Portland General Electric

It’s a Wired World
Teacher’s Guide

Introduction
It’s a Wired World uses experiments and activities to explain electricity-related science concepts to students in grades 4-8. Through a focus on circuits, the booklet teaches the basic principles of electrical safety in daily life. **Please encourage students to take the booklet home and share it with their families, especially the home electrical safety inspection on the back cover**.

It’s a Wired World has been formatted for use in classrooms or informal settings by cooperative learning groups of four to six students. However, the activities can easily be presented by the teacher or leader or by one small student group as a demonstration. Activities can also be done by students individually.

Materials for each activity are listed. Ideally, each small group would have its own set of materials. However, quantities in the materials list are given for a single group or person. Simply multiply by the number of groups to find how much you will need for a full class.

It’s a Wired World fulfills the following Oregon Academic Content Standards for science and health education.

Grade 4
Science
4.1 Structure and Function: Living and non-living things can be classified by their characteristics and properties.

> 4.1P.1 Describe the properties of forms of energy and how objects vary in the extent to which they absorb, reflect, and conduct energy.

4.3 Scientific Inquiry: Scientific inquiry is a process of investigation through questioning, collecting, describing, and examining evidence to explain natural phenomena and artifacts.

> 4.3S.1 Based on observations identify testable questions, design a scientific investigation, and collect and record data consistent with a planned scientific investigation.
> 4.3S.2 Summarize the results from a scientific investigation and use the results to respond to the question being tested.

4.4 Engineering Design: Engineering design is a process of using science principles to solve problems generated by needs and aspirations.

> 4.4D.1 Identify a problem that can be addressed through engineering design using science principles.
> 4.4D.2 Design, construct, and test a prototype of a possible solution to a problem using appropriate tools, materials, and resources.

Grade 5

Science

5.3 Scientific Inquiry: Scientific inquiry is a process of investigation based on science principles and questioning, collecting, describing, and examining evidence to explain natural phenomena and artifacts.

> 5.3S.1 Based on observations and science principles, identify questions that can be tested, design an experiment or investigation, and identify appropriate tools. Collect and record multiple observations while conducting investigations or experiments to test a scientific question or hypothesis.

Health Education: Health Skills

Demonstrate ability to use health skills, to obtain and interpret health information, to manage personal behaviors, and to advocate for health and safety issues.

- HE.05.HS.01 Identify and access resources at home, at school, and in the community for health and safety information.
- HE.05.HS.02 Demonstrate management skills to prevent unsafe situations and promote behaviors that enhance health and safety.
- HE.05.HS.04 Use communication skills to help self and others avoid unsafe situations and promote healthy behaviors.
- HE.05.HS.05 Use a goal-setting model to set goals that enhance health and safety.
- HE.05.HS.06 Use a decision-making model to make positive health and safety decisions.
- HE.05.HS.07 Advocate for the benefits of safe and healthy actions and environments at home, at school, and in the community.

Health Education: Unintentional Injury Prevention

Demonstrate accessing information, self-management, interpersonal communication, goal-setting, and decision-making skills while understanding the components of injury prevention.

- HE.05.IP.01 Identify ways to prevent fires and reduce the risk of injuries in case of fire.

Grade 6

Science

6.2 Interaction and Change: The related parts within a system interact and change.

> 6.2P.2 Describe the relationships between: electricity and magnetism, static and current electricity, and series and parallel electrical circuits.

6.3 Scientific Inquiry: Scientific inquiry is the investigation of the natural world based on observation and science principles that includes proposing questions or hypotheses, and developing procedures for questioning, collecting, analyzing, and interpreting accurate and relevant data to produce justifiable evidence-based explanations.

> 6.3S.1 Based on observation and science principles propose questions or hypotheses that can be examined through scientific investigation. Design and conduct an investigation that uses appropriate tools and techniques to collect relevant data.

6.4 Engineering Design: Engineering design is a process of identifying needs, defining problems, developing solutions, and evaluating proposed solutions.

> 6.4D.1 Define a problem that addresses a need and identify science principles that may be related to possible solutions.
>
> 6.4D.2 Design, construct, and test a possible solution to a defined problem using appropriate tools and materials. Evaluate proposed engineering design solutions to the defined problem.

Grade 7
Science
7.3 Scientific Inquiry: Scientific inquiry is the investigation of the natural world based on observation and science principles that includes proposing questions or hypotheses, and designing procedures for questioning, collecting, analyzing, and interpreting multiple forms of accurate and relevant data to produce justifiable evidence-based explanations.

> 7.3S.1 Based on observations and science principles propose questions or hypotheses that can be examined through scientific investigation. Design and conduct a scientific investigation that uses appropriate tools and techniques to collect relevant data.

7.4 Engineering Design: Engineering design is a process of identifying needs, defining problems, identifying constraints, developing solutions, and evaluating proposed solutions.

> 7.4D.1 Define a problem that addresses a need and identify constraints that may be related to possible solutions.
> 7.4D.2 Design, construct, and test a possible solution using appropriate tools and materials. Evaluate the proposed solutions to identify how design constraints are addressed.

Grade 8
Science
8.2 Interaction and Change: Systems interact with other systems.

> 8.2P.2 Explain how energy is transferred, transformed, and conserved.

8.3 Scientific Inquiry: Scientific inquiry is the investigation of the natural world based on observations and science principles that includes proposing questions or hypotheses and designing procedures for questioning, collecting, analyzing, and interpreting multiple forms of accurate and relevant data to produce justifiable evidence-based explanations and new explorations.

> 8.3S.1 Based on observations and science principles propose questions or hypotheses that can be examined through scientific investigation. Design and conduct a scientific investigation that uses appropriate tools, techniques, independent and dependent variables, and controls to collect relevant data.

8.4 Engineering Design: Engineering design is a process of identifying needs, defining problems, identifying design criteria and constraints, developing solutions, and evaluating proposed solutions.

> 8.4D.1 Define a problem that addresses a need, and using relevant science principles investigate possible solutions given specified criteria, constraints, priorities, and trade-offs.

Health Education: Health Skills
Demonstrate ability to use health skills, to obtain and interpret health information, to manage personal behaviors, and to advocate for health and safety issues.

> HE.08.HS.01 Access home, school, and community resources to meet specific health and safety needs.
> HE.08.HS.02 Use strategies that promote health and prevent unsafe situations.
> HE.08.HS.05 Use a goal-setting model to set short- and long-term goals for healthy living.
> HE.08.HS.06 Use a decision-making model that will enhance health and well-being.
> HE.08.HS.07 Advocate to self, peers, family, and community members the benefits of health and safety-enhancing practices.

Health Education: Unintentional Injury Prevention
Demonstrate accessing information, self-management, interpersonal communication, goal-setting, and decision-making skills while understanding the components of injury prevention.

HE.08.IP.01	Explain ways to reduce risk of injuries while traveling to and from school and in the community.
HE.08.IP.02	Identify rules and laws intended to prevent injuries.
HE.08.IP.03	Demonstrate personal responsibility to follow safety-related rules.

Following are objectives, background information, teaching strategies, and suggested assessment for each segment of the booklet. We have included a reproducible quiz at the end as a summary of learning.

PAGES 2-3

Main Ideas

Page 2: Electricity is part of our everyday lives. There are safety hazards associated with the equipment that brings it to us.
Page 3: Electricity travels in a closed path called a circuit.

Objectives

Students will
- identify locations of potential danger in the circuit that runs from power plant to home or school and back.
- build a circuit.
- compare and contrast the circuit they built with the path of electricity from the power plant to home or school.

Materials

Give each group
- 1 D-cell battery
- 1 flashlight bulb
- 1½ feet of 22-gauge wire
- tape
- paper clips

What You Need to Know

Electricity only travels in a closed loop called a circuit. When you turn on a light or appliance, you are closing a circuit. Electricity will leave a circuit to take the easiest path to the ground. Safety hazards occur anywhere a person could come into contact with electrical lines or equipment. As long as a person is touching the ground (or something in contact with the ground), electricity has the potential to travel through him or her, causing shock, burns, or even death.

Getting It Across

Have students read the information and follow the steps on the page.
Page 2: Ask students to share the potential safety hazards they identify.
Page 3: Ask students to share their successful and unsuccessful circuits.

Did They Get It?

Are students able to
- identify the circuit electricity travels from the power plant to the home and back?
- identify the circuit electricity travels from the battery to the light bulb and back?

Answers

Page 2: Potential safety hazards include the following: *1. climbing transmission towers or contacting high-voltage lines or overhead distribution lines in your neighborhood with kites or balloons; 2. entering a substation (for example, to retrieve a ball or toy); 3. contacting the service drop to home or school with TV antennas, ladders, long poles, or if the lines come in underground, by digging; climbing trees near power lines; 4. playing on or around a pad-mounted transformer*. Other hazards students may think of include indoor hazards, such as using appliances near water in the bathroom or kitchen; putting fingers or other objects in outlets or toasters; overloading outlets; running cords underneath carpets; unplugging an appliance by pulling the cord, not the plug.

Page 3: What requirements must be met in order for the bulb to light? *The wire must connect solidly at each terminal of the battery and at two places on the bulb (usually on the tip and on the side). If the connection is broken in any way, the circuit is not complete and the bulb cannot light.*

PAGES 4-5

Main Idea

Page 4: Students need to know the difference between conductors and insulators in order to understand when they are in danger of contacting electricity and when they are not.

Page 5: Water is an excellent conductor of electricity and if a person touches water that is electrified, even if he or she does not touch the source of the electricity, he or she will be shocked.

Objectives

Students will

- formulate operational definitions of insulators and conductors.
- demonstrate that water is a conductor of electricity.

Materials

Each group will need

- 2 alligator clips
- the circuits they made on page 3
- a banana, a metal paper clip, a rubber band, a metal fork, a wood pencil, a penny, plus a variety of other items such as aluminum foil, a toothpick, dirt, glass, paper, a drinking straw, and so on.
- a glass pint or quart jar
- 2 nails
- one 3″ × 5″ piece of cardboard or cardstock (so that the nails don’t touch each other)
- salt
- water

What You Need to Know

Page 4: Students are able to work with these batteries and wires because the voltage is minimal (1.5 V per D-cell battery). The paper clip, metal fork, and penny should all be identified as conductors due to their metal content. The other materials are insulators.

Page 5: Teams will need to add a lot of salt to their water in order for electric current to flow. The voltage of the battery is so low that additional particles must be added to make the water more conductive. It is the impurities in water that make it a good conductor. Pure water will not conduct electricity. However, pure water is found only in the laboratory. That’s why there is so much emphasis on the conductivity of water.

Getting It Across

Page 4: Have teams read the information and follow the steps on the page. Students should first test their circuit by connecting it without using any of the trial materials. Ask teams to share their predictions and results. Were the results the same? If not, why not? (Be sure the experimental setup was not at fault.) What conclusions can

students draw about conductors and insulators? *(They might generalize that metals are good conductors or glass or plastic is a good insulator.)*
Page 5: Be sure students add plenty of salt to the water. Then have them predict, experiment, and note their observations. Share results. Emphasize that the salt is needed because the battery is weak. Its low voltage keeps them safe and allows them to experiment with electricity.

Did They Get It?

Are students able to

- list materials that are conductors and insulators?
- draw the path electricity traveled through their test circuits?
- state that water is an excellent conductor of electricity?

PAGES 6-7

Main Ideas

Circuits can carry a specific amount of electricity. That amount is measured in watts, volts, and amps. When there is some kind of "leak" in a circuit that allows the electricity out of its specified path, a short circuit results. The electricity will go to the ground, and if you are in the way, like Ben Franklin was, it will travel through you.

Objectives

Students will

- practice converting from one unit of measure to another.
- recognize that there are limits to the amount of current a circuit can carry.
- demonstrate a short circuit and define it.

Materials

Each group will need

- 6″ of thick wire
- the circuits they made on page 3

What You Need to Know

- Watts, volts, and amps are the units of measure of electricity. Students need to understand these units and their relationship in order to calculate whether a circuit can carry the load required of it.
- A short circuit is a circuit through which electricity is not able to complete its travel because the circuit is grounded somewhere.
- It is important to emphasize that although Ben Franklin was not seriously hurt in the example, electricity is always dangerous. Electricity's unpredictability adds to its danger.
- Remind students that they are able to work with these batteries and wires because the voltage is minimal (1.5 V per D-cell battery).

Getting It Across

Page 6: Help students read the opening narrative. They need to know that watts measure work, amps measure electric current, and volts measure the "pressure" of the current. You might help them remember the relationship by showing them that they can remember the formula $W = V \times A$ by remembering West Virginia, "W. VA." The application at the bottom of the page shows them one of the main reasons to learn this formula—so they can tell what causes a circuit to become overloaded.
Page 7: Have students read the information and follow the steps. **Be sure students understand that they should immediately disconnect the thick wire and battery after they observe what happens.** The wires will get hot.

Did They Get It?
Are students able to
- calculate the number of amps required by household appliances?
- describe a short circuit and compare it to the story about Ben Franklin?

Answers

Page 6
table lamp, 0.83 A; vacuum cleaner, 7.5 A; color TV, 1.42 A; answering machine, 0.05 A; space heater, 10 A; ceiling fan, 0.17 A; computer, 0.03 A.
1. You would need 21.25 A.
2. Yes.
3. The space heater.

Page 7
1. Students' predictions will vary.
2. Students' observations will also vary but should include an observation that the wires get hot.
3. Because the electricity traveled a shorter route than the intended circuit.
4. Ben Franklin functioned like the thick wire in the students' experiments. Electricity traveled through his body instead of through the circuit and he got shocked.

PAGES 8-9

Main Ideas

Electricity will always take the easiest route to the ground. It is this attribute of electricity that makes it dangerous to people, because we are almost always touching the ground or something in contact with the ground. Circuits have built-in safety equipment, such as three-pronged plugs, ground fault circuit interrupters (GFCIs), fuses, and circuit breakers, to help prevent dangerous situations.

Objectives

Students will
- identify the potential danger of electric shock.
- recognize that a person must be grounded to get shocked.
- build a basic switch and explain how it works.

Materials

Give each group 1 bulb holder, 1 brass fastener, and several paper clips, large and small.

Groups will also need
- the circuits they made on page 3
- a piece of cardboard

What You Need to Know

Electricity always travels the easiest path to the ground. Birds sitting on an electric line do not get shocked because they are not touching anything that is touching the ground. The lines they sit on are insulated from the ground by glass or ceramic discs that do not allow the line to touch the pole, which would be a route to the ground. However, if those birds take flight and their wings touch two lines at once, or if they touch the pole and the wire at the same time, they will get shocked and could die.

Switches are a convenient way to open and close a circuit. Circuit breakers and fuses are like automatic switches that open a circuit if it becomes overloaded.

Getting It Across
Have teams read the information and follow the steps on the page.
Page 8: Use the example of the bird on the wire to be sure students understand that they are in danger because they are always grounded. You might suggest that they try to find ways not to be grounded and evaluate the ideas as a class. (Remember that rubber tennis shoes or rubber kitchen gloves *cannot* shield a person from electric current. Utility workers use special equipment to touch electric equipment.)
Page 9: If students cannot figure out how to construct a switch, here is a diagram.

Did They Get It?
Are students able to
- identify dangerous situations around electricity?
- explain what grounding has to do with the danger of contacting electricity?
- build a switch and explain how it works?

Answers
Page 8: Top left picture: *Putting a fork in a toaster is dangerous because the metal fork could conduct electricity and the person could be shocked*. Top right picture: *These wires are dangerous because the insulation is missing.* Bottom left picture: *It is dangerous to have an electric radio near water because water conducts electricity.* Bottom right picture: *It's dangerous to try to retrieve a kite from power lines because you give electricity a path to the ground, and it can travel down the kite and through you!*
Page 9: Sample explanation: (*When the switch is turned on, the contact points of the brass fastener or the paper clip connect to the wires and complete or close the circuit. The bulb lights. When the switch is turned off, the arms break the connection, and the circuit is open. The bulb goes out.)*

PAGES 10-11
Main Ideas
Students wire a simple distribution system, which demonstrates again that the path electricity travels from the power plant to homes and back is a circuit just like the one they built. The model distribution system also allows students to understand the function and dangers of substations.

Objectives
Students will
- design and build an electric circuit for a model shoebox cabin.
- wire the cabins together to learn the function of distribution lines and substations, and how neighborhoods are linked to power plants.
- trace the path of electricity from its source at the power plant to the substation to the cabins and back again.
- be able to identify potential dangers of substations.

Materials
Give each group
- 4 feet of wire
- 1.5 feet of wire
- one or two colors of yarn
- the bulbs, bulb holders, and batteries from their circuits
- 1 shoebox or other small box
- art supplies such as scissors, tape, glue, pencils, crayons, rulers, drawing paper, construction paper

What You Need to Know
- The bulb holders will be very useful in this activity, if students have not already used them.

- The shoebox cabin village works best if no more than four cabins are hooked together. Hook up the D-cell batteries in series (like a flashlight) to power the network.
- Substations are a crucial link in the electricity distribution network. Electricity from many different power plants comes into a substation. The voltage level is stepped down, and the electricity is distributed from the substation to homes, schools, and businesses.
- Be sure students understand that substations do not actually generate electricity, even though in the shoebox cabin network, the batteries are located in the substations. Electricity is generated at the power plants.

Getting It Across
Have teams read the information and follow the steps on the page. Have teams show each other the path that electricity follows in each cabin. When the shoebox cabin network is complete, ask students to trace the path of electricity from the power plant through the cabins and back again.

Did They Get It?
Are students able to
- successfully draw the electrical circuit for the cabin and transfer the drawing to the model?
- wire the cabins together into a network?
- identify the hazards of substations and make appropriate signage to warn people away?
- identify the power plant as the source of electricity, and trace the circuit electricity travels from the power plant to the substation to the cabins and back again?

<u>PAGES 12-13</u>
Main Ideas
Appropriate behavior in electrical emergencies is counterintuitive. Instead of rushing in to help, everyone must be certain that the source of electricity is no longer live. Otherwise, the would-be rescuer will also be shocked.

Objectives
Students will
- practice research and interview skills.
- analyze information to find the cause of an electrical accident.
- identify bodily effects of contact with electricity.
- apply their knowledge of circuits to explain how to prevent electrical accidents and how to behave in situations involving downed power lines and other electrical hazards.

What You Need to Know
<u>Page 13</u>: This is an introduction to the idea that other people may not be able to help someone trapped in a car with a power line on it. The best help onlookers can be is to call 911 or the local emergency number. Students may think that if a person is already shocked or burned, the danger is over. But if the source of electricity is still live and near or touching the victim, the situation could be deadly for someone who approaches too closely.

Getting It Across
<u>Page 12</u>: Have teams read the information and research their topics. As teams share their stories with the class, ask the class to identify how the accident happened, how electricity affected the body (if possible), and how the accident could have been prevented.
<u>Page 13:</u> Have students read the information on the page. Ask them why the best help might be to stay away from someone who has been shocked or burned. *(Because the helper could become part of electricity's path and also get hurt.)* Ask students to name the steps to take in the event of an electrical emergency. *(1. Stay away from the person who is hurt. 2. Tell an adult to turn off the power at the circuit box. 3. Call for help.)* Ask students why no one should use water to put out an electrical fire. *(Because water conducts electricity. The person dousing the*

flames could be shocked as electricity travels through the stream of water, or water could spread out in a pool from the victim and the source of electricity and hurt anyone standing in that water.)

Did They Get It?

Are students able to

- name the causes of electrical accidents in the examples they find?
- list several safety “rules” that could have prevented these accidents?
- demonstrate how to leave a car with a power line on it?
- describe the dangers to the rescuer in an electrical emergency and list appropriate steps to take?

PAGES 14-15

Main Ideas

Letting others know about electrical safety is one of the best ways to reinforce student learning.

Objectives

Students will

- develop questions to survey others about their safety knowledge.
- correct any misconceptions others may have.
- develop a skit to teach younger children about electrical safety.

What You Need to Know

These pages ask your students to organize their knowledge and share it with others. Surveys will reveal others’ misconceptions or lack of knowledge. Your class skits could be used as one way to be sure younger students have accurate information. Students may use the scenes suggested or make up their own skits.

Getting It Across

Have students use the information they gather as the basis for the skits they develop. Ask teams to talk with younger students after the performance to find out what they learned from the skits and to reinforce their learning.

Did They Get It?

Are students able to

- draw accurate conclusions about what others do and do not know about electrical safety?
- create a skit to teach younger students some basic safety rules?

Summary Quiz

Fill in the blanks.

1. Electricity travels in a closed path called a __________________.
2. In the circuit that serves your home, the electricity comes from the ____________________.
3. Name three conductors:
   __________________ _____________ _________________
4. Electric current is measured in _____________. The "pressure" behind it is measured in volts. The work of electricity is measured in ______________.

Write or draw your answer in the space provided.

5. Describe two dangerous situations around electricity outdoors:
6. Describe two dangerous situations around electricity indoors:
7. Draw your battery and bulb circuit and show the path that electricity travels in this circuit.
8. Describe or draw the path electricity would take if a person contacted electricity because the insulation on the cord of their electric lawn mower was cracked and the grass was wet.

Answers to Quiz

1. circuit
2. power plant or generating plant
3. Answers will vary. Examples: wire, paper clip, water, nails
4. amps, watts
5. Climbing transmission towers; contacting high-voltage lines or overhead distribution lines in your neighborhood with kites or balloons; entering a substation (for example, to retrieve a ball or toy); playing on or around a pad-mounted transformer; contacting the service drop to home or school with TV antennas, ladders, long poles, or if the lines come in underground, by digging; climbing trees near power lines.
6. Using appliances near water in the bathroom or kitchen; putting fingers or other objects in outlets or toasters; overloading outlets; running cords underneath carpets; unplugging an appliance by pulling the cord instead of the plug.
7. Students should show the bulb with wires connected to the tip and side of the metal housing at the bottom, and the battery with wires connected to each end. Electricity travels from the battery through the wire to the bulb, across the filament, and through the other wire back to the battery.
8. Electricity would travel from the power cord of the lawn mower through the water in the grass and up through the person's legs. Depending on the position of the person at the time of contact, electricity could simply travel up one leg and down the other. Or it could travel up one leg, through the heart, and out a hand that was touching the mower handles.