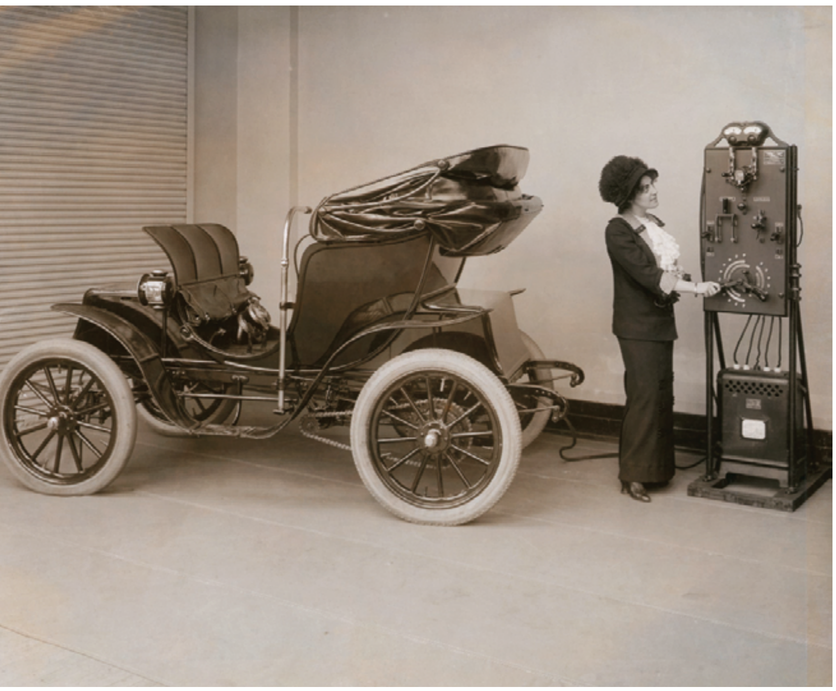
LESSON 4

Storing and Using Energy in a Battery



CORBIS/SCHENECTADY MUSEUM; HALL OF ELECTRICAL HISTORY FOUNDATION

A young woman recharges the batteries in her 1912 electric car. In the early years of automobiles, electric cars were popular.

INTRODUCTION

In Lesson 3, you charged your battery and tested it with a lightbulb. Everyone in the class used the same charging time. But suppose you and your classmates charged your batteries for different lengths of time. How might the amount of time you spent charging the batteries affect how long they last when you use them to light a flashlight? Lesson 4 will help you answer this question.

OBJECTIVES FOR THIS LESSON

Investigate how the energy stored in batteries depends on the time the battery is charged.

Apply experimental design techniques in conducting an investigation.

Construct a graph of data.

Use a graph to make and test a prediction.

Draw conclusions based on evidence in your data.

Getting Started

1. On the basis of what you did in Lessons 2 and 3, review your definition of a battery.

2. Listen as your teacher reviews how to hook your battery to the battery charger and how to tell whether your battery is charging properly.

3. Suppose you connected the battery to the charger for different amounts of time. In your science notebook, write a hypothesis about how you think the charging time would affect the operation of the lightbulb.

4. Discuss with the class how you can test your hypothesis using appropriate experimental design. Be sure to identify the independent variable and the dependent variable.

MATERIALS FOR LESSON 4

For you

- Your partly completed copy of Student Sheet 2.1: What Do We Know About Batteries? (from Lesson 2)
- 1 copy of Student Sheet 4.1: Measuring the Energy Stored in a Battery

For your group

- 1 battery charger

For you and your lab partner

- 2 D-cell batteries
- 1 flashlight
- 1 student timer (or clock with a second hand)

Inquiry 4.1
Charging Batteries for Different Lengths of Time

PROCEDURE

1. Go to your assigned battery charger. Two pairs of students will work at the same charger.

2. Place your batteries in the charger. Follow the safety guidelines and instructions. After charging your batteries for 30 seconds (0.5 minutes), unplug the charger and remove the batteries.

3. Switch the flashlight to the "Off" position. Put the two batteries in the flashlight (see Figure 4.1) so that they line up positive end to negative end. Turn on the switch and start the student timer. Stop the timer when the bulb is no longer lit.

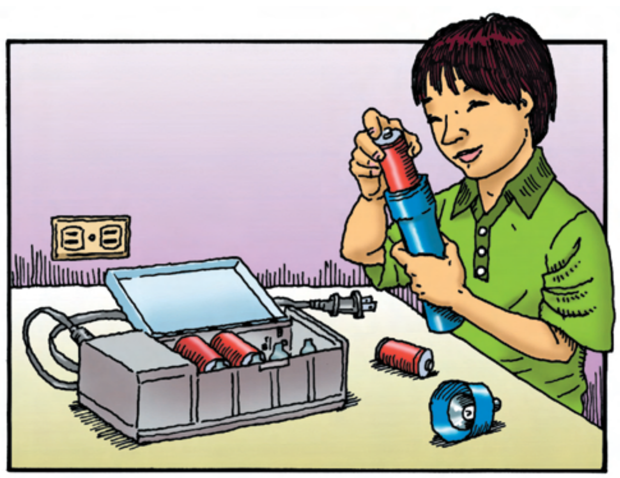


Figure 4.1 *Make sure the flashlight is turned off before you remove the batteries from the charger and place them in the flashlight.*

4. Record the time in Table 1 on Student Sheet 4.1. Later, your data will become part of the data used to calculate class averages.

5. Repeat Steps 2 through 4, charging your batteries for 60, 120, and 240 seconds and discharging them through the lightbulb after each charging. Record the data in your table after each trial.

6. Share your data with the rest of the class. Compute the class average for each trial. Record the class averages in the data table.

7. Construct a graph of class data on Student Sheet 4.1. Follow these guidelines:

   A. Decide which variable you controlled—the charging time or the time the bulb stayed lit—when you did the experiment. This is the independent variable; it goes on the *x* axis.

   B. Determine the dependent variable from your observations. This variable goes on the *y* axis.

   C. Label each axis with the name of its variable and its unit of measure (minutes or seconds). For example, "Battery-charging time (seconds)" and "Time bulb stays lit (seconds)."

   D. For each axis, choose a scale that includes all your data points. Make sure to divide the scale on each axis into equal units.

8. Use your graph to predict how long the bulb will stay lit if you charge the battery for 180 seconds. Record the prediction in your notebook.

9. Test your prediction and record the results.

10. With your lab partner, discuss your results and how you can use graphs to make predictions. Be prepared to discuss your results with the class.

REFLECTING ON WHAT YOU'VE DONE

1. Discuss the following questions with your lab partner and write the answers in your science notebook.

A. Discuss with your lab partner any patterns you observe in data that come from class averages. For each trial, why is it better to use the class average instead of results from only one pair of students?

B. Describe the shape of the graph that comes from the class averages. What does it tell you about the length of time the battery was charged and how long the bulb stayed lit?

C. How did you use the graph to make your prediction about how long the flashlight would stay on if you charge the batteries for 180 seconds?

D. How did the length of time the bulb stayed lit compare with the length of time you predicted?

E. Why was it helpful to use a graph to make your prediction? Could you have made your prediction another way?

F. Do your data support your hypothesis? Give evidence from your data.

2. Go back to the chart on Student Sheet 2.1: What Do We Know About Batteries? On the basis of what you have observed and measured in this lesson, fill in the last column "What I Learned." Be ready to share your answers with the class.

Electric Cars: Back to the Future?

CORBIS/JONATHAN BLAIR

Before cars were invented, horses were a common means of transportation. They are still a useful form of transportation today. In some cities, police officers use horses to get through congested car traffic.

In 1900, automobiles were not yet a part of American life. A total of 4200 cars were sold in the entire United States in that year. Cars were pleasure vehicles that could be afforded only by the very rich.

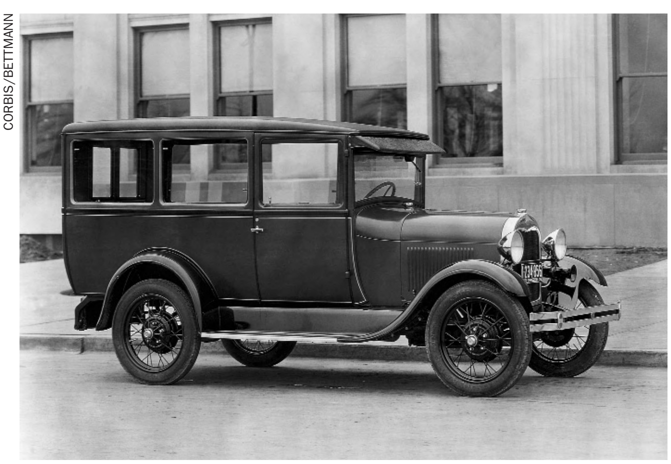
That's probably no surprise. But how about this: Of those 4200 cars, only 12 percent were powered by gasoline. The rest were powered by steam or electricity. Electric cars were very popular a century ago. Many used the Edison Cell, a nickel–iron battery. These cars could travel 50 miles on each charge. They reached a speed of 40 miles an hour—not fast by today's standards, but a big improvement over a horse and carriage!

What changed things? The invention of the starter motor. Before the starter was invented, owners of cars that ran on gasoline had to crank up their engines by hand. This was a big disadvantage. With the starter, gasoline soon became the fuel of choice. There was plenty of it, and it was cheap. More and more people wanted cars. The auto industry grew at an incredible rate. By 1924, electric cars had nearly disappeared from the road.

CORBIS/HULTON-DEUTSCH COLLECTION

Above: *Thomas Edison stands next to his Baker electric car.*

CORBIS/BETTMANN



Left: *1928 Ford Model A. Electric cars had to take a back seat to these popular gasoline-powered cars.*

CORBIS/DEAN CONGER

Pollution from gasoline-powered vehicles is a major problem in many cities of the world.

For 50 years or so, things went fine. By the 1970s, however, Americans became worried about gasoline shortages. Environmental groups expressed concern about the effects of fuel emissions on air quality. The U.S. Congress passed "clean air" legislation that imposed new regulations on the auto industry.

One result was a search for alternative fuels. Electricity, used in the first cars, was a natural choice. Manufacturers began to design battery-powered vehicles to replace gasoline-powered cars.

Instead of using chemical energy that has been stored in the form of gasoline, electric cars (sometimes called "EVs," which stands for "electrical vehicles") use chemical energy that has been stored in a large rechargeable battery. When a driver steps on the pedal, a vehicle system controller sends power to an electric drive motor.

AP/WIDE WORLD PHOTOS

A modern electric car

When it's time to recharge an electric car, the owner hooks a charge plug into a 240- or 120-volt charge device. Recharging at 120 volts takes up to 24 hours; at 240 volts, it takes about 6 hours. Some EVs have special brakes that generate electricity instead of heat friction. The brakes stop the car and recharge the battery at the same time!

EVs have three big advantages over gasoline-powered vehicles:

1. They're clean: EVs have no tailpipe emissions. Their engines don't generate fumes or waste fuel while idling.
2. They're quiet: EVs, unlike combustion engines, make almost no sound.
3. They're smooth: Most EVs don't have gears—no jerky acceleration!

Despite these advantages, people are still not willing to switch to electrically powered cars. The reasons are evident: power, speed, convenience, and cost. Gasoline-powered cars can go from 0 to 60 miles per hour in 6 seconds or less. They can go 200 miles between refills. EVs accelerate more slowly—a big disadvantage on the highway. Most go between 50 and 100 miles between charges. Their top speeds are still lower than those of cars with gasoline engines; however, they are getting faster. Some test vehicles have been clocked at up to 183 miles per hour. Finally, the cost of battery-pack replacements for EVs is quite high.

At the present time, electric cars are more expensive to operate than gasoline-powered cars are, but over time the costs will level out. Fuel costs for battery-powered cars, experts predict, will be 1 or 2 cents a mile. Fuel costs for gasoline-powered engines range from 5 to 10 cents a mile. In addition, EVs don't need transmissions, motor oil, or tune-ups.

When you get your license and start driving, you'll still go to the gas station and say, "Fill it up!" But who knows—by the time your own son or daughter starts to drive, the order may be, "Plug it in!" ☐

Putting the Wind to Work

AP/WIDE WORLD PHOTOS

Winds from Hurricane Roxanne lash Sanchez, Mexico

The power of wind can be a popular topic—especially when hurricane season rolls around or a tornado levels a town in the Midwest.

CORBIS/LEE SNIDER

An early windmill. Windmills like this one used the power of the wind to rotate huge grindstones that crushed grain brought from local farms.

But the force of winds can be put to good use as well. For thousands of years, people have put the wind to work—to move boats, pump water, and grind grain.

Down on the Farm

Wind power can also be harnessed to generate electricity—if you choose the right location. That's where wind parks enter the picture. A wind park, or wind farm, is a large group of windmills built in a single area. Wind parks are usually erected in large, flat, open spaces, because hills, mountains, tall trees, or buildings block winds.

The largest wind farm in the United States covers 54 acres and contains 7500 windmills. It is located near San Francisco. This wind farm

WARREN GRETZ/DOE/NREL

Wind farms need large, open spaces. So do cows!

DAVE PARSONS/DOE/NREL

A close-up view of a modern windmill. The force of the wind turns the blades and rotates the vertical shaft that transfers the wind power to an electric generator.

was built in 1981. It has generated billions of kilowatt-hours of electricity.

Wind parks have also been built in many other countries. A wind park in Wales provides electricity to 20,000 homes. Wind power supplies 5 percent of the electricity in Denmark.

Transforming Energy

You can think of wind power as a form of solar energy. The sun warms the earth's atmosphere unevenly, causing air to move, swirl, and create wind. A wind turbine, perched at the top of each modern-day windmill, captures the wind. Most modern wind turbines have three large blades—sometimes more than 15 meters long.

Some windmills are as high as a 10- or 20-story building. Winds are stronger at higher levels than at lower ones. Therefore, tall windmills harness powerful gusts that are swirling above the earth's surface. Small windmills capture a gentle breeze.

All windmills work the same way. The blades rotate like a propeller when wind blows on them. The blades are connected to a hub that turns a shaft. The shaft runs into a generator, which converts mechanical energy to electrical energy. Electrical current then flows from the generator through the power lines of the local electric company and carries the energy to the user.

Putting the wind to work is a good idea for several reasons. It is environment-friendly. No pollution! It is inexpensive. And wind is a renewable resource. *You* may worry about "running out of wind," but nature never will! □