Section 1 Generating Electricity

What Do You See?

Learning Outcomes

In this section, you will

- **Trace** energy transformations.
- **Plan** a model for electricity.
- **Construct** a circuit that lights a bulb.
- **Adjust** the brightness of a light bulb with a hand generator.

What Do You Think?

Usually, when you need electricity, all you have to do is plug an appliance into the wall.

- **How is the electricity that you use generated?**
- **Oil can be used as an energy source to generate electricity. What other sources of energy can you identify?**

Record your ideas about these questions in your *Active Physics* log. Be prepared to discuss your responses with your small group and the class.

Investigate

In this *Investigate*, you will explore how people use electricity to improve their lives. You will then set up a simple circuit to investigate the energy required to light a light bulb. Finally, you will investigate how a light bulb produces light from the electricity flowing in a circuit.

Part A: What Electrical Appliances Do You Really Need?

1. Before embarking on your study of electricity, discuss why some people may not, or cannot, use electricity available through utility power lines. Think about their needs and wants.

a) In your log, list some of the reasons why people do not or cannot access electrical power from utility power lines.

b) What sources of electricity would be available to those who do not obtain their electrical power from utility companies?

c) If you did not have electricity available to you, how could you store and prepare your food?

d) What forms of entertainment do not require electricity?

2. If you had a limited amount of electricity, which electrical appliances would you choose to use? Which appliances would you eliminate?

a) In your log, list the five top electrical appliances that you would choose.

3. Compare the lists as a class. You will return to these lists at the end of the chapter as you complete the *Chapter Challenge*. Since the wind generator will probably not be able to supply all the electricity required for these appliances, you will have to learn about electricity to improve your list.

Part B: Investigating a Closed Circuit

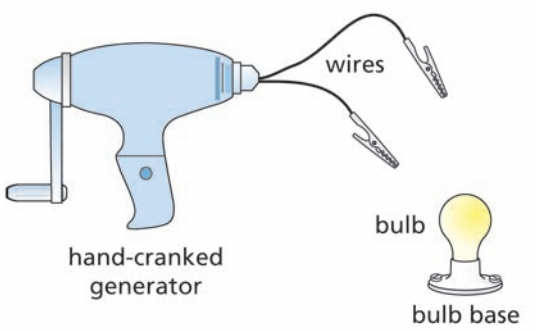
1. You will be provided with a bulb, bulb base, connecting wires, and a generator. Assemble the bulb, bulb base, connecting wires, and hand generator. Turn the crank of the generator to make the bulb light.

Never turn the crank too fast. You can strip the gears!

a) Draw a diagram of how you assembled the equipment for the bulb to light. This is called a closed *electric circuit*. Under what conditions will the bulb not light? Use words and a diagram in your answer.

b) What are the effects of changing the speed or direction of cranking the generator?

c) What are the effects of reversing the connections of the wires to the bulb or to the generator?



2. Replace the bulb that you have been using with a blinking bulb, the kind used in some toys, flashlights, and holiday decorations. As before, use the generator to make it light. Keep cranking the generator to make the bulb go through several on-and-off cycles.

a) Describe any difference that you can feel in cranking the generator when the bulb is on compared to when the bulb is off.

b) How do you think that the blinking bulb works? What makes it go on-and-off?

The steel wool will get very hot. Do not touch it while conducting the experiment. Allow the steel wool to cool before removing it.

3. Replace the blinking bulb with tiny strands of steel wool within the bulb socket. (Hint: The fewer strands you use, the better this works.) Crank the generator and observe what happens to the steel wool. Be careful not to touch the hot steel wool. You may push the steel wool with the point of a pencil to provide a better contact with the socket. You may also remove the socket and connect the ends of the steel wool to the alligator clips.

a) Describe the appearance of the steel wool when the generator is being cranked.

b) What factors affect whether or not the steel wool glows, how much it glows, and for how long?

c) What were the similarities and differences between the steel wool and the light bulbs that were used?

d) What would happen if too much electrical energy flowed through a wire in the wall of a house?

4. Unscrew the bulb from its bulb base. Assemble the bulb, connecting wire, and hand generator (no bulb base), and turn the crank of the generator to make the bulb light. Experiment with placing the wires on different parts of the bulb to try to make it light. Draw a diagram of how you assembled the equipment for the bulb to light.

5. Was the electrical energy that you used to "light things up" in this investigation "free"? Did you get something for nothing? Using your observations in this *Investigate*, write a short paragraph to answer each of the following questions:

a) What was the energy source for each part of the *Investigate* (bulb, blinking bulb, steel wool)? Was it free energy, at no cost?

b) How did you make the hand generator work? What is it doing? What forms of energy were involved in the investigation, and in what order did the forms appear?

c) How is the energy source used in this investigation different from the source used to light a bulb in a flashlight, or in a house lamp?

Physics Talk

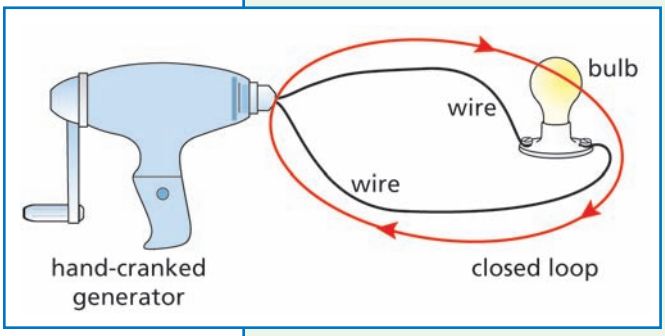
GENERATING ELECTRICITY

Electrical Circuit

Physics Words

electrical circuit: a route along which electricity can flow.

In this section, you created a closed **electrical circuit** that could light a bulb. The electricity appeared to go from the generator to the light bulb and then back to the generator. The circuit resembled a "closed loop," like a circle.



To get the bulb to light, you had to turn the crank of the hand generator. The faster you turned the crank, the more electrical energy was generated and the brighter the bulb became. When you used the blinking bulb, you probably noticed that when the bulb went off, it was very easy to turn the crank. That is because you did not need to generate any energy to light the bulb.

Energy Transformations

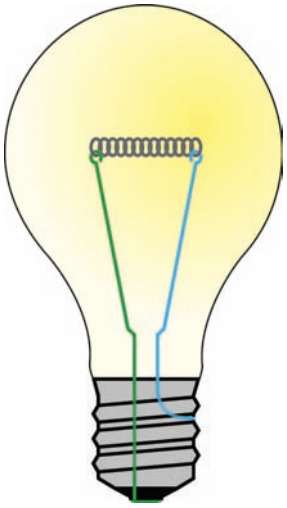
The energy to turn the crank came from your hand. You got the energy from eating food. The chemical energy from your food became mechanical energy to turn the crank of the generator. The mechanical energy you supplied became electrical

energy. This electrical energy then turned into the light and heat of the bulb. There are lots of energy transformations required to light a bulb.

Electricity for your home is also created by a generator. The details of how a generator produces electricity will be explored in another chapter. The generators needed to produce the amounts of electricity required in a city are much, much larger than your hand generator. People cannot turn these large turbines. Wind or falling water is needed to turn the turbines in similar ways to you turning the crank of the hand generator. Steam can also be used to turn the turbines. To make the steam, heat is produced by burning oil, coal, or gas, or causing uranium to fission.

The production of electricity requires a source of energy. That energy can come from you (as in the *Investigate*), the wind (as in the dwelling in the *Chapter Challenge*), or from large power plants.

How Does a Light Bulb Work?



When you used a tiny strand of steel wool, you found that the steel wool would glow when electricity flowed through it. When Thomas Edison invented the light bulb, he tried thousands of different materials until he found one that would not burn out but would continue to glow when electricity ran through it. It was necessary to put that tiny piece of material (the filament) in a glass-enclosed container. To make the connection to the wires, the light bulb you used has two terminals — one for each side of the wire.

One side of the wire is connected to the bottom of the bulb. The other side is connected to the metal on the side of the bulb that also is used to screw the bulb into the socket. That was a clever technology — to use the metal screw threads as one end of the wire.

The glowing and burning steel wool also shows you the danger of too much electricity in a circuit. Without safety measures, wires get overheated and cause fires. Fuses are one such safety measure that you will learn about in a later section.

Light bulbs are just one device that uses electricity to do something useful. Electric motors convert electricity into mechanical work. Ovens and stoves convert electrical energy into heat to cook food. Refrigerators and air conditioners use electrical energy to cool things. Fans convert electrical energy into mechanical energy to move air. Electrical energy is also used to produce light and sound in your televisions and computers. Try living for a weekend without using any electrical device of any kind!

Checking Up

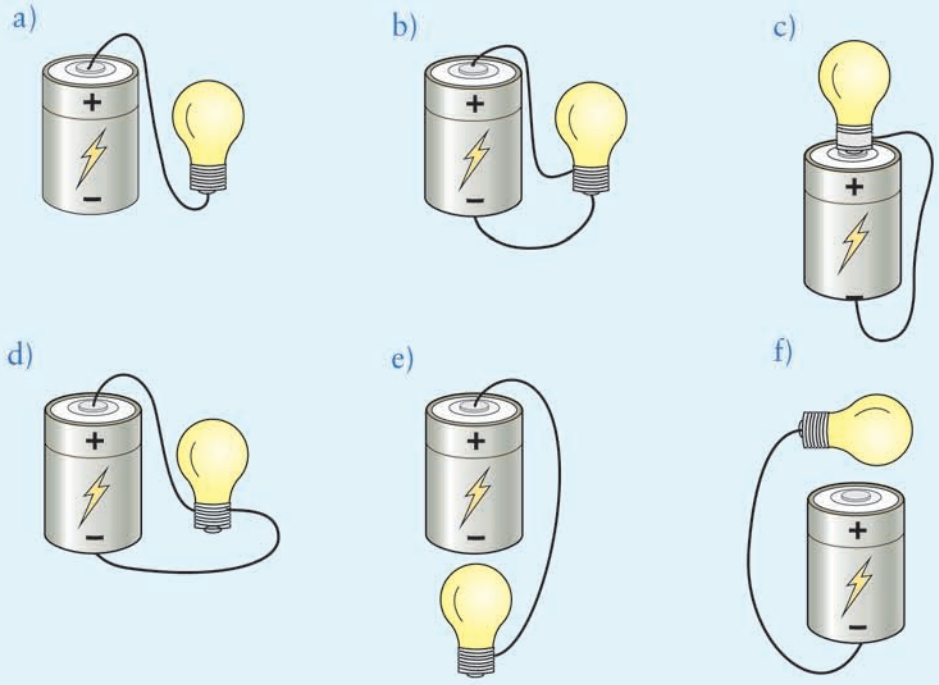
1. Energy is necessary to make a light bulb light. Where did the energy come from to light the bulb during your investigation?
2. Why was it easier to turn the handle of the generator connected to the blinking bulb when the blinking bulb was off?
3. Compare and contrast the glowing steel wool with the filament of a light bulb.

Active Physics Plus

+Math	+Depth	+Concepts	+Exploration
	◆		◆

Closed Electrical Circuit

1. Using only a single wire and a battery, construct a circuit that will make a bulb light. Keep a record of all of your attempts. Identify the diagram for the circuit that lights the bulb, and include in your diagram the picture of the wiring inside the bulb.
2. Identify which of the circuits shown below will or will not light the bulb.
3. The blinking bulb you investigated must have some mechanism to make it turn on and off. Design a blinking bulb.



What Do You Think Now?

At the beginning of this section, you were asked the following:

- **How is the electricity that you use generated?**
- **Oil can be used as an energy source to generate electricity. What other sources of energy can you identify?**

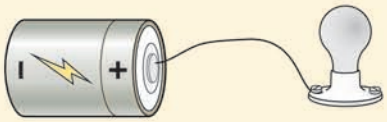
How would you answer these questions now? Use what you have learned about electricity using generators to create a circuit to revise your previous answers, if needed.

Physics

Essential Questions

What does it mean?

A person describes a flashlight that uses a battery and a bulb. It looks like this:



Is this the complete circuit?
Will the bulb light?

How do you know?

Given a generator or a battery, two wires, and a bulb, draw a circuit that will light the bulb and one that will not the light the bulb.

Why do you believe?

Connects with Other Physics Content	Fits with Big Ideas in Science	Meets Physics Requirements
Electricity and magnetism	* Conservation laws	Experimental evidence is consistent with models and theories

* "You can't get something for nothing." When generating electrical energy, where does the energy come from?

Why should you care?

Physics allows you to describe electricity, but cultural and economic factors determine how much electricity you use and how you use it. Describe why considering culture and economics along with physics would be important in the selection of electrical appliances for a home.

Reflecting on the Section and the Challenge

This section has given you some experience with using a generator to provide energy for electric light bulbs. The generator and the light bulb used in this section are scaled-down versions of the ones in the home for which you are designing an appliance package. The one in that dwelling will have the wind turn the crank to produce the electricity. One additional feature will exist in the electrical system for the dwelling: The electrical energy from the generator will be able to be stored in batteries until it is needed to operate lights and other appliances.

Part of your challenge is to write a training manual to help instructors teach the local people about their wind-generator system. You will want to include something about the necessity for a complete circuit and an illustration of such a circuit in the training manual. You will probably also want to include something about how the energy is generated and transformed. The key point is that you cannot get electrical energy without some input of energy. You can turn the crank of a generator using human energy, the wind, or other sources of energy.

Physics to Go

1. Electrical appliances plug into the wall with a single plug, but a plug has at least two prongs (sometimes there is a third one, but the minimum is two). Why do you think that this is the case? Refer to what you know about closed circuits in your answer.
2. You know that electricity comes "out of the wall." You also know that it "starts" in a power plant. Draw a picture that shows how you think the electricity is "created" and how it gets to your home.
3. Explain what you think electricity is, how it behaves, and how it does what it does.
4. A bulb holder has two terminals. Draw a diagram to show how these terminals connect to the light bulb.
5. There is a flashlight that you squeeze again and again to get the light bulb to light. How is this similar to the hand generator you used in this section?
6. A light bulb has output energy of light and heat. List five other electrical appliances. For each appliance, the input energy is electrical. What is the output energy?

In the following questions, choose the best answer from those provided.

7. Electrical energy can be transformed into
   a) light
   b) heat
   c) sound
   d) all of the above
8. Which of the following is designed to convert energy into mechanical work?
   a) electric fan
   b) kerosene heater
   c) flashlight
   d) baking oven
9. Choose the correct sequence of energy transformations in the *Investigate* with the hand generator:
   a) light to heat to mechanical
   b) mechanical to electrical to light and heat
   c) mechanical to heat to light
   d) electrical and mechanical to light and heat

10. ***Preparing for the Chapter Challenge***

Part of your challenge is to write an outline for a training manual. Write down the key point(s) from this section that you will need to include in your manual.

Inquiring Further

1. **Energy-efficient light bulbs**

The kind of light bulb you used in this section is an incandescent bulb. Another kind of light bulb that is sold is labeled "energy efficient." Research these kinds of bulbs by visiting a home supply store. Look at the labels for these bulbs and make note of factors such as the number of lumens (the amount of light) produced and the amount of power (watts) consumed. Compare these with traditional incandescent bulbs.

2. **History of light bulbs**

Research the history of the light bulb. Be prepared to present your research to the class.