Lesson 3: A Systematic Look at the Incandescent Light Bulb

Overview

Through first hand observations of an incandescent light bulb, students discover its internal components. Students expand their circuitry knowledge by considering the pathway of electrical energy through a light bulb and by incorporating the bulb into an electrical system – a complete circuit. They also explore the concept of a system by considering the implications of a nonworking component of a light bulb.

Teacher Background

Imagine life without light bulbs. The incandescent light bulb is an ingenious device that changed the way humans live. While many scientists contributed to the invention of the light bulb, it is Thomas Edison that is most often recognized for perfecting the incandescent bulb. Edison not only invented a practical light bulb, but he used his knowledge of electricity and gas lighting to invent an entire system of electrical lighting. This system included bulbs, generators, and wires. Edison's light bulb invention was not without great controversy.

The word "incandescent" refers to "white, glowing, or luminous with intense heat." Incandescent light bulbs are composed of several internal structures that work together to produce light and heat. The structure that emits light is called a filament. This tiny, horizontal, thin wire that is supported at the end of two small vertical wires gets very hot (as hot as 4500 degrees F!) when an electric current passes through it and thus emits light. Filaments are often made of tungsten. Tungsten is a metal with a very high melting point (point at which it will melt or catch fire). Incandescent bulbs have several other key parts including a glass cover, 2 support wires that attach to either end of the filament, a wire attachment point, a ceramic insulator, and a metal tip. Inside the light bulb is an inert gas, such as argon, that prevents the metal from coming into contact with oxygen and thus prevents the filament from burning out.

Exploring parts of a light bulb offers an experience in systems since a light bulb is a very common example of a system. A system can be described as a set of interacting parts that work together to form a unified whole. Human-made systems usually have a certain purpose and are designed to work as a coherent entity.

As with parts in any system, if one or more parts of a bulb were missing or not working, the light bulb would not light up. For example, if the filament breaks or burns out, the circuit is no longer complete and the bulb wouldn't light. To prevent this filament from burning out, it is encased in an oxygen free glass bulb. This oxygen free chamber prevents combustion and erosion of the filament. The prevention of combustion is a reaction between the very hot metal of the filament and oxygen, if it were present. Other parts of this light bulb system include the two contact points that are present at the side and base of the bulb. These contact points allow the electrical current to enter and exit the bulb. They connect to two wires that attach to the filament, which is held up by a tiny glass mount that comes up through the center of the bulb. The metal base hides the place where these wires touch, making it difficult for students to conceptualize the wires' role in completing a circuit. All of these seemingly simple parts have a function in providing a complete pathway for the electrical energy or current to move through the light bulb. Remember, in order for a light bulb to light up, it needs to be part of a complete circuit. If the bulb has broken parts or is arranged or connected improperly in an electrical system, it will not light up.

Switches offer a safe and simple way for users of lights and other electrical devices to open and close the circuit to and from the device. By switching open the circuit the light can be shut off. By switching the circuit closed the light can be lit.

Upper elementary students should be given the opportunity to explore the parts of a system and how they work together. Exploration of a system should include explaining ways that things may not work well (or at all) if a part or parts are missing, broken, worn out, mismatched, or misconnected. While these experiences are an early introduction to systems, it is not expected that students identify the light bulb as a system per se but rather develop the sense that individual parts working together can do more than each part individually. Furthermore, while students are introduced to the names of the parts of the light bulb, the intent is not to have

students memorize these terms. The parts are identified for the purpose of aiding class discussions and other forms of communication.

While the incandescent light bulb is slowly being replaced with a new generation of energy saving compact florescent devices and LEDs (light emitting diodes) it offers a "look" into the components of a common electrical device. This focused look at incandescent light bulbs assists in developing a small-scale understanding of an electrical system and prepares students for examining electrical systems on a larger scale.

Students will undoubtedly state that there are a wide variety of light bulbs available. A walk down the aisle of a local hardware store will reveal the different choices, such as incandescent bulbs, halogen bulbs, compact florescent bulbs, LEDs, and an array of others. Alternative lighting choices will be introduced in later lessons.

Key Ideas

- Light bulbs are made up of smaller parts, each with its own function. The parts work together to light the bulb.
- In a complete circuit, electrical energy not only flows to the light bulb, but through the light bulb.
- If a part of the bulb or circuit is missing, broken, worn out, mismatched, or misconnected, the circuit will not be complete.
- Many circuits incorporate switches. The simplest switch has two metal contacts that, when touching, complete the circuit and allow electricity to flow and, when separated, break the circuit and not allow the electricity to flow.

Lesson Goals

Students will:

- recognize that light bulbs have parts and that the parts work together (as a system).
- describe the flow of electrical energy through a light bulb.
- explain how a simple switch can be used to control the flow of electrical energy.

Vocabulary

circuit: a complete pathway or loop through which electricity travels.

filament: a thin thread of metal, often made of tungsten that becomes very hot and emits light as an electric current passes through it.

incandescent light bulb: a source of light that emits light as an electric current is passed through a thin filament which glows with intense heat.

open circuit: an incomplete pathway or loop that interrupts the flow of electricity.

closed circuit: a complete pathway or loop that allows electricity to travel.

switch: a device that allows circuit to be connected and disconnected.

system: a set of interacting parts that work together to form a unified whole.

Preparation

- Prepare materials. (See Materials List below)
- Test batteries and bulbs in student's basic circuit kits.
- Become familiar with the internal components of the different styles of incandescent light bulbs.
- Make an overhead or poster of the light bulb diagram and desk lamp diagram.
- Cut additional wire into 12" pieces and strip off the plastic coating 1" from each end.
- Preview video clip used in step 4. (Students will view the first 55 seconds of the clip.)

Materials

Item	Quantity
Wire stripper	1
An assortment (4-6 different styles) of incandescent light bulbs (e.g. flashlight bulb, holiday replacement bulbs, decorative flame or teardrop shaped bulbs, etc. Avoid bulbs with frosted or colored glass.)	1 set per group
Trays or boxes (for distribution of bulbs and to prevent bulbs from accidental breakage)	1 per set of bulbs (to contain the set) and individual ones for students to place bulbs on as they making observations
Hand lens	1 per student
Safety goggles	1 per student
Scientist's Notebook	1 per student
Colored pencils	1 set per group
Access to LCD projector, laptop, speakers, internet (to show light bulb video clip)	1 per class
Basic Circuit Kit: • Wire, 22-gauge, insulated (one 12" piece, stripped) • D battery • Replacement incandescent flashlight bulb	1 per student (Have spare materials on hand)
Supplementary Circuit Components: • Bulb holder (some bulb holders may require a Philips head screwdriver) • Battery holder • Two additional 12" pieces of wire, stripped	1 set per student (Have spare materials on hand)
Switch Components • Index card • Two brad fasteners • Two paper clips	1 set per student
Teacher Resource 3.1: Incandescent Light Bulb Diagram	1
Teacher Resource 3.2: Desk Lamp Diagram	1
Desk or Clamp Lamp (prop/optional)	1
Student Handout 3.1: The Light Bulb Problem	1 per student
Extension cord	1

Safety Notes

To prevent bulbs from rolling off the tables or desks, it is recommended that bulbs be kept in a box or tray. Make suggestions as to how students should handle bulbs and what should happen in terms of clean up/disposal if one should break. Goggles should be worn when working with objects that can break and shatter such as light bulbs. Keep a dust pan and broom on hand to sweep up any broken light bulb glass.

Time Required: 2-3 sessions

Session 1: Investigate light bulbs, diagram and label parts and discuss the pathway of electricity through the bulb, steps 1-4.

Session 2: Construct a complete simple circuit, construct and incorporate switch into the circuit.

Session 3: Complete Student Handout 3.1.

Connection to *Maine Learning Results: Parameters for Essential Instruction (MLR)* and *National Science Education Standards (NSES)*

- Give examples that show how individual parts of organisms, ecosystems, or human-made structures can influence one another. MLR A1(3-5) a
- Explain ways that things including organisms, ecosystems, or human-made structures may not work as well (or not at all) if a part is missing, broken, worn out, mismatched, or misconnected. MLR A1(3-5) b
- Electricity in circuits can produce light, heat, sound, and magnetic effects. Electrical circuits require a complete loop through which an electrical current can pass. NSES B(K-4) 10

Teaching The Lesson

Engage

1 Uncover student thinking.

Hold up a light bulb and pose the following question: *How do you think electricity travels through the light bulb?"*

Ask students to take a few moments to use words and sketches to describe their thinking about the path electrical energy takes through a light bulb.

Ask a few students to share their current thinking about how electrical energy moves through a light bulb. Pay close attention to the ideas students share. Most students probably have not thought about the pathway electricity takes through the bulb. The metal casing at the bottom of most light bulbs prevents students from observing the presence and position of the two contact wires that are part of a complete circuit. A close examination of the components of the bulb involved in the pathway of electrical energy through a complete circuit will be explicitly addressed in this lesson.

Explore

2 Observe and sketch light bulbs.

Distribute a hand lens to each student and an assortment of incandescent light bulbs (in a tray to prevent rolling off the table) to each group of students. Instruct students to examine the various bulbs, noting similarities and differences through words and sketches in their notebooks.

3 Examine parts of light bulb.

Ask students what they noticed about the different light bulbs. Call attention to the fact that light bulbs are made up of smaller parts. Ask, *"What parts do all of the bulbs seem to have in common?"*

Students should notice that each bulb has a filament, two support wires, a glass base, and wire contact points. Ask students to comment on why they think these parts are found in all the bulbs. (All of these parts are involved in the pathway of electrical energy through the bulb.) Discuss how the parts of the bulb are related to the critical contact points observed and discussed in Lesson 2. The

main focus of this discussion is to help students begin to see how the parts of a light bulb provide a pathway of electrical energy and how the pathway of electricity flows through the light bulb when part of a simple circuit.

4 Explore pathway of electrical energy.

Show students the diagram of the parts of an incandescent light bulb, Teacher Resource 3.1. Ask students to draw a cut away view label the key parts of the bulb (filament, glass cover, wires, metal base, (glass) support, gas, contact points). Remember, the intent of asking students to add labels to their light bulb diagrams is not to have students memorize the parts of an incandescent light bulb, but rather to aid communication. Trace the path of electrical energy through the parts of the light bulb. Ask students to add a colored line and arrows showing the pathway of electricity through the bulb in their own drawings. This one minute video clip can be shown to reinforce the pathway of electric current takes through a light bulb: http://www.youtube.com/watch?v = YnMP1Uj2nz0

> **Note:** *Students view the first 55 seconds of the clip. The last few seconds of the clip shows the bulb exploding and is unnecessary and potentially distracting for students. Use the clip to help students recognize how electric current travels through the bulb and as a result, the filament gets hot and glows. Be aware that because the only evidence of the pathway of electricity that students can readily see is the glowing filament. Students may think that the wires leading up to the filament are not part of the circuit. Clarify with students by questioning them as to why only the filament "glows" and not the whole circuit.*

Following the clip, students pair up to share and discuss their sketches that show the path electricity takes through the bulb (peer check in). Check to see if students have questions or found discrepancies in their sketches. Clarify questions and/or rectify discrepancies. Summarize once again the complete electrical pathway to reinforce the idea that electrical energy must pass through the identified parts of the bulb in order for the bulb to light.

Students, still working in pairs, first discuss and then describe individually in their notebooks how the smaller, individual parts of the bulb work together to accomplish the task of emitting light. Once students have completed this task, students talk with their partner and list three specific examples of what might happen if certain parts of the bulb were missing, broken, or worn out. For example, students are probably familiar with burned out light bulbs. Incandescent bulbs often burn out because the filaments wear out and break, which causes a disruption in the electrical flow. After students have completed this task, ask a few pairs to share their examples with the class.

5 Construct an electrical circuit.

Hold up a light bulb again and ask, *"Why doesn't the bulb light?"* Confirm that in order to light the bulb, electricity must follow a pathway through the battery, wires, and bulb, making a complete circuit. Give each student a kit of materials and instruct each one to construct a complete circuit that includes a light bulb. Ask students to draw and describe their circuit configuration in their notebooks and use a colored line and arrows to note the pathway of electrical energy through the entire circuit, including the light bulb. Suggest that a cut-away drawing would show the pathway electrical energy takes through the circuit. It may be helpful for students to trace the circuit path with their fingers. Students may need to see an example of a cut-away drawing and discuss their characteristics, if they are not familiar with them.

6 Discuss circuits as systems.

Engage in a discussion about the individual parts making up the circuit and how the individual parts of the circuit work together to perform the task of lighting a bulb. During the discussion, students should refer to the sketches and descriptions in their scientists' notebooks. Ask students to give specific examples of what might happen if certain parts of the circuit were missing, broken, worn out, misconnected, or mismatched. For example, students might say that the bulb might not light because the wires were not properly connected to the critical contact points on the bulb, the battery was dead, the bulb was blown, or there wasn't enough power in the battery to light the bulb, etc. Emphasis during this discussion should be that many parts of a circuit work together to accomplish a task, in this case lighting a bulb. If one part of the circuit is not functional, the bulb will not light.

7 Introduce the switch.

Ask students how they initiated the flow of electrical energy through the circuit:

- *How do we turn the light bulb on and off?* (By connecting and disconnecting the wires from the battery and/or the bulb. Demonstrate this action as it is being discussed.)
- *How is this like the way we turn the flashlight or our lights at home on and off?* (Switches are used to turn flashlights and lights on and off at home.)

Demonstrate how to make a simple switch using an index card, brass fasteners, and a paper clip. Instruct each student team to make one. Students integrate the switch into their circuits and use the switch to control the flow of electricity to the bulb. They draw

the circuit showing the switch operating in two ways: closing the circuit (lighting the bulb) and opening the circuit (not lighting the bulb).

Hold up the following prefabricated components: a switch, battery and bulb holder, and bulb. Ask students to share their ideas as to what these items might be used for. Explain to students that the bulb and battery holder help to hold the parts of the circuit more securely in place. Show students how to integrate these components into a complete circuit, pointing out the critical contact points of the battery and bulb holder and the switch. Allow students a few minutes to create a circuit using these new components and instruct students to make a cut-away sketch of a complete circuit that clearly shows the pathway of electrical energy includes the new components.

8 Revisit electrical energy pathways (complete circuits).

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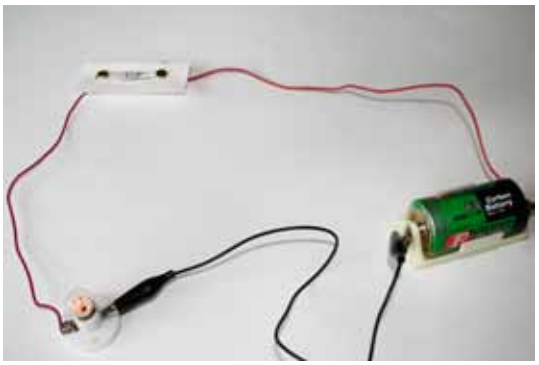
Direct students to discuss in small groups at their tables their understanding of the specific pathway electrical energy takes in the circuit they've constructed that includes the prefabricated components. As students are discussing their circuit configuration note what they are finding. Students may notice that their classmates have integrated the components in slightly different ways.



Note: *Some students may hold naïve ideas about how the circuit works even after building one successfully. They may think that each wire brings electrical energy from the battery up to the light bulb rather than electrical energy traveling in one direction through the wire "loop." Or they may think one wire is active and one is not. Use their thinking to guide your questioning and discussion.*

9 Discuss parts and wholes connection.

Revisit the idea of systems (parts and wholes) focusing on the additional components (bulb and battery holder and switch) by engaging in a brief discussion similar to the earlier conversations about the relationship(s) between the individual parts making up the circuit and the overall system's task. Encourage students to refer to the sketches and descriptions in their notebooks during the discussion. As before, ask students to provide specific examples of what might happen if certain parts of the circuit were missing, broken, worn out, misconnected, or mismatched. Ask students how the circuit has changed. (It has gotten more complex.)

Reflect And Discuss 

10 Facilitate discussion of light findings.

Refer back to the *Early Light* cards and the *Light Cards* students created by examining lights found in their homes and communities in Lesson 1. Show students a simple desk lamp and ask: *What parts do these lamps have in common with lamps found at home?* Students may identify the individual parts of the lamp such as the bulb, bulb holder, wire cord, and switch. Support this exercise with either a cut away diagram of a lamp showing critical parts that students could draw or place in their notebooks and/or by labeling the parts of the lamp with the word as it is identified. If the idea that the lamp needs to be connected to a power source to be a complete circuit doesn't surface, pose the question to students: *How can a lamp be considered a complete circuit? How do the individual parts of the lamp work together to provide a pathway for electrical energy?* Conversely, give an example of a part that could be missing, not working, or connected improperly, and describe how this affects the circuit.

Explain and use the Teacher Resource 3.2 showing that lamp cords are actually two bundles of wire: one wire provides a pathway for electrical energy to go toward the lamp and one carries electrical energy/electricity away from the lamp.

During this discussion, students may notice that the wires and cords have a plastic coating on them. If they do not, call attention to this detail by asking students why they think the wires might be covered with plastic. This question sets the stage for Lesson 4, which introduces insulators and conductors.

11 Bring lesson to a close.

Bring the lesson to a close by asking students to complete the prompt on Student Handout 3.1: The Light Bulb Problem. Collect, review, and summarize these prompts prior to Lesson 4.

Home-School Connection 

Light Bulb Survey.

Guide students through a process for conducting a light bulb survey in their homes. Suggest using a tally system or simple data table to count and record the number of bulbs in their homes. This should include categorizing light bulbs by type. Ex: incandescent, compact florescent, florescent, LED, halogen, etc. The survey could be extended in a number of ways:

- Create a class tally chart.
- Calculate the percentages of each type of bulb used.
- Graph the different wattage of the various bulbs used.

> **Note:** *In Lesson 8, students compare the amount of energy, heat, bulb life, and light output for various light bulb types. Previewing this lesson may help to determining how extensively to investigate bulbs at this point.*

Planning Ahead 

Collect, review, and summarize student responses from Student Handout 3.1 prior to Lesson 4. Select responses that describe how Addison should connect the various components of the circuit, in particular those that mention the role of the key parts of the light bulb or address specific parts-wholes ideas.

Extensions

Student may:

- investigate early light bulbs, making note of materials used to make filaments and considering the following questions:
  Why were these materials selected?
  What properties do these materials have?
- examine various types of switches.
- research the work of Thomas Edison and the many other contributors to the development of the incandescent light bulb.
- read Doolinrg, M. (2005). *Young Thomas Edison.* New York: Holiday House.
- read deMauro, L. (2005). *Time for kids: Thomas Edison: A brilliant inventor.* New York: Harper Collins.
- create a the timeline of inventions contributing to the invention of the light bulb.

Connection to Maine Agencies

MEEP (Maine Energy Education Program) has Home Lighting Inventory and will come to interested schools, free of charge. Students take an inventory of the lighting in their homes – number of fixtures, types of bulbs, and how long the lights are used per day – to see what impact lighting has on their electricity consumption. The MEEP website is **http://www.meepnews.org/classroom activities**

For schools in Aroostook County, a Maine Public Service (MPS) representative will come to interested schools, free of charge, to guide and support concepts developed in this lesson. A description of programs is available at **www.mainepublicservice.com**. Click on the education section of the site. To schedule a visit contact Nancy Chandler at207.760.2556 or nchandler@mainepublic service.com

Online References and Resources

Additional background on electric circuits:

http://www.teachersdomain.org/resources/phy03/sci/phys/mfe/lp_electric/index.html

Edison's early light bulb collection that served as evidence in legal battles around patents of the incandescent light bulb. The collection includes images and descriptions of the various prototypes Edison developed. http://www.edisonian.com/

Sites that provide insight into the historical timeline and inventors of the light bulb:

Edison National Historic Site:
http://www.nps.gov/edis/home.htm

Lemelson Center for the Study of Innovation and Invention:
http://invention.smithsonian.org/centerpieces/edison/

Thomas A. Edison Papers:
http://edison.rutgers.edu/