SCIENCE FRIXION STEM LESSON PLANS

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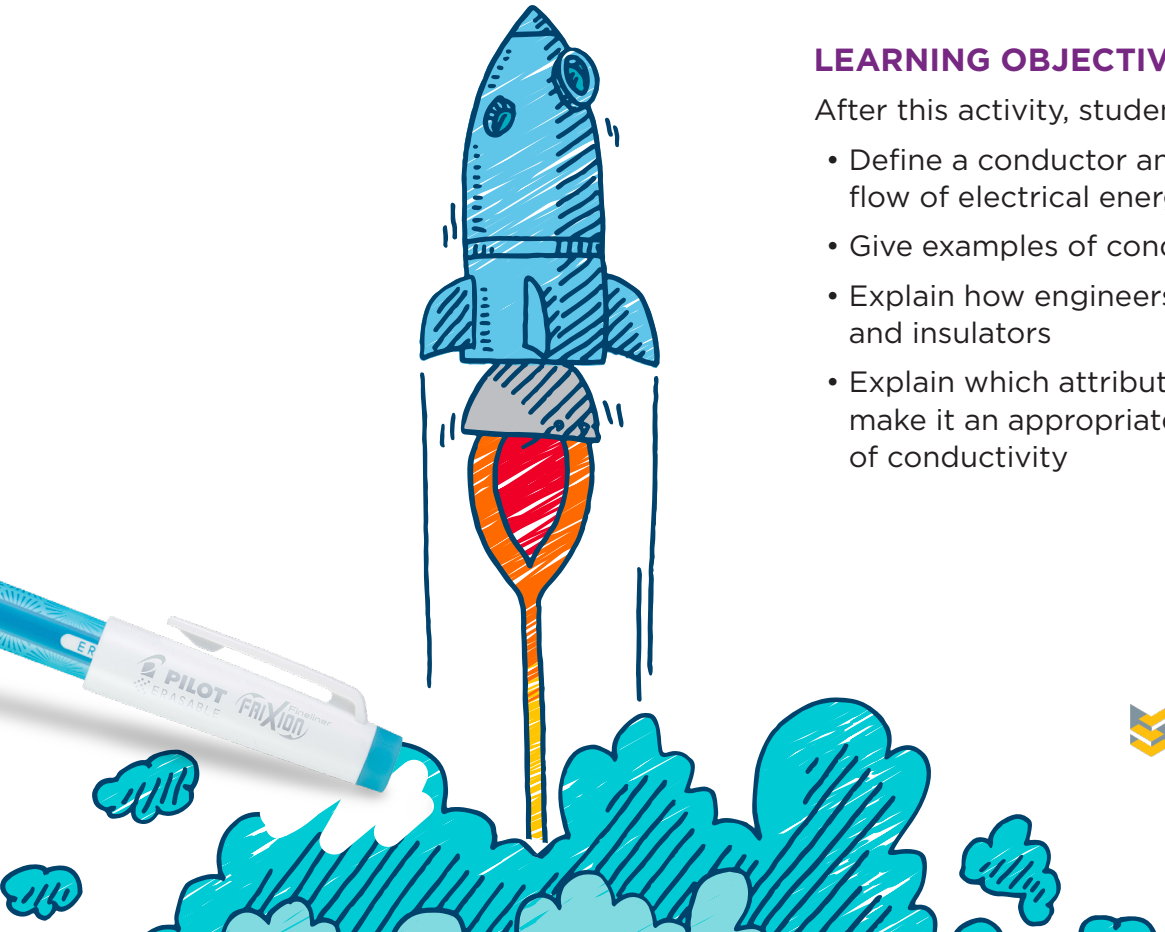
Bringing science to life with the incredible, ERASABLE FriXion pens, markers and highlighters.

Grades 3–5

ELECTRICAL CONDUCTIVITY: CONDUCTORS & INSULATORS

Student groups make simple conductivity testers, each using a battery and light bulb. Using the thermo-sensitive ink in FriXion pens as an indicator of conductivity, they learn the difference between conductors and insulators of electrical energy as they test a variety of materials for their ability to conduct electricity.



LEARNING OBJECTIVES

After this activity, students should be able to:

- Define a conductor and an insulator in the flow of electrical energy
- Give examples of conductors and insulators
- Explain how engineers use conductors and insulators
- Explain which attributes of FriXion ink make it an appropriate and reliable indicator of conductivity

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MATERIALS

Each group needs:

- FriXion Pens
- 1 battery (1.5 or 6 V)
- 1 light bulb in a light bulb holder
- 1 meter (3 ft) of insulated copper wire in 30 cm (1 ft) sections, or 3 alligator clips
- 1 thick rubber band
- 2 large paper clips
- Cap-style pencil erasers
- Chopsticks or wooden dowels
- 2 clean-head, metal thumbtacks
- An assortment of several objects to be tested as conductors or insulators, such as aluminum foil, paper, glass, copper, plastic, salt water, etc.
- Masking tape for marking

INTRODUCTION/MOTIVATION

What are some items that get really warm to the touch on a hot day? (Possible answers: Metals, dark-colored items.) Have you ever touched a metal spoon that had been sitting in a bowl of hot soup and found the spoon handle to be very hot? The metal spoon conducts heat from the hot soup through the spoon to the handle. Materials that conduct heat may also conduct electricity.

Have you ever heard of conductors or insulators? These are important vocabulary words when we are learning about how electrical current moves.

A conductor is any item or material that provides a path for energy to flow. This means that electricity and electrical current can move freely around, in and through a conductor. A wire is a good example of a conductor of electrical energy. Wires connect appliances to electrical outlets in walls. Electrical current (electrons) flows through the wires to make the appliances work.

The opposite of a conductor is an insulator. An insulator is any item or material that does not let electricity or electrical current flow thought it. Insulators are important in keeping us safe from strong electrical current. Electrical engineers use a rubber glove, which is a good insulator, to protect themselves from any wires they touch. The plastic or rubber coatings on the wire for your keyboard, mouse or TV plug are examples of insulated wires. Insulators also keep two wires from touching each other or keep a person from touching the electricity in a wire.

Safety is the main reason to understand which materials are conductors of electrical current and which are insulators. That is why we never stick a piece of metal (a good conductor) into a wall outlet. The amount of electrical current that would flow through the metal into your body can really hurt you! When designing electrical equipment, engineers keep in mind what parts of their equipment need to be insulated and what parts need to conduct electricity, so the electrical current flows in the right direction and the equipment works properly.

A circuit is the path through which electrical current flows. Electrical engineers use conductors to connect the elements in a circuit, such as a light bulb to a battery. Today, we are going to make a conductivity tester and then test many items to see if they are conductors or insulators. This will help us understand a little more about how electrical charge moves through a circuit and how much engineers need to know about electricity to keep us safe.

One way we will test the heat flowing through the circuits is by using FriXion pens. By design, FriXion erasable pens, markers and highlighters incorporate science, technology, and engineering. The unique, heat-sensitive ink uses covalent bonds to help the ink to:

- **Write smoothly** in many different colors
- **Be 'erased' completely** and become invisible when it's rubbed with the eraser or gets hotter than 140°F (65°C)
- **Reappear** when the ink gets colder than 14°F (–20°C)

The heat-sensitive chemistry in FriXion three types of chemical compounds that react to one another. When you rub the ink with the hard rubber eraser, heat created by friction causes the temperature-sensing compound to activate the acid compound, making the ink clear.

The 3 compounds are:

A. The Color Pigment

B. A Color-Activating/Developer

C. A Temperature Regulator

When A & B bond you can see the ink color. When that bond is broken with heat, B & C bond and the ink becomes invisible. If the ink is cooled down, then the bond between A & B is reformed and the ink color will reappear.

PROCEDURE

Before the Activity

- Gather materials
- Make sure students are familiar with how FriXion pens work and how they will work within the experiment

With the Students

1. Ask the class if electrons flow through all materials the same? Discuss the difference between conductors and insulators.
   - Create the bulb assembly by placing a small 1.5V bulb in a bulb holder
   - Place a paper clip at each end of the battery. Use the rubber band to hold the paper clips in place
   - Attach a wire to each paper clip, making sure that either the insulation is removed from each end of the wire touching the paper clip, or use alligator clips instead of the wire

- Attach one wire from the battery terminal to the light bulb assembly
- Attach a second wire to the other end of the battery
- Attach the third wire from the open end of the light bulb assembly
- Wrap the free ends of wire around two, clean-head, metal thumbtacks
- Create two testing probes by attaching an eraser cap to the end of a chopstick or wooden dowel and pushing a thumbtack firmly into the eraser. You will need two probes
- Make sure the circuit works by pressing the two testing probes (thumbtacks) together. If the light bulb does not light up, the circuit was constructed incorrectly

2. To test an object, apply the two testing probes to opposite ends of each object. If the light bulb lights up, then the object is a conductor. If the bulb does not light up, then the object is an insulator. Hint: Make sure you do not touch the two testing probes together or the reading is invalid.

Explanation: In a conductor, electric current flows freely; in an insulator it cannot flow freely. "Conductor" implies that the outer electrons of the atoms in the material are loosely bound and free to move through the material. Most atoms hold on to their electrons tightly and are insulators.

3. Have the students guess whether the objects they plan to test are "conductors" or "insulators." Using the masking tape, have students label each item "conductor" and "insulator" using the FriXion pens. Next attach the tape to the various everyday objects they plan to test. Ensure the tape label is laying flat against the object to ensure a proper reading.

4. During testing, have students observe any changes to the FriXion ink on the labels.

5. After testing is completed, have the student teams compare their results for which test objects were considered conductors and which were considered insulators. Have them look for patterns and hypothesize theories. For example: Most metals are good electrical conductors. Most non-metals are good insulators. To conclude, ask students to think of everyday examples in which materials, like those they tested, are used as conductors and insulators. For example, plastic wall outlet covers, light switch covers, metal wires in plugs with plastic coatings, jumper cables with plastic handles and wire coatings, etc.

DISCUSSION QUESTIONS

- How did the wording on the tape change? Why? What caused the FriXion ink to disappear?
- Did the FriXion ink only disappear on conductors?
- Why is FriXion ink disappearing an indicator of conductivity?
- How could this be helpful?