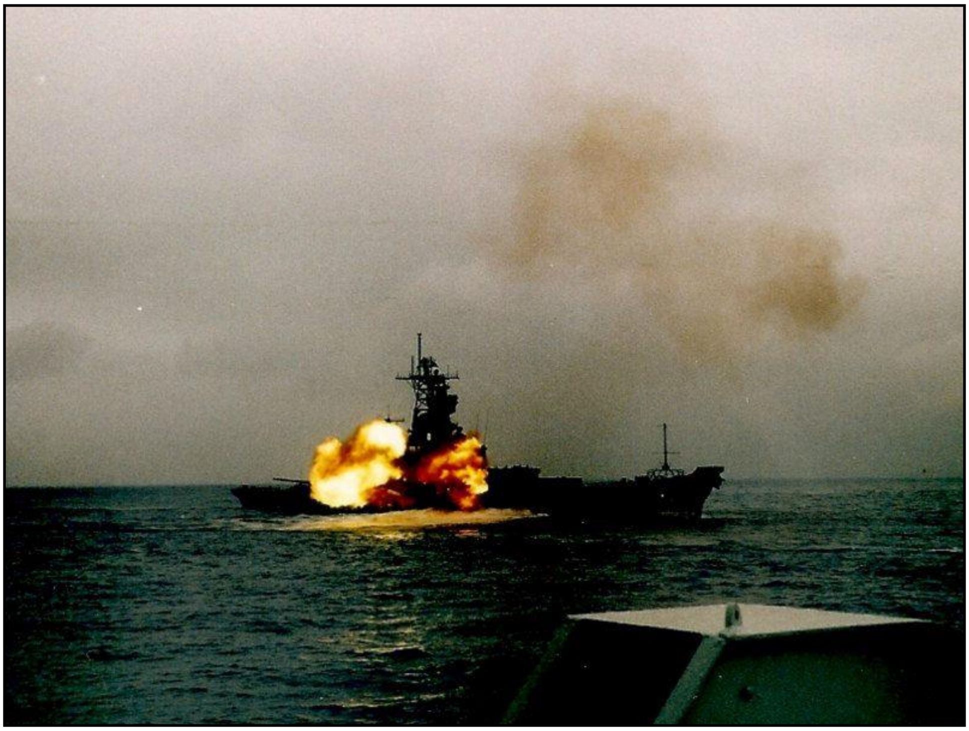



Rick
ARROWHEAD

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