NYC Companion Lesson

Investigating Electrical Devices

Overview

This hands-on activity builds on and reinforces students' understanding of the transfer and conversion of energy. From the *Harnessing Human Energy* unit, students understand that the energy from a battery can be used to power electrical devices, and in this lesson, students focus on how that energy is transferred from the battery to the device. Students are challenged to build an electrical device that is powered by a battery and has a mechanism that can turn a lightbulb on and off. By completing this challenge, students gain an understanding that the energy is transferred through the wire and that the device must be connected to the battery in a closed loop. The purpose of this lesson is for students to gain experience with electric circuits and develop an understanding of how energy is transferred by electric currents.

Recommended Placement: *Harnessing Human Energy*, after Lesson 2.2
Suggested Time Frame: 60 minutes (can spread across multiple class periods)

NYS P–12 Science Learning Standards

Performance Expectations	• **MS-PS3-6:** Make observations to provide evidence that energy can be transferred by electric currents.
Disciplinary Core Ideas	• **PS3.B: Conservation of Energy and Energy Transfer:** ° (NYSED) An electric circuit is a closed path in which an electric current can exist. (MS-PS3-6)
Science and Engineering Practices	• **Practice 3:** Planning and Carrying Out Investigations • **Practice 4:** Analyzing and Interpreting Data • **Practice 6:** Constructing Explanations and Designing Solutions
Crosscutting Concepts	• Cause and Effect • Energy and Matter

Vocabulary

- convert
- electric circuit
- electric current
- energy
- system
- transfer

Materials & Preparation

Materials

For the Class

- Investigating Electrical Devices copymaster
- 1 roll aluminum foil
- 20 small binder clips
- 10 craft sticks
- 40 paper clips, assorted sizes*
- 2 rolls of masking tape*
- 20 rubber bands*
- 1 box of metal brads**
- assorted springs**
- 2 large index cards*
- marker*
- optional: additional building materials such as pieces of cardboard, pencil erasers, metal nuts, bolts, and washers*

For Each Group of Four Students

- 1 D cell battery**
- 1 battery holder**
- 2 wires with alligator clips**
- 1 incandescent lightbulb
- 1 lightbulb socket
- 1 tray*

For Each Student

- Investigating Electrical Devices student sheets*

*teacher provided
**from *Harnessing Human Energy* kit

Preparation

Safety Note: Battery Voltage

Each battery has only between one and two volts, which is a safe voltage. Students cannot get shocked from these batteries. Heat from a short circuit could cause discomfort or even a minor burn. If students feel a battery getting very hot, they should immediately disconnect the lightbulb.

1. **Print Investigating Electrical Devices copymaster.** Locate the Investigating Electrical Devices copymaster on the New York City Resources webpage: www.amplify.com/amplify-science-new-york-city-resources. Make one copy of all pages for each student.

Preparation (continued)

2. **Create and post vocabulary cards on the classroom wall.** With a marker, write "electric circuit" and "electric current" in large print on separate index cards. Post both cards on the classroom wall.

3. **Gather the following materials from the *Harnessing Human Energy* kit:**
   - D cell batteries
   - battery holders
   - wires with alligator clips
   - assorted springs
   - metal brads

4. **Gather the following materials from the NYC Companion kit:**
   - incandescent lightbulbs
   - lightbulb sockets
   - aluminum foil
   - binder clips
   - craft sticks

5. **Gather teacher provided materials:**
   - paper clips
   - masking tape
   - rubber bands
   - any additional building materials

6. **Organize materials on trays for groups of four students.** On each tray, include the following:
   - 1 D cell battery
   - 1 battery holder
   - 2 wires with alligator clips
   - 1 incandescent lightbulb
   - 1 lightbulb socket

   Set the trays aside to distribute during the lesson

7. **Organize additional building materials in a central location where all groups can access them:**
   - aluminum foil
   - binder clips
   - craft sticks
   - metal brads
   - springs
   - paper clips
   - masking tape
   - rubber bands
   - any additional building materials

8. **Locate and review the Rubrics for Assessing Students' Circuit Design Solutions in the Assessment section of this lesson.** These rubrics can help you plan to support

students as they complete their design plans and draw conclusions during the lesson. After the lesson, use the rubrics to formatively assess students' developing facility with Science and Engineering Practices as well as their understanding of Disciplinary Core Ideas.

9. **Immediately before the lesson have on hand the following materials:**
   - student sheets
   - trays of materials
   - additional building materials

Science Background

An electric current is *the way that electrical energy is transferred from one place to another (for example, through wires)*. An electric circuit is *a closed path in which an electric current can exist*. This can include an arrangement of conductors (usually wires), a source or sources of electrical energy (such as a solar panel, battery, or a fuel-burning power plant), and electrical devices that convert the electrical energy to other energy forms. In this lesson, students get experience with the simplest kind of circuit—a series circuit with a source, a wire or other metal objects that carry electric current from the source (a battery) to a device (a light), and another wire that carries the electric current from the device back to the source. They also need to create a mechanism that turns the light on and off. Their switch should open and close the loop of the circuit.

Instructional Guide

Explore and Activate Prior Knowledge

1. **Hold up a battery and a lightbulb to review concepts.** Ask students if you were to connect the battery to the light how they would know there is energy in the system. Then ask them to describe the energy in the system. [The light shines, and light is a form of energy; potential energy from the battery transfers to the lightbulb and converts to light energy.]
2. **Lead a discussion about the transfer of energy.** Ask students to share their ideas about how the energy from the battery gets to the lightbulb. Students may have noticed in the *Harnessing Human Energy* Simulation that potential energy from the battery first converts to electrical energy, and then the electrical energy converts to light energy.
3. **Introduce the electrical device challenge.** Inform students they will investigate how electrical energy gets to the light by building an electrical device with a lightbulb and battery. They need to include a mechanism that will allow them to turn the light on and off. Point out the different objects that they can use to build their device: battery, lightbulb, socket, and wires provided in each tray and other building materials at the central station.
4. **Distribute materials to groups of four.**
5. **Groups brainstorm and come up with their first plan.** Distribute Investigating Electrical Devices student sheets and direct students to Part 1: Building Electrical Devices. Give groups time to first discuss what they could do with the objects, come up with a plan, and then sketch and label a diagram of their planned energy system. If needed, encourage students to first make the lightbulb shine without the on/off mechanism and use that to brainstorm how to add something that will turn the lightbulb on and off.

Construct New Ideas

6. **Students build electrical devices.** Give students time to build their device, modifying and rebuilding as needed.
7. **After students have created the device, have them answer the reflection questions in Part 1.**
8. **Students present devices.** Have students present their devices to the rest of the class. You can have them come up to the front of the class one group at a time or have students place their devices around the room and walk around to look at each one.
9. **Discuss how energy gets to the lightbulb.** Prompt students to share how energy gets from the battery to the light. [Energy from the battery is transferred to the light when it is connected with a wire.]

10. **Introduce the vocabulary word *electric current.*** Explain that the energy from the battery got to the lightbulb through an electric current.

    An electric current is the way that electrical energy is transferred from one place to another (for example, through wires). Potential energy in the battery is converted to electrical energy and transferred by the current. It then converts to light energy when it reaches the lightbulb.

    Point out that the vocabulary word is posted on the classroom wall. Students can also find the definition in the glossary at the back of their Student Editions.

11. **Discuss students' on and off mechanisms.** Ask students to share how their mechanisms worked to turn the light on and off. Highlight responses related to closing the loop or making a continuous path.

12. **Introduce the vocabulary word *electric circuit.***

    When your lightbulbs were on, you created an electric circuit. An electric circuit is a closed path in which an electric current can exist. In order for the electric current to flow, the wire needs to be connected to both ends of the battery in a closed loop. When the path is open, the particles cannot flow.

    Point out that this vocabulary word is also posted on the classroom wall and the definition can be found at the back of their Student Editions.

Apply New Ideas

13. **Introduce second challenge.** Explain that students will use what they figured out when building circuits to make a broken device whose lightbulb does not light up. They will give it to another group who will work to fix it. Inform students that they should not destroy any of the parts of the device. The group that fixes the device must explain how they fixed it and why the lightbulb can now light up.

14. **Give students time to make broken devices.** They can make a brand new device or use the device from the previous part of the activity.

15. **After students have created the broken device, have them answer the first question in Part 2: Designing Solutions for Fixing Broken Electrical Devices.**

16. **Have groups switch devices and determine how to fix it to make the light turn on.** If time permits, they can reset the device to be broken again and switch with another group. After they fix the first broken device, have students answer the questions in step 2.

17. **Students disassemble devices and return materials.** Toward the end of the lesson, have students disassemble their electrical devices. Have them return any reusable materials, like binder clips, springs, and brads, back to the central station.

Rubrics for Assessing Students' Circuit Design Solutions

The rubrics below may be used to review students' design plans and conclusions to formatively assess students' developing facility with Science and Engineering Practices and understanding of Disciplinary Core Ideas.

Rubric 1: Assessing Students' Performance of the Practice of Designing Solutions

Note that this rubric applies to Part 2 of the Investigating Electrical Devices student sheets. Rubric 1 is designed to monitor and support students as they develop dexterity with the practice of Designing Solutions. For each criterion, levels are described to monitor students' progress by indicating the degree to which students can independently demonstrate fluency with the science practice. This rubric may be used formatively to support students' facility with the practice of Designing Solutions. It features targeted questions a teacher may use to assess students' design solutions and provides specific feedback for revisions and for future encounters with the practice.

Rubric 1: Assessing Students' Performance of the Practice of Designing Solutions		
Criteria	**Description and possible feedback**	**Level**
Applies scientific ideas or principles to design a solution. Are scientific ideas used in constructing a design solution?	Students don't specify why they designed their solution for fixing the broken device in the way that they did. Possible feedback: *Why did you think your solution would get the lightbulb to light up?*	0
	Students specify why they designed their solution for fixing the broken device in the way that they did, but don't apply scientific ideas in constructing their design solutions. Example: There was a wire hanging off, so we will connect it. We will do this because loose wires are dangerous. Possible feedback: *What do you know about how circuits work? Could that have helped you to design your solution?*	1
	Students specify why they designed their solution for fixing the broken device in the way that they did and apply scientific ideas in constructing their design solutions. Example: There was a wire hanging off, so we will connect it. We will do this because that will complete the loop that connects the battery and the light.	2

Rubric 2: Assessing Students' Understanding of Science Ideas Encountered in the Unit

Note that this rubric applies to the reflection questions in Part 1 and the design solutions in Part 2 of the Investigating Electrical Devices student sheets. Rubric 2 considers whether students have constructed and applied ideas in a way that is consistent with accepted science ideas. This rubric is designed to be formative, and space is provided to note if students are demonstrating understanding or are struggling with ideas in the lesson. If students are having difficulty, you may consider having groups discuss their solutions with the group with which they exchanged devices. Have one group share their solution for fixing the broken device and why they fixed it the way that they did. The group that built the broken device can then share the solution they described in response to question 1. Then the groups can switch roles. As students compare and discuss the rationale for their solutions, remind them that they can refer to the diagrams of their electrical devices that they created (in Part 1 of the Investigating Electrical Devices student sheets). Discussing these examples will help all students construct understanding that an electric circuit is a closed path in which an electric current can exist.

Rubric 2: Assessing Students' Understanding of Science Ideas Encountered in the Unit		
Criteria	**Description**	**Is there evidence of student understanding?**
Consistent with accepted science ideas. Are students' conclusions consistent with accepted science ideas?	Students demonstrate understanding of the idea that for energy to be transferred by an electric current, there must be a closed path electric circuit. Example: When the light is on, the battery and light bulb are connected by the wires in a continuous loop. When the light is off, the loop is broken.	

Investigating Electrical Devices

Part 1: Building Electrical Devices

Use the provided items to make an electrical device where you can turn the light on and off.

Design Diagram

In the space below, draw your energy system, showing the different parts and how they are connected. Add labels and captions that help explain how your energy system works. If you modify your design while building, update your diagram below.

Answers will vary.

Investigating Electrical Devices (continued)

Reflection Questions

1. How does energy get from the battery to the light?

The wire and metal objects connect the battery to the light, which allows energy to be transferred. The battery and light have to be connected in a loop. Each end of the battery has to somehow be connected to each terminal of the lightbulb.

2. How does your on and off mechanism work? Explain how turning on your device causes energy to get to the light and how turning it off prevents energy from getting to the light.

When the light is on, the battery and lightbulb are connected in a continuous loop with wire or other metal objects. There is a path from one end of the battery to one terminal of the lightbulb and another path from the other terminal of the lightbulb to the other end of the battery. When the light is off, the loop is broken.

Possible Student Responses

Investigating Electrical Devices (continued)

Part 2: Designing Solutions for Fixing Broken Electrical Devices

Step 1: Build an electrical device that does not work to light up the lightbulb.

1. How would another group fix the device?

Answers will vary. Students should mention that the device can be fixed if the wires that connect the battery and the light are all connected in a loop.

Step 2: Fix another group's broken electrical device.

2. What will you do to fix the broken device? Why will that work to fix the device?

Answers will vary. Students should describe a solution that completes the loop that connects the battery and the light and explain that for a device to work, the wires that connect the battery and the light need to all be connected in a loop.

3. Were you able to fix the device?

Answers will vary.