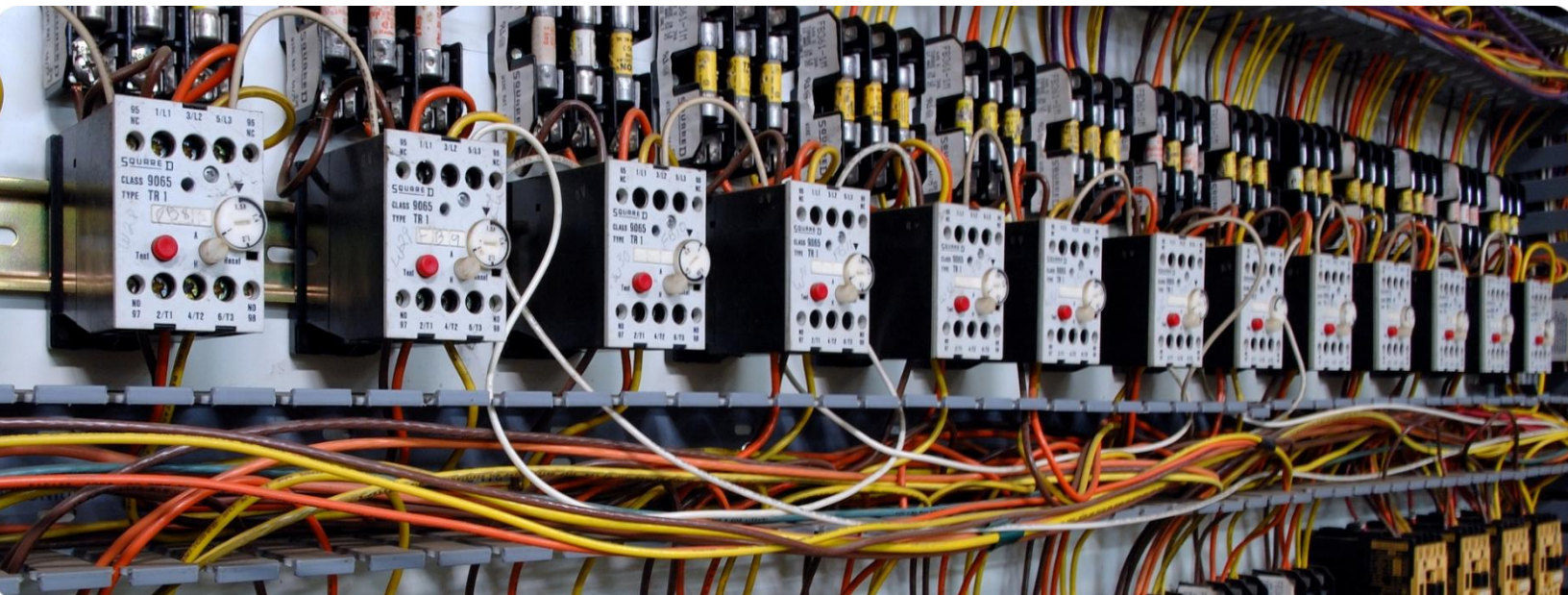


Participant Resource Guide

Electrical Foundations

May 2026



Course Outline

- Module 1: Introduction to Electricity

Module 2: Basic Electrical Principles

- Module 3: AC and DC Electricity
- Module 4: Circuit Components & Architecture
- Module 5: Magnetism and Electromagnetism
- Module 6: Electrical Tools
- Module 7: Safety and PPE



U.S. Department of Transportation
Federal Transit Administration

Course: Electrical Foundations

Version Date: May 2026

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Module 2 - Basic Electrical Principles

Objectives


- Define and explain voltage, current, and resistance.
- Describe how voltage, current, and resistance are related in a simple circuit.
- Predict how changes in voltage or resistance affect current before measuring.
- Use Ohm's Law to calculate a missing value in a basic circuit.

Key Terms

- Ampere (A)
- Current
- Ohm (Ω)
- Ohm's Law
- Resistance
- Volts
- Voltage
- Watts (W)

Participant Resource Guide

Basic Electrical Principles




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Agenda

- Welcome and Warm Up
- 2.1 – Voltage, Current, and Resistance
- 2.2 – Ohm's Law
- Quiz and Wrap Up



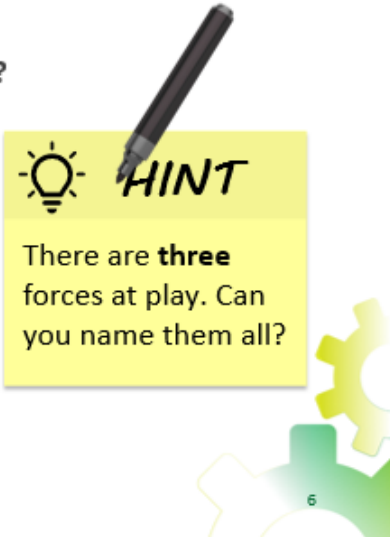
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Warm Up

Have you ever experienced any of the following?

What do you think causes these issues?

- Lights dimming when something turns on
- Phone charging faster/slower
- Space heater drawing a lot of power
- Circuit breaker tripping
- Car battery struggling to start



Notes:

- Have you ever experienced any of these situations?
 - Maybe lights dim when something turns on, or a circuit breaker trips.
 - Maybe your phone charges faster or slower, or a car struggles to start.
- These are all real-world electrical issues you've likely seen before.
- We've been talking about them: voltage, current, and resistance.
- Throughout this lesson, you are going to connect these everyday experiences to what's happening inside the circuit.
- By the end, you'll be able to explain and predict these situations using Ohm's Law.



Notes:

- This section defines voltage, current, and resistance, and explains their roles in electrical circuits.

Voltage, Current, and Resistance

Before Video: What do you remember about the following terms from Module 1?

- Current
- Voltage

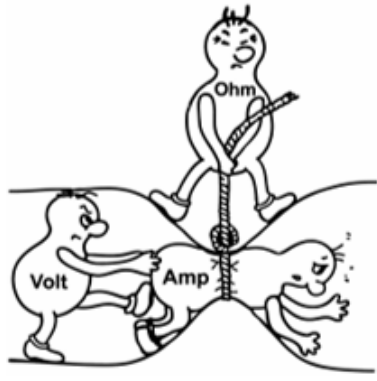
After video: How would you describe voltage, current, and resistance using the water analogy?



Notes:

- What do you remember about voltage and current from module 1?
- You'll learn more about current and voltage in today's lesson, and a new term in this module: Resistance.
- This is an important concept in Ohm's Law, which you'll learn more about in today's lesson.
- This video reviews the relationship between voltage, current, and resistance using a water analogy and pulls everything all together in under a minute.
- How would you describe voltage, current, and resistance using the water analogy?


How does electricity move through a circuit?



Voltage = Push of electrons

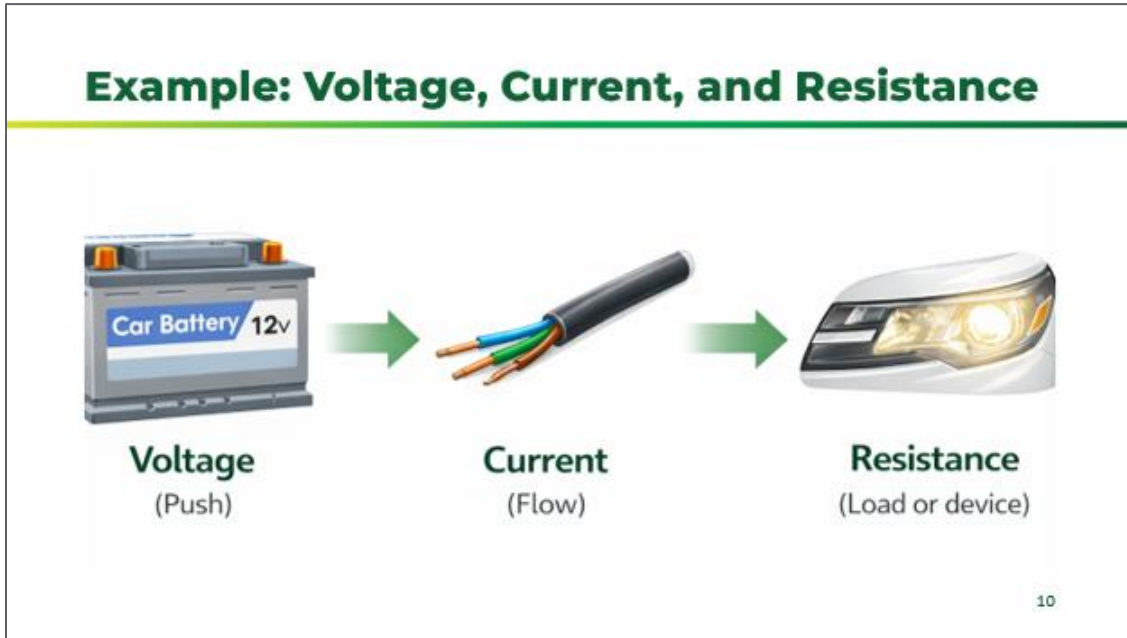
Current = Movement of electrons

Resistance = What slows the movement of electrons



Notes:

- Voltage, current, and resistance help explain how electricity behaves in a circuit.
- Each part plays a role:
 - **Voltage** is what **pushes** electrons and drives electricity through the system. Again, this is similar to water pressure in a pipe.
 - **Current** is the movement of electric charge, like water flowing through a pipe.
 - **Resistance** is the **opposition** that slows the flow down. This is similar to pipe size or anything that might slow water running through a pipe.
- Just like in plumbing, higher pressure pushes more water, narrower pipes slow the flow, and the system only works if everything is balanced.
- This comparison makes it easier to visualize what's happening in an electrical circuit—even if you can't see the electrons moving.
- Higher pressure (voltage) = faster flow (current), unless resistance blocks it.

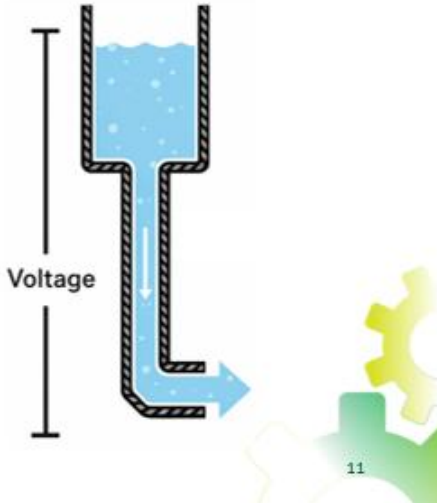


Notes:

- How are voltage, resistance, and current used in a vehicle?

What is Voltage?

- **Voltage** is the push that makes electricity move.
- If there is no voltage, nothing moves even if the wires are perfect.



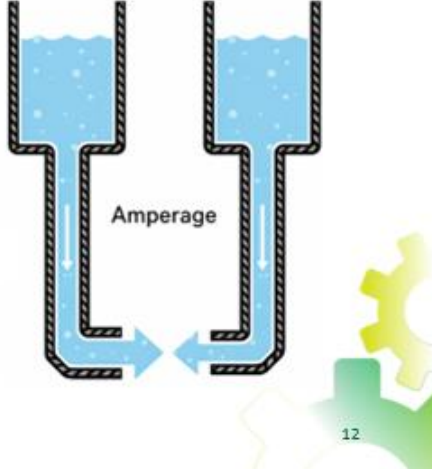
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Notes:

- When thinking about voltage, ask yourself: *What pushes electricity?*
- **Voltage** is the force that pushes electric charges through a conductor. It's what gives electrons the energy to move.
 - In a water analogy, the **pressure** at the end of the hose represents **voltage**, and the **water in the tank** represents **electrical charge**.
 - The **more water in the tank**, the **greater the charge** available, which increases **the pressure measured at the end of the hose**—just like higher charge levels can result in higher voltage.
- We measure voltage in volts, and the higher the voltage, the more energy there is to push those charges through the circuit.
- Think back to the water analogy: voltage is like water pressure.
 - If the pressure increases, the water flows faster. The same is true in electricity—higher voltage means a stronger push for current.
- If there is no voltage, nothing moves—even if the wires and components are working perfectly.
 - Low voltage = weak push
 - High voltage = strong push
- It's also important to understand limits:
 - Too much voltage can damage equipment
 - Too little voltage can cause improper operation or shutdown

What is Current?

- **Current** is the flow of electric charge.
- It's what happens when electrons move through a conductor, like a wire.
- We measure it in amperes, or **amps**.
- A circuit can have voltage but no current if something is broken or turned off.

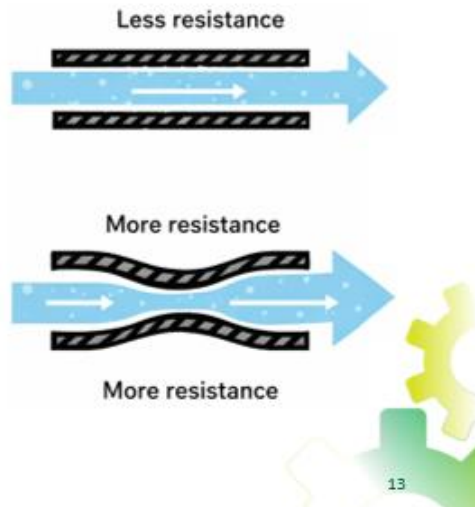


Notes:

- **Current** is the flow of electric charge—it's what happens when electrons move through a conductor, like a wire. We measure it in amperes, or **amps**.
- Current represents the actual movement of electrons in a circuit—how many charges pass a point each second.
 - In a water analogy, current is like the **flow rate of water through a pipe**. The stream of water represents electrons moving through a wire.
 - The faster and stronger the flow, the more current is moving through the system.
- This also connects to other parts of the system:
 - A **bigger tank creates more pressure (voltage)**, which can increase flow.
 - A **narrower pipe creates more resistance**, which reduces flow.
- So, if voltage is the push, current is the movement that push creates.
- Current is what actually does the work in a circuit—powering lights, motors, and equipment.
- It's important to control current levels:
 - Too much current can blow fuses or trip breakers.
 - It can also cause overheating in wires or equipment.
 - Too little current can cause equipment to malfunction or struggle to operate properly.

What is Resistance?

- Resistance is anything that slows electricity down.
- Represented by the Greek letter Ω .
- Heaters, motors, and light bulbs are resistance in a circuit using current and voltage to do useful work.



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Notes:

- **Resistance** is the opposition to the flow of electric current; it slows the movement of electrons through a circuit. It is measured in ohms, represented by the Greek letter Ω .
 - In a water analogy, resistance is like a **narrow or rough section of a pipe**, it makes it harder for water to flow.
- The narrow sections of a pipe slow the flow of water, just like resistance slows the movement of electricity.
- The key idea: **higher resistance means less current will flow for a given voltage.**
- This relationship is important when troubleshooting:
 - Increased resistance can reduce system performance.
 - Bad connections or damaged wires increase resistance.
 - Increased resistance often leads to heat buildup in the circuit.
- Heaters, motors, and light bulbs are resistance in a circuit using current and voltage to do useful work.
- Understanding resistance helps technicians identify problems like loose connections, corrosion, or damaged conductors.

Electrical Problems On The Job

When something isn't working, it's because voltage, current and/or resistance has changed.

What you see on the job:

- Equipment faults
- Dim lights
- Hot wires or enclosures
- Devices off



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Notes:

- When something isn't working, it usually comes down to a change in voltage, current, or resistance.
- These changes show up as problems you can see or feel on the job.
 - For example: dim lights, equipment faults, or devices not turning on.
- Sometimes you'll notice heat—like hot wires or enclosures—which can signal too much current or resistance issues.
- As technicians, your job is to recognize these symptoms and trace them back to what changed in the circuit.

Knowledge Check



Which statement best describes current in an electrical circuit?

(A). The push that makes electricity move.

(B). The flow of electricity through the circuit.

(C). Anything that slows electricity down.

(D). The voltage rating printed on equipment.

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Knowledge Check



A circuit has voltage, but no electricity is flowing. What is missing?

(A). Voltage

(B). Power

(C). Current

(D). Resistance

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Summary and What's Next

- Voltage is the push that tries to move electricity through a circuit
- Current is the flow of electricity that does the work
- Resistance is anything that slows the flow of electricity
- Understanding voltage, current, and resistance helps technicians describe what electricity is doing, even before using formulas or tools.

Next, we'll use these ideas to predict what equipment should be doing.

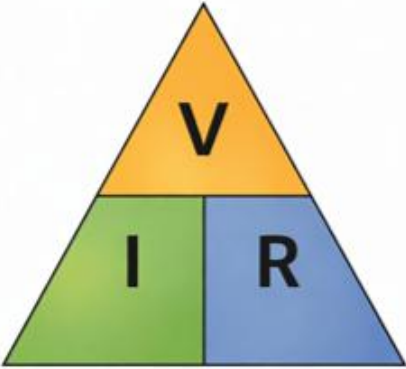
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Notes:

- **Voltage** is the push that moves electricity through a circuit.
- **Current** is the flow—it's what actually does the work.
- **Resistance** is what slows that flow down.
- When you understand how these three work together, you can start to describe **what electricity is doing**, even before using tools or formulas.
- Next, you're going to build on this and start predicting what equipment should be doing in real situations.

2.2 – Ohm’s Law

Now that we know what voltage, current, and resistance are, we’ll learn how they depend on each other using Ohm’s Law.



Notes:

- Now that you know what voltage, current, and resistance are, you’ll learn how they depend on each other using Ohm’s Law.

Why Ohm's Law Matters on the Job

Ohm's Law is how electricity behaves in real equipment, not just a formula. It explains what's happening in every light, motor, heater, and control circuit you work on.

It helps you:

- ✓ **Find problems faster.** Voltage drops, shorts, open circuits
- ✓ **Protect equipment.** By preventing too much current
- ✓ **Trust your meter readings.** And know what they mean
- ✓ **Work safer.** By knowing how much current a circuit can handle




Notes:

- Ohm's Law isn't just a formula. It explains how electricity behaves in real equipment.
- You'll see it in everything you work on lights, motors, heaters, and control circuits.
- It helps you in a few key ways:
 - It helps you find problems faster—like voltage drops, shorts, or open circuits.
 - It helps protect equipment by preventing too much current.
 - It helps you trust your meter readings and understand what they're telling you.
- And it helps you work safer by knowing how much current a circuit can handle.
- **Bottom line:** Ohm's Law helps you understand what's happening, so you can make better decisions on the job. Understanding that relationship saves time, parts, and headaches.

Units of Measurements

Quantity	Unit	Symbol	Other things you may see
Voltage	Volts	V, E	E = Electromotive force (EMF)
Current	Ampere	A, I	I = Intensity
Resistance	Ohm	Ω , R	



Notes:

- To be able to make meaningful statements about these quantities in circuits, you need to be able to describe their quantities in the same way that we might quantify mass, temperature, volume, length, or any other kind of physical quantity.
- Just like feet measure distance, volts, amps, and ohms measure electrical properties.

Voltage

- **V** – Most common (e.g., $V=IR$ = $IRV=IR$)
- **E** – Sometimes used in textbooks, especially for **electromotive force** (EMF)

Current

- **A** – Most common, interchangeable with “I”
- **I** – Standard symbol for electric current, used for describing intensity
- **i** – Used for instantaneous or time-varying current (AC analysis)

Resistance

- **R** – Standard symbol for resistance
 - **r** – Sometimes used for **internal resistance** or **small resistance** values in circuits
- What you see in the third column is an old-school way of communicating these terms. However, you may still see them in the field, so it is important to know.


Decimals in Electrical Work

Technicians frequently see decimal values when measuring electricity.

Examples:

- 12.6 V
- 0.35 A
- 0.02 Ω

Small decimal differences can indicate voltage drops, resistance changes, or equipment problems.



Notes:

- Technicians often work with decimal values when measuring electricity.
 - Decimals help us see **small but important differences** in voltage, current, and resistance.
 - For example, readings like 12.6 volts or 0.35 amps may seem small, but they can tell us a lot about what's happening in a circuit.
 - These small differences can help identify issues like voltage drops, poor connections, or failing components. The more precise the measurement, the better we can diagnose problems.
 - In 1.588
 - a) 5 is in the tenths place
 - b) 8 is in the hundredths place
 - c) 8 is in the thousandths place
 - As a technician, paying attention to decimals helps you catch issues early—before they become bigger problems.
-
-
-
-
-

Decimals in Electrical Work

Each step changes the value by 10 times.

Example:
 $1 \rightarrow 10 \rightarrow 100 \rightarrow 1000$
Each step = $10\times$ larger

Decimals move the other direction:
 $1 \rightarrow 0.1 \rightarrow 0.01 \rightarrow 0.001$


A digital multimeter with a red and black casing. The LCD screen shows the number '1588'. Three vertical labels are positioned above the screen: 'Tenth' with a yellow arrow pointing to the '1', 'Hundredths' with a green arrow pointing to the '5', and 'Thousandths' with a blue arrow pointing to the first '8'. The multimeter has various buttons and a scale at the bottom. To the right of the multimeter is a green gear icon with the number '22' below it.

Notes:

- Our number system is based on 10—each place value changes by a factor of 10.
- When you move to the right, numbers get larger:
 - $1 \rightarrow 10 \rightarrow 100 \rightarrow 1000$
- Each step is 10 times bigger
- Decimals move in the opposite direction:
 - $1 \rightarrow 0.1 \rightarrow 0.01 \rightarrow 0.001$
- Each step is 10 times smaller
- Another way to think about it:
 - Move the decimal to the right \rightarrow the number gets larger.
 - Move the decimal to the left \rightarrow the number gets smaller.
- On the meter display:
 - The first digit is the tenths place
 - Next is the hundredths
 - Then the thousandths
- Understanding place value helps you read measurements accurately and recognize small changes that can point to real issues in a circuit.

Electrical Prefixes

Prefix	Symbol	Value
Mega	M	Million: 1,000,000
Kilo	k	Thousand: 1,000
Base	—	1
Milli	m	Thousandth: 0.001
Micro	μ	Millionth: 0.000001



Notes:

- Electrical values can vary a lot—from very large to very small—so we use prefixes to make them easier to read and work with.
- Starting at the top with **larger numbers**:
 - Mega means one million—used for very large values.
 - Kilo means one thousand.
- The base unit is just 1—this is your standard unit like volts, amps, or ohms.
- Moving **smaller numbers**:
 - Milli means one-thousandth.
 - Micro means one-millionth.
- As you move down the chart, the values get smaller each step.
- These prefixes help you quickly understand the size of a measurement without dealing with long numbers or lots of zeros.
- On the job, you’ll see larger prefixes in power systems and smaller ones in control circuits and electronics.

Understanding Amps and Milliamps

Electrical values are often very small. We use milliamps (mA) and millivolts (mV) to communicate these small numbers.

To convert Amps to Milliamps (A → mA)	To convert Milliamps to Amps (mA → A)
Multiply by 1,000 or move decimal 3 places <u>right</u> .	Divide by 1,000 or move decimal 3 places <u>left</u> .
<i>Examples:</i> <ul style="list-style-type: none">• 1 A = 1,000 mA• 0.5 A = 500 mA• 0.002 A = 2 mA	<i>Examples:</i> <ul style="list-style-type: none">• 1,000 mA = 1 A• 250 mA = 0.25 A• 2 mA = 0.002 A

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Notes:

- Electrical values are often very small, so instead of using long decimals, we use prefixes like milli.
- Milli means one-thousandth, or 1/1000.
- You'll commonly see this with millivolts (mV) and milliamps (mA).
- When converting, the key is moving the decimal 3 places:
- **Amps to milliamps → move the decimal right (number gets bigger).** For example:
 - 1 volt equals 1,000 millivolts
 - 0.5 volts equals 500 millivolts
 - 0.002 amps equals 2 milliamps
- **Milliamps to amps → move the decimal left (number gets smaller).** For example:
 - 1,000 mA = 1 A
 - 250 mA = 0.25 A
 - 2 mA = 0.002 A
- These conversions help you read meters correctly and communicate measurements clearly on the job.

Converting Electrical Measurements

Directions: Convert the following from either amps to milliamps or milliamps to amps.

1. 0.75 A = mA
2. 0.003 A = mA
3. 500 mA = A
4. 250 mA = A
5. What is the measured current in milliamps?
6. Is the sensor receiving the correct amount of current? Convert the measurement to milliamps and explain.

Activity

Converting Electrical Measurements

Units	Symbol	Value	Example
Amps	A	1.000	1.000 A = 1000 mA
Milliamps	mA	1000	1000 mA = 1.000 A
Microamps	µA	1,000,000	1,000,000 µA = 1.000 A

How to Convert Electrical Measurements

Convert Amps to Milliamps: Multiply the number of amps by 1,000. (1 A = 1,000 mA)

Convert Milliamps to Amps: Divide the number of milliamps by 1,000. (1,000 mA = 1 A)

Conversion Practice

Directions: Convert the following from either amps to milliamps or milliamps to amps.

1. 0.75 A = _____ mA
2. 0.003 A = _____ mA
3. 500 mA = _____ A
4. 250 mA = _____ A
5. A sensor in a system is rated for 100 mA. Is it receiving the correct amount of current? Explain.
6. A sensor in a system is rated for 100 mA. Is it receiving the correct amount of current? Explain.



Activity

Converting Electrical Measurements

Electrical Prefixes

Prefix	Symbol	Value	Example
Mega	M	Million: 1,000,000	Used when testing insulation with a megohmmeter—high resistance indicates good insulation on cables or equipment
Kilo	k	Thousand: 1,000	Found in high-voltage systems, such as traction power or substations
Base	—	1	Common voltage in standard electrical outlets or control circuits
Milli	m	Thousandth: 0.001	Measuring low current in control circuits, sensors, or electronics
Micro	μ	Millionth: 0.000001	Capacitor ratings in control boards, power supplies, or timing circuits

How to Convert Electrical Measurements

To convert Amps to Milliamps (A → mA)	To convert Milliamps to Amps (mA → A)
Multiply by 1,000 or move decimal 3 places right . Examples: <ul style="list-style-type: none"> • 1 A = 1,000 mA • 0.5 A = 500 mA • 0.002 A = 2 mA 	Divide by 1,000 or move decimal 3 places left . Examples: <ul style="list-style-type: none"> • 1,000 mA = 1 A • 250 mA = 0.25 A • 2 mA = 0.002 A

Conversion Practice

Directions: Convert the following from either amps to milliamps or milliamps to amps.

- 0.75 A = _____ mA
- 0.003 A = _____ mA
- 500 mA = _____ A
- 250 mA = _____ A
- A technician measures the current in a control circuit and sees a reading of 0.6 A on the meter. The equipment manual lists the normal operating range in milliamps (mA). What is the measured current in milliamps? _____
- A sensor in a transit system is rated to operate at 150 mA, but a technician measures the current and finds it is only 0.12 A. Is the sensor receiving the correct amount of current? Convert the measurement to milliamps and explain.

Ohms Law

Describes the **relationship between voltage, current, and resistance** in a circuit.

$$V = I \times R$$

- **V** – Voltage (**volts**)
- **I** – Current (**amperes**)
- **R** – Resistance (**ohms**)




Notes:


- **Ohm's Law** was discovered by George Simon Ohm and is a fundamental principle in electronics and electrical engineering.
- It describes the **relationship between voltage, current, and resistance** in a circuit with a simple formula: **V = I × R**
 - V stands for Voltage (measured in volts).
 - I stands for Current (measured in amperes or amps).
 - R stands for Resistance (measured in ohms).
- This equation tells us that voltage equals current times resistance. If you know any two of these values, you can always figure out the third.

Using Ohm's Law


Using Ohm's Law, you can easily calculate any one of the three variables, if the other two are known. Cover the value you're trying to find, and what's left gives you the equation.



$V = I \times R$



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



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

Reminder - The symbol for resistance is interchangeable for both **R** and Ω .

Notes:

- Ohm's Law isn't just a formula—it's a tool you can use to solve problems in any electrical circuit.
 - Remember, the symbol for resistance is interchangeable for both R and Ω .
 - The triangle diagrams make it easy: Cover the value you're trying to find, and what's left gives you the equation.
- If you're solving for **voltage**, use $V = I \times R$
- To find **current**, use $I = V \div R$
- And for **resistance**, use $R = V \div I$
- These triangle charts are a great way to quickly remember which formula to use, especially when troubleshooting or doing basic calculations in the field.
- You won't calculate every time we see a problem. Most of the time, technicians notice the result first — then use Ohm's Law to think through what must have changed.

Module 2 - Basic Electrical Principles

Resource

Ohm's Law: Predicting Changes

Use this chart to determine how current responds to changes in voltage and resistance.

Voltage	Resistance	Current
Up	Same	Up
Up	Up	Same
Same	Down	Up
Same	Same	Same
Same	Up	Down
Down	Same	Down

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Notes:

- In your Participant Resource Guide, you'll find the "Ohm's Law: Predicting Current Changes" chart.
- This chart will be a useful reference for you to determine how current responds to changes in voltage and resistance.



Ohm's Law: Predicting Changes

Use this chart to determine how current responds to changes in voltage and resistance.

Voltage	Resistance	Current
Up	Same	Up
Up	Up	Same
Same	Down	Up
Same	Same	Same
Same	Up	Down
Down	Same	Down

Practice: Predicting Current Changes

Use Ohm's Law to calculate the current in each circuit and determine how changes in voltage and resistance affect current flow.

1. **Voltage Same + Resistance Down = Current Up**

A circuit starts with:

Voltage = 18V

Resistance = 9Ω

Current = 2A

The resistance decreases to 3Ω while the voltage stays the same. What is the new current? _____ amps

2. **Voltage Same + Resistance Up = Current Down**

A circuit starts with:

Voltage = 20V

Resistance = 5Ω

Current = 4A

The resistance increases to 10Ω while the voltage stays the same. What is the new current? _____ amps

Module 2 – Basic Electrical Principles

3. Voltage Down + Resistance Same = Current Down

A circuit starts with:

Voltage = 24V

Resistance = 6Ω

Current = 4A

The voltage decreases to 12V while the resistance stays the same. What is the new current? _____ amps

4. Voltage Up + Resistance Up = Current Same

A circuit starts with:

Voltage = 12V

Resistance = 3Ω

Current = 4A

The voltage increases to 24V and the resistance increases to 6Ω. What is the new current? _____ amps

5. Voltage Down + Resistance Down = Current Same

A circuit starts with:

Voltage = 20V

Resistance = 10Ω

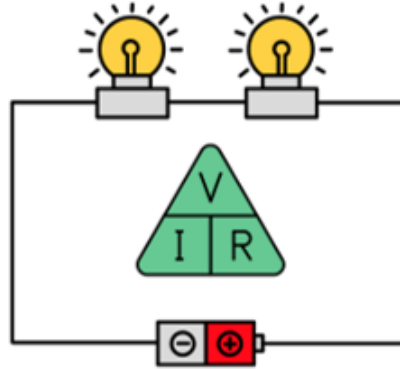
Current = 2A

The voltage decreases to 10V and the resistance decreases to 5Ω. What is the new current? _____ amps

Ohm's Law in Action



Goal: Predict what will happen to the current when changes are made to voltage and resistance in a simple circuit.

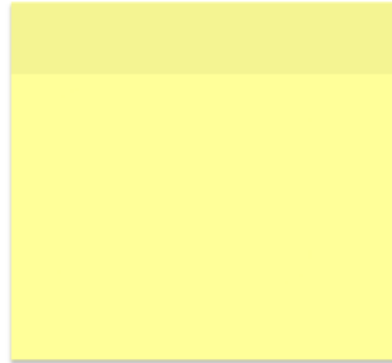


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Calculating Ohm's Law

Task: Given a circuit with a **12V** battery and a **4 Ω** resistance, calculate the current.

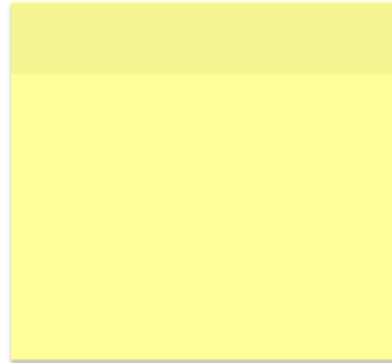
- Which equation do we need?
- What goes in the equation?
- What is the solution?



Calculating Ohm's Law

Task: A heater pulls **5A** current and has a **3 Ω** resistance, calculate the voltage.

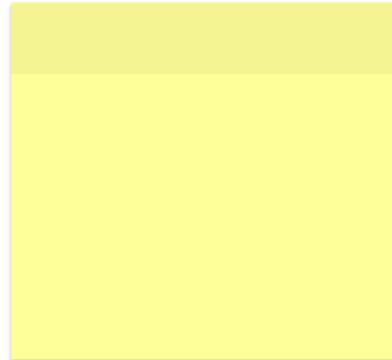
- Which equation do we need?
- What goes in the equation?
- What is the solution?



Calculating Ohm's Law

Task: Given a circuit with a **20V** battery and a **5A** current, calculate the resistance.

- Which equation do we need?
- What goes in the equation?
- What is the solution?



Calculating Ohm's Law



Directions: Use Ohm's law to solve the equations on the "Calculating Ohm's Law" handout. Remember that small decimal differences can mean big changes.

You may work with a partner if you choose.

Module 2 – Basic Electrical Principles

Activity

Calculating Ohm's Law

Directions: Use Ohm's law to solve the equations below. Remember that small decimal differences can mean big changes.

1. Given a circuit with a 120 battery and a 0.5 resistance, calculate the current.
2. A motor draws 10 of current and has a 0.5 resistance, calculate the voltage.
3. Given a circuit with a 120 battery and a 24 current, calculate the resistance.
4. Given a circuit with a 480 battery and a 0.0 resistance, calculate the current.
5. Identify both, I, of current and the a 0.0 resistance, calculate the voltage.
6. Given a circuit with a 7.0 battery and a 0.000 current, calculate the resistance and round to the nearest hundredth.
7. Given a circuit with a 120 source and a 0.0 resistance, calculate the current and round to the nearest hundredth.
8. A circuit carries 2.70 of current and has a 0.0 resistance, calculate the voltage and round to the nearest hundredth.

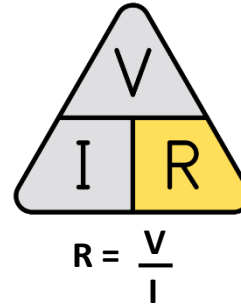
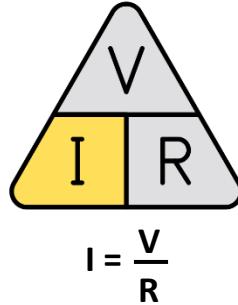
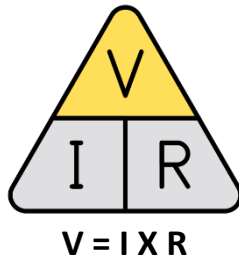
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Activity

Calculating Ohm's Law

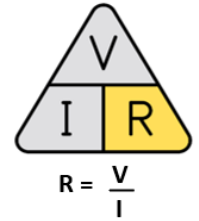
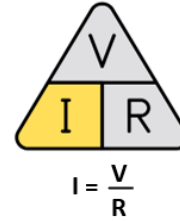
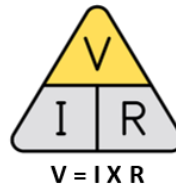
Directions: Use Ohm's law to solve the equations below. Remember that small decimal differences can mean big changes.



- Given a circuit with a 24V battery and a 6 Ω resistance, calculate the current.
- A motor draws 4A of current and has a 5 Ω resistance, calculate the voltage.
- Given a circuit with a 10V battery and a 2A current, calculate the resistance.
- Given a circuit with a 48V battery and a 12 Ω resistance, calculate the current.
- A device pulls 3A of current and has an 8 Ω resistance, calculate the voltage.
- Given a circuit with a 5.7V battery and a 3.89A current. Calculate the resistance and round to the nearest hundredth.
- Given a circuit with a 128V source and a 10.5 Ω resistance. Calculate the current and round to the nearest hundredth.
- A circuit carries 2.76A of current and has a 16 Ω resistance. Calculate the voltage and round to the nearest hundredth.

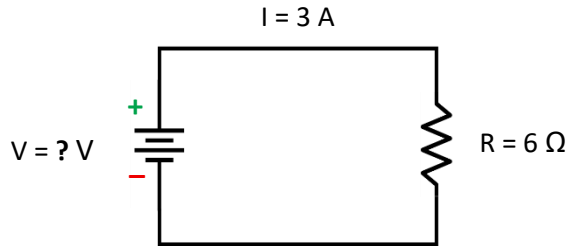
 **(Optional) Activity**

Additional Practice: Calculating Ohm's Law

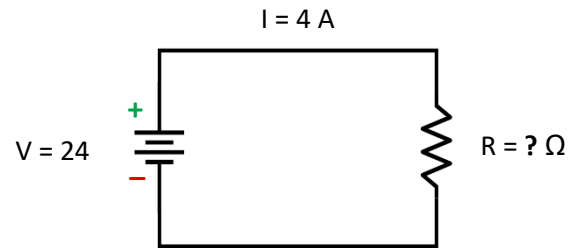


Directions: Use Ohm's law to solve the equations.

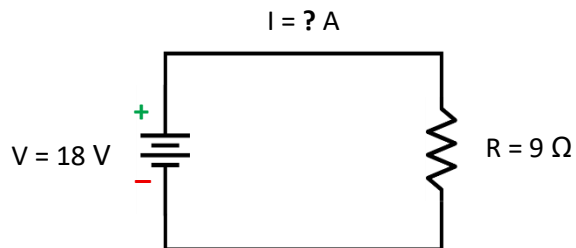
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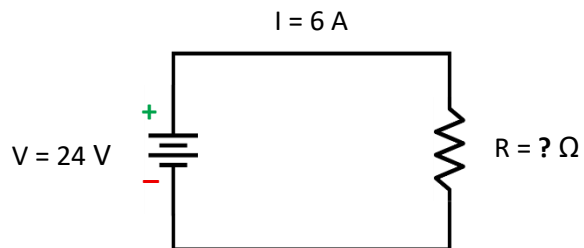
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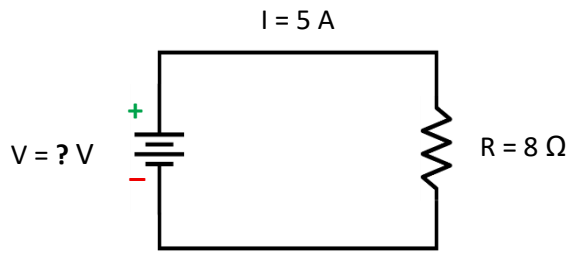


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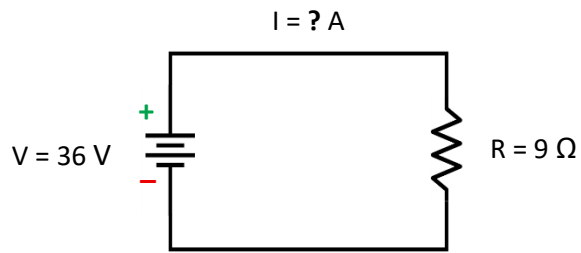


Module 2 – Basic Electrical Principles

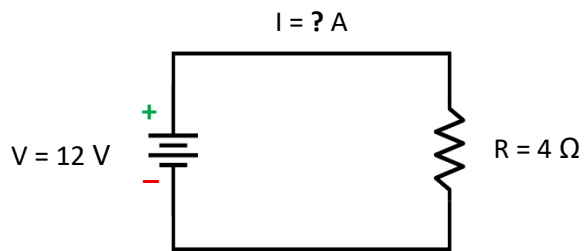
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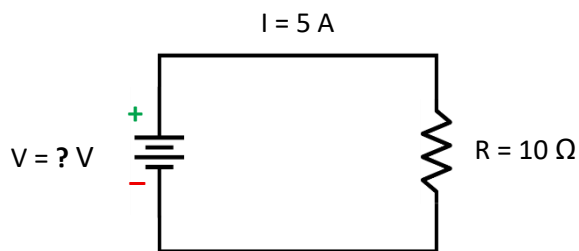
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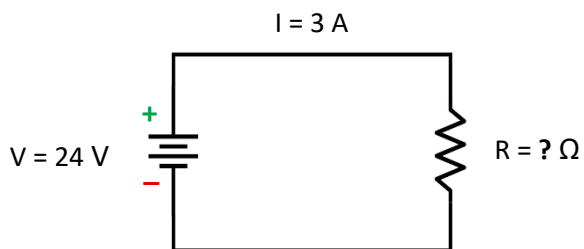
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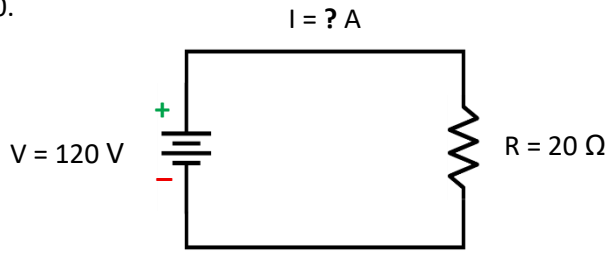


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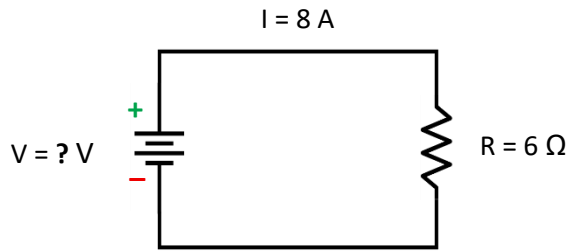


Module 2 – Basic Electrical Principles

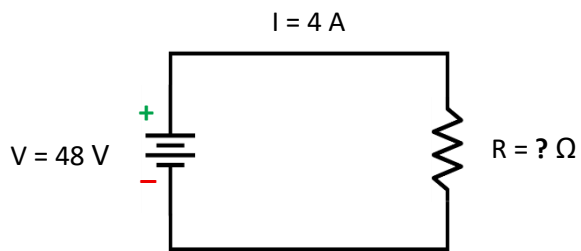
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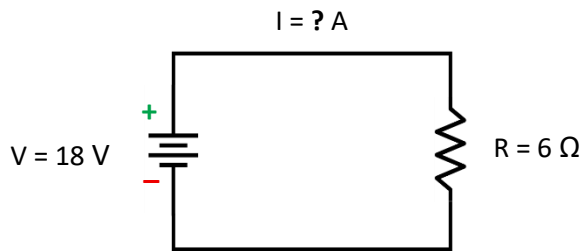
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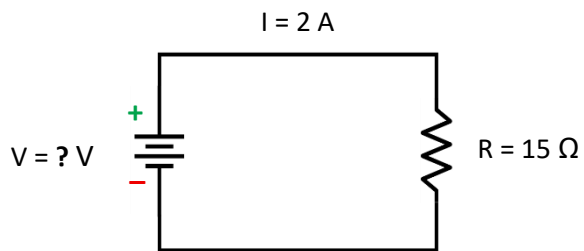
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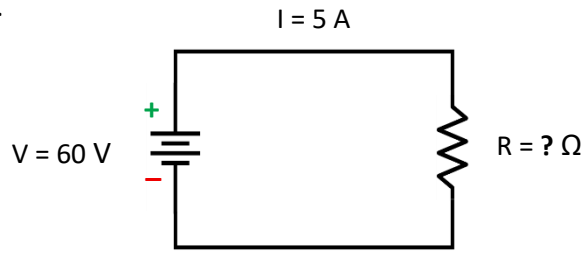


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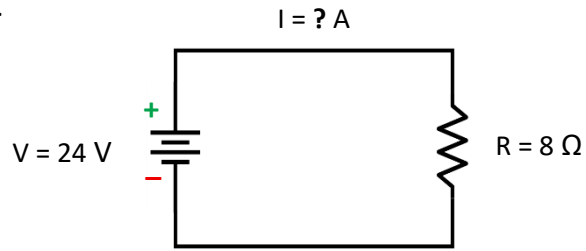


Module 2 – Basic Electrical Principles

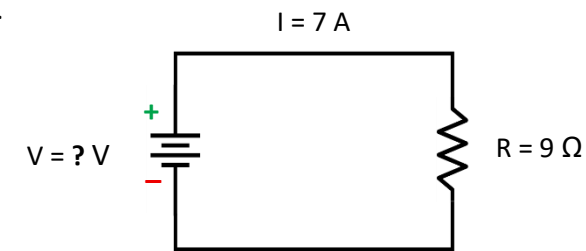
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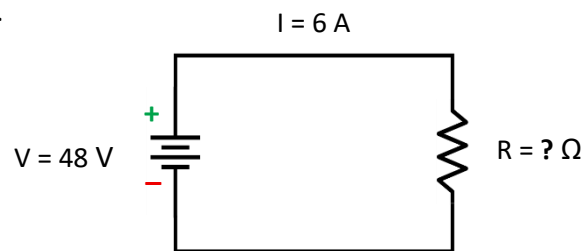
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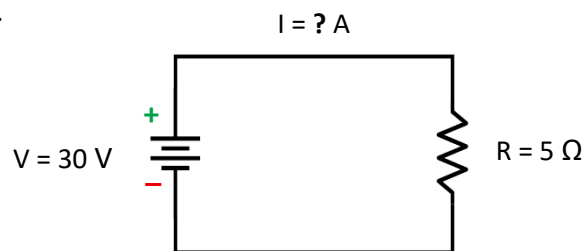
17.



18.



19.






Predicting Current

Use a thumbs up, thumbs down, or flat hand to respond.

What happens to current when...

- resistance increases and voltage stays the same?
- voltage increases but resistance stays the same?
- both voltage and resistance increase?
- voltage stays the same and resistance decreases?
- voltage decreases and resistance stays the same?

 Increase
 Stays the same
 Decrease

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Watts (W)

- Electrical power is measured in **watts (W)**.
- Power describes how much electrical energy is used or produced.
- *Examples:*
 - Light bulb → 60 W
 - Heater → 1500 W
 - Motor → 500 W
- **Watts = Volts × Amps**
- Higher watts = more power being used



Notes:

- Power is measured in watts, and it tells us how much electrical energy is being used or produced.
- Think of watts as the *total work being done* in a circuit.
- Looking at these examples:
 - A light bulb uses a small amount of power.
 - A heater uses a lot more.
 - A motor falls somewhere in between.
- We calculate power using volts and amps: **Watts = Volts X Amps**
- So, if either voltage or current increases, power also increases.
- Higher watts means more energy is being used—which often means more heat, more work, or more output from the equipment.

Horsepower (HP)

- Mechanical power is measured in Horsepower (HP).
- HP describes how much work a motor or engine can do over time.
- *Examples:*
 - Small fan motor → ¼ HP
 - Air compressor → 5 HP
 - Train traction motor → Hundreds or Thousands of HP
- **1 HP = 746 W**
- Horsepower = Mechanical Power



Notes:

- Horsepower (HP) is another way to measure power, but it is usually used to describe **mechanical power** instead of electrical power.
- Electric motors are often rated in horsepower because they produce motion or mechanical work.
- In transit systems, horsepower can describe the strength or output capability of motors used in equipment such as fans, pumps, compressors, or traction systems.
- **One horsepower is equal to about 746 watts.**
- In general, higher horsepower means a motor can do more work or move heavier loads.
- Examples:
 - Small fan motor = 1/4 HP
 - Shop air compressor = 5 HP
 - Train traction motor = hundreds or thousands of HP

Knowledge Check



Ohm's Law explains the relationship between which three electrical quantities?

(A). Voltage, power, and time

(B). Voltage, resistance, and temperature

(C). Voltage, resistance, and speed

(D). Voltage, current, resistance

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Knowledge Check



If the voltage in a circuit increases and the resistance stays the same, what happens to the current?

(A). Current decreases

(B). Current increases

(C). Resistance increases

(D). Resistance decreases

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Knowledge Check



Task: Given a circuit with a **25V** battery and a **5A** current, calculate the resistance.

- Which equation do we need?
- What goes in the equation?
- What is the solution?

$$R = V / I$$

$$R = 25V / 5A$$

$$R = 5\Omega$$

Knowledge Check



Scenario: A circuit breaker repeatedly trips in an electrical circuit. Based on voltage, current, and resistance, what might be causing this?

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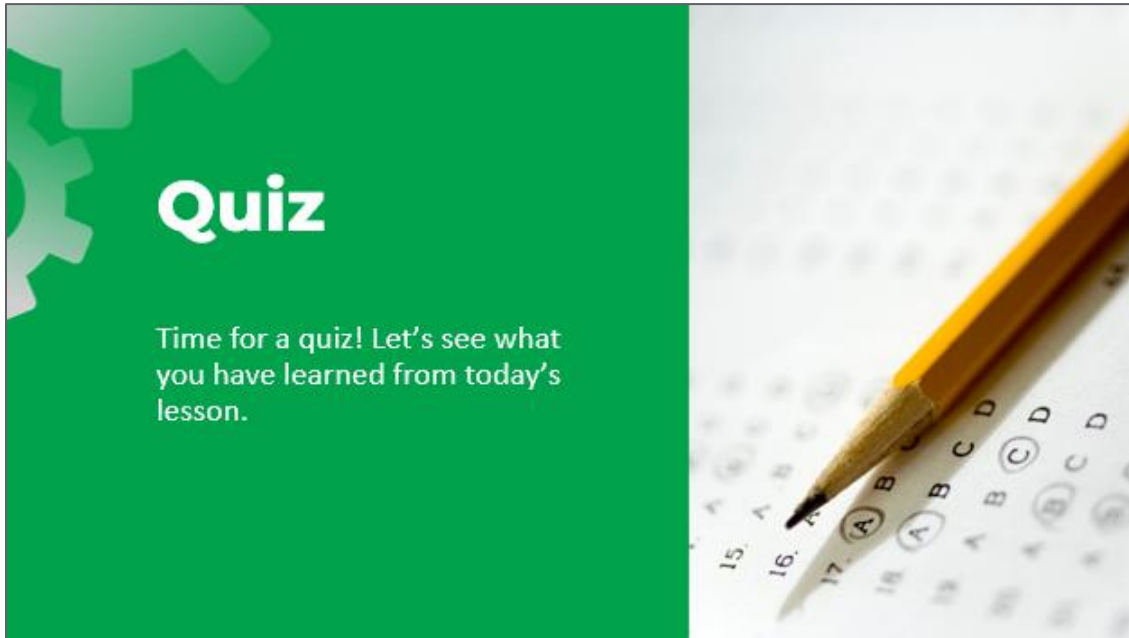
Module Summary

- Identify voltage, current, and resistance.
- Describe how each functions within an electrical circuit.
- Use Ohm’s Law to understand their relationship.
- Recognize the symbols (V, I, R) and calculate missing values.

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Notes:

- First, being able to identify voltage, current, and resistance is essential.
- You should be able to describe each one and recognize how they show up in a circuit.
- Second, Ohm’s Law ties everything together.
- It helps you understand how voltage, current, and resistance are related.
- You should now be able to identify the symbols—V, I, and R—and use them to calculate missing values.
- These concepts are the foundation for troubleshooting and understanding how electrical systems behave on the job.



Notes:

- Time for a quiz! Let's see what you have retained from today's lesson.

Revisiting Objectives

- Define and explain voltage, current, and resistance.
- Describe how voltage, current, and resistance are related in a simple circuit.
- Predict how changes in voltage or resistance affect current before measuring.
- Use Ohm’s Law to calculate a missing value in a basic circuit.

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Notes:

- If you were explaining today’s objectives to someone else, how would you summarize what they mean and why they matter?
- Which of today’s objectives do you feel most confident about? Which were most challenging? Explain your reasoning.
- Can you give an example of how you could apply one of today’s objectives in a real-world situation?
