LESSON 8

Batteries and Current

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This hydrologist and his aide are collecting water samples in a limestone cave in West Virginia. The battery-powered lights in their helmets make it possible for them to see in these dark, underground caves.

INTRODUCTION

In Lesson 6, you investigated current in both series and parallel circuits. You learned how to measure current with an ammeter. You found that the current is the same no matter where you measure it in a series circuit. You also found that in a parallel circuit each line has its own current. In Lesson 7, you investigated voltage and learned how to use a voltmeter to measure the voltages of compound batteries. You also observed how voltage affects the brightness of lightbulbs. Voltage and current are two important measurements in electrical circuits. In this lesson, you will investigate how current and voltage are related in a circuit.

OBJECTIVES FOR THIS LESSON

Design and conduct an experiment to determine the relationship between the number of batteries in a circuit and the current through a lightbulb.

Observe the effect on a lightbulb's brightness when the current through the lightbulb is changed.

Getting Started

1. Review with your group how to use ammeters in circuits, including what ammeters measure and how ammeters are connected in a circuit.

2. Set up the circuit shown in Figure 8.1

3. Draw the schematic for the circuit in Figure 8.1 in your science notebook.

Figure 8.1 *Connect a battery, a lightbulb, an ammeter, and a switch in series to measure the current through the lightbulb.*

MATERIALS FOR LESSON 8

For you
1 copy of Student Sheet 8.1: Batteries and Current in Circuits

For your group
1 circuit systems kit

4. Close the switch in your circuit and record the current through the ammeter.

5. Discuss the following question with the class:

   Is the current through the ammeter the same as the current through the lightbulb? Explain your reasoning.

Inquiry 8.1 Investigating How Batteries Affect Current

PROCEDURE

1. Discuss the following question with your group:

   What do you think would happen to the current through the ammeter if you added more batteries to the circuit?

2. Review Student Sheet 8.1. Use this student sheet to complete this inquiry.

3. Design an experiment to find out how changing the number of batteries in your circuit affects the current through the lightbulb.

4. Complete the following steps and record your findings on your student sheet:

A. Identify the independent and dependent variables in your investigation.

B. Write a hypothesis about how changing the number of batteries will affect the current through the lightbulb.

C. Write a procedure describing how you will change the batteries and measure the current.

D. Draw a data table to record your data and observations.

E. Enter your data on the graph on your student sheet.

F. Analyze your data and write a conclusion about the following:

- how changing the number of batteries affected the current
- how changing the current through the lightbulb affected its brightness

REFLECTING ON WHAT YOU'VE DONE

1. Share with the class what you did in your experiment and what you found out about the current through a lightbulb and the brightness of the lightbulb.

2. Look back at your hypothesis for your experiment. Answer the following question in your science notebook: Based on the results of all the groups, was your hypothesis supported or not supported by the results of the experiments? Share your answers with the class.

3. Review the results of your investigations about voltage and brightness from Lesson 7. Write a sentence or two in your science notebook summarizing what you have learned about batteries, current, and lightbulbs in this lesson and in Lesson 7.

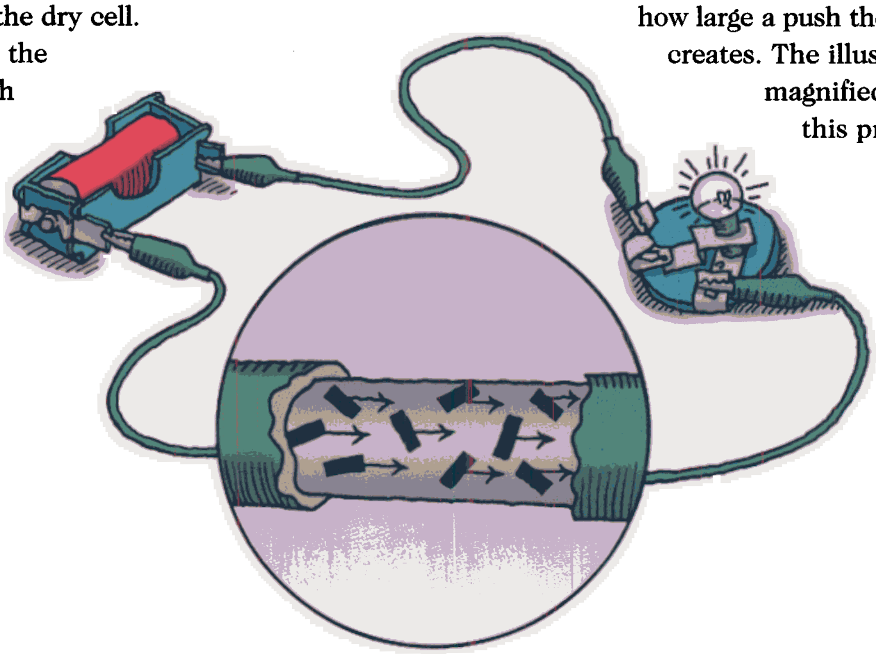
4. Share your written summaries with the class.

Batteries, Voltage, and Current

The batteries you use in your experiments are 1.5-volt batteries. Just exactly what does it mean for a battery to have a voltage of 1.5 volts? What does that tell you about the battery?

A battery is an energy source for a circuit. It contains chemical energy that can be converted into electrical energy. Early batteries, like Volta's battery, were wet cells. They were called wet cells because they used metals set in liquids like salt water or an acid, called electrolytes. Today, most batteries are dry cells. A dry-cell battery is also made of two metals. But a moist paste, rather than a liquid electrolyte, separates the metals. The chemical reactions in the battery produce two oppositely charged terminals, one positive and one negative. These terminals are marked on the dry cell. The battery has the potential to push charges in a wire connected to the terminals of the battery.

As you saw in Lesson 6, current flows through all parts of a closed circuit, including the battery. In Lesson 3, you saw how opposite charges can attract one another. The wires in your circuits have both positive and negative charges. The negative charges can move around easily, but the positive charges cannot. When you close a switch in a circuit, the positive terminal of the battery attracts negative charges in the wire while the negative terminal repels the negative charges. These forces push the negative charges in the wire. This movement of negative charges creates the current in the wire. When the current passes through the filament, electrical energy is transformed into heat and light in the lightbulb. The voltage of a battery is a measure of how large a push the battery creates. The illustration is a magnified view of this process.

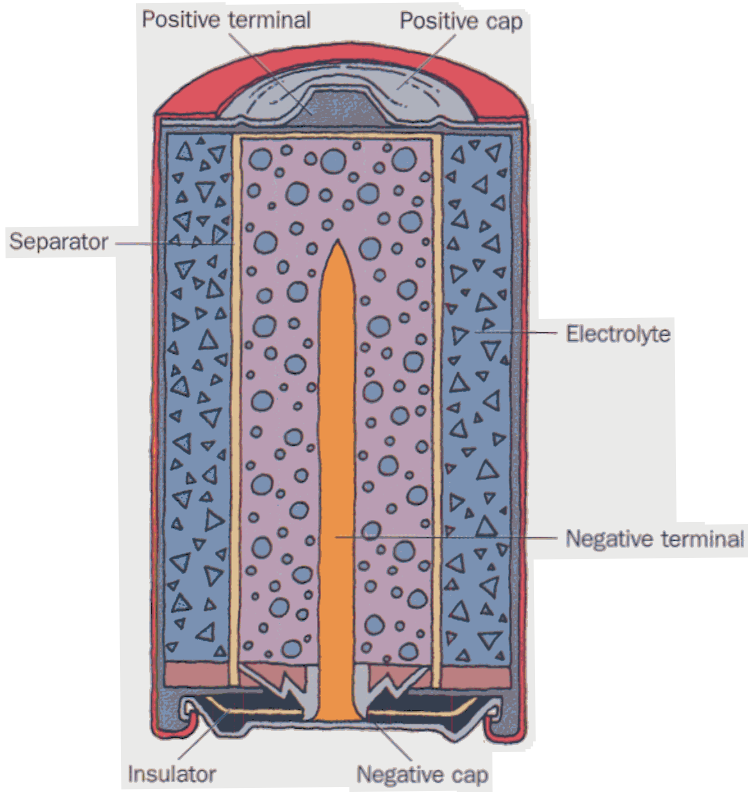


Electrical forces make charges in a wire drift in one direction.

By comparing the voltages of batteries, you can tell which batteries have the greater potential to push the current along. A 9.0-volt battery has six times the push potential of a 1.5-volt battery.

What happens to a battery when it runs down? A "dead" battery has lost its ability to undergo chemical reactions. Some batteries can be recharged. Recharging reverses the chemical reactions in the battery and restores its ability to push charges. (Note that you should only recharge batteries that are designed to be recharged. Otherwise, a non-rechargeable battery may explode. Since most batteries contain acids, that means you could be seriously injured.)

The following is a diagram of a typical 1.5-volt dry-cell battery. ☐



Interior of a dry-cell battery

QUESTIONS

1. What does a battery provide for a circuit?
2. What does it mean for a battery to have a 1.5-volt potential?
3. What does current do in a circuit?

ELECTRICAL LINE MECHANIC:
A Tough but Rewarding Job

The help wanted ad said, "Looking for hard worker who likes to climb."

Jon Rogers, who loved to climb trees as a child, thought, "This sounds like the job for me." It was. Jon Rogers has been a line mechanic (a person who fixes electrical equipment) since 1972. Today he works for the Potomac Electric Power Company (PEPCO) in Washington, D.C., and Maryland.

A line mechanic is the person you might see at the top of a 12-meter-high electrical pole, fixing wires and transformers. It's dangerous work, but line mechanics are thoroughly trained long before they ever touch a live line (a line that has electricity turned on).

Learning Respect for Electricity

When Rogers first joined PEPCO, he went through a "school gang." For 6 weeks, he and nine other trainees received intensive on-the-job training. Today, new workers must have a whole year of training.

The first thing the "gang" learned was how to drive the large trucks that line mechanics use in their work. Those trucks included bucket trucks that could lift line mechanics up to 12 meters

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Jon Rogers at work on the lines

into the air, material trucks capable of carrying 6800-kilogram transformers, and pole-cats (cranes) with trailers that could haul and install 10- to 30-meter poles.

Members of the school gang then had to learn how to dig holes for poles by hand. They dug eight of these holes, each of which measured 2 meters deep and just over half a meter wide. After they finished digging the holes, they had to set a 15-meter pole in each hole. For 2 to 3 weeks they trained on these poles. During that time, they learned how to climb properly and how to work with both hands while perched 15 meters above the ground!

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Line mechanics' gloves, buckets, and other equipment help to protect them from danger and electrical shocks.

Next—with the electricity turned off—they learned how to use tools properly and install hardware, wires, transformers, and other equipment. When they felt confident doing those jobs, they were given rubber gloves and sleeves to wear while working. Because the gloves and sleeves are designed to protect line mechanics from electric shock, they are made of high-quality rubber that is one-fourth centimeter thick. Imagine having to manipulate tools, nuts, and bolts wearing such thick gloves!

Finally, Rogers and his fellow trainees were ready to work with the equipment energized. "One of our first jobs with live power was installing a transformer on a pole and connecting underground service to the new transformer. This provided new electrical service to a house," Rogers says. "We also installed street lights, three other transformers that stepped down the voltage from 7600 volts to 120 volts, and installed five spans of wire to 'feed the transformers.' We then energized our new installation."

Throughout the training, PEPCO stressed safety and the importance of wearing proper protective clothing and of having the right tools for the job.

The biggest lesson Rogers learned was respect for electricity. "You can't take anything for granted. Electricity is invisible, but also very powerful. You have to know what you're working with. When line mechanics get hurt, it is often because they didn't follow safety rules," Rogers explains.

Helping Others Is Satisfying

Over the years, Rogers has been promoted to more responsible positions. Today, he is a lead line mechanic. He leads crews that do everything from replacing the lightbulbs in street lights (which are much bigger and heavier than the kind used in a home) to installing underground cables and transformers for a new subdivision of houses. Sometimes Rogers works alone, responding to customer complaints. Solving those complaints may be as simple as tripping a circuit breaker at a customer's home. Other times, it may require replacing a broken pole—a job that could take 10 to 15 hours.

Line mechanics face on-the-job dangers every day. First and foremost is the electrical hazard. Although many people in the electric industry work with high-voltage lines and equipment, the line mechanic is the only worker who actually handles the high-voltage lines (2,400–19,200 volts). "We work on energized lines so as not to inconvenience our customers," Rogers explains.

Line mechanics face other dangers as well, such as falling while climbing poles, slipping or falling from the top of a pole or on a transmission tower, and getting injured while using tools and equipment and working in bad weather.

But for Jon Rogers, the risks are well worth the satisfaction he gets from his job. In addition to enjoying working outside, Rogers likes helping others. "I get a lot of satisfaction knowing I'm capable of building, maintaining, and repairing the electrical distribution system. So many things run on electrical energy—and so many people depend on us line mechanics to keep things working."

He also enjoys the excitement. "We work in all kinds of weather—hurricanes, ice storms, heat, cold. While many construction workers call it a day when the weather gets too bad, that is often when we must do our most important work. We are out working in all types of weather, at all times of the day or night. We can work 12 to 20 hours at a time—because getting the lights back on is job #1."

Sometimes Rogers and his fellow line mechanics are sent to other areas of the country to help out following big storms. During his career, Rogers has been sent to South Carolina (after Hurricane Hugo), Boston (after Hurricane Gloria), and Maine (following disastrous ice storms).

Preparing for the Future

Jon Rogers loves his work and wishes everyone could have an enjoyable job. To get a good job now or in the future, Rogers says, you need two very important skills. The first is to be able to communicate well, both orally and in writing. The second is to know how to solve problems. "Every job requires you to be able to problem solve," says Rogers. "No matter what kind of work you do, you have to be able to figure out the best way to fix things." □

QUESTIONS

1. What skills are needed to do the job of a line mechanic?
2. What kind of training is needed?
3. What are some of the positive aspects of this job? What are some of the risks?

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Ice storms often bring down power lines. When they do, line mechanics may work long days to repair damages and restore electrical power to consumers.