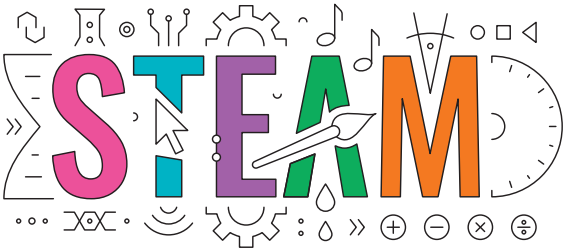

Circuit Wizard

Lesson Plans

Hamilton Buhl®

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Phone: 1-800-631-0868

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Lesson Plans for SKU #: CW16

Circuit Wizard

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Hamilton Buhl

Lesson 1: How to Build a Simple Circuit

Subject: Engineering • Grade Level: Middle to High School

Learning Objectives

- Students will be able to learn the basic components of circuits and the role of each part.
- Students will be able to learn the three states of the circuit, open circuit, path, short circuit.
- Students will be able to understand the harm caused by short circuits and the application of local short circuits.

Materials: Batteries, light bulbs, wire, wire strippers, electrical tape, safety goggles, simple circuit diagram

Begin by reviewing the basic components of circuits. A circuit is a path that electricity can flow through. The basic components of a circuit are:

Battery: The battery provides the power for the circuit.

Light bulb: The light bulb is the device that uses the electricity.

Wire: The wire connects the battery and the light bulb.

Switch: The switch controls the flow of electricity in the circuit.

Resistor: The resistor limits the amount of current that flows through the circuit.

Show students the three states of a circuit:

Open circuit: An open circuit is a circuit where the electricity cannot flow. This happens when there is a break in the wire or when a switch is turned off.

Path circuit: A path circuit is a circuit where the electricity can flow freely. This happens when the wire is unbroken and the switch is turned on.

Short circuit: A short circuit is a circuit where the electricity flows through a shortcut. This happens when the wire touches another wire or a metal object.

Lead a discussion about the harm caused by short circuits and the application of the local short circuits. Explain that short circuits can cause fires and damage to equipment. They can also be dangerous to people. However, short circuits can also be used to control the flow of electricity in a circuit. For example, a short circuit can be used to turn on a light bulb or a motor.

Have students build their own simple circuits. Provide them with batteries, light bulbs, wire, wire strippers, electrical tape, safety goggles, and a diagram of a simple circuit. Once they have built their circuits, have them test them to make sure that the light bulbs light up.

Conclude the lesson by reviewing the objectives and answering students' questions.

Assessment:

Observe students as they build their circuits. Make sure that they are using the correct materials and that they are following the correct safety procedures.

Ask students questions about the components of a circuit and the three states of a circuit.

Have students write a short summary of what they learned in the lesson.

Differentiation:

For students who are struggling, provide them with more support during the building process. You can help them to identify the correct materials and to follow the correct safety procedures.

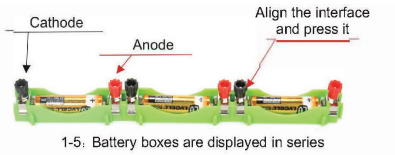
For students who are ahead, challenge them to build more complex circuits. You can provide them with additional batteries, light bulbs, and wire. You can also challenge them to build circuits with different components, such as switches and resistors.

Extensions:

- Have students research different types of circuits.
- Have students design and build their own circuits.
- Have students create a presentation about circuits for their classmates.

Battery Case Use Tips:

Three No.5 battery boxes can be used independently, or two or three sections in series or parallel. Figure 1-5 shows battery boxes connected in a series. Figure 1-6 shows the battery boxes in parallel.



1-5: Battery boxes are displayed in series

1-6: Battery boxes are connected in series to form a battery pack

Circuit Wizard™

Experiments:

1. Form a circuit as shown in Figure 1-1 and Figure 1-2. Close the switch to make the circuit work. What is a circuit breaker?
   Think: What are the parts of the most basic circuit, and what are the functions of each part?
2. Why is this connection method as shown in Figure 1-3 wrong and what are the results?
   Think about and summarize the three kinds of circuits state.
3. As shown in Figure 1-4, turn on switch S2 and observe the two indicator light bulb conditions, then close switch S1 again, and again observe the two bulbs. Analyze the current path of the switch in different states.

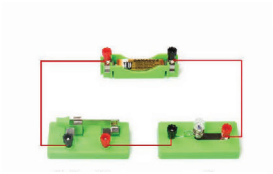


Figure 1-1: Proper Connection

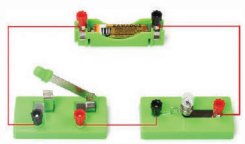


Figure 1-2: Open circuit

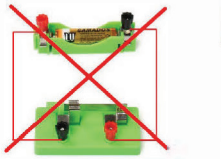


Figure 1-3: Improper circuit

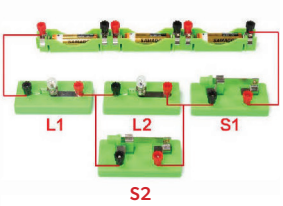


Figure 1-4: Close S1 and S2.
Bulb L2 is short-circuited

Lesson 2: Understanding Series and Parallel Circuits

Subject: Engineering • Grade Level: Middle to High School

Learning Objectives

- Students will be able to define a series circuit and a parallel circuit.
- Students will be able to connect a series circuit and a parallel circuit.
- Students will be able to identify the basic characteristics of series circuits and parallel circuits.

Materials: Battery box, batteries, switch, small light bulbs, wire, light bulb socket

Procedure: Begin by reviewing the basic components of circuits. A circuit is a path that electricity can flow through.
Basic components of a circuit are:

Battery: The battery provides the power for the circuit.
Light bulb: The light bulb is the device that uses the electricity.
Wire: The wire connects the battery and the light bulb.
Switch: The switch controls the flow of electricity in the circuit.
Resistor: The resistor limits the amount of current that flows through the circuit.

Introduce the concepts of series circuits and parallel circuits. A series circuit is a circuit where the components are connected in a single path. In a series circuit, the electricity flows through each component in the same order. A parallel circuit is a circuit where the components are connected in separate paths. In a parallel circuit, the electricity can flow through any of the paths.

Have students build a series circuit. Provide them with a battery box, a battery, a switch, two light bulbs, wire, and a small lamp holder. Have them connect the battery to the light bulbs in a single path. Once they have built the circuit, have them turn on the switch and observe what happens. The light bulbs should light up in the same way.

Have students build a parallel circuit. Provide them with the same materials as before, but have them connect the light bulbs in separate paths. Once they have built the circuit, have them turn on the switch and observe what happens. The light bulbs should light up independently of each other.

Lead a discussion about the basic characteristics of series circuits and parallel circuits. Explain that in a series circuit, the current is the same through all of the components. This means that if one light bulb burns out, the other light bulbs will also go out. In a parallel circuit, the current is divided among the components. This means that if one light bulb burns out, the other light bulbs will still work.

Conclude the lesson by reviewing the learning objectives and answering students' questions.

Assessment:
Observe students as they build the circuits. Make sure that they are using the correct materials and that they are following the correct safety procedures.

Ask students questions about the components of circuits, series circuits, and parallel circuits.

Have students write a short summary of what they learned in the lesson.

Differentiation:
For students who are struggling, provide them with more support during the building process. You can help them to identify the correct materials and to follow the correct safety procedures.

For students who are ahead, challenge them to build more complex circuits. You can provide them with additional batteries, light bulbs, and wire. You can also challenge them to build circuits with different components, such as switches and resistors.

Extensions:
- Have students research different types of circuits.
- Have students design and build their own circuits.
- Have students create a presentation about circuits for their classmates.

Experiments:

1. Form a circuit as shown in Figure 2-1. Observe and explore the characteristics of the circuit (outside the power supply the current is always from the positive terminal of the power supply, flowing through a circuit to the negative terminal).
2. Then, according to Figure 2-1 and Figure 2-3, change the connection method of the switch; study the function and explore the characteristics of the series circuit.
3. Form a parallel circuit as shown in Figure 2-4 and analyze the current flow direction; then close each switch, and observe the function of each switch in the circuit.

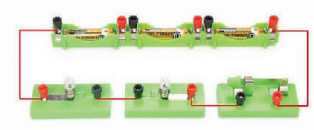


Figure 2-1

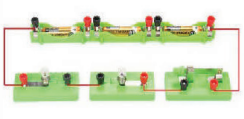


Figure 2-2

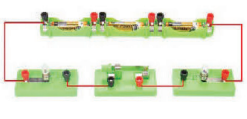


Figure 2-3

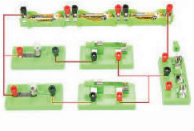


Figure 2-4

Lesson 3: Measuring Current with an Ammeter

Subject: Engineering • Grade Level: Middle to High School

Learning Objectives

- Students will be able to understand the measuring range and dividing value of the two ranges of ammeter.
- Students will be able to correctly connect the ammeter to the circuit and measure the current with different ranges.
- Students will be able to summarize the ammeter applicable methods and precautions.

Materials: Battery box, batteries, switch, ammeter, small light bulb, wire, light bulb socket

Procedure:

Begin by reviewing the basic components of an ammeter. An ammeter is a device that measures the current in a circuit. The ammeter has two ranges: a low range and a high range. The low range is used to measure small currents, and the high range is used to measure large currents.

Next, show students how to connect the ammeter to the circuit. The ammeter should be connected in series with the component that is being measured. This means that the current must flow through the ammeter in order to be measured.

Have students measure the current in a simple circuit with a light bulb. Provide them with a battery box, a battery, a switch, a light bulb, wire, and a lamp holder. Have them connect the ammeter in series with the light bulb. Once they have connected the ammeter, have them turn on the switch and observe the ammeter reading. The ammeter reading should be in the low range.

Have students repeat the experiment using the high range of the ammeter. Provide them with a battery box, a battery, a switch, a light bulb, wire, a lamp holder, and an ammeter set to the high range. Have them connect the ammeter in series with the light bulb. Once they have connected the ammeter, have them turn on the switch and observe the ammeter reading. The ammeter reading should be in the high range.

Lead a discussion about the ammeter applicable methods and precautions. Explain that the ammeter should always be connected in series with the component that is being measured. The ammeter should never be connected in parallel with the component that is being measured. The ammeter should also be turned off when it is not in use.

Conclude the lesson by reviewing the learning objectives and answering students' questions.

Assessment:

Observe students as they connect the ammeter to the circuit and measure the current. Make sure that they are using the correct ranges of the ammeter and that they are following the correct safety procedures.

Ask students questions about the measuring range and dividing value of the two ranges of ammeter, and how to correctly connect the ammeter to the circuit.

Have students write a short summary of what they learned in the lesson.

Differentiation:

For students who are struggling, provide them with more support during the building process. You can help them to identify the correct materials and to follow the correct safety procedures.

For students who are ahead, challenge them to measure the current in more complex circuits. You can provide them with additional batteries, light bulbs, and wire. You can also challenge them to measure the current in circuits with different components, such as resistors.

Extensions:

- Have students research different types of ammeters.
- Have students design and build their own ammeter.
- Have students create a presentation about ammeters for their classmates.

Experiments:

1. Connect the circuit as shown in Figure 3-1 to measure the current of a bulb, and read the ammeter.
2. As shown in Figure 3-2, the connection method is wrong, the ammeter is not able to work properly, and cannot access the circuit. Note: Watch the pointer before using the ammeter. Is the zero knob reading zero?

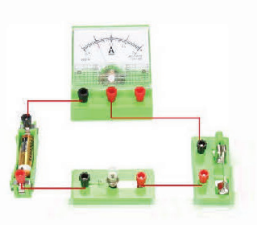


Figure 3-1

Figure 3-2

Lesson 4: What are Conductors, Insulators, Semiconductors and Superconductors?

Subject: Engineering • Grade Level: Middle to High School

Learning Objectives

- Students will be able to define a conductor and an insulator.
- Students will be able to distinguish between conductors and insulators.
- Students will know that there is no strict boundary between conductors and insulators, and that under certain conditions they can be converted to each other.
- Students will understand what semiconductors are and their applications.
- Students will inquire about superconductivity and its applications.

Materials: Battery box, batteries, switch, ammeter, small light bulb, wire, light bulb socket, a variety of materials such as metal, plastic, wood, rubber, and glass

Procedure:

Begin by reviewing the basic properties of conductors and insulators. Explain that conductors are materials that allow electricity to flow through them easily. Insulators are materials that prevent electricity from flowing through them.

Next, have students experiment with different materials to see if they are conductors or insulators. Provide them with a variety of materials, such as metal, plastic, wood, rubber, and glass. Have them touch each material to a battery and an ammeter. If the ammeter registers a reading, then the material is a conductor. If the ammeter does not register a reading, then the material is an insulator.

Lead a discussion about the fact that there is no strict boundary between conductors and insulators. Explain that the conductivity of a material can change depending on the conditions. For example, a material that is normally an insulator can become a conductor if it is heated to a high temperature.

Explain to students that semiconductors are materials that have intermediate conductivity between conductors and insulators. Semiconductors are used in a variety of electronic devices, such as computers, cell phones, and light bulbs.

Inquire about superconductivity. Explain that superconductors are materials that have zero electrical resistance. This means that electricity can flow through them without any loss of energy. Superconductors are used in a variety of applications, such as magnetic levitation trains and medical imaging devices.

Conclude the lesson by reviewing the learning objectives and answering students' questions.

Assessment:

Observe students as they experiment with different materials to see if they are conductors or insulators. Make sure that they are using the ammeter correctly and that they are following the correct safety procedures.

Ask students questions about the properties of conductors, insulators, semiconductors, and superconductors.

Have students write a short summary of what they learned in the lesson.

Differentiation:

For students who are struggling, provide them with more support during the experiments. You can help them to identify the correct materials and to use the ammeter correctly.

For students who are ahead, challenge them to research different types of conductors, insulators, semiconductors, and superconductors. You can also challenge them to design and build their own electronic devices that use semiconductors.

Extensions:

- Have students research the history of conductors, insulators, semiconductors, and superconductors.
- Have students design and build their own experiments to test the conductivity of different materials.
- Have students create a presentation about conductors, insulators, semiconductors, and superconductors for their classmates.

Experiment:

Put some common school supplies such as erasers, a small knife, coin, ruler, screwdriver (bring your own). Access the circuit to see the light bulb. See whether or not they emit light to determine whether or not these objects connected to the circuit can conduct enough current to understand conductors and insulators.

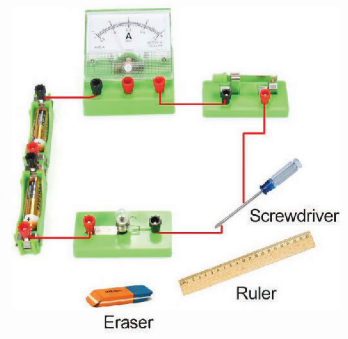


Figure 4-1

Lesson 5: Circuit Diagrams

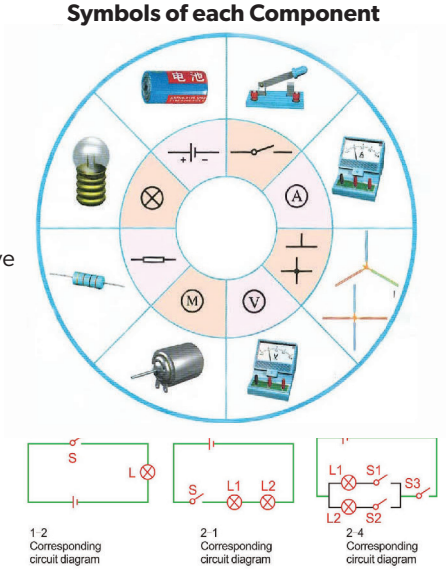
Subject: Engineering • Grade Level: Middle to High School

Learning Objectives

- Students will be able to know the circuit diagram symbols of common electrical components.
- Students will be able to draw the circuit diagram accurately and standardized.
- Students will be able to draw the corresponding circuit diagram according to the physical diagram, can connect the physical circuit according to the circuit diagram.
- Students will have preliminary ability to analyze circuits and can analyze circuits with the thought of equivalent circuits.

Materials: Battery box, batteries, switch, ammeter, small light bulb, wire, light bulb socket, a variety of circuit diagrams and physical circuits

Circuit Diagram with Symbols of each Component



Procedure:

Begin by reviewing the basic components of circuits. Explain that circuits are made up of components, such as batteries, light bulbs, switches, and resistors. Each component has a different symbol in a circuit diagram.

Next, show students a variety of circuit diagrams and physical circuits. Have them identify the components in each circuit and match the circuit diagram to the physical circuit.

Have students practice drawing circuit diagrams. Provide them with a variety of components and have them draw the circuit diagram for each component.

Lead a discussion about the importance of drawing circuit diagrams accurately and standardized. Explain that circuit diagrams are used to communicate the design of a circuit to others. It is important that the circuit diagram is accurate and standardized so that others can understand it.

Have students draw the corresponding circuit diagram according to the physical diagram. Provide them with a physical circuit and have them draw the circuit diagram for it.

Have students connect the physical circuit according to the circuit diagram.
Provide them with a circuit diagram and have them connect the physical circuit according to it.

Lead a discussion about the analysis of circuits. Explain that circuits can be analyzed by looking at the circuit diagram. The thought of equivalent circuits can be used to analyze circuits.

Have students analyze circuits with the thought of equivalent circuits. Provide them with a circuit diagram and have them analyze it using the thought of equivalent circuits.

Conclude the lesson by reviewing the learning objectives and answering students' questions.

Assessment:

Observe students as they draw circuit diagrams and analyze circuits. Make sure that they are using the correct symbols and that they are following the correct procedures.

Ask students questions about the circuit diagram symbols of common electrical components, how to draw circuit diagrams accurately and standardized, how to connect physical circuits according to circuit diagrams, and how to analyze circuits with the thought of equivalent circuits.

Have students write a short summary of what they learned in the lesson.

Differentiation:

For students who are struggling, provide them with more support during the drawing and analysis activities. You can help them to identify the correct symbols and to follow the correct procedures.

For students who are ahead, challenge them to draw more complex circuit diagrams and to analyze more complex circuits. You can also challenge them to design and build their own circuits.

Extensions:

- Have students research the history of circuit diagrams.
- Have students design and build their own circuit diagrams.
- Have students create a presentation about circuit diagrams for their classmates.

Experiment:

Figure 5-1 and Figure 5-2 can be analyzed and simplified and the circuit diagram can be drawn.

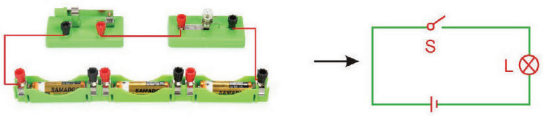


Figure 5-1 Figure 5-2

Lesson 6: The Current Rule of Series Circuits

Subject: Engineering • Grade Level: Middle to High School

Learning Objectives

- Students will master the current size law of the series circuit.
- Students will be able to use the series circuit current law for the circuit – Calculate.
- Students will be able to explore the characteristics of series circuits with ammeter.

Materials: Battery box, batteries, switch, ammeter, small light bulb, wire, light bulb socket

Procedure:

Begin by reviewing the basic components of circuits. Explain that circuits are made up of components, such as batteries, light bulbs, switches, and resistors. The current rule of series circuits states that the current in a series circuit is the same at all points in the circuit.

Next, show students a simple series circuit with a battery, a light bulb, and a wire. Have them identify the components in the circuit and explain how the current flows through the circuit.

Have students connect a ammeter in series with the light bulb in the circuit. Explain that the ammeter measures the current in the circuit. Have students turn on the switch and observe the ammeter reading. The ammeter reading should be the same at all points in the circuit.

Lead a discussion about the characteristics of series circuits. Explain that the current in a series circuit is the same at all points in the circuit. This means that if one light bulb burns out, the other light bulbs will also go out. The voltage drop across each component in a series circuit is equal to the current in the circuit times the resistance of the component.

Have students explore the characteristics of series circuits with ammeter. Provide them with a variety of components and have them build different series circuits. Have them measure the current and voltage drop across each component in the circuit.

Conclude the lesson by reviewing the learning objectives and answering students' questions.

Assessment:

Observe students as they build and measure series circuits. Make sure that they are using the ammeter correctly and that they are following the correct procedures.

Ask students questions about the current rule of series circuits, how to use an ammeter to measure current in a series circuit, and the characteristics of series circuits.

Have students write a short summary of what they learned in the lesson.

Differentiation:

For students who are struggling, provide them with more support during the building and measuring activities. You can help them to identify the correct components and to follow the correct procedures.

For students who are ahead, challenge them to build more complex series circuits and to measure the current and voltage drop across more components in the circuit. You can also challenge them to research the history of series circuits.

Extensions:

- Have students research the uses of series circuits in real life.
- Have students design and build their own series circuits.
- Have students create a presentation about series circuits for their classmates.

Experiment:

Figure 6-2 and Figure 6-3: Connect the ammeter to different places in the series circuit to explore the series circuit results. What are its characteristics?

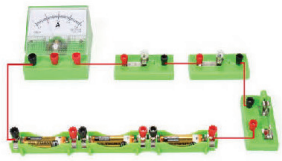


Figure 6-1

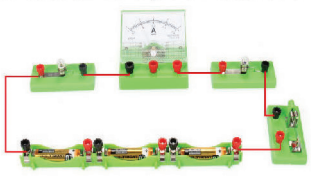


Figure 6-2

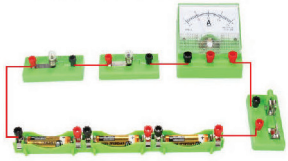


Figure 6-3

Lesson 7: The Current Law of Parallel Circuits

Subject: Engineering • Grade Level: Middle to High School

Learning Objectives

- Students will master the rule of parallel circuit and current size of each branch.
- Students will learn to calculate with the law of parallel circuit current.
- Students will be able to explore the characteristics of parallel circuits with ammeter.

Materials: Battery box, batteries, switch, ammeter, light bulb socket, wire, light bulb socket

Procedure:
Begin by reviewing the basic components of circuits. Explain that circuits are made up of components, such as batteries, light bulbs, switches, and resistors. The current rule of parallel circuits states that the total current in a parallel circuit is equal to the sum of the currents in each branch of the circuit.

Next, show students a simple parallel circuit with two light bulbs and a battery. Have them identify the components in the circuit and explain how the current flows through the circuit.

Have students connect a ammeter in each branch of the circuit. Explain that the ammeter measures the current in each branch of the circuit. Have students turn on the switch and observe the ammeter readings. The sum of the ammeter readings should be equal to the current of the battery.

Lead a discussion about the characteristics of parallel circuits. Explain that the total current in a parallel circuit is equal to the sum of the currents in each branch of the circuit. This means that if one light bulb burns out, the other light bulbs will still work. The voltage across each branch of a parallel circuit is the same.

Have students explore the characteristics of parallel circuits with ammeter. Provide them with a variety of components and have them build different parallel circuits. Have them measure the current and voltage across each branch of the circuit.

Conclude the lesson by reviewing the learning objectives and answering students' questions.

Assessment:
Observe students as they build and measure parallel circuits. Make sure that they are using the ammeter correctly and that they are following the correct procedures.

Ask students questions about the current rule of parallel circuits, how to use an ammeter to measure current in a parallel circuit, and the characteristics of parallel circuits.

Have students write a short summary of what they learned in the lesson.

Differentiation:
For students who are struggling, provide them with more support during the building and measuring activities. You can help them to identify the correct components and to follow the correct procedures.

For students who are ahead, challenge them to build more complex parallel circuits and to measure the current and voltage across more components in the circuit. You can also challenge them to research the history of parallel circuits.

Extensions:
- Have students research the uses of parallel circuits in real life.
- Have students design and build their own parallel circuits.
- Have students create a presentation about parallel circuits for their classmates.

Experiment:

As shown in Figures 7-1, 7-2, 7-3, connect the ammeter to the main circuit and each branch of the parallel circuit respectively. Analyze the experimental data to explore the parallel circuit trunk current and each branch current relationship.

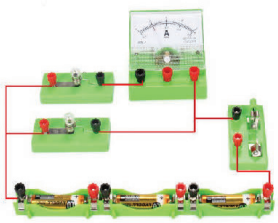


Figure 7-1

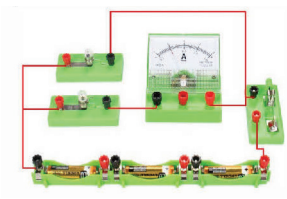


Figure 7-2

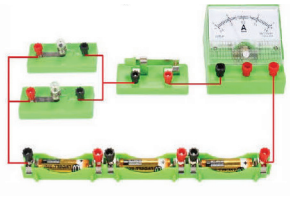


Figure 7-3

Lesson 8: Measuring Voltage with a Voltmeter

Subject: Engineering • Grade Level: Middle to High School

Learning Objectives

- Students will know the scale of the voltmeter, know the two quantities of the voltmeter's value range and relative relevance.
- Students will be able to correctly connect the voltmeter to the circuit.
- Students will further learn the habit of predicting the range.
- Students will summarize the voltmeter use method and matters needing attention.
- Students will know the voltage between the series battery pack and each battery's relationship.

Materials: Battery box, batteries, switch, voltmeter, small light bulb, wire, light bulb socket

Procedure:

Begin by reviewing the basic components of circuits. Explain that circuits are made up of components, such as batteries, light bulbs, switches, and resistors. A voltmeter is a device that measures the voltage in a circuit.

Next, show students the scale of the voltmeter. Explain that the scale shows the different voltages that the voltmeter can measure. The two quantities of the voltmeter's value range are the maximum voltage that the voltmeter can measure and the smallest voltage that the voltmeter can measure. The relative relevance is that the maximum voltage must be greater than the smallest voltage.

Have students connect a voltmeter to a simple circuit with a battery and a light bulb. Explain that the voltmeter should be connected in parallel with the light bulb. Have students turn on the switch and observe the voltmeter reading. The voltmeter reading should be equal to the voltage of the battery.

Lead a discussion about the habit of predicting the range. Explain that it is important to predict the range of the voltmeter before connecting it to a circuit. This will help to prevent the voltmeter from being damaged.

Summarize the voltmeter use method and matters needing attention. Explain that the voltmeter should always be connected in parallel with the component that is being measured. The voltmeter should also be turned off when it is not in use.

Have students measure the voltage between the series battery pack and each battery. Provide them with a series battery pack with three batteries and have them connect the voltmeter to each battery in the pack. Have students turn on the switch and observe the voltmeter readings. The voltmeter readings should be the same for each battery.

Conclude the lesson by reviewing the learning objectives and answering students' questions.

Assessment:

Observe students as they connect the voltmeter to the circuit and measure the voltage. Make sure that they are using the voltmeter correctly and that they are following the correct procedures.

Ask students questions about the scale of the voltmeter, how to predict the range of the voltmeter, and how to use the voltmeter to measure voltage.

Have students write a short summary of what they learned in the lesson.

Differentiation:

For students who are struggling, provide them with more support during the connecting and measuring activities. You can help them to identify the correct components and to follow the correct procedures.

For students who are ahead, challenge them to measure the voltage in more complex circuits. You can also challenge them to research the history of voltmeters.

Extensions:

- Have students research the uses of voltmeters in real life.
- Have students design and build their own voltmeter.
- Have students create a presentation about voltmeters for their classmates.

Experiment:

As shown in Figure 8-1, use a voltmeter to measure the voltage of one battery, two batteries, and three batteries.

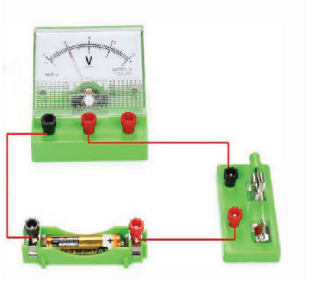


Figure 8-1

Lesson 9: The Voltage Rule of Series Circuits

Subject: Engineering • Grade Level: Middle to High School

Learning Objectives:

- Students will further skilled use of voltmeter voltage measurement.
- Students will master the voltage of each part of series circuit and the total voltage of circuit and the relationship between.
- Students will be able to apply the series circuit voltage law for circuit calculation.

Materials: Battery box, batteries, switch, voltmeter, small light bulb, wire, light bulb socket

Procedure:

Begin by reviewing the basic components of circuits. Explain that circuits are made up of components, such as batteries, light bulbs, switches, and resistors. The voltage rule of series circuits states that the total voltage of a series circuit is equal to the sum of the voltages across each component in the circuit.

Next, show students a simple series circuit with a battery, two light bulbs, and a voltmeter. Have them identify the components in the circuit and explain how the voltage flows through the circuit.

Have students connect the voltmeter to each light bulb in the circuit. Explain that the voltmeter measures the voltage across each light bulb. Have students turn on the switch and observe the voltmeter readings. The sum of the voltmeter readings should be equal to the voltage of the battery.

Lead a discussion about the relationship between the voltage of each part of the series circuit and the total voltage of the circuit. Explain that the voltage of each component in a series circuit is equal to the total voltage of the circuit divided by the number of components in the circuit.

Have students apply the series circuit voltage law for circuit calculation. Provide them with a series circuit with a battery, three light bulbs, and a voltmeter. Have students calculate the voltage across each light bulb.

Conclude the lesson by reviewing the learning objectives and answering students' questions.

Assessment:

Observe students as they connect the voltmeter to the circuit and measure the voltage. Make sure that they are using the voltmeter correctly and that they are following the correct procedures.

Ask students questions about the voltage rule of series circuits, how to use the voltmeter to measure voltage, and the relationship between the voltage of each part of the series circuit and the total voltage of the circuit.

Have students write a short summary of what they learned in the lesson.

Differentiation:

For students who are struggling, provide them with more support during the connecting and measuring activities. You can help them to identify the correct components and to follow the correct procedures.

For students who are ahead, challenge them to apply the series circuit voltage law to more complex circuits. You can also challenge them to research the history of the voltage rule of series circuits.

Extensions:

- Have students research the uses of the voltage rule of series circuits in real life.
- Have students design and build their own series circuits.
- Have students create a presentation about the voltage rule of series circuits for their classmates.

Experiment:

The voltmeters in Figure 9-1, 9-2, and 9-3 measure the voltages at L 1, L2, and L2 respectively. The total voltage of the circuit, analysis of experimental data, summarize the rule.

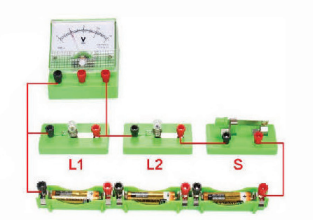


Figure 9-1

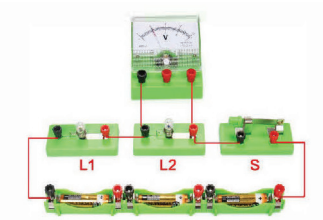


Figure 9-2

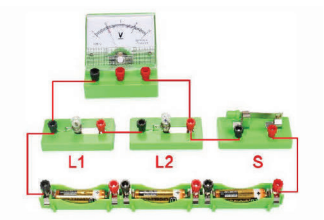


Figure 9-3

Lesson 10: The Voltage Rule of Parallel Circuits

Subject: Engineering • Grade Level: Middle to High School

Learning Objectives

- Students will master the voltage and total circuit voltage at both ends of each branch of the parallel circuit and the relationship between pressure.
- Students will be able to use the parallel circuit voltage for circuit calculation.

Materials: Battery box, batteries, switch, voltmeter, small light bulb, wire, light bulb socket

Procedure:

Begin by reviewing the basic components of circuits. Explain that circuits are made up of components, such as batteries, light bulbs, switches, and resistors. The voltage rule of parallel circuits states that the voltage at both ends of each branch of a parallel circuit is the same.

Next, show students a simple parallel circuit with a battery, two light bulbs, and a voltmeter. Have them identify the components in the circuit and explain how the voltage flows through the circuit.

Have students connect the voltmeter to each light bulb in the circuit. Explain that the voltmeter measures the voltage across each light bulb. Have students turn on the switch and observe the voltmeter readings. The voltmeter readings should be the same for each light bulb.

Lead a discussion about the relationship between the voltage at each part of the parallel circuit and the total voltage of the circuit. Explain that the voltage at each component in a parallel circuit is the same as the voltage of the battery.

Have students use the parallel circuit voltage for circuit calculation. Provide them with a parallel circuit with a battery, three light bulbs, and a voltmeter. Have students calculate the voltage across each light bulb.

Conclude the lesson by reviewing the learning objectives and answering students' questions.

Assessment:

Observe students as they connect the voltmeter to the circuit and measure the voltage. Make sure that they are using the voltmeter correctly and that they are following the correct procedures.

Ask students questions about the voltage rule of parallel circuits, how to use the voltmeter to measure voltage, and the relationship between the voltage at each part of the parallel circuit and the total voltage of the circuit.

Have students write a short summary of what they learned in the lesson.

Differentiation:

For students who are struggling, provide them with more support during the connecting and measuring activities. You can help them to identify the correct components and to follow the correct procedures.

For students who are ahead, challenge them to apply the parallel circuit voltage law to more complex circuits. You can also challenge them to research the history of the voltage rule of parallel circuits.

Extensions:

- Have students research the uses of the voltage rule of parallel circuits in real life.
- Have students design and build their own parallel circuits.
- Have students create a presentation about the voltage rule of parallel circuits for their classmates.

Experiments:

Measure the voltage U1 at both ends of L 1 as shown in Figure 10-1, and then measure the voltage U2 at both ends of L2 as shown in Figure 10-2. 10-3 Measure the parallel circuit voltage U and record it respectively to summarize the parallel circuit voltage rule.

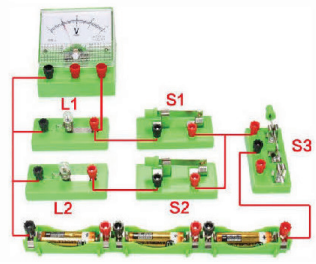


Figure 10-1

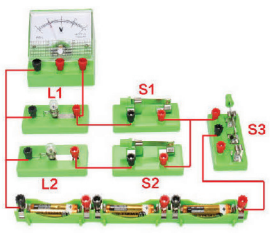


Figure 10-2

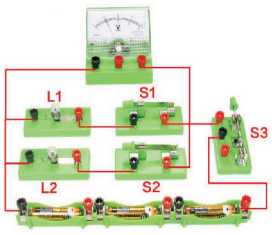


Figure 10-3

Lesson 11: The Voltage Rule of Battery Series

Subject: Engineering • Grade Level: Middle to High School

Learning Objectives

- Students will know what current in series, will form a series battery pack.
- Students will know the total voltage of the series battery pack and each battery and the relationship between.

Materials: Battery box, batteries, switch, voltmeter, wire

Procedure:

Begin by reviewing the basic components of circuits. Explain that circuits are made up of components, such as batteries, light bulbs, switches, and resistors. A battery series is a type of circuit where batteries are connected in series.

Next, explain that when batteries are connected in series, the current in the circuit is the same at all points in the circuit. This is because the electrons have to flow through each battery in the series.

Have students connect two batteries in series. Explain that the total voltage of the series battery pack is equal to the sum of the voltages of each battery in the pack. Have students measure the voltage of the series battery pack with a voltmeter. The voltmeter reading should be equal to the sum of the voltages of the two batteries.

Lead a discussion about the relationship between the total voltage of the series battery pack and the voltage of each battery in the pack. Explain that the voltage of each battery in a series battery pack is equal to the total voltage of the pack divided by the number of batteries in the pack.

Have students connect three batteries in series. Have students measure the voltage of each battery in the series battery pack with a voltmeter. The voltmeter readings should be equal to the total voltage of the pack divided by 3.

Conclude the lesson by reviewing the learning objectives and answering students' questions.

Assessment:

Observe students as they connect the batteries in series and measure the voltage. Make sure that they are using the voltmeter correctly and that they are following the correct procedures.

Ask students questions about the voltage rule of battery series, how to connect batteries in series, and the relationship between the total voltage of the series battery pack and the voltage of each battery in the pack.

Have students write a short summary of what they learned in the lesson.

Differentiation:

For students who are struggling, provide them with more support during the connecting and measuring activities. You can help them to identify the correct components and to follow the correct procedures.

For students who are ahead, challenge them to connect more batteries in series and to measure the voltage of each battery in the pack. You can also challenge them to research the history of battery series.

Extensions:

- Have students research the uses of battery series in real life.
- Have students design and build their own battery series.
- Have students create a presentation about battery series for their classmates.

Experiment:

As shown in Figure 11-1, measure the voltages of three batteries and connect two batteries in series to measure their voltages Voltage (Figure 11-2). Analyze the relationship between the total voltage of two batteries in series and the voltage of each battery again. Figure 11-3 Measures the total voltage of three batteries and the voltage of each battery.

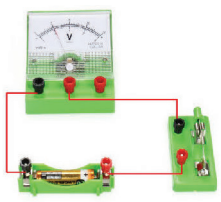


Figure 11-1

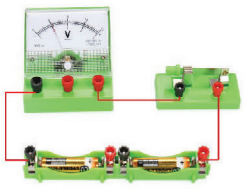


Figure 11-2

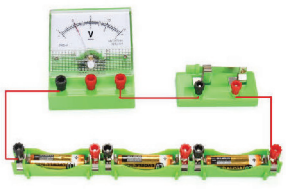


Figure 11-3

Lesson 12: The Voltage Rule of Parallel Battery Packs

Subject: Engineering • Grade Level: Middle to High School

Learning Objectives

- Students will know what is the parallel battery and battery parallel conditions.
- Students will know the relationship between the total voltage of the parallel battery pack and each battery.

Materials: Battery box, batteries, switch, voltmeter, wire

Procedure:

Begin by reviewing the basic components of circuits. Explain that circuits are made up of components, such as batteries, light bulbs, switches, and resistors. A parallel battery pack is a type of circuit where batteries are connected in parallel.

Next, explain that when batteries are connected in parallel, the voltage across each battery in the pack is the same. This is because the batteries are not connected in series, so the electrons do not have to flow through each battery in the pack.

Have students connect two batteries in parallel. Explain that the total voltage of the parallel battery pack is equal to the voltage of each battery in the pack. Have students measure the voltage of the parallel battery pack with a voltmeter. The voltmeter reading should be equal to the voltage of each battery.

Lead a discussion about the relationship between the total voltage of the parallel battery pack and the voltage of each battery in the pack. Explain that the voltage of each battery in a parallel battery pack is the same as the voltage of the battery itself.

Have students connect three batteries in parallel. Have students measure the voltage of each battery in the parallel battery pack with a voltmeter. The voltmeter readings should all be equal to the voltage of each battery.

Conclude the lesson by reviewing the learning objectives and answering students' questions.

Assessment:

Observe students as they connect the batteries in parallel and measure the voltage. Make sure that they are using the voltmeter correctly and that they are following the correct procedures.

Ask students questions about the voltage rule of parallel battery packs, how to connect batteries in parallel, and the relationship between the total voltage of the parallel battery pack and the voltage of each battery in the pack.

Have students write a short summary of what they learned in the lesson.

Differentiation:

For students who are struggling, provide them with more support during the connecting and measuring activities. You can help them to identify the correct components and to follow the correct procedures.

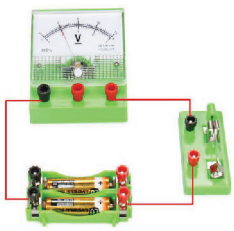
For students who are ahead, challenge them to connect more batteries in parallel and to measure the voltage of each battery in the pack. You can also challenge them to research the history of parallel battery packs.

Extensions:

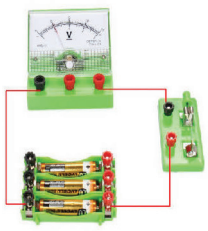
- Have students research the uses of parallel battery packs in real life.
- Have students design and build their own parallel battery pack.
- Have students create a presentation about parallel battery packs for their classmates.

Experiment:

Measure the voltage of a battery according to the method in Figure 12- 1, and connect the batteries with the same voltage in parallel. Analyze the relationship between the voltage after parallel connection and the voltage of each original battery.



12–1 Two batteries are connected in parallel



12-2 Three batteries Parallel battery string

Lesson 13: Measuring the Working Current of an LED

Subject: Engineering • Grade Level: Middle to High School

Learning Objectives

- Students will understand the unidirectional conductivity of diodes.
- Students will be able to measure the working current of an LED.
- Students will understand the energy-saving and environmental protection characteristics of LEDs.
- Students will understand the use of LEDs.

Materials: Battery box, batteries, switch, ammeter, wire, diode

Procedure:

Begin by reviewing the basic components of circuits. Explain that circuits are made up of components, such as batteries, light bulbs, switches, and resistors. A diode is a component that only allows current to flow in one direction.

Next, explain that LEDs are diodes that emit light when current flows through them. The working current of an LED is the amount of current that it needs to emit light.

Have students connect an LED to a battery and a switch. Explain that the LED will only light up when the switch is turned on. Have students measure the current through the LED with an ammeter. The ammeter reading should be equal to the working current of the LED.

Lead a discussion about the energy-saving and environmental protection characteristics of LEDs. Explain that LEDs are very efficient, meaning that they use less power than other types of light bulbs. LEDs also have a long lifespan, so they do not need to be replaced as often as other types of light bulbs. This makes LEDs a good choice for energy-saving and environmentally friendly lighting.

Have students research the uses of LEDs in real life. LEDs are used in a variety of applications, such as traffic lights, flashlights, and cell phones. Explain that LEDs are becoming increasingly popular as a light source because of their energy-saving and environmental protection characteristics.

Conclude the lesson by reviewing the learning objectives and answering students' questions.

Assessment:

Observe students as they connect the LED to the battery and measure the current. Make sure that they are using the ammeter correctly and that they are following the correct procedures.

Ask students questions about the unidirectional conductivity of diodes, the working current of LEDs, and the energy-saving and environmental protection characteristics of LEDs.

Have students write a short summary of what they learned in the lesson.

Differentiation:

For students who are struggling, provide them with more support during the connecting and measuring activities. You can help them to identify the correct components and to follow the correct procedures.

For students who are ahead, challenge them to measure the working current of different types of LEDs. You can also challenge them to research the history of LEDs.

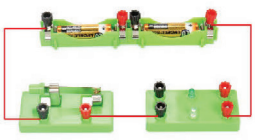
Extensions:

- Have students research the uses of LEDs in real life.
- Have students design and build their own LED circuit.
- Have students create a presentation about LEDs for their classmates.

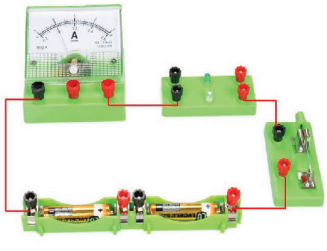
Experiment:

As shown in Figure 13-1, plug in one of the LEDs Circuit (Note that the power supply uses two batteries in series, about 3V voltage, If the voltage is high, the diode will breakdown and burn out. Change the current direction of the access circuit and watch. Check the diode's luminescence.

As shown in Figure 13-2, the LED is measured by an ammeter. What is the constant operating current?



13-1 Pay attention to distinguish between positive and negative terminals when connecting



13-2

Lesson 14: Factors that Affect the Resistance of a Conductor

Subject: Engineering • Grade Level: Middle to High School

Learning Objectives

- Students will learn that resistance is a basic property of conductors.
- Students will be able to say several factors affecting the size of conductor resistance.

Materials: Battery box, batteries, switch, ammeter, wire, pencil (bring your own)

Procedure:

Begin by reviewing the basic components of circuits. Explain that circuits are made up of components, such as batteries, light bulbs, switches, and resistors. A resistor is a component that resists the flow of current.

Next, explain that the resistance of a conductor is determined by several factors, including the length of the conductor, the cross-sectional area of the conductor, and the material of the conductor.

Have students connect a battery, a switch, an ammeter, and a piece of wire in a series circuit. Explain that the ammeter will measure the current flowing through the wire. Have students measure the current flowing through the wire for different lengths of wire. The students should observe that the current decreases as the length of the wire increases. This is because the longer the wire, the more resistance it has.

Have students repeat thes experiment, but this time with wires of different cross-sectional areas. The students should observe that the current increases as the cross-sectional area of the wire increases. This is because the larger the cross-sectional area, the less resistance the wire has.

Have students repeat the experiment, but this time with wires made of different materials. The students should observe that the current varies depending on the material of the wire. This is because different materials have different resistivities.

Conclude the lesson by reviewing the learning objectives and answering students' questions.

Assessment:

Observe students as they connect the components in the circuit and measure the current. Make sure that they are using the ammeter correctly and that they are following the correct procedures.

Ask students questions about the resistance of a conductor, the factors that affect the resistance of a conductor, and the relationship between the length, cross-sectional area, and material of a conductor and its resistance.

Have students write a short summary of what they learned in the lesson.

Differentiation:

For students who are struggling, provide them with more support during the connecting and measuring activities. You can help them to identify the correct components and to follow the correct procedures.

For students who are ahead, challenge them to research the history of resistance. You can also challenge them to design and build their own circuit that measures the resistance of different materials.

Extensions:

- Have students research the uses of resistance in real life.
- Have students design and build their own circuit that uses resistance to control the flow of current.
- Have students create a presentation about resistance for their classmates.

Experiment:

Use a pencil (bring your own) to access the circuit, change the length of the access lead, observe the ammeter and lamp and changes in bubble brightness.

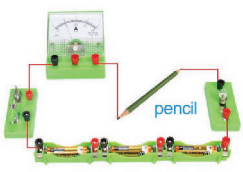


Figure 14-1

Lesson 15: Using a Sliding Rheostat to Change the Brightness of a Bulb

Subject: Engineering • Grade Level: Middle to High School

Learning Objectives

- Students will understand the structure of a sliding rheostat and know the principle of a sliding rheostat.
- Students will be able to correctly use a sliding rheostat and know the characteristics of six connection methods of a sliding rheostat.
- Students will explore and understand the function of a sliding rheostat in a circuit through experiment.

Materials: Battery box, batteries, switch, sliding rheostat, wire

Procedure:

Begin by reviewing the basic components of circuits. Explain that circuits are made up of components, such as batteries, light bulbs, switches, and resistors. A rheostat is a variable resistor, which means that it can change its resistance.

Next, explain the structure of a sliding rheostat. A sliding rheostat is made up of a resistance wire and a sliding contact. The resistance wire is made of a material with a high resistance, such as nichrome. The sliding contact is made of a material with a low resistance, such as copper.

Explain the principle of a sliding rheostat. When the sliding contact is moved closer to one end of the resistance wire, the resistance of the rheostat decreases. When the sliding contact is moved closer to the other end of the resistance wire, the resistance of the rheostat increases.

Have students connect a battery, a switch, a sliding rheostat, and a light bulb in a series circuit. Explain that the light bulb will only light up when the switch is turned on. Have students move the sliding contact of the rheostat to different positions and observe the brightness of the light bulb. The students should observe that the brightness of the light bulb decreases as the sliding contact is moved closer to one end of the resistance wire. This is because the resistance of the rheostat decreases, which allows more current to flow through the circuit.

Have students repeat the experiment, but this time with different connection methods of the sliding rheostat. The students should observe that the brightness of the light bulb varies depending on the connection method of the sliding rheostat. This is because the different connection methods change the total resistance of the circuit.

Conclude the lesson by reviewing the learning objectives and answering students' questions.

Assessment:

Observe students as they connect the components in the circuit and move the sliding contact of the rheostat. Make sure that they are following the correct procedures.

Ask students questions about the structure of a sliding rheostat, the principle of a sliding rheostat, and the characteristics of six connection methods of a sliding rheostat.

Have students write a short summary of what they learned in the lesson.

Differentiation:

For students who are struggling, provide them with more support during the connecting and experimenting activities. You can help them to identify the correct components and to follow the correct procedures.

For students who are ahead, challenge them to research the history of rheostats. You can also challenge them to design and build their own circuit that uses a rheostat to control the brightness of a light bulb.

Extensions:

- Have students research the uses of rheostats in real life.
- Have students design and build their own circuit that uses a rheostat to control the speed of a fan.
- Have students create a presentation about rheostats for their classmates.

Experiment:

As shown in Figure 15-2, connect the circuit, move the sliding rheostat slice, and observe the brightness change of the bulb How does the current flow through the sliding rheostat? How does sliding resistive change the resistance of the connected circuit?

The sliding rheostat has four terminals, each of which are connected in pairs to the circuit, giving a total of six connections. So, what's the difference between these six connections? What are the connections that can change the resistance? What are the connections that cannot change? How many kinds of connection methods are there for variable resistance? What are its characteristics?

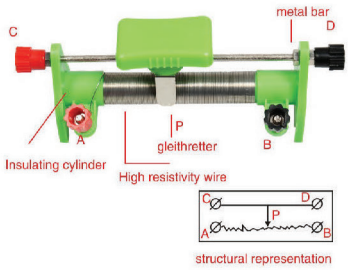


Figure 15-1

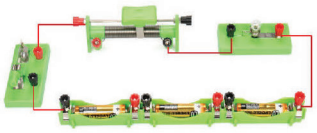


Figure 15-2

Lesson 16: Ohm's Law

Subject: Engineering • Grade Level: Middle to High School

Learning Objectives:

- Students will learn the relationship between conductor current and voltage at both ends through experiment.
- Students will master the relationship between conductor current and conductor resistance through experiments.
- Students will learn the relationship between current, voltage and resistance in a local circuit (a section of circuit), so as to understand ohm law.
- Students will be able to use Ohm's law formula for circuit calculation.

Materials: Sliding rheostat, ammeter, voltmeter, resistor, battery case, battery, switch, wire

Procedure:

Begin by reviewing the basic components of circuits. Explain that circuits are made up of components, such as batteries, light bulbs, switches, and resistors. A resistor is a component that resists the flow of current.

Next, explain Ohm's law. Ohm's law states that the current in a circuit is directly proportional to the voltage across the circuit and inversely proportional to the resistance of the circuit.

Have students connect a battery, a switch, an ammeter, a voltmeter, and a resistor in a series circuit. Explain that the ammeter will measure the current flowing through the circuit, the voltmeter will measure the voltage across the resistor, and the resistor will measure the resistance of the circuit.

Have students adjust the sliding rheostat to different positions and observe the readings on the ammeter and voltmeter. The students should observe that the current in the circuit increases as the voltage across the resistor increases. They should also observe that the current in the circuit decreases as the resistance of the resistor increases.

Have students repeat the experiment, but this time with different resistors. The students should observe that the current in the circuit varies depending on the resistance of the resistor. This is because the different resistors have different resistances.

Conclude the lesson by reviewing the learning objectives and answering students' questions.

Assessment:

Observe students as they connect components in the circuit and adjust the sliding rheostat. Make sure they are following the correct procedures.

Ask students questions about Ohm's law, the relationship between current, voltage, and resistance, and the results of their experiments.

Have students write a short summary of what they learned in the lesson.

Differentiation:

For students who are struggling, provide them with more support during the connecting and experimenting activities. You can help them to identify the correct components and to follow the correct procedures.

For students who are ahead, challenge them to research the history of Ohm's law. You can also challenge them to design and build their own circuit that demonstrates Ohm's law.

Extensions:

- Have students research the uses of Ohm's law in real life.
- Have students design and build their own circuit that uses Ohm's law to control the brightness of a light bulb.
- Have students create a presentation about Ohm's law for their classmates.

Experiment:

From previous experiments, we guess that the current may be affected by the voltage as well as by the current. When we design experiments to study the relationship between current and voltage and resistance, we should study separately. Below, we use a fixed resistance to replace a conductor or a section of circuit to test the relationship between these three physical quantities.

As shown in Figure 16-1, connect the 5 ohm and 15 ohm resistors respectively, and adjust the sliding rheostat each time The voltage at both ends of R value is unchanged, and the change of current in the circuit is measured and recorded at the same time. Summarize the relationship between current and resistance.

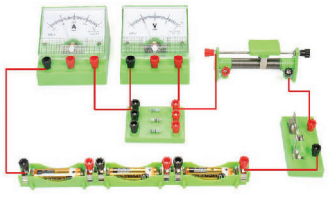


Figure 16-1

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