Throughout the guide, teaching tips are in red.

Activity Description & Estimated Class Time

This activity requires one 50-minute block. Students use a battery and a light bulb in a complete circuit to determine if different test items can conduct electricity. This activity should be done after Magnets, 4.P.1.1.

Objectives

Students will demonstrate knowledge and understanding of the following ideas and content:

- Some materials are conductors of electricity and some materials act as insulators.

Students demonstrate this knowledge and understanding by testing a variety of materials and identifying them as insulators or conductors.

Correlations to NC Science Standards

4.P.2.1 *Compare the physical properties of samples of matter (strength, hardness, flexibility, ability to conduct heat, ability to conduct electricity, ability to be attracted by magnets, reactions to water and fire).*

Brief Science Background

Electricity passes through different materials differently. It moves through some materials easily, only a little through some other materials, and not at all through others. Each particular kind of material always conducts electricity the same. The amount of electricity that a material will conduct is one of its basic properties. We know that a material conducts electricity when that material can complete a circuit so that electricity reaches everything in the circuit. Most metals conduct electricity well. The wires used to carry electricity from one place to another are made of metal. The water in our bodies conducts some electricity, but it does not conduct well. If you touch a wire that is carrying electricity, some electricity passes through your body and you might get a shock, but not all of the electricity can pass through. Other things, like ceramics and plastic, do not conduct electricity. Pieces of ceramic on power poles and plastic insulation on wires make sure that electricity is not conducted out of the wires to places it does not belong.

Part 1 — What Conducts –50 minutes

Materials

Materials for the Whole Class

- to project for class: BLM 1 How to Test an Object, BLM 3 concept cartoon
- a demonstration conductivity tester and paperclip

Materials for Pairs of Students

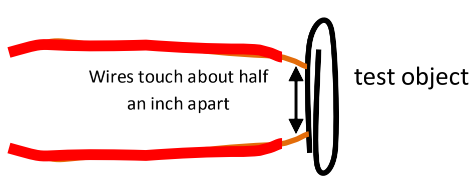
- bag of 10 test objects
  - brass
  - aluminum
  - cardboard
  - a paper clip
  - steel
  - plastic
  - rubber
  - rock
  - magnetite
  - a pipe cleaner
- conductivity tester circuit and 9v. battery
- 6-inch piece of 14-gauge insulated wire (red coating)
- BLM 2: Prediction Table

Preparation

1. Clip the 9v batteries and battery holders together before giving them to students. To keep batteries fresh, disconnect them after the class uses the conductivity tester.
2. Have complete bags of test objects ready to hand out
3. Be ready to demonstrate testing a paperclip for conductivity (step 2, below).

Procedure

1. Give a working conductivity tester to each pair. Challenge students to make the bulb light. Once all groups have lit the bulb by touching the ends of the two wires together, explain that they have made a complete circuit: a continuous path through which electricity can flow. In this circuit, touching the wires together allows electricity from the battery to go from one terminal through the wires, provide energy for the bulb to light, and go back to the other terminal. Electricity from the battery does not travel through air. Before the wires touch, electricity does not have a continuous path from one terminal of the battery to the other, so the bulb does not light.
2. Ask students to remove the cardboard and paperclip from their bags of test items. Use a paperclip to demonstrate how the conductivity tester works. Advise students be sure the ends of the wires do not touch each other. Both wires should touch the test object at the same time and be separated from each other by about half an inch, as shown in BLM 1.



Procedure cont.

3. Ask students to try their testers on the paperclip and report what happens to the light bulb when the wires touch it. Explain that electricity can travel through some materials and we call those materials electrical conductors. Paper clips, which are made from steel, are able to complete the pathway from one terminal of the battery to the other and light the bulb. When the two wires touch something (and not each other) and the bulb lights, the thing they touch is a conductor.
4. Have students do the same test with the piece of cardboard and report results. Explain that materials that do not allow electricity to flow are called electrical insulators.
5. Ask students to put conductivity testers away in the bag (wires not touching, bulb not lit).
6. Explain that one physical property of a material is the ability to act as a conductor or an insulator.
7. Ask students to lay out the test items on BLM 2: Prediction Table, one item per rectangle in the left hand (Item) column, in any order. In the Prediction column across from each item, ask them to write a "C" if they think the material will conduct, and an "I" if they think it will insulate.
8. Tell students that when they complete predictions, they can use the conductivity tester to test the items and record "C" or "I" for each item in the "Result" column on BLM 2.
9. Ask students for any results that surprised them.

Wrap-Up

Hold up a piece of insulated wire and inform students that this is the kind of wire used to carry electricity around their homes.) Challenge students to use their testers to investigate the wire for its properties as a conductor or an insulator. **Students should find that the copper wire is an electrical conductor while the red coating is an electrical insulator.**

Ask the students why they think insulator-covered wires are used in houses. **They are used to prevent shocks, shorts, and fires (see Detailed Background Information in the Appendix).**

Guided Practice

Guided Practices are similar to typical tests, but require students to reveal their thinking about content. They serve as a practice before a test and should not be graded. They are intended to expose misconceptions *before* an assessment and to provide opportunities for discussion, re-teaching, and for students to justify answers. They are best given as individual assignments without the manipulatives used in the activity. In that context, pose the following "test items" to the class. Ask students to write responses in notebooks.

1. Project BLM 3

2. Without bias for or against any of the four ideas expressed in the cartoon, go over each of the following with the whole class to be sure everyone understands what the student in the cartoon is saying:

   - one student observes that all of the parts of the electrical system in a house are made of plastic, so plastic must be a conductor of electricity,
   - another student comments that maybe the plastic insulates so people don't get shocked from the electricity,
   - a third student wonders how the electricity could move,
   - a fourth student says that metal is a good electrical conductor.

3. Ask students to consider whether they agree or disagree with each of the four ideas in the concept cartoon — <u>and why</u>. Ask them to discuss this as a team then, after 5 minutes, get together with another small group to come up with one response to each statement that they all accept.

4. Ask students: "Think about the electric supply system and the electrical appliances in your house or apartment. Where are the conductors and where are the insulators?"

Answer Key

#3— "...all of the parts of the electrical system in a house are made of plastic, so plastic must be a conductor of electricity." **The plastic is only on the outside of the wire. The wire can conduct if the inside part conducts.**

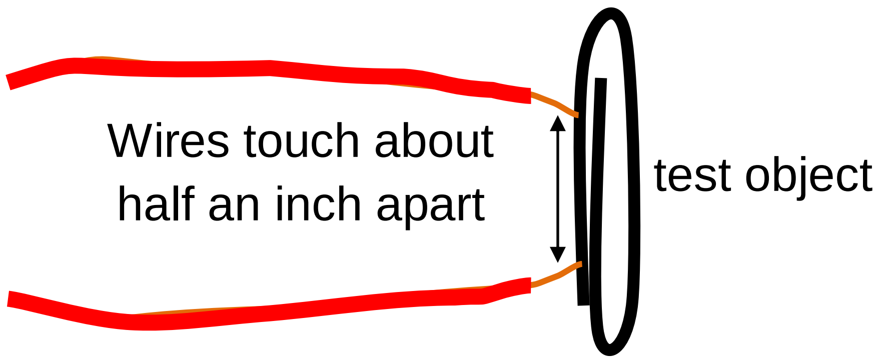
#3— "...maybe the plastic insulates so people don't get shocked from the electricity." **This makes sense if we understand that the plastic is only on the outside of the wire.**

#3— "...how the electricity could move" **If the whole wire were made of plastic, the electricity could not move. However, plastic is only on the outside and metal is on the inside, so the electricity can move through the metal.**

#3— "...metal is a good electrical conductor." **If the wires are conducting, then this makes us suspect that there might be metal on the inside of the wires.**

#4— **Most cords of electrical appliances have a plastic insulator material on the outside and metal wires inside. Most wires in a house or apartment are made of copper with a plastic insulator material wrapped around them.**

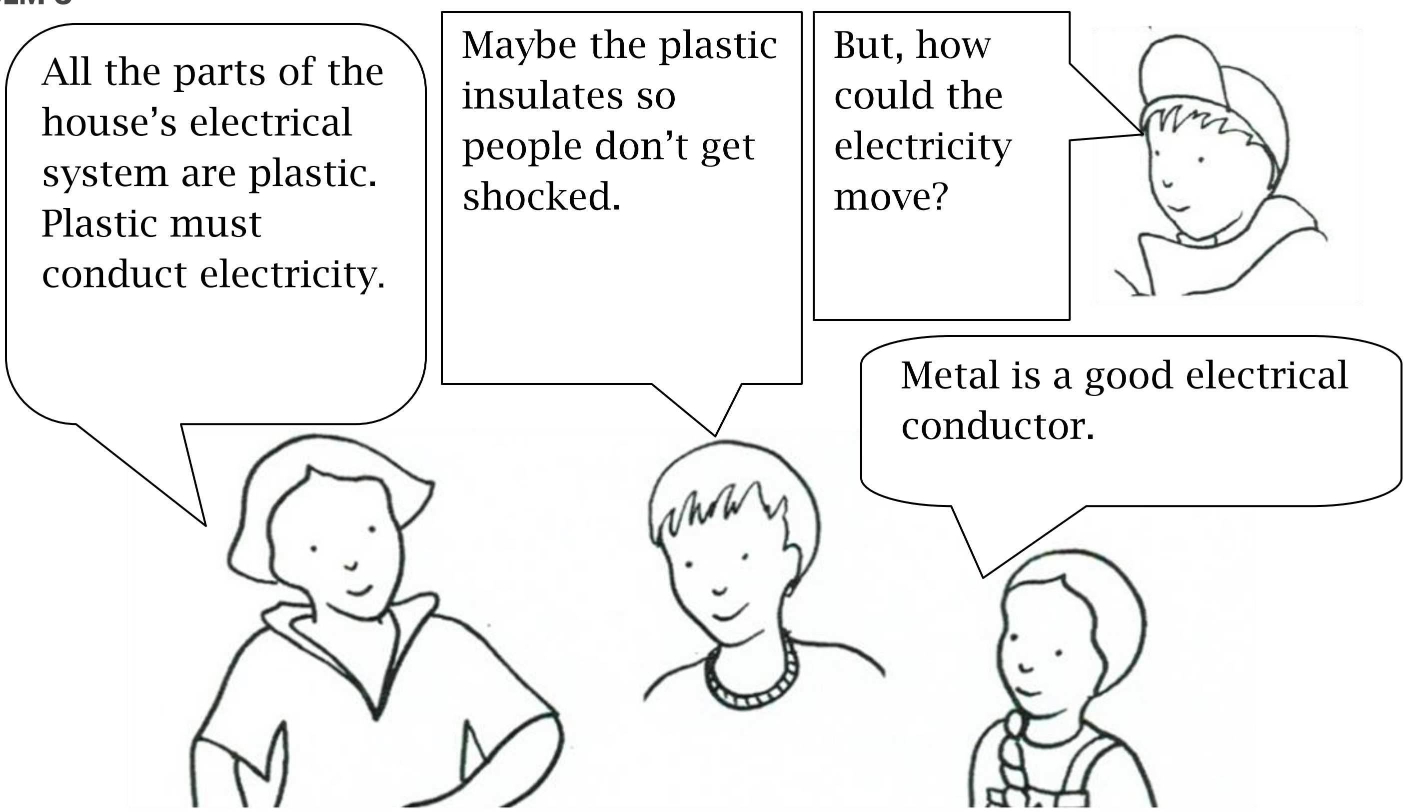
BLM 1

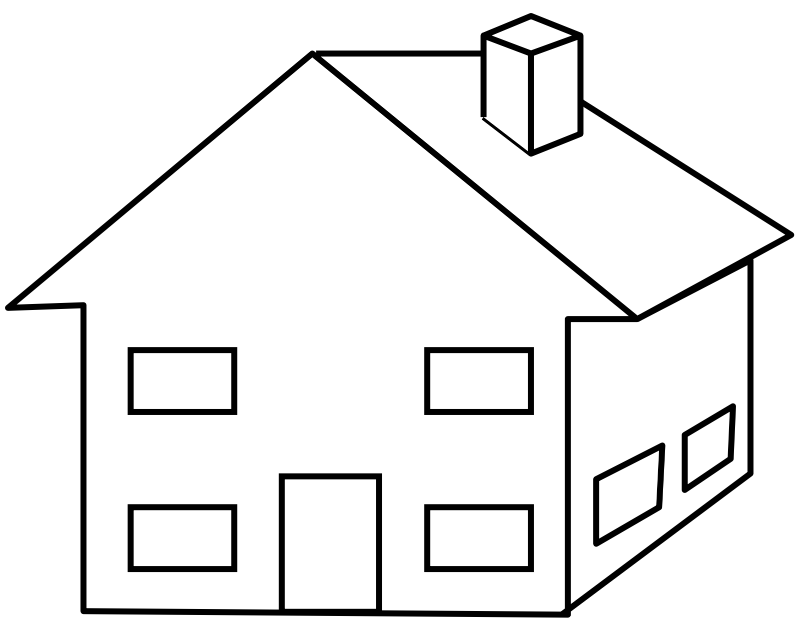


BLM 2 : Prediction Table

ITEM	Prediction	Result

BLM 3





Think about the electric supply system and the electric appliances in your house or apartment. Where do you think there are conductors and where do you think there are insulators? Why do you think that?

Appendix

Common Student Preconceptions About This Topic

Children commonly associate electricity with familiar devices such as lamps or televisions, which need to be plugged in to operate. They tend to regard electricity itself as a substance that is somehow moved from the plug, through the cord, and into the device. There the electricity is given to the device so the device can do what it is supposed to do. Ideas about atoms and electrons are abstractions that are not part of children's concrete experiences. Therefore, these ideas do not help children make sense of electricity or how it works. On the other hand, most young students will enthusiastically make simple circuits to light a bulb without understanding how circuits accomplish this. Some think that only one wire from the battery will light the bulb. Others regard a second wire as a "safety." Others think two wires are necessary, but that both carry electricity from the battery to the light bulb. However, regardless of their confusion about circuits, most children can make sense of the idea that some materials can carry electricity and some can't.

Detailed Background Information

All materials are made of atoms, and all atoms contain one or more negatively charged electrons that surround a central positively-charged nucleus. The positively charged protons in the nuclei attract the electrons and keep them with the atom. Some types of atoms, such as most metal atoms, leave some of the electrons less tightly bound to the nucleus. These loosely attached electrons can move easily to adjacent atoms and be replaced by electrons from other nearby atoms. This flow of electrons is electrical *current*. Materials in which electrons flow easily in this way are electrical *conductors*. Materials that tightly bind all of the electrons are electrical *insulators*. Glass is an example of an insulator.

In a conductor, moving electrons carry electrical energy from one place to another. In the circuit students use in these activities, chemical reactions in the battery create a force that moves the electrons. The reactions push electrons into a copper wire connected to one end of the battery and pull electrons into the wire connected to the other end. This pushing and pulling is called *voltage*. Different types of batteries produce different amounts of voltage. AA batteries, for example, produce 1.5 volts, while car batteries push harder, producing 12 volts.

An electrical "short", called a "short circuit," is an unintended connection that completes a circuit before the electrical energy reaches the object that is supposed receive the power. Short circuits can be dangerous because they can overheat the circuit and cause fires.

If a circuit powered by a battery includes as light bulb, bell, or small motor, these objects use electrical energy to do work. They convert some of their energy to light, heat, sound, and/or kinetic energy. In doing so, they somewhat restrict the flow of electrons. This restriction of current is known as electrical *resistance*. However, if a circuit has nothing to restrict the flow, the electrons transfer their energy to the wire and back to the battery, causing them both to heat up. Unless the circuit is broken, the heat build-up can eventually make the battery explode, potentially causing chemical burns or other serious injuries.

Appendix cont.

In a building's wiring, short circuits can happen when two wires that were not intended to touch each other come into contact. This sometimes occurs in older homes with wiring wrapped with a layer of braided cotton, before plastic became the standard insulating material. After many years, the cotton gets brittle or eaten by insects or rodents. Any disturbance breaks the brittle covering, exposing the wires inside. If wires from two sides of the circuit touch, the current takes the path of least resistance. With little resistance, wires overheat and burn the insulation, and fire starts in the wall.

In an appliance's electrical cord, a short can happen when insulation is accidentally cut, frayed, or pulled away from the plug (which can happen if someone pulls on the cord instead of the plug). Also, inside an appliance, wires and connections can come loose. If another conductor touches exposed or broken wires while the device is on, a short can occur. Since water is a good conductor, spilling a drink on an appliance, or spilling it on a plug connected to a device that is turned on, can cause a short circuit. Fortunately, buildings are equipped with circuit breakers or fuses to help prevent a fire in the event of a short circuit. Whenever an excessive amount of current flows through them, these devices immediately stop the flow of electricity in the circuits involved.

Exposed wires can also cause an electrical shock. A shock occurs whenever contact with electricity causes current to flow in the body. Human bodies, being made mostly of water, are good conductors of electricity, so touching a "live" wire, that is, one carrying current, makes the body become part of the circuit. In many cases the body offers the path of least resistance for the flow of electrons, creating a short circuit and a potentially severe shock. Touching the prongs of a loose plug in an outlet can likewise deliver a shock. The author of this information got quite a jolt as a child when, before outlet covers were child-proofed, she inserted a metal hair clip into an electrical outlet. Thanks to her home's fuses, she survived the experiment undamaged.