DC Electricity Basics

Trailer Circuits STEM Kit Curriculum

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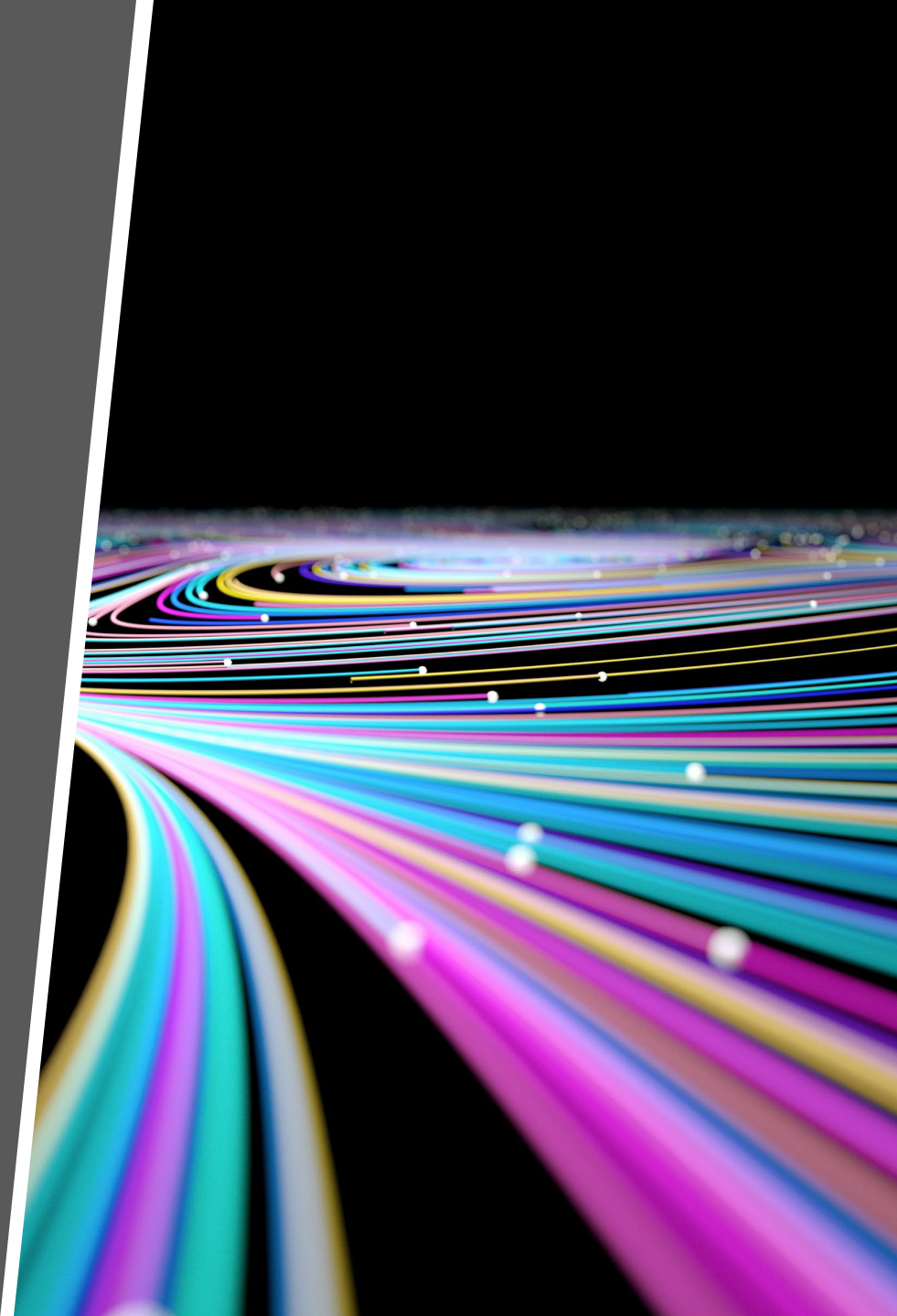

Workplace Safety: OSHA

- The Occupational Safety and Health Administration (OSHA) is charged with assuring safe and healthy working conditions for employees by setting and enforcing standards as well as providing training, outreach, education, and assistance
- Since its creation in 1970, worker deaths have fallen from 38 per day in 1970 to 13 per day in 2014
- There is still nearly one electrical-related worker fatality every day
- Common causes of electrical-related fatalities are:
  - Contact with power lines
  - Lack of ground-fault protection
  - Path to ground missing
  - Equipment not used in prescribed manner
  - Improper use of extension cords

Source: OSHA (https://www.osha.gov/oshstats/commonstats.html)

Electricity Is Dangerous

- Electricity can kill!
  - Current kills
  - Not voltage… but voltage leads to current
- Low voltages (like AA batteries) are unlikely to produce enough current to cause harm
- Injuries can include:
  - **Burns:** From arcs and heat generated by current flow
  - **Internal Injuries:** From electricity flowing through internal organs, such as the heart
  - **Involuntary Muscle Contractions:** Muscles operate on tiny electrical currents; large currents can cause extreme body movements than can damage muscles, tendons, ligaments, and even bones
  - **Falls:** Muscle contractions and loss of consciousness can cause falls, particularly when the victim is on a ladder

Current	Effect
0.5-3 mA	Tingling sensations
3-10 mA	Painful muscle contractions
10-40 mA	“Cannot let go” phenomena
30-75 mA	Respiratory paralysis (possibly fatal)
100-200 mA	Ventricular fibrillation (likely fatal)
200-500 mA	Heart clamps tight
1.5 A	Tissues and organs start to burn

Trailer Circuits STEM Kit: Why Its Safe

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- Engineers have designed this kit to *behave* just like the 12VDC system you would find in a car or truck
- This kit will measure, light up, and show all the same values that you would see if you were working on an actual vehicle
- But… its powered by 4 AA batteries and controlled by a complex circuit board that electrical engineers designed to keep you safe
- If you have ever watched someone incorrectly try to “jump” a dead car’s battery… you probably saw a lot of sparks and maybe even heard some painful yelling.

  …That WILL NOT happen with this Kit.

We encourage you to learn, experiment, test, connect, and figure it out <u>safely</u> here, so you are ready to <u>safely</u> work on a real car in the future.

Rule 1: Electrical Safety

- ***Never*** **work on a live circuit**
- Before doing any work, turn off the power at the source
  - In a house, this means flipping the circuit breaker off
  - In a car, this means ensuring it is completely turned off
  - **With the Trailer Circuits STEM Kit, this means turning the switch on the bottom to "off"**

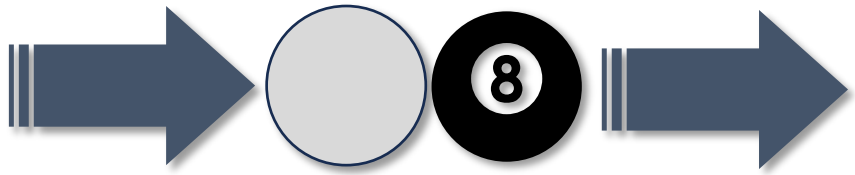
What Is Electricity?

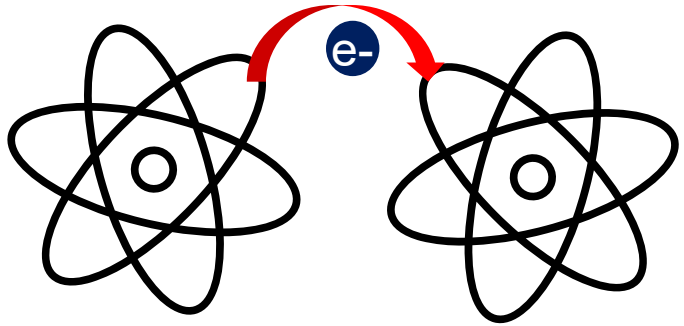
Electricity Is…

- **One of the 4 fundamental forces of the universe:**
  - Gravitational force
  - Weak nuclear force
  - Strong nuclear force
  - **Electromagnetic force**
- **Electromagnetism has 2 parts**:
  - Electrical force
  - Magnetic force
  - Both forces can be measured, drawn, and used, either separately or together

Electricity Is…

- **Energy transfer!**
- Just as a cue ball's energy is transferred into another ball when they collide…
- **Electrons** impart energy when they move from one atom to the next
- **This movement of electrons is electricity**





Electricity

- We have been studying electricity since the 1700s… and we are still learning about it today
- As you learn, you will see history's role in the names, units, and stories that have brought us to today's electrically driven world
  - Charles de **Coulomb** 1736-1806
  - George Simon **Ohm** 1789-1854
  - Andre' **Ampe're** 1775-1836

How We Talk About Electricity

How We Talk About Electricity

- We communicate and measure electricity with these concepts:

Current	Voltage
Resistance	Power

Electricity Is Like Water in a Hose

- Like water flowing through a hose…

Voltage →
- There is pressure

Current →
- The diameter of the hose matters
  - Narrow hose = only a little water can flow
  - Wide hose = lots of water can flow

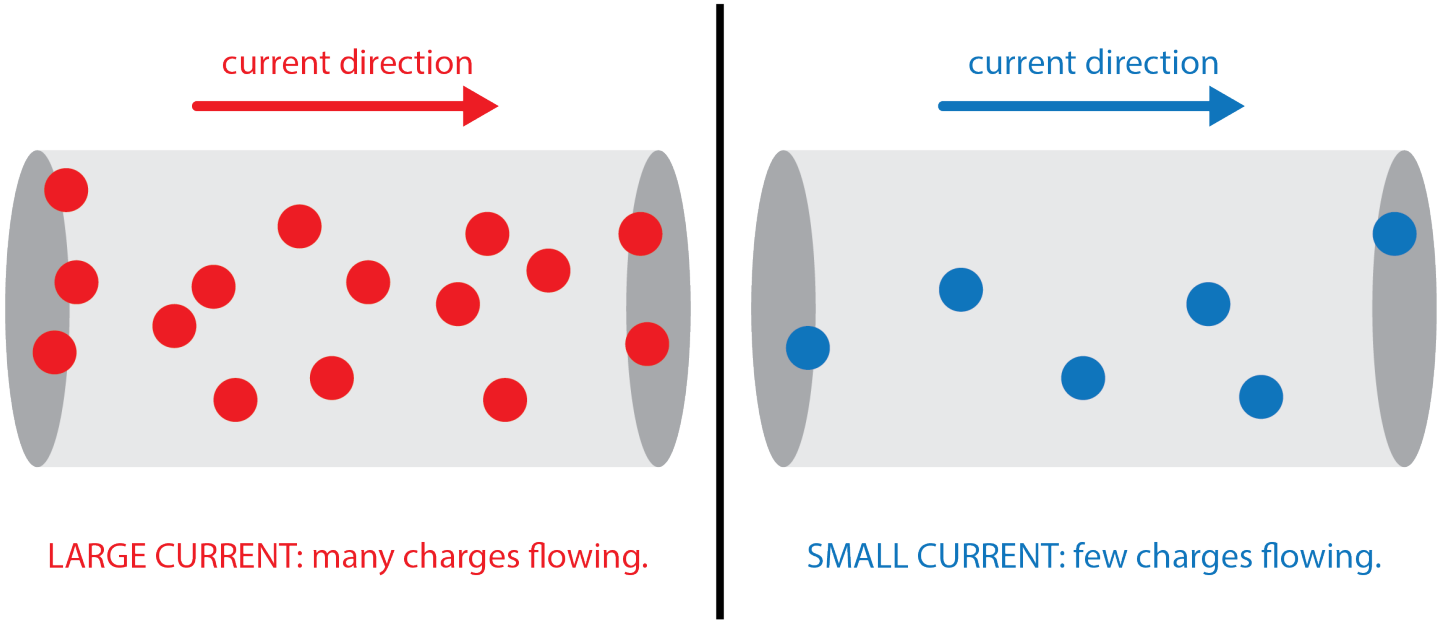
Resistance →
- If sand gets into the hose, the flow slows

Voltage

- Also known as electromotive force (EMF)
- Voltage is a measure of electrical pressure, or **potential energy**, between areas of few electrons and more electrons
- Measured in volts
- Shown as V or E in calculations, most commonly as E

Amperage Is Current

- Current (or amperage) is the measure of the quantity of electrons flowing through a circuit
- Measured in amps or amperes
- Shown as I in calculations



Resistance

- The ability of a material to impede (slow) the flow of electrons
- It is measured in Ohms (Ω) and abbreviated as R
- The Ohm is a measurement of the amount of opposition to current flow that exists in a circuit object
- A **circuit object** is any device in a circuit that the current must flow through
- Examples of circuit objects in vehicles:
  - Resistors
  - Lights
  - Closed switches
  - Diodes

Power

- ***Power*** is a measure of energy or work that can be done
- It is measured in watts (W)
- It is shown as P in calculations
- **Note:** 1 Horsepower = 746 W
- *Example:* A 60 W incandescent light bulb uses 30 more times energy than a 3 W LED light bulb

Often Used By Electricians: Load

- The load is any device in a circuit that uses both current and voltage
- All loads consume power
- If a load on a circuit is too large, dangerous conditions can develop:
  - Circuit breaker trips
  - A fuse blows
  - Lights on the circuit may dim
  - Heat can be generated = fire risk
- In the Trailer Circuit STEM Kit, the lights of the trailer are the load

Electricity: 2 Types of Current

AC

Alternating **C**urrent

- Most common
- Used in homes and industry
- Is what power plants and generators produce

DC

Direct **C**urrent

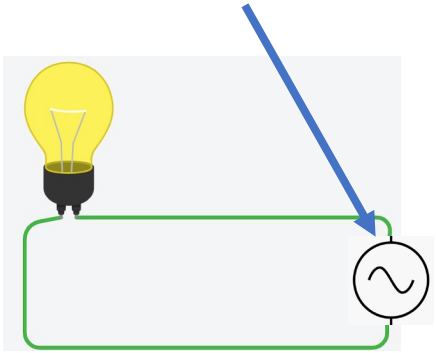
- Used in computers, phones, and vehicles
- Easily stored
- Is what comes from batteries

The biggest difference is how the electrons flow in each

AC and DC are Very Different

AC

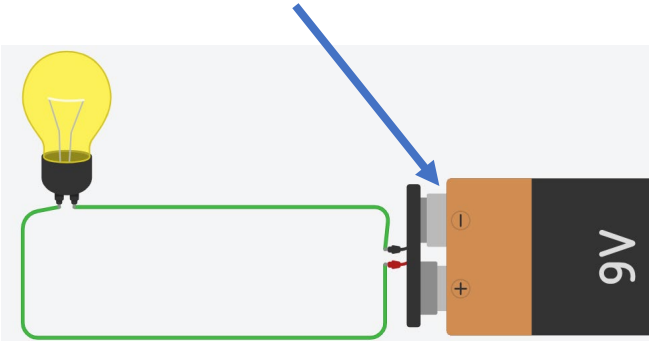
AC Power Source



Current changes direction, *alternating back and forth*

DC

DC Power Source



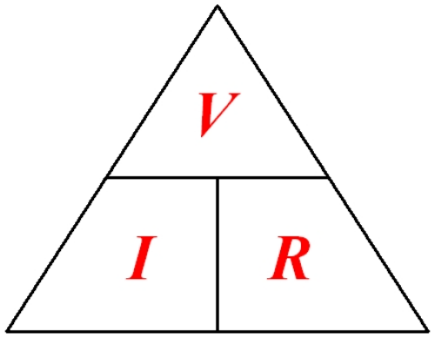
Current *flows the same* direction, *from – to +.*

Ohm’s Law

Ohm’s Law

- These measurements are related by Ohm’s law
- Ohm’s law mathematically shows the relationship between voltage, current, and resistance in a circuit

$$V = I\,R$$

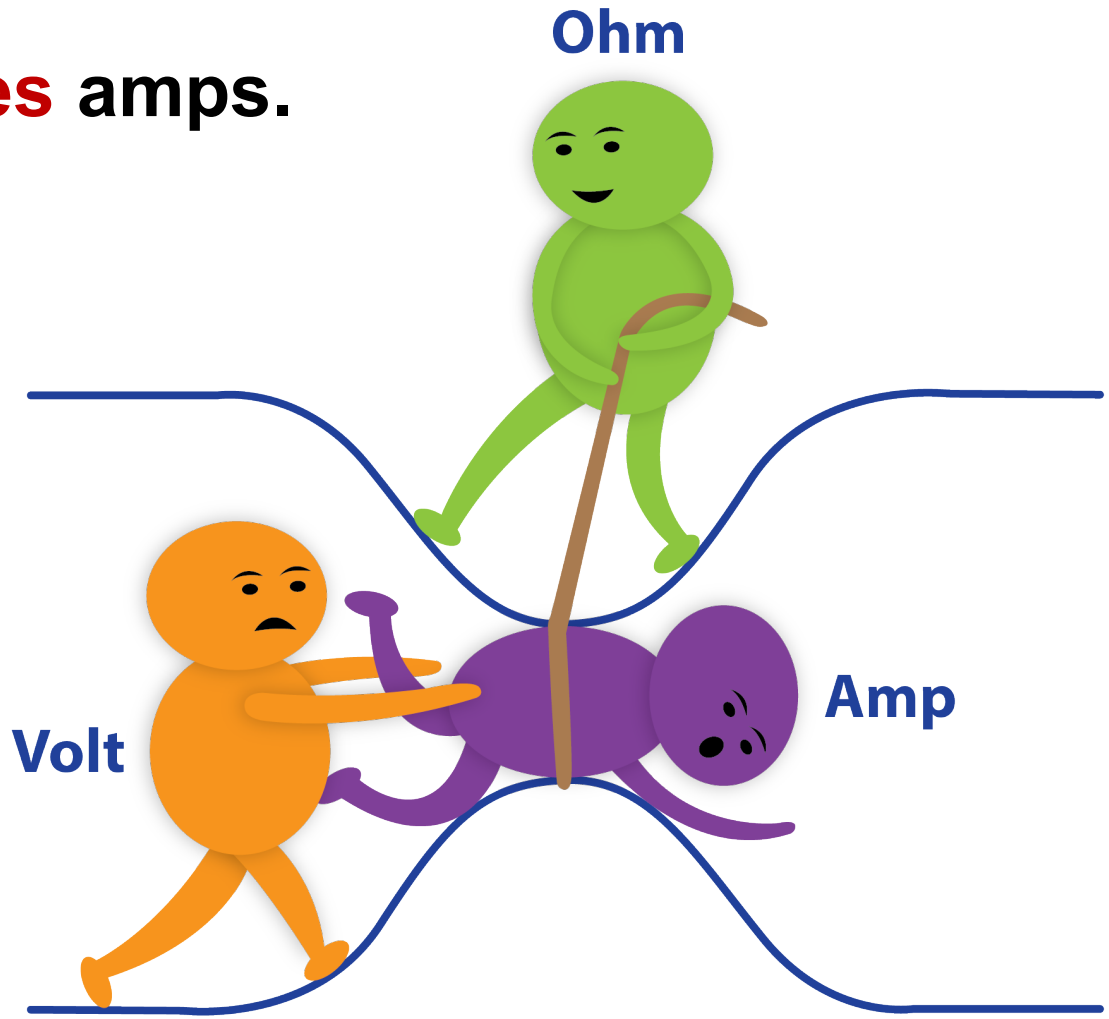


$$I = \frac{V}{R} \qquad R = \frac{V}{I}$$

You can imagine Ohm's Law like this…

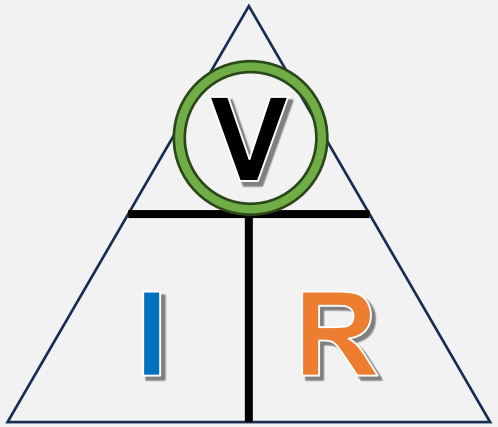
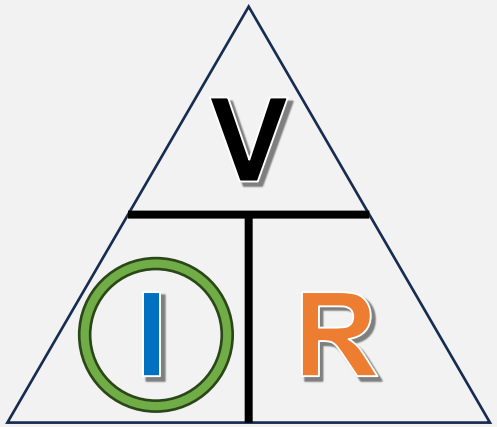
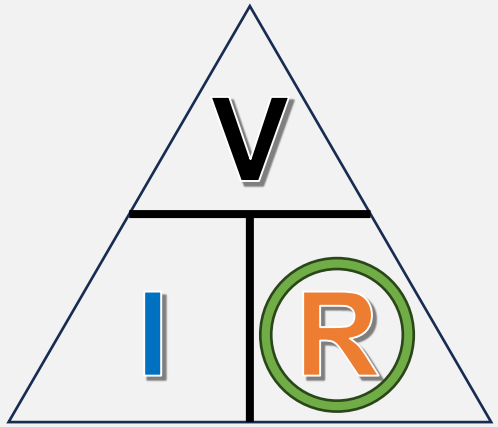
Voltage pushes amps

as resistance is opposes amps.



Math Tool

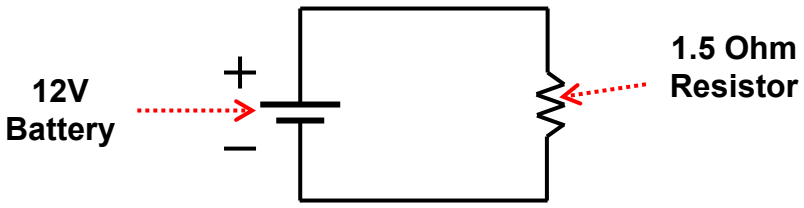
- Use the Ohm's law pyramid to find the right equation

To Find Voltage	To Find Current	To Find Resistance
		
$V = I \times R$	$I = \frac{V}{R}$	$R = \frac{V}{I}$

Ohm's Law Example 1

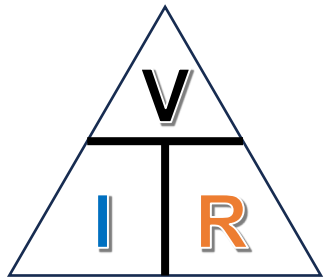
If V is 12 volts and R is 1.5 Ohms, what is the current in this circuit?

Step 1: Which form of Ohm's law solves for I?



Step 2: Solve for I

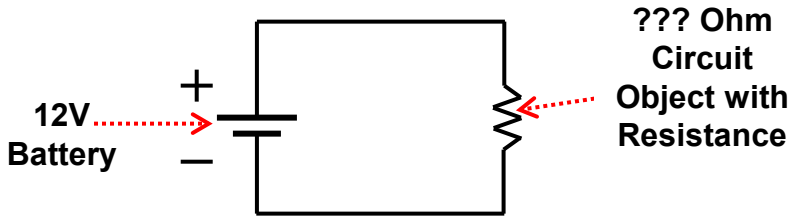
- I = V/R
- I = 12 volts / 1.5 ohms
- I = ***8 amps***



Ohm's Law Example 2

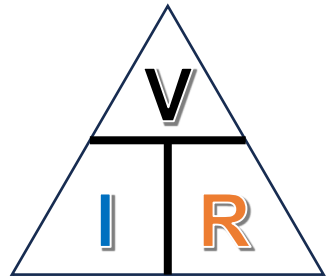
If V is 12 volts and the circuit load is 0.25 amps, what is the resistance of this load?

Step 1: Which form of Ohm's law solves for R?



Step 2: Solve for R

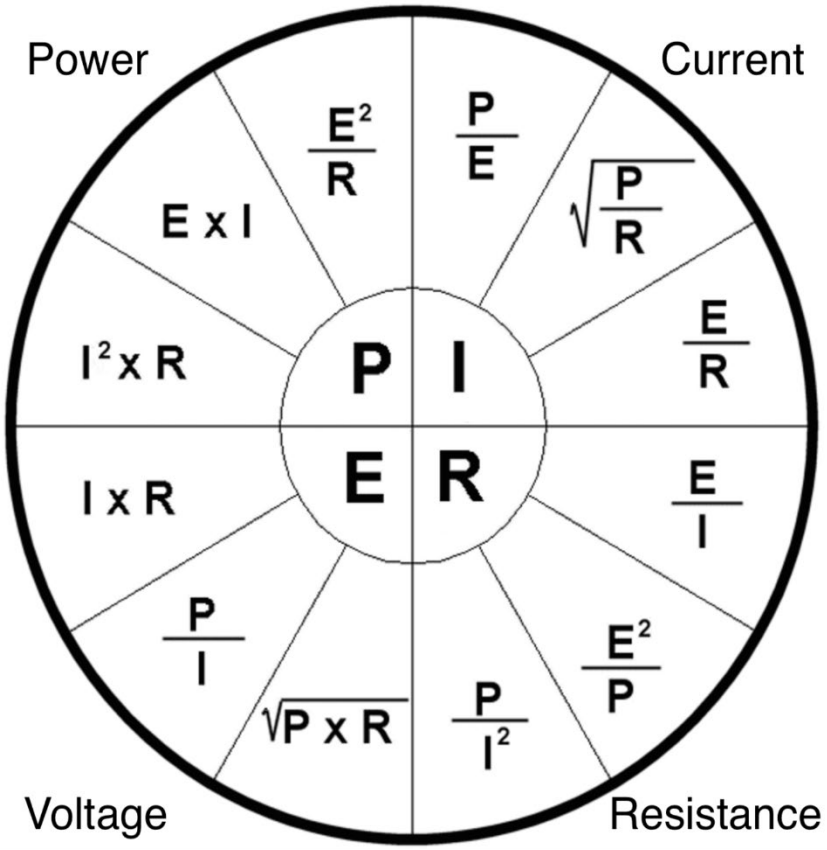
- R = V/I
- R = 12 volts / 0.25 amps
- R = ***48 Ohms***



Math of Electricity

Electrical PIE Chart

- **Used by electricians**
- **2 changes to notice:**
  1. **V** (voltage) is now symbolized with **E**
  2. Adds in **P** for **P**ower *(unit is Watts)*
- **Why use this?**
  - Any electrical *unknown*, can be found from any *2 knowns*
  - *Electricians **must** be ready to make calculations in the field to perform safe work*



PIE Chart: Voltage Calculations

Remember… E = Voltage

<u>Example Problem 1</u>: If 24 W are used with a current of 2 A, how much voltage is provided?

STEP 1: List your knowns.

P = 24 W and I = 2A

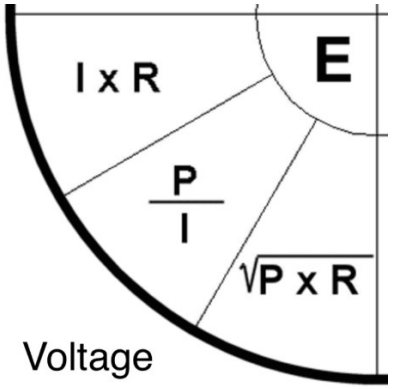
STEP 2: Identify your equation on the PIE Chart.

E = P/I

STEP 3: Solve!

E = 24 W / 2A

E = ***12V***



PIE Chart: Amperage Calculations

Remember… E = Voltage

<u>Example Problem 1</u>: If a 12 V system consumes 24 W, what is the amperage?

STEP 1: List your knowns.

E = 12 V and P = 24 W

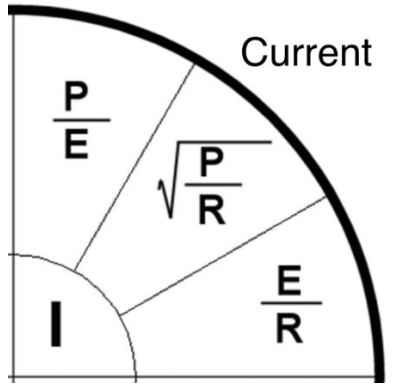
STEP 2: Identify your equation on the PIE Chart.

I = P/E

STEP 3: Solve!

I = 24 W / 12 V

I = ***2 Amps***



PIE Chart: Resistance Calculations

Remember… E = Voltage

Example Problem 3: If a 12 V system has 2 amps on it, how much resistance is present?

STEP 1: List your knowns.

E = 12 V and I = 2 amps

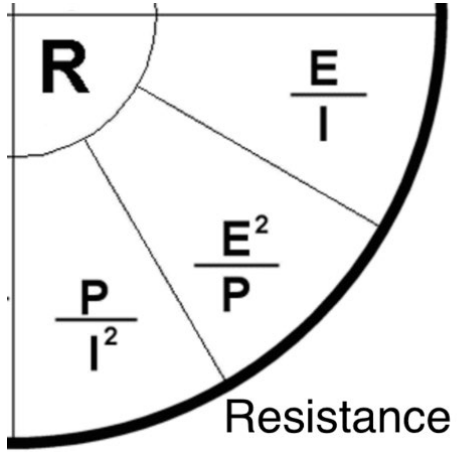
STEP 2: Identify your equation on the PIE Chart.

R = E/I

STEP 3: Solve!

R = 12 V / 2 Amps

R = ***6 Ω*** *(Ω is the symbol for Ohms)*



PIE Chart: Power Calculations

Remember… E = Voltage

<u>Example Problem 4</u>: If a 12 V system has 3 amps of current on it, how much power is being consumed?

STEP 1: List your knowns.

E = 12 V and I = 3 Amps

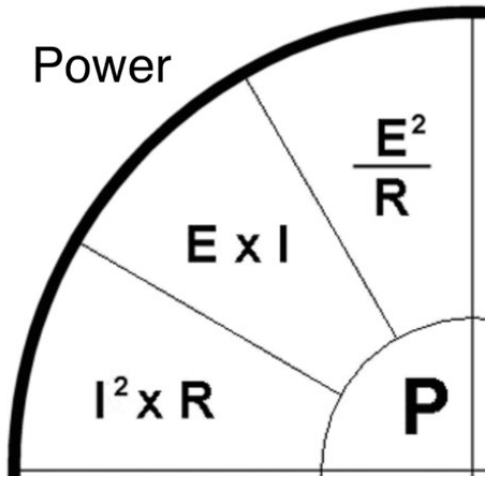
STEP 2: Identify your equation on the PIE Chart.

P = E x I

STEP 3: Solve!

P = 12 V x 3 Amps

P = ***36 W***



Done with the student workbook activity for lesson 1?

See your instructor to check the key and/or turn in.

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