RESOURCE LIBRARY
ACTIVITY : 30 MINS

Building Circuits

Students experiment with batteries, wires, bulbs, and switches to assemble series and parallel circuits and to test for conductivity in sample items.

GRADES

4 - 8

SUBJECTS

Physics

CONTENTS

6 PDFs

OVERVIEW

Students experiment with batteries, wires, bulbs, and switches to assemble series and parallel circuits and to test for conductivity in sample items.

For the complete activity with media resources, visit:
http://www.nationalgeographic.org/activity/building-circuits/

Program

DIRECTIONS

1. Activate students' prior knowledge about electricity.

Find out what students already know about electricity. Encourage them to identify objects in the room that use electricity. Ask: *Do you know how electricity travels to power these devices?* (Electricity travels through circuits.) Ask: *How is electricity used in more complicated projects, like powering a robot?* Explain that electricity is used to provide power to various parts of the robot, such as moving mechanical parts, systems that provide control for the robot (like the CPU), and data-gathering components (like sensors).

2. Introduce the concept of a circuit.

Draw a circle on the board. Ask: *Is the shape open or closed*? (It is closed.) Now draw a circular shape that is not complete, like a "u," on the board. Ask: *Is this shape open or closed?* (It is open.) Inform students that in order for electricity to flow and power a device, there must be an unbroken, or closed, pathway. Do a quick demonstration using the room's lights. Flip the light off in the classroom. Tell students when the light goes off, the circuit is open and electricity cannot reach the bulb to produce light. Reference the shapes previously drawn on the board. Flip the light back on. Tell students the circuit is now closed and electricity is free to travel and illuminate the bulb.

3. Students build a simple circuit to light a bulb with the help of a diagram and demonstration.

Tell the class they will now build a closed simple circuit to light a bulb. Show the class the separate pieces they will use: a D cell battery; the holder for the D cell battery; four alligator clip leads; a 2.5 volt, 0.2 amp, or smaller bulbs with a screw-type base; and two bulb holders. Separate the class into working groups of 2-4 students and distribute the parts listed above to each group. Explain that their group goal is to work together to build a simple circuit that will light the bulb. Explain that you will demonstrate how to build a circuit and they will follow along, but later on they will need to work in their groups to build a circuit on their own. Draw a simple circuit diagram on the board, and label and explain all of the parts, using the provided diagram. Walk the class through building the circuit using the How to Build a Simple Circuit handout.

After groups have successfully lit the bulb, have them make a labeled sketch of the circuit they built in their notebooks. Ask: *What would happen if a switch were added to this circuit?* Provide each group with a single knife switch and have them update their circuit. Elicit answers from students that help them make connections between the closed circuit they just built, and the earlier demonstration with the classroom light that creates an open and closed circuit. Update the diagram you previously drew on the board to include a switch using the Simple Circuit with Switch diagram provided.

4. Students build series and parallel circuits in small groups.

Ask students to remove the knife switch from their circuit, so they have a simple circuit again. Ask the class to predict what will happen if an additional bulb is added to the simple circuit, without making any other changes. (Again, the knife switch should no longer be included in the circuit.) Have students record their predictions in their notebooks. As students are making predictions, give an additional light bulb and bulb holder to each group. Then, allow groups time to experiment with lighting two bulbs on a single pathway. Remind groups of what a single closed pathway is by drawing attention back to the diagram on the board and the first circuit they built. Facilitate as needed. Use the provided How to Build a Series Circuit handout that contains a diagram to check student work.

After they have successfully built their circuits, tell students that this type of circuit is called a series circuit. It has a single pathway from the energy source (battery) through a series of loads (bulbs) and back to the energy source. Ask: *What happened when a second light bulb was added?* Explain that the bulbs are dimmer because the additional bulb slows the flow of electricity in the circuit, causing the lights to dim. Ask: *What might happen with the addition of a third bulb?* Explain they could expect the bulbs to be even dimmer or not light at all. Ask: *What would happen if a component in the circuit is disconnected or if there is a broken bulb in this circuit?* (The circuit will be open and none of the bulbs will work.) Have students make a labeled sketch of their series circuit in their notebooks and record their observations about building this type of circuit.

Pose the following question to the class: *If one bulb in your circuit went out, what would be necessary in order for the other bulb to remain lit?* Explain that the configuration of the circuit must change so bulbs are on separate closed pathways with the energy source. Allow time for groups to experiment with building a circuit that lights both bulbs, with the additional challenge that one bulb must remain lit when a single component is disconnected within the circuit. Facilitate as needed. Use the provided How to Build a Parallel Circuit handout that contains a diagram to check student work.

Explain that this type of circuit is called a parallel circuit, where bulbs are connected on separate pathways. Each bulb in a parallel circuit will be equally bright, but will drain the battery at an accelerated rate. Have students compare and contrast the working models of parallel circuits created by each group. Ask: *Were all the groups' parallel circuits the same?* Have students make a labeled sketch of their parallel circuit in their notebooks and record their observations about building this type of circuit.

5. Review the different types of circuits.

Review the similarities and differences between the four different types of circuits that students discussed during the activity: open, closed, series, and parallel. Have a discussion about the applications of each type of circuit.

Give students the example of street lights being configured in parallel circuits. Remind the students that in a parallel circuit, the current to each load, like a bulb, is separate, so if one bulb burns out, the others will still work. Ask the class: *Why would this be useful?* (Because if one light goes out, the rest will stay on, ensuring the safety of people on that street.) Encourage students to share other applications in everyday life.

Modification

If there are not enough materials for these activities to be done in small groups, the teacher can do them as demonstrations using student volunteers.

Modification

To adapt this activity for younger students, complete activity steps 1-3, then do the Extending the Learning section of the activity.

Informal Assessment

Have students build working models of series and parallel circuits without instruction.

Extending the Learning

Students examine the conductivity of objects by testing predictions about conductors within their circuits.

Ask: *Why is electricity able to flow through a wire?* Explain that wire is made of metal and metal is a good conductor of electricity. Ask the class to predict what kinds of materials they think electricity will flow through easily and what materials electricity will not flow through easily.

Remind the class that a circuit must be closed for electricity to flow continuously through it. Show the class items from around the classroom, such as the following: a paperclip, a piece of string, an eraser, a rubber band, and a penny. Invite students to predict which items will be good conductors and which will not be good conductors. Have students record these predictions in their notebooks or on a separate sheet of paper.

Use the diagram sheet provided to instruct groups in constructing a broken circuit using three wires, a bulb, and a battery. Have students introduce the items from around the classroom into the circuit by attaching an alligator clip in the circuit to two sides of the object. If the bulb lights, then the item is a good conductor; if the bulb does not light, the item is not a good conductor.

Have students record their results in their notebooks or on their paper, next to their original predictions. Ask: *Were your predictions accurate? What objects make good conductors, and what objects make poor conductors?* Typically objects made of metal are good conductors and most non-metal materials do not conduct electricity well.

OBJECTIVES

Subjects & Disciplines

- Physics

Learning Objectives

Students will:

- Construct simple, series, and parallel circuits
- Understand and be able to explain the difference between series and parallel circuits
- Understand and be able to explain the difference between open and closed circuits

Teaching Approach

- Learning-for-use

Teaching Methods

- Discovery learning
- Experiential learning
- Hands-on learning

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Learning and Innovation Skills
    - Communication and Collaboration
    - Creativity and Innovation
    - Critical Thinking and Problem Solving
- Critical Thinking Skills
  - Analyzing
  - Applying
  - Creating
  - Evaluating
  - Remembering

    - Understanding
- Science and Engineering Practices
    - Asking questions (for science) and defining problems (for engineering)
    - Developing and using models
    - Planning and carrying out investigations

National Standards, Principles, and Practices

NATIONAL SCIENCE EDUCATION STANDARDS

• **(5-8) Standard A-1**:
Abilities necessary to do scientific inquiry
• **(5-8) Standard A-2**:
Understandings about scientific inquiry
• **(5-8) Standard B-3**:
Transfer of energy
• **(K-4) Standard A-1**:
Abilities necessary to do scientific inquiry
• **(K-4) Standard A-2**:
Understandings about science and technology
• **(K-4) Standard B-1**:
Properties of objects and materials
• **(K-4) Standard B-3**:
Light, heat, electricity, and magnetism

NEXT GENERATION SCIENCE STANDARDS

• **Energy**:
4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.
• **Energy**:
4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
• **Engineering Design**:
MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

• **Engineering Design**:
3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
• **Engineering Design**:
MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
• **Engineering Design**:
3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
• **Engineering Design**:
MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
• **Engineering Design**:
3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

Preparation

What You'll Need

MATERIALS YOU PROVIDE

- 1 D cell battery holder per group
- 1 D cell battery per group
- 1 single knife switch per group
- 2, 2.5 volt, 0.2 amp, or smaller mini bulbs with a screw-type base per group
- 2 bulb holders for mini lamp bulbs per group
- 3 alligator clip leads per group
- Items to test for conductivity: 5 paperclips, 5 pieces of string, 5 erasers, 5 rubber bands, 5 pennies (1 of everything per group)

REQUIRED TECHNOLOGY

- Internet Access: Required

PHYSICAL SPACE

- Classroom

SETUP

Set up room so it is conducive for working in groups of two to four students.

GROUPING

- Large-group instruction

BACKGROUND & VOCABULARY

Background Information

Electricity is used to light houses and run televisions, computers and other electronic devices. Electricity can power various robot components, such as mechanical platforms, sensor systems, controllers, and joints.

Electricity is provided by energy sources such as generators or batteries. Generators convert mechanical energy into electricity, and batteries convert chemical energy into electricity.

Electric current is the flow or movement of electrons (negatively charged particles). Higher current means more electrons are flowing through a circuit. Resistance is a measure of how difficult it is for electricity to flow. Voltage is how much energy the electrons have and is sometimes described as how hard they are being “pushed.” Current, resistance, and voltage are related: The current (in amperes) in a simple circuit is equal to the voltage (in volts) divided by the resistance (in ohms).

Electrical conductors like copper, other metals, and ionic solutions (like salt water) are materials that allow electrons to move freely through them. Electrical insulators are difficult for electrons to move through. A resistor reduces or limits the flow of electrons (dimmer switches on lamps contain resistors). A capacitor contains conductors separated by insulators, and can store electric charge, even out current, or release the charge very rapidly (as for a camera flash).

A conducting loop is called a circuit. Circuits have three essential components; a conductive pathway (such as a copper wire), an energy source (such as a battery or generator), and a load (such as a light bulb or a heating element in a toaster).

A closed circuit is an unbroken pathway and allows current to flow. A circuit must be closed in order to power a light bulb or other load. An open circuit is a broken pathway that does not allow current to flow. An open circuit cannot provide electricity to the load. A switch is a way to open and close a circuit, by either allowing or stopping the flow of electrons. The wall switch in many classrooms and homes contains a strip of metal that contacts the circuit in the “on” position, causing the light to come on; when the switch is in the “off” position, the circuit is broken, turning the light off.

In a series circuit, a series of bulbs or other loads are connected in a single pathway so electricity flows through each one. With a single pathway, if a wire is cut, a switch is opened, or a load ceases to work, all loads within the circuit will cease to work because the path has been interrupted.

In a parallel circuit, there are two or more pathways through which electricity can flow. The bulbs or other loads on different pathways in this circuit are said to be parallel to one another. If a bulb in a parallel circuit burns out, electricity will still flow to other bulbs on other pathways, allowing the bulbs to continue to light.

Prior Knowledge

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Recommended Prior Activities

- None

Vocabulary

Term	Part of Speech	Definition
battery	*noun*	device containing one or more electric cells which store chemical energy that can be converted into electrical power.
circuit	*noun*	complete pathway through which electricity flows.
closed circuit	*noun*	continuous pathway through which electricity can flow.
conductive pathway	*noun*	course of an electrical circuit.
electric current	*noun*	flow of electricity, or charged particles, through a conductor.
electricity	*noun*	set of physical phenomena associated with the presence and flow of electric charge.
electron	*noun*	negatively charged subatomic particle.
energy source	*noun*	location in which the energy resource (oil, coal, gas, wind, etc.) is converted into electrical energy.
load	*noun*	component within a circuit that transforms electricity into a different form of energy such as light, heat, or sound.
open circuit	*noun*	incomplete pathway that prohibits the free flow of electricity.
parallel circuit	*noun*	pathway (closed circuit) in which the electrical current is divided into two or more parallel paths and returns through one path. If the loads in this circuit are bulbs and one blows out, there is still electricity flowing to the other loads.
series circuit	*noun*	electrical pathway where all the loads are connected in sequence, forming a single pathway through which electricity can flow.
switch	*noun*	device that allows an electrical circuit to be opened or closed.

For Further Exploration

Video

- Tech Topics: Electricity

FUNDER