University of Wyoming
Science Posse

Fun With Electricity
Luke Dosiek

Lesson Plan: Electric Circuits (~130 minutes)

Concepts

1. Electricity is the flow of electric charge (electrons).
2. Electric Charge is a property of subatomic particles.
3. Current is the movement of electric charge.
4. Voltage is the electric potential that exists to move a charge.
5. Power is the rate at which electric energy is flowing in a circuit.
6. Ohm's Law: Power = Voltage x Current.
7. Resistance is a physical property that quantifies how well a charge can move through a material.
8. Ohm's Law: Voltage = Current x Resistance.
9. Electric circuits provide a means to harness electrical energy and use it in our everyday lives.
10. Circuits require a voltage source to operate.
11. Circuits require a closed loop to operate; that is they need a path for the electric current to return to its source.
12. Circuits can be connected in either series or parallel.
13. Components connected in series have identical current, but different voltage.
14. Components connected in parallel have identical voltage, but different current.

Key Questions

1. What is electricity?
2. What are electric charge, current, voltage, and power, and how are they related?
3. Can current flow without a voltage source?
4. How does the resistance of a material determine how much electric current flows through it?
5. Will current flow through an open (disconnected) circuit? Why or why not?
6. What is the difference between series and parallel connections?
7. Where do we find electric circuits in our lives?

Student Learning Objectives	Standards
Students will be able to explain how electric current flows in a circuit.	WYO 8.A.S.1.7, 11.A.S.1.7; Benchmarks 13 and 14
Students will be able to wire a basic circuit.	
Students will be able to take measurements on a circuit.	
Students will be able to explain the difference between series and parallel connections.	

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Anticipatory Set

- Electricity and electric circuits are all around us.
- Discuss examples of electric circuits and electricity.
- In order to further explore the concepts of electricity a basic knowledge of the electric circuit is required.
- Electrical engineers work daily with circuits.

Key Terms

Electricity	Charge	Coulomb
Current	Ampere	Voltage
Resistance	Ohm	Power
Watt	Ohm's Law	Circuit
Series	Parallel	

Teaching Plan

General Plan
- Part 1: Introduce electricity
- Part 2: The electric circuit
- Part 3: Electric circuit activity

The accompanying PowerPoint presentation, Electricity.ppt, closely follows the following teaching plan.

- Part 1: Introduce electricity
  - Define **electricity** as the physical phenomena associated with the flow or movement of **electric charge. (10 min.)**
    - This is just a definition. Let the students ask questions about electricity and discuss, leading them to the definitions and explanations below.
  - Define **electric charge** as a fundamental property of some subatomic particles. **(20 min.)**
    - Protons have a positive charge
    - Electrons have a negative charge
    - Neutrons have no charge (neutral)
    - Particles of opposite charge are attracted to each other
    - Particles of negative charge are repelled
      - Use North and South magnetic poles as an analogy
    - The SI (Le **S**ysteme **I**nternational) unit for charge is the **coulomb (C)**
      - It takes 6.25×10^{18} protons to equal one coulomb!

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- This is 6,250,000,000,000,000,000 protons!
- How many coulombs is 6.25 x 10^{18} electrons? (**negative one coulomb)**

- The space around an electric charge is called the **electric field**.
- Explain that a **conductor** is something which freely allows the motion of electric charge and an **insulator** is the opposite; it greatly resists the flow of charge.
- A buildup of electric charge on an insulator creates **static electricity.**
  - Use a balloon as an example demonstration.
  - Rub the inflated balloon on someone's hair and watch the hair stand up in the presence of the excess charge!
- In a conductor, a buildup of charge will freely move through the conductor, resulting in **electric current**.

- Define **electric current** as the flow of electric charge. **(20 min.)**
  - Typically the electric charge is in the form of electrons
  - As a result, electric current, and electricity in general, is often defined as the flow of electrons. This is not always a true definition, as electric current can be the result of the flow of other charged particles, so it's best to stick with the idea that current is the flow of charge.
  - In fact "conventional current," which is what is used by all electrical engineers, is the flow of positive charge.
  - The flow of charge in a current carrying wire is really just a flow of energy, transferred from one charged particle to the next.
  - So it's not electrons racing through a wire, it's their charges.
  - The actual electrons move much more slowly through the wire. In fact their movement is called **electron drift**.
  - Use Newton's Cradle as an example to help visualize this.

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    - The momentum moving through the balls that forces the ball at the far end to move almost instantaneously is like the electric current in a wire. The motion of all of the balls moving at once is like the actual motion of the electrons in the wire.
    - The SI unit of current is the **Ampere (A)**.
    - Current is measured with an **ammeter.**
    - Current can only flow in the presence of an electric field, often provided by a **voltage source**
  - Define **voltage** as the electric potential between two points. **(10 min.)**
    - It is the potential for an electric field to cause an electric current to flow.
    - Going back the Newton's Cradle, the force of gravity that causes the first ball to move can be thought of as the voltage that causes the current to flow.
    - The SI unit for voltage is the **volt (V)**.
    - How many volts are in
      - a AA battery? (**1.5 V**)
      - the wall outlet? (**120 V**)
      - the power lines in the street? (about **13,000 V**)
      - the large power lines? (up to **765,000 V)**
      - lightning? (about **100,000,000 V)**
    - Voltage is measured with a **voltmeter.**
  - Define **electric power** as the rate at which electrical energy is transferred. **(5 min)**
    - The SI unit for power is the **watt (W).**
    - **Ohm's Law: Power = Voltage x Current**
  - Define **resistance** as a physical property which describes how well electric current flows in a material **(5 min)**
    - The SI unit for resistance is the **ohm (Ω)**
    - **Ohm's Law: Voltage = Resistance x Current**
  - Go through a simple example of Ohm's law using a single resistor connected to a voltage source and calculate the current being drawn and the power being consumed. **(15 min)**
    - If a 5 Ω resistor is connected to a 12V battery, how much current is drawn from the battery?
      - Current = Voltage / Resistance = 12V / 5 Ω = 2.4A
    - How much power is the resistor consuming?
      - Power = Voltage x Current = 12V x 2.4A = 28.8 W

- Part 2: The electric circuit
  - Define the **electric circuit** as a connection of two or more components to form a **closed loop. (5 min)**

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- The closed loop is necessary to allow the electric current to flow from one point of the voltage source to the other **(5 min)**
  - Remember, a voltage is the electric potential between **two** points.
- Circuit elements can be connected in either **series or parallel** configurations **(20 min)**
  - Series components are connect in line with each other.
    - They provide a single path for the current to flow.
    - Therefore, they share the same current
    - **Components in series have the same current**
    - They divide the voltage among themselves
    - **Components in series have different voltages**
    - The different voltages add up to the original total voltage of the voltage source
  - Parallel components are connected side by side.
    - Each component provides a different path for the current to flow
    - **Components in parallel have different currents**
    - The different currents add up to the current in the voltage source
    - **Components in parallel have the same voltage**
- Use the Christmas light example. If one light goes out, do they all go out? Does this mean the lights are series or parallel? **(If they all go out, it's series, if not it's parallel. If SOME go out, then it's a combination of series and parallel!) (5 min)**
- Discuss other examples of electric circuits from the tiny (microprocessors) to the large (the power lines). **(5 min.)**

- Part 3: Electric circuit inquiry (**30 min**)
  - Break the students up into groups of 4 or less.
  - Hand out the activity sheets and materials
  - They are building simple circuits with batteries for the voltage sources and small light bulbs for the components.
  - Be sure to help them connect the circuits, as they probably have never done so before
  - They connect the bulbs in both series and then parallel configurations
  - They measure the voltages and currents of each bulb in both configurations to verify the properties of series and parallel connections
  - As the students perform the experiments, stress the closed loop idea in the circuits, as well as the basic definitions of electricity.
    - What is the battery doing?
    - Where is the current flowing?
    - Do your measurements make sense? Why?

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- By the end the students should be able to calculate the power and resistance of the lamps from their voltage and current measurements.

Example circuits for the activity:

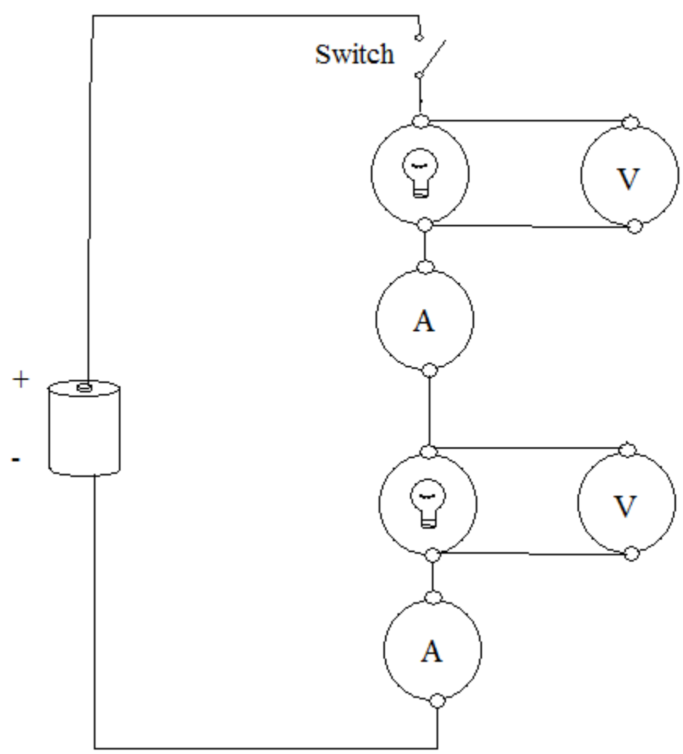

Fig. 1 - The series connection of the circuit

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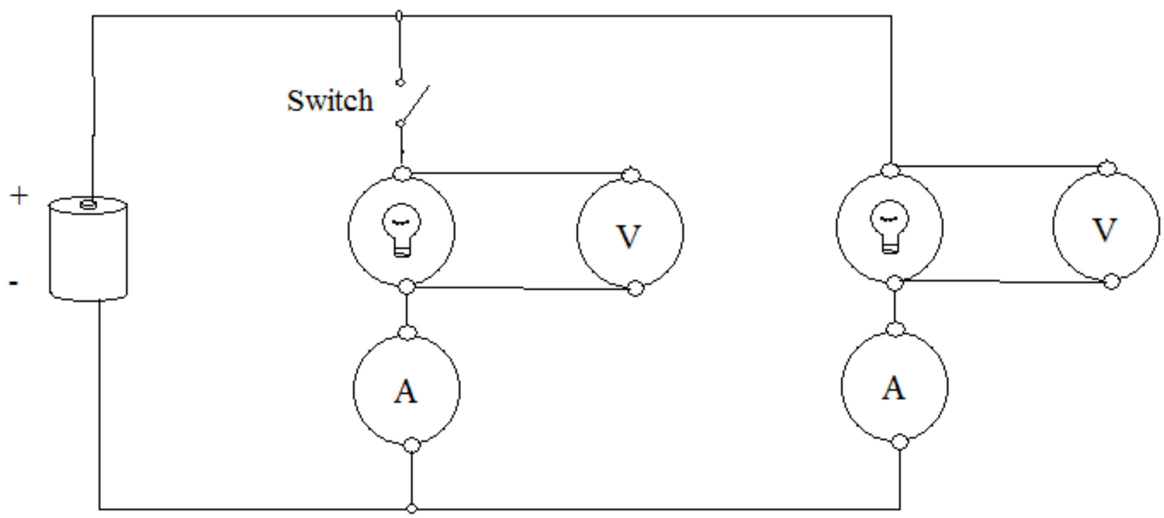

Fig. 2 - The parallel connection of the circuit

Resources

Electricity.ppt PowerPoint file
Balloon
Newton's Cradle
Series vs Parallel and Related Materials

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Lesson 1 Unshifted Activity: Series vs. Parallel

Purpose

Electricity is all around us. Electric circuits provide a way to harness that electricity and make it perform a useful task. In this activity you will learn how an electric circuit is constructed. You will also discover the difference between series and parallel connections, and how to measure voltage and current in a circuit. In doing so, you will gain a better understanding of how electricity flows through the wires of a circuit.

Materials

- Battery with holder
- 2 Lamps
- 2 Ammeters
- 2 Voltmeters
- 8 Wires
- 1 Switch

Procedure

1. Form groups and gather your materials as instructed by your teacher.
2. You will first build the **series** circuit. Connect the components as shown in Figure 1. Use the clips on the wires to make the connections. For the meters, make sure they both get connected in the same direction (the red terminal closer to the + terminal of the battery, or “up” on the drawing below).
3. Begin with the switch closed.
4. Record the readings from the meters
   - Ammeter 1 = ______________________ A
   - Ammeter 2 = ______________________ A
   - Voltmeter 1 = ______________________ V
   - Voltmeter 2 = ______________________ V

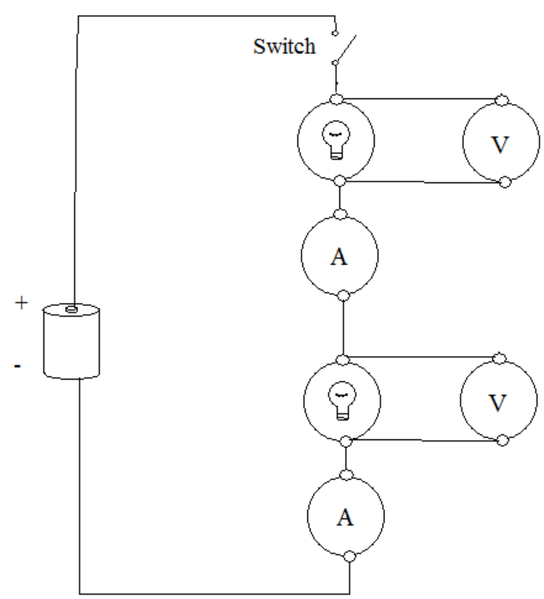

Fig. 3 - The series connection of the circuit

5. Now open the switch. What happened?

____

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6. Now connect the circuit as shown in Figure 2. This is the **parallel** circuit.
7. Begin with the switch closed.
8. Record the readings from the meters
    - Ammeter 1 = ______________________ A
    - Ammeter 2 = ______________________ A
    - Voltmeter 1 = ______________________ V
    - Voltmeter 2 = ______________________ V
9. Now open the switch. What happened?

    ____

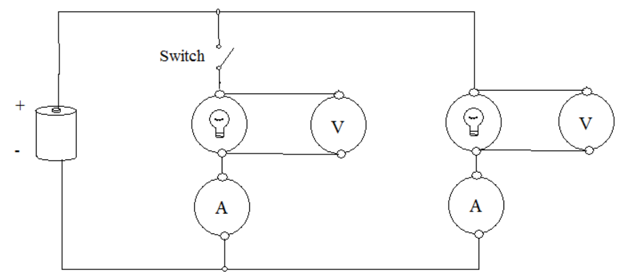

Fig. 4 - The parallel connection of the circuit

Discussion Questions

1. Components in series have the same ________________________.
2. Components in parallel have the same ________________________.
3. In the series circuit, why did opening the switch turn off both bulbs?
    ____
    ____
    ____
4. In the parallel circuit, why did opening the switch turn off only one bulb?
    ____
    ____
    ____
5. Why does electricity flow through the light bulbs?
    ____
    ____
    ____
6. Give three examples of electric circuits that are in your classroom right now
    ____
    ____
    ____

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Lesson 1 Shifted Activity: Series vs. Parallel

Purpose
Electricity is all around us. Electric circuits provide a way to harness that electricity and make it perform a useful task. In this activity you will learn how an electric circuit is constructed. You will also discover the difference between series and parallel connections, and how to measure voltage and current in a circuit. In doing so, you will gain a better understanding of how electricity flows through the wires of a circuit.

Materials
- Battery with holder
- 2 Lamps
- 2 Ammeters
- 2 Voltmeters
- 8 Wires
- 1 Switch

Experimentation: Part 1

Design a data-collection sheet on which you can record any measurements or observations based on the goals listed below. Then using the equipment provided, try to complete the following.

- Light the bulbs.
- Measure a voltage.
- Measure a current.

Experimentation: Part 2

Based on the class discussion and your experience in Part 1, design a new data-collection sheet for the tasks below. Now do the following.

- Predict the difference between series and parallel connections.
- Test your predictions and record the results.
- Propose a way to calculate the resistance and power of the bulbs.
- Calculate the resistance and power of the bulbs and record the results.

Summary

1. Analyze and summarize the results of your experiment.
2. List any questions you still have about your experiment.
3. Describe what you have learned about electric circuits from this activity.

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