How Can You Light A Bulb?

Target Group: 3rd – 5th grade (meets 4th grade NGSS Physical Science standard)

Prior Knowledge: This activity is designed to introduce circuits, identify some types of energy transfer in circuits, and explore conductive and non-conductive materials. No prior knowledge is expected.

Learning Objective: Build working circuits and use them to describe how energy is transferred in circuits.

- **NGSS Standard 4-PS3-2:** Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
- **P.EN.E.5 (P.EN.04.51, Michigan):** Demonstrate how electrical energy is transferred and changed through the use of a simple circuit.
- **P.PM.E.5 (P.PM.04.53):** Identify objects that are good conductors or poor conductors of heat and electricity.

Time: 45 - 60 minutes

Materials:

- Laptops/computers for each student (students can work in pairs if needed). Have the computers set up on the Circuit Construction Kit (DC Only) page before students arrive.
- Activity sheet for each student (separate document, also duplicated below instructor notes).
- PhET simulation: Circuit Construction Kit (DC Only), http://phet.colorado.edu/en/simulation/circuit-construction-kit-dc
- Teacher computer that can be projected for all to see or a laptop on a document camera to project the screen and/or student papers.

Engage (5 – 10 minutes):
Ask students what an electrical circuit is—how do they identify one? What kinds of things can it do? How do they know if the circuit is working?

Introduce students to the PhET simulation. Tell them this simulation will help them explore circuits. Allow them to mess around with the simulation, do not show and tell them how it works. Encourage them to answer the questions on the first page of the Student Sheet, which is focused on orienting students to the program and making the program work for them.

Assist with clicking/selecting things on the screen if needed, it is important that students are comfortable connecting and disconnecting pieces.

Explore (10 – 15 minutes):
Allow students to work through page 2 of the Student handout. They will build 5 circuits. As students work, monitor progress. Allow students to explore, fail, and try again. Do not intervene quickly. Encourage students to check with neighbors if they get stuck.

Encourage students to draw their circuits and write what they see. If needed, help students focus on details—is the bulb brighter or dimmer? How can you tell? (length and thickness of the lines coming from the bulb).

Circuits 1 – 3 are designed to help students explore different ways to light a bulb, with 1 – 2 looking at the effect of more energy (brighter bulb). Circuit 3 pushes students to think about the simplest circuit they can make, and helps students focus on the connecting points of the light bulb. Students may struggle with this circuit, let them explore and help each other.

Circuit 4 allows students to explore the use of a switch.

Circuit 5 encourages creativity and critical thinking. How else can students make a bulb light up?

As students finish the circuit exploration page (page 2), allow them to begin to write responses to page 3 questions. Pull the class back together to discuss once all students have completed circuit 4. Students can go back and work on circuit 5 as time permits.

EXPLAIN (15 – 20 minutes):
Have the students minimize their screens so the focus is on the discussion and not the simulation.

Invite 1 – 2 students to share the circuits they built for circuits 1 – 4. Students can build their circuit on the instructor's computer or put their paper on the document camera. Talk about the different parts of the circuit (source-battery, load-bulb, path-wires). Ask students what is happening in the circuits. Allow students to edit their work if needed.

Point out the blue dots, ask students what they represent. Do they move in one direction or both directions? What does the motion depend on? Make a circuit on the instructor computer and project it for all students to see if this helps focus the discussion. It is possible to build two circuits on the same screen, orient the batteries differently. This will help students focus on the direction of the current—and the everyday connection to why it matters how we put batteries into devices!

Have students explain the purpose of a switch. Ask them to list 5 devices that have switches. Define an open circuit as one that does not have electricity flowing through it. A closed circuit is a complete circuit that has electricity flowing through it.

Invite a few students to share their 5^{th} circuit and explain how it works.

Allow students to complete page 3 of the student handout.

ELABORATE (10 – 15 minutes):
Ask students if any material can be used for a wire or a path. Introduce the "grab bag" and allow students to test the items in the grab bag in a circuit of their choosing. Encourage students to record results. Have students examine the results and look at the pictures of the objects to focus on the property(ies) of the materials that allow electricity to flow through the material.

Briefly have students report out on their results. Allow students to share the common property or properties of the conducting materials.

Students may note that pencil lead often does conduct electricity; they may have used pencil lead for electrodes outside of class or in a different activity. Students may also note that electricity will flow through a person (so why not the hand or the dog). The instructor may have even shown this by passing around an energy ball or other device that makes noise or light when a slightly sweaty hand completes the circuit. This would be an appropriate place to talk about materials that conduct well and those that conduct weakly. Which type or types of materials are represented here?

As students complete the activity and page 4 of the Student sheet, challenge them to figure out what a resistor is/what it does. Students can also try building circuits with multiple batteries—what happens if the batteries are connected to each other in different ways (+ to -, - to -, or + to + ends). Encourage them to view the schematic option or explore what the voltmeter and ammeter do. These options may build towards future lessons, or may simply be of interest to students.

Student Materials
A copy of the 4-page student materials follows the answer key below.

How Can You Light A Bulb? (Answer Key)

One way we will study energy transfer is through circuits. We will use the PhET simulation called *Circuit Construction (DC only)* to start exploring circuits.

Your goals for this lesson:
1. Build a few working circuits.
2. Describe how energy is transferred in circuits.
3. Tell about the properties of materials that conduct electricity.

Directions
1. Drag wires, batteries, and bulbs into the box. Mess around for a few minutes. Try to build a circuit. You built a circuit if the light bulb glows. Move parts around to make your circuit work. If you start a fire, make a different circuit!

   As you experiment, answer the questions on this page.

2. What happens when you right click on a piece? *The word "remove" appears*

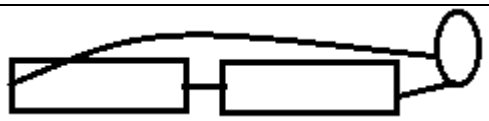
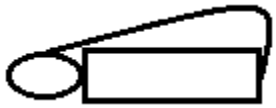
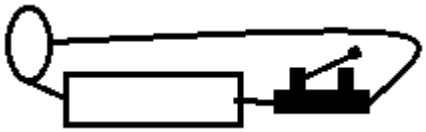
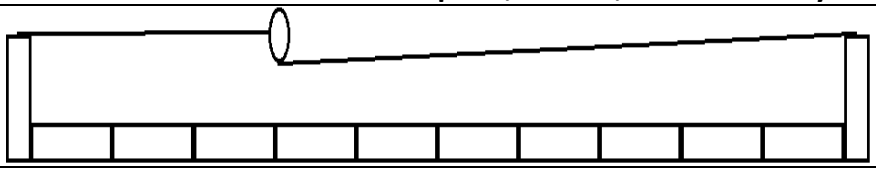
3. What happens when you right click on a red dot? *The words "split junction" appear.*

4. What happens when you click on the words "split junction"? *The pieces move apart.*

5. What does "split junction" mean? *Move the pieces of a circuit apart.*

6. You will build a few circuits on the next page. You will sketch each circuit. Make a key in the space below to show how you will draw wires, batteries, and bulbs.

   Students will likely use a circle for a bulb,  *a line for a wire,* *and a square or rectangle for the battery.* 

Circuit and Parts to use	Sketch of your working circuit	What did you see?
Circuit #1 2 wires 1 light bulb 1 battery		*Bulb lit up, blue dots moved on screen*
Circuit #2 3 wires 1 light bulb 2 batteries		*Bulb lit up but had more/thicker lines, blue dots moved on screen*
Circuit #3 1 wire 1 light bulb 1 battery		*Hard to get wire and bulb attached right to see the light*
Circuit #4 3 wires 1 light bulb 1 battery 1 switch		*Could put the switch different places, close switch to see the bulb go on.*
Make a new and different circuit for #5. List the parts, draw it, and tell what you saw.		
Circuit #5 *12 batteries* *1 bulb* *2 wires*		*This made a fire!*

7. What parts did every working circuit need? *Each circuit needs a wire, battery, and bulb*

8. What has to happen to get the light bulb to light up? *The two ends of the bulb need to attach to the two ends of the battery. One or more wires is needed to get the battery and bulb connected.*

9. Where do the wires need to attach to the light bulb? What happens if the wires are not attached correctly?
   One wire needs to attach to each part of the bulb. There are two places for wires to attach to a bulb. Two different wires or a wire and a battery must be attached to each part of the bulb.

10. What do you think the blue dots are in your circuits? *Electricity, electrical current, electrons*

11. What forms of energy are transferred from battery to light bulb? *Chemical energy in the battery is transferred into electrical energy in the circuit, then to light energy in the bulb.*

12. What does the switch do? *The switch allows the flow of electricity to be turned on and off, to stop and start the current.*

Build a working circuit. Put a “Grab Bag” item in the circuit. Report your results below.

Item	What happens in the circuit
Dollar bill	*No light, no electricity flowed, not a conductor*
Paper clip	*Light bulb came on, electricity flowed, conductor*
Penny	*Light bulb came on, electricity flowed, conductor*
Eraser	*No light, no electricity flowed, not a conductor*
Pencil lead	*No light, no electricity flowed, not a conductor*
Hand	*No light, no electricity flowed, not a conductor*
Dog	*No light, no electricity flowed, not a conductor*

13. Describe the property or properties of the “Grab bag” items that made the light bulb light up.
    Items from the “grab bag” that made the light bulb light up were made of metals. Students may mention that other materials, such as the pencil lead, hand, and maybe the dog should have conducted as well, based on past experiences.

Name _____

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Circuit #2 3 wires 1 light bulb 2 batteries		
Circuit #3 1 wire 1 light bulb 1 battery		
Circuit #4 3 wires 1 light bulb 1 battery 1 switch		
Make a new and different circuit for #5. List the parts, draw it, and tell what you saw.		
Circuit #5		

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9. Where do the wires need to attach to the light bulb? What happens if the wires are not attached correctly?

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