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ACTIVITY : 20 MINS

Circuits with Friends

Students explore the parts of a circuit by modeling, as a group, a "human" circuit.

GRADES

2 - 5

SUBJECTS

Engineering

OVERVIEW

Students explore the parts of a circuit by modeling, as a group, a "human" circuit.

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

Program

DIRECTIONS

1. Activate students' prior knowledge about electricity.

Invite students to spend a minute or two writing down what comes to mind when they think of robots. When finished, allow students to share what they wrote with the class. Ask students to offer ideas on how robots and electricity are related.

Have students share what they already know about electricity. Ask: *What examples of electricity do you see in the natural world? How do you use electricity in your day-to-day life?* Explain that electricity or electrical current is the movement of electrons from one location to another. In order for electricity to power some of the everyday items the students mentioned, it must flow through closed pathways called circuits.

2. Demonstrate electric flow with a game of "trash can golf" using tennis balls, and compare electric flow to the current in a stream or river.

Place an empty trash can on its side and have students form a perpendicular line approximately ten feet away. Give each child a tennis ball, and ask them to try to roll it into the open end of the trash can all at once. After the big roll, count how many tennis balls successfully made it into the trash can. Next, have students line up again and place an obstacle, such as a stack of books, between the trash can and the line of students. Have them try to roll the balls into the trashcan again, and count the number of successful balls. When finished, have students compare how many balls went into the trash can when the path was clear and how many went in when there was an obstacle in the path.

Continue this idea by comparing the game of trash can golf to a flowing stream. Explain that the first time students rolled the tennis balls, it was similar to how water flows in a river. The second time there was an obstacle, as if a beaver had built a dam on the river. The water cannot move past the dam. Explain that this game is like electricity flowing, and the two types of rivers are like two different kinds of circuits. A circuit is a path that electrons can flow through. When electrons flow along, it creates electricity. A closed circuit is like a river that has no obstacles on it. An open circuit is like a river where a huge beaver dam has stopped the flow of water (i.e. electricity). The tennis balls the students rolled are like electrons.

3. Students model a closed circuit by holding hands in a large circle and passing around tennis balls.

Tell students that they will act out models of electricity flowing through circuits by passing tennis balls (electrons) to one another. Explain that all circuits have some basic components, three of which are; an energy source, a conductive pathway, and a load. An energy source, like a battery, supplies the electric current. The conductive pathway, typically metal wire, provides a path on which the current travels. And the load, like a light bulb, consumes the electricity that flows to it along the closed pathway.

First, have students form a line. Hand a tennis ball to the first student in the line. Tell the students that each tennis ball represents an electron. Have that student pass the electron to the next student in line, and so forth, so that the ball travels to the end of the line. Hand a second tennis ball to the first student in the line and repeat. Keep handing the first student additional balls and instruct all students that they must pass on a ball when they receive another. Ask: *What happens when the electrons reach the end of the line?* (There is no one left to pass the tennis balls to.) Ask: *How can we change how we're standing to keep the electricity flowing?* (They can form a circle.)

Have students form a large circle holding hands. Explain that this circle is like a closed circuit, or the river without a beaver dam. Then have everyone step toward the center of the circle until all of their shoulders are touching. (You should be part of the circle, because you will be acting as the "power source.") Have students stop holding hands, and show them six tennis balls. Ask: *What do these tennis balls represent?* (Electrons.) Explain that these are going to "flow" through the "path" they have created. Each student, without breaking his or her shoulder connections to their neighbors, will pass the ball they receive to their neighbor clockwise around the circle. Explain to the students that they can only pass the ball to a neighbor whose shoulder they are "connected" to.

Assign the student next to you (the one to whom the tennis balls will take the longest to reach) the role of the "load." Explain that he or she should yell out or sing each time a tennis ball reaches him or her.

Remind students that they are participating in a model of a circuit. Place a tennis ball into the hand of one student, and repeat until all six balls are in motion, moving around the circle as students pass them from one to another. Allow the balls to travel around the circle of students a few times and then halt the action. Explain that the students have formed a closed circuit—an unbroken, never-ending path for the electricity to flow through. Explain that having an unbroken path is important. In a real circuit, the electrons can be compared to water flowing in a stream. Ask: *What are we modeling when the tennis balls are passed around our circle?* (A circuit.)

4. Students model an open circuit, through which tennis balls cannot "flow."

Ask students to predict what will happen if two or more students are removed from the circle. Then, tap two or more students who are next to each other out of the circle; the idea is to create a sizable gap that will prevent balls from reaching the student who is playing the "load." Be sure to have the remaining students stay in their original positions. Repeat the exercise of passing the balls around the circle. At the gap, there should be a buildup of tennis balls because the tennis balls cannot cross the empty space. If students attempt to pass tennis balls over the gap, remind them that they can only pass the tennis balls to a neighbor whose shoulder they are "connected" to. Ask: *Why can't the tennis balls cross the empty space?* Explain that they have formed an open circuit—a broken path that electricity cannot flow through continuously. Explain that it doesn't matter where in a circuit a break occurs—if there is a break anywhere, electricity cannot flow through it. Remind students that this is like the river with the beaver dam—there is an obstacle preventing the flow of electricity. Ask students if the pupil playing the part of the load will have the opportunity to yell or sing in this instance. (No, because the tennis balls will never make their way back around to this student.)

5. Discuss and define the parts of a circuit.

Discuss the difference between a closed circuit, where everyone is close enough in the circle to pass the balls from one to another, and an open circuit, when there is a large enough gap somewhere in the circle that the balls can no longer be passed. Remind students that all circuits have some basic components, three of which are: an energy source, a conducting pathway, and a load. Remind students of the definitions of each of these parts from the beginning of the activity.

6. Have a group discussion and check for understanding.

Check for student understanding by asking the following questions: *When was the circle a closed circuit?* (When all students were touching shoulders or when all students stood close enough to pass the tennis ball from one to another.) *When was the circle an open circuit?* (When students were removed from the circle, making it impossible to pass the ball.) Have students identify the energy source in the human circuit, or model. Ask: *Where did the electrons in our models come from?* (The instructor who passed the tennis balls into the circle.) Have students identify the conductive pathway in the model. Ask: *What was the path that electrons flowed through in our models?* (Students are the conductive pathway.) Have students identify the load in the models. Ask: *Who acted as the load in the models? Why is a load an important part of a circuit?* (Students should identify the load you appointed. The load is important because it can help identify if a circuit is open or closed.) Finally, discuss the real life equivalents of the parts of the model. For example, an energy source can be a battery or a generator, and conductive pathways are made from materials that can easily conduct electricity, such as wire.

Modification

If space is limited, a smaller group can demonstrate the activity for the class.

Modification

Other objects can be used in place of tennis balls as long as they are easy to pass from person to person.

Modification

Use this activity as a quick warm up or review with older students.

Informal Assessment

Have students model open and closed circuits in smaller groups.

Extending the Learning

Have students make a list of all the electrical components in their bedrooms that use circuits. Their lists should include items like light switches, electronics, etc.

OBJECTIVES

Subjects & Disciplines

- Engineering

Learning Objectives

Students will:

- Identify the parts of a circuit
- Model open and closed circuits
- Explain the difference between an open and a closed circuit and the conditions necessary for a circuit to work

Teaching Approach

- Learning-for-use

Teaching Methods

- Demonstrations
- Discovery 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 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-3:**
Light, heat, electricity, and magnetism

NEXT GENERATION SCIENCE STANDARDS

• **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.

Preparation

What You'll Need

MATERIALS YOU PROVIDE

- At least six tennis balls
- Large bucket, cooler, trash can, or other container, at least 30 centimeters x 30 centimeters x 30 centimeters (1 foot x 1 foot x 1 foot)
- Stack of books or other physical obstacle

REQUIRED TECHNOLOGY

- Internet Access: Optional
- Tech Setup: 1 computer per classroom

SETUP

Ensure that students have enough space to easily form a large circle

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.

Batteries and generators get the electrons that are already in the wires to flow. Generators use mechanical energy to cause electrons to flow; batteries use chemicals to get the electrons moving.

Electric current is the flow or movement of electrons (negatively charged particles). Higher current means more electrons are flowing through a circuit. Resistance measures the impediment to the flow of electricity. Voltage is the force that an electrical current has in relation to the resistance of a circuit. It is sometimes described as how hard the electrons are being "pushed," in the same way pressure has the force to push water through a garden hose. 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.

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, or 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.
conductor	*noun*	material that transfers heat, light, electricity, or sound.
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.
power source	*noun*	device that supplies energy.

For Further Exploration

Interactives

- Circuit Building Game
- Challenge using Circuits

FUNDER