I. Lighting a Light Bulb

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

Prior Knowledge: Because this is intended as an introductory lesson on electricity, students do not need any prior knowledge of circuits.

Learning Objective: We will explore electricity and determine what makes a light bulb light by testing different electric pathways.

- **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.
- **CDE Physical Science 1.1:** Energy comes in many forms such as light, heat, sound, magnetic, chemical, and electrical (1.1a) electricity in circuits requires a complete loop through which current can pass
- **CCSS.ELA-Literacy.SL.4.1**: Engage effectively in a range of collaborative discussions (1-on-1, in groups, and teacher-led) with diverse partners on *grade 4 topics and texts*, building on others' ideas and expressing their own clearly.

Time: 45 - 60 minutes

Materials:

- Laptops/computers for each student*
- Activity sheet for each student (see below)
- Projector & document camera (optional)
- PhET simulation: Circuit Construction Kit (DC Only) http://phet.colorado.edu/en/simulation/circuit-construction-kit-dc

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Comment [1]: •If necessary, students can be paired & share 1 laptop, but teacher must then monitor to ensure that both students have the opportunity to 'drive' the Sim. Periodic instructions to switch who controls the computer would be needed.

Time	Procedure	Teaching Tips
3 minutes	**Introduction**: • Ask students to generate and share questions about electricity. • Distribute activity sheets and review today's learning objective.	• *Time saver:* If possible, have computers logged on and set up for Circuit Construction sim.
10 minutes	**Explore:** • Allow 5 minutes to explore the PhET sim, *Circuit Construction Kit (DC only)* http://phet.colorado.edu/en/simulation/circuit-construction-kit-dc • After 5 minutes, have students share ideas and findings with a partner. Monitor student discussion. Call attention to important findings or components of the sim and facilitate a discussion of these as a whole class.	• *Management tip:* Have turn-and-talk or think-pair-share norms in place. Once students have the routines for sharing collaboratively, time can be used most effectively. In my classroom, pairing is purposeful but varies depending upon activity. • Project the sim as you highlight findings

20 minutes	**Procedure:** • Students will follow along on their activity sheet as teacher facilitates. • Tell students that they will be exploring what is needed to make a lightbulb light. • Draw students' attention to the first table (# 3). Explain the table to students: They will attempt to make a pathway using the components in the first column, determine its effectiveness in lighting the bulb, and record any additional observations. While the 1st portion of the table is directed, students may manipulate the sim as they choose for the next 3 parts. • Allow students to explore different circuits, monitoring student findings to help facilitate class discussion. • After 10 minutes, call class together. Allow students 2 minutes to record a successful attempt to light the bulb in #4. • #5 Have students turn and share with their partner before having a whole class discussion. • Highlight interesting findings. Ask students to share both successful and unsuccessful circuits: *What worked? What didn't work?* Emphasize that in order to light the bulb, the current (blue electrons) needed a pathway to move from a source (battery) to a receiver (bulb).	• Look for both successful and unsuccessful circuits to share both what *does* work and what *doesn't* work. • For each class discussion, my kids move to our meeting area (out of their seats, away from distracting laptops!) The sim can be projected for students to manipulate when showing the whole class something; if moving the whole group does not work due to room set up or time, you can also have students simply turn their laptops.

15 minutes	• Guide students to the second table (# 6) and allow them about 10 minutes to explore the 3 inquiry questions.
	• Monitor student progress. After about 10 minutes, stop students and have them share findings with their partner before class discussion.
	  • Possible questions/concepts to highlight during whole group discussion:
	  ✓ What happens if we add one more battery? *Bulb gets brighter/the blue circles – electrons – speed up.*
	  ✓ What happens to the current when the battery is flipped? *If the battery is flipped, the electric current flows in the opposite direction because the electrons (represented by the blue circles)*
		• It is likely that students will discover problems or ideas in addition to these; be flexible! Monitor as students are working to highlight findings for whole group.
		• For closing discussion, move students back to the meeting area if possible.

	flow from the negative (-) side to the positive (+) side. ✓ How could you turn off the bulb? *Students may have done this by splitting the junction at any point on the circuit or by using a switch. In order to turn off the bulb, the pathway must be broken. This is called an open circuit. *Relate the switch in the circuit to a light switch on the wall. What happens to the circuit when the switch is turned off?* • Writing: Send students back to their seats and have them share their understandings through writing and drawing in number 8 on their activity sheet.	
5 minutes	**Wrap-Up Discussion** • Review learning objectives and share new learning. • Introduce the term *circuit.* Electric circuits are like a circle – a loop or pathway that electrons can follow to go from the source (battery) to the receiver (bulb).	• Optional: Use a document camera to project student answers in # 8.

II. Exploring Circuits

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

Prior Knowledge: This is intended as a follow-up lesson to *Lighting a Light Bulb;* It can also be adapted to stand alone, in which case students would need to know that circuits are like a loop or pathway that electrons follow from the source → receiver.

Lesson Objective: We will use our knowledge of circuits to create pathways that can light several bulbs at once.

- **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.
- **CDE Physical Science 1.1:** Energy comes in many forms such as light, heat, sound, magnetic, chemical, and electrical (1.1a) electricity in circuits requires a complete loop through which current can pass
- **CCSS.ELA-Literacy.SL.4.1**: Engage effectively in a range of collaborative discussions (1-on-1, in groups, and teacher-led) with diverse partners on *grade 4 topics and texts*, building on others' ideas and expressing their own clearly.

Time: 45 - 60 minutes
Materials:

- Activity Sheet for each student (see below)
- Laptop/computer for each student
- PhET Sim: Circuit Construction Kit (DC Only) http://phet.colorado.edu/en/simulation/circuit-construction-kit-dc
- Projector (optional)
- String of Christmas lights

Time	Procedure	Teaching Tips
10 minutes	• Distribute Activity sheets and have students access the sim: http://phet.colorado.edu/en/simulation/circuit-construction-kit-dc • *(#1) Explore:* Students will reinforce their learning from the previous lesson by exploring the sim and making a successful circuit. • (#2) Have students *Turn and Talk* with their partner to share circuit and discuss the question, "Is there more than 1 way to make a working circuit?" "What do working circuits require?" ✓ A *circuit* is the pathway that electrons follow to produce electricity. It requires an electricity source (battery) and receiver (bulb).	• Setting up computers with the sim prior to lesson saves time. • Rather than an introduction that reviews concepts learned in Day 1, students will use (& refresh!) this knowledge in the *Explore*. • Share a few students' drawings of successful circuits under doc cam during review discussion. • Establish *turn&talk* norms at the beginning of the year so that students use their discussion &collaboration time effectively.

15 minutes	• Review today's objective with students.
	• We will be creating different types of circuits that will keep several bulbs lit brightly, no matter how many there are or if one bulb goes out.
	• Read inquiry question with kids: *Can you light several bulbs brightly with one battery*?
	• (#3) Students will complete the table in order to explore different configurations until they can light 2 bulbs brightly.
	• First, all students will create a working circuit with one bulb and one battery to observe the bulb's brightness.
	• Then, students will be tasked with adding a second bulb to that circuit.
	• Suggested questions to ask as you circulate:
	  ○ *What do you notice about the brightness of the bulbs?*
	  ○ *Why do you think this happens?*
	• Monitor student exploration in order to elicit examples of circuits that light 2 bulbs brightly during whole class discussion. The discussion is an important component of student understanding the 2 different types of circuits.
	• After about 15 minutes or as students are wrapping up the table, call students' attention to the two *Turn and Talk* questions (#4).
		• Project the Activity Sheet and review expectations for each column before setting students off to work on each task.
		
		• Take note of different ways of creating the circuits so that you can call on these students to share.

5 minutes	• (#4) Students will *Turn and Talk*: Were you able to create a circuit that lights 2 bulbs brightly? How is this kind of circuit different from circuits with 2 dimly lit bulbs or 1 bulb? • Call on students who had a successful parallel circuit to share with class. Discuss similarities across the solutions and point out how this type of circuit uses only one source, but both receivers have their own pathway for electrons to flow on. • Draw or display the 2 different types of circuits on the board and discuss the difference.	**Series:** **Parallel:**  
10 minutes	• (#5) Read the situation in #5 with the class. • Students look at a series circuit with 3 bulbs and then must design another circuit that will light them brightly. • (6) Students will talk with a partner about	• Remind students that when designing their circuit, they are not testing it with the sim, but using their

	what would happen if a bulb burns out in the series circuit (Circuit A). After their discussion, student pairs can test their theories together or it can be done as a whole class, depending on time constraints.	knowledge from the class discussion above. They will be able to share ideas and test in #6.
5 minutes	• Introduce the terms *series circuits* and *parallel circuits*. Students will fill in (#7) the table on their activity sheet as each type of circuit is displayed/discussed.	• In my classroom, we have a Science Wall to anchor student learning. Each time new vocabulary or concepts are introduced, the word, definition, and an illustration/picture (often depicted by a student) are added to the wall. Students use the Science Wall as a reference throughout units.
10 – 15 minutes	• Show students a string of Christmas lights and tell them to imagine that they work for a company that produces these types of lights. • (#8) Based on their investigation today, which type of circuit would be best for a string of lights? Why? • Have students discuss ideas and then complete the short constructed response.	• If students need writing support, the teacher might provide scaffolding by guiding these students to use a graphic organizer of pros/cons for each circuit type or providing sentence frames. (i.e "A _____ circuit would be best for a string of lights because __")

III. Using Objects to Complete a Circuit

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

Prior Knowledge: This lesson can be used as the 3rd day of the circuit lessons: *Lighting a Bulb* and *Exploring Kinds of Circuits* or as a stand-alone lesson. If used independently, students should have an understanding of basic electric circuits. This should include the knowledge that a circuit is a loop through which electrons can flow from an electricity source → receiver and a familiarity with series and parallel circuits.

Learning Objective: We will use our knowledge of circuits to identify common objects that complete a circuit.

- **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.
- **CDE Physical Science 1.1:** Energy comes in many forms such as light, heat, sound, magnetic, chemical, and electrical; objects can be either conductors or insulators (1.1.b)
- **CCSS.ELA-Literacy.SL.4.1**: Engage effectively in a range of collaborative discussions (1-on-1, in groups, and teacher-led) with diverse partners on *grade 4 topics and texts*, building on others' ideas and expressing their own clearly.

Time: 45 - 60 minutes

Materials:

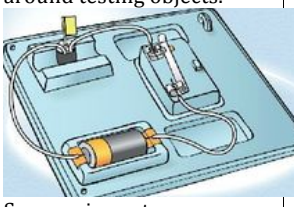
- Activity Sheet for each student (see below)
- Laptop/computer for each student or pairs
- PhET Sim: Circuit Construction Kit (DC Only) http://phet.colorado.edu/en/simulation/circuit-construction-kit-dc
- Materials to create circuits: circuit board, D-cell battery, wires, light bulbs & bulb holders

Time	Procedure	Teaching Tips

5 minutes	• *Introduction:* Review vocabulary and content from prior lessons on circuits.
	  ○ A *circuit* is the pathway that electrons follow to produce electricity. It requires an electricity source (battery) and receiver (bulb).
	  ○ Display a series and parallel circuit and ask students to identify the type and difference between the two.
		✓ In my classroom, our Science Wall displays learned concepts and vocabulary. Students use this as a reference when reviewing previous days' learning.

10 minutes	• Have students access the sim: http://phet.colorado.edu/en/simulation/circuit-construction-kit-dc • *(#1) Explore:* Students will use 5 minutes to make different circuits to light 4 bulbs. • *(#2) Turn and Talk*: Students will share their circuits with the partner, focusing on the following questions:	✓ Keep the exploration to 5 – 10 minutes. Students could continue to work in only this section forever if a time limit is not set! ✓ Monitor student work; support struggling students if needed by

	○ What type of circuit did you make? ○ Is there more than one way to design a circuit that will light several bulbs? • If time allows, share some circuits as a whole group. Call on different students to create their circuits on the projected laptop. • (#3) *Predict*: Ask students: What will happen if you split the junction between the 2 wires? Allow them to share predictions. • Use the sim to test student predictions. This can be done by students on their own laptops or on projected laptop for class to see.	using prompting 'what if' questions such as "What if you tried a parallel circuit?" "What if you added more batteries?" ✓ Have chosen students replicate their circuits on the class laptop (projected) during the explore. This will save time, as they can be displayed but will not have to be created during discussion.
15 minutes	• *Discussion:* Introduce today's first **inquiry question**: "Can common objects be used to complete a circuit?" • Have students *turn and talk* to discuss ideas and make predictions. • (4) Students will create a simple series circuit, replicating the schematic drawing on their activity sheet. • Once students are successful in lighting the bulb, they will test the common objects in "grab bag" and record their results in the chart. • Tell students to think like scientists and observe each object carefully.	✓ If a student needs help, encourage him/her to talk with their partner to try to solve the problem before you offer guidance. ✓ Monitor student work and discussion so that you can highlight important findings when you meet to share as a whole group
10 minutes	• Students will complete and discuss # 6. Facilitate discussion of similarities/comparisons between successful objects and unsuccessful objects. • Students should determine that the 2 objects made of metal allowed the current to pass through the circuit. Ask students if any other objects in the grab bag should complete the circuit based on this rule. (*The pencil lead*!) • Students will most likely say that the bulb did not light when using the lead and, therefore, pencil lead does not let electricity flow through it. If possible, project the circuit with the pencil for students to see and ask them to watch the electrons closely. • Students will notice that the electrons are moving very slowly, but the lightbulb does not light. Ask students how they could increase the speed of the electrons. (*Add batteries!*) Test with students.	✓ For both #6 & 7, you either might give students time (a minute or 2) to write down their own ideas before sharing or have them turn and talk before recording ideas. Whichever works in your classroom, I do think it's important to have students write their responses, as it holds them accountable.

	• Have students complete #11, generating a list of other objects that would allow electricity to flow and complete the circuit.	
5 minutes	• Once students have demonstrated an understanding of this concept, introduce the terms *conductors* and *insulators* and add to science wall. ○ **Conductors** are objects that conduct electricity by allowing electrons to flow through them. Objects that do not allow electricity to flow through them are called **insulators.**	In my classroom, we have a Science Wall to anchor student learning. Each time new vocabulary or concepts are introduced, the word, definition, and an illustration/picture (often depicted by a student) are added to the wall. Students use the Science Wall as a reference throughout units.
15 minutes	• Optional activity: In our classroom, which objects are conductors and which are insulators? Can you design a circuit that can be used to test your predictions? • Show students possible materials: circuit boards, D-cell batteries, wires, and light bulbs. Tell students they may use whichever materials need to create a real life circuit to test classroom objects. • Once students have designed a circuit that can test, allow them to build it and explore the classroom, searching for conductors.	✓ Show students the materials that they can use. If accessible, a circuit base like this one makes it much easier for students to walk around testing objects.  ✓ Some pairs or teams may develop a design before others. If a team is struggling to design or make a working conductor tester, have another group support them OR ask prompting questions to guide their thinking.

Name _____ Date _____

I. Lighting a Light Bulb

Objective: We will explore electricity and determine what makes a light bulb light by testing different electric pathways.

1. **Explore:** Take 5 minutes to explore the sim.
2. **Turn and Talk:** Talk about your findings with a partner. 

3. Try to create different pathways that will light the light bulb.

Components (parts) I used to make a pathway:	Did the bulb light? (circle Y or N)		Observations
3 wires, 1 lightbulb, and a battery	Yes	No	
	Yes	No	
	Yes	No	
	Yes	No	

4. Draw one of the working pathways here:

5. **Turn and Talk:** Share some of your findings with your partner. 
   - Is there more than one way to create a working pathway?
   - What did you notice about successful pathways?

6. Complete the table below.

How can you…	What did you do? (write or draw)	What other changes do you notice?
..make the bulb brighter?		

local 6/27/14 1:02 PM
Comment [2]: Monitor student discussion so you can call attention to important findings or components of the sim. Facilitate a discussion of these as a whole class; preferably projected on whiteboard.

local 7/15/14 7:06 PM
Comment [3]: Explain table to students; they must first try to make a lightbulb light using 3 wires, 1 lightbulb and a battery. Then, they'll record if the light bulb lit and any observations. For the next 3 cells, students can choose the parts they will use and record them.

local 8/1/14 2:03 PM
Comment [4]: Students may have found a variety of ways to get the lightbulb to light. Base your discussion on their findings, but be sure to emphasize that every working pathway needed an energy source (battery) and a way (wires) to connect both sides of it to the bulb.

local 7/15/14 7:11 PM
Comment [5]: While students work, circulate and have discussions with individuals/partners. Refrain from directing their actions, but reinforce their understanding through questioning. For example, if a student added another battery to make the bulb brighter, you might ask "What do you think would happen if you added *another* battery?"

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Comment [6]: Students may write or draw what they did in this column.

How can you…	What did you do?	What other changes do you notice?
…change the direction of the electrical current?		
…turn off the bulb without pushing pause?		

7. **Turn and Talk:** Share your findings with your partner.
   - In order for the bulb to light, what needs to happen?
   - What components did every working pathway have?

8. In the box below, use your understanding to explain how a light bulb turns on. You can use words or pictures to help show what you know.

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Comment [7]: Watch as students complete this task. They may see that all you need to do is split the junction between to components; this opens the pathway so that the electrons cannot flow through. Another possible solution & topic for discussion would be adding a switch. How is using a switch similar to splitting the connection between 2 parts of your pathway?

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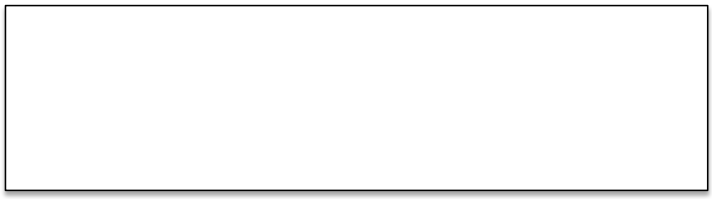
Comment [8]: You might also ask students what *didn't* work.

Name _____ Date_____

II. Exploring Kinds of Circuits

Objective: We will use our knowledge of electric circuits to create and analyze different pathways that can light several bulbs at once.

1. **Explore:** Take 5 minutes to explore the sim and build a working circuit. Draw your successful circuit below and label the electricity source and receiver.



2. **Turn and Talk:** Share your working circuit with your partner.

- Is there more than one way to create a working circuit?
- What do working circuits require?

Inquiry Question: Can you light several bulbs brightly with one battery?

3. Complete the following table by creating, drawing, and observing circuits that meet the criteria.

Create a circuit using…	Drawing of your circuit:	Did the bulb or bulbs light?		Observations brightness? speed of electrons?
1 bulb, 1 battery, 3 wires		Yes	No	
2 bulbs, 1 battery, 3 wires		Yes	No	
2 bulbs, 1 battery, 4 wires		Yes	No	
Try that one again: Make a *different* circuit using 2 bulbs, 1 battery, 4 wires		Yes	No	

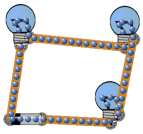
local 8/1/14 2:06 PM
Comment [9]: Have students turn and talk about their ideas.

local 8/1/14 2:06 PM
Comment [10]: Suggested questions as you circulate: What did you notice about the brightness? Why do you think that is? *Can also be used during whole group discussion.

local 8/1/14 2:06 PM
Comment [11]: Monitor student work for this task. Look for students who are able to make a circuit that lights both bulbs brightly – a parallel circuit. When discussing as a whole group, you can refer to this student to explain/share their successful circuits with the class.

4. **Turn and Talk**:
   - Were you able to create a circuit that lights 2 bulbs brightly?
   - How is this kind of circuit different from circuits with 2 dimly lit bulbs or 1 bulb?

5. Circuit A is a working circuit that uses 3 bulbs and 1 battery. The electrons flow throughout the circuit, but the bulbs do not light brightly. They're so dim you can hardly tell that they are lit!

Circuit A: 

Without the sim, design a circuit that lights 3 bulbs brightly using only 1 battery. Draw your circuit below.

6. **Turn and Talk:** In Circuit A, what would happen if one of the light bulbs burned out or broke? What about in the circuit you designed?

7.

Type of Circuit	What it is	What it looks like
_____ Circuit	a circuit that has one pathway for electricity to flow from the source to all receivers	
_____ Circuit	a circuit that has individual pathways from the source to each receiver	

8. Imagine you work for a company that designs strings of Christmas lights. Which type of circuit would be the best design to use? Why? Use evidence from your investigation to support your choice.

_____

_____

_____

_____

_____

_____

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Comment [12]: Call on students who had a successful parallel circuit to share with class. Show students how this type of circuit uses only one source, but both receivers have their own pathway for electrons to flow on. Display both types of circuits for students to see the difference.

local 8/1/14 2:06 PM

Comment [13]: Test students theories (either students can test together or class can test on projected circuit). Discuss why.

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Comment [14]: Display a string of lights and have students discuss their ideas together before beginning the short constructed response.

Name _____ Date _____

III. Using Objects to Complete a Circuit

Objective: We will use our knowledge of electric circuits to identify common objects that complete a circuit.

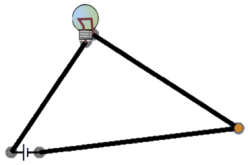
1. **Explore:** Take 5 minutes to explore the sim. Make several different circuits that light 4 light bulbs. Draw one working circuit below.

2. **Turn and Talk:** Share your working circuit with your partner.
- What type of circuit did you make?
- Is there more than one way to design a circuit that will light several  bulbs?

3. **Predict**: What will happen if you split the junction between 2 wires in a working circuit?

Inquiry Question: Can common objects be used to complete a circuit?

4. **Let's test it!** Using 3 wires, a battery, and a bulb, create the following series circuit:



5. Open your circuit by disconnecting two of the components. Click on "Grab Bag." Try to close the circuit using each item and complete the table below.

Grab Bag Item	Did the bulb light?	
Dollar	Yes	No
Paper Clip	Yes	No
Penny	Yes	No
Eraser	Yes	No
Dog	Yes	No
Hand	Yes	No
Pencil Lead	Yes	No

local 8/1/14 2:09 PM
Comment [15]: Keep this time limited. It is not the focus of the lesson and students could work on this part for hours! Some kids may make 1 circuit, others may make several.

local 8/1/14 2:09 PM
Comment [16]: Have students come up to create their working circuits on the class laptop while others continue to explore. This will save time when sharing.

local 8/1/14 2:09 PM
Comment [17]: Discuss predictions – in partners, small groups, or whole class. Then test predictions on the circuits already projected on board.

local 8/1/14 2:09 PM
Comment [18]: Have students talk about their ideas and predictions here.

local 8/1/14 2:09 PM
Comment [19]: Students should Reset All here. Prompt if needed.

6. What do the materials that were able to light the bulb have in common?

7. What other objects would complete the circuit?

These objects are called **conductors** because they conduct electricity by allowing it to flow through them. Objects that do not allow electricity to flow through them are called **insulators.**

*8. Look around our classroom. What objects do you see that you are **conductors?**

9. Using our classroom circuit materials, design a circuit that would allow you to test these classroom objects. (Think about how you tested the grab bag objects!)

My Design:

10. Build the circuit and test the classroom objects that you predicted!

Conductors: **Insulators:**

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Comment [20]: Once students come to the conclusion that both of the metal objects allowed electricity to flow, ask if any other objects in the grab bag should complete the circuit based on this rule. Draw students' attention to the pencil lead. Did anyone observe anything happening in the circuit? Project the circuit with the pencil, if possible. If not, have all students test the lead again. They should notice that the electrons move very slowly, but the lightbulb does not light.

local 8/1/14 2:09 PM
Comment [21]: Ask students what they could do to increase the speed of the electrons to light the bulb more brightly. (Add batteries!) Test this (and other suggestions) with class.

local 8/1/14 2:09 PM
Comment [22]: Optional extension; Dependent upon time and materials.

local 8/1/14 2:09 PM
Comment [23]: If time allows (or the following day), talk about classroom conductors and insulators. Some classroom objects – staplers, mounted white boards, wall joints – might surprise students!