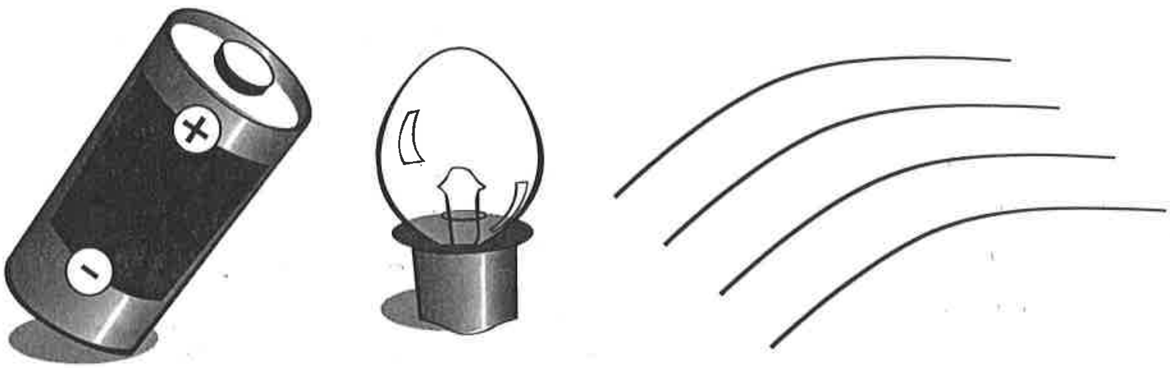
Batteries, Bulbs, and Wires



Kirsten has a battery and a small bulb. She wonders how many strips of wire she will need to connect the battery and the bulb so that the bulb will light. What is the *smallest number* of wire strips Kirsten needs to make the bulb light up?

A One strip of wire

B Two strips of wire

C Three strips of wire

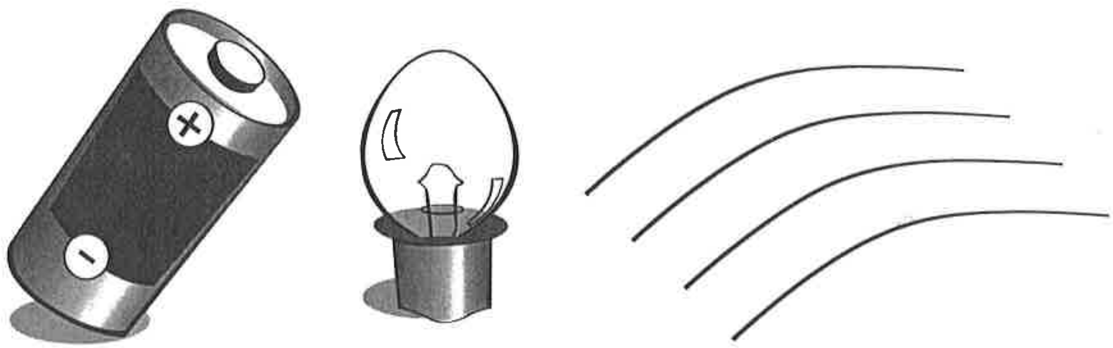
D Four strips of wire

Explain your thinking about how to light the bulb. Draw a picture to support your explanation.

Picture:

Batteries, Bulbs, and Wires

Teacher Notes



Purpose

The purpose of this assessment probe is to elicit students' ideas about complete circuits involving lightbulbs. The probe reveals whether students recognize the pathway of electricity in a complete circuit, including its path through a lightbulb, in order to light a bulb using only one strip of wire and a battery.

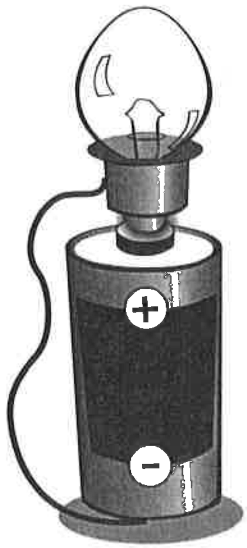
Related Concepts

complete circuit, electricity

Explanation

The best answer is A: One strip of wire. If you closely examine a flashlight bulb, you will see two small wires sticking up in the bulb that are connected by a very fine wire called a *filament.* The two wires on either side of the filament extend downward into the base of the bulb where you cannot see them through the metal casing that surrounds the base of the bulb. One of these wires goes down to the very bottom of the base (the pointed end). The other wire is connected to the side of the metal base (sometimes the side is ridged so that it can screw into a socket). Knowing where these wires end up on the base of the bulb (the tip and the side) is necessary in order to use one wire to make a circuit that lights a bulb.

The battery, wire, and bulb need to be connected in such a way that it forms a complete circuit. To do this, hold the end of the wire against the negative terminal (the bottom of the battery or smooth end). The other end of the wire should touch or wrap around the side of the metal casing that forms the base of the lightbulb. With the wire wrapped around the metal side of the bulb and the other end



touching the bottom of the battery, touch the tip of the base of the lightbulb to the positive terminal (bumpy end) and the bulb will light.

The lightbulb lights with just one wire because the electricity flows out of the negative terminal (bottom of the battery), through the wire, into the wire that is attached to the side of the metal casing on the base of the bulb, up through that wire inside the bulb, across the filament, and down the other wire inside the bulb where it is attached to the point on the base of the bulb that touches the positive terminal (the bump) of the battery, completing a full circuit.

Be aware, however, that students can choose the best answer, "one wire," and still have an incorrect configuration of a circuit. For example, some students may touch one end of the wire to the battery and the other to the bulb, thinking the energy from the battery will flow through the wire to the bulb. Students who choose two wires as their answer may understand that a complete circuit is needed, but not understand the internal architecture of a lightbulb.

Curricular and Instructional Considerations

Elementary Students

"Batteries and bulbs" is a common instructional topic found in elementary school curriculum materials that help students acquire skills of inquiry while learning what a complete circuit is and about the architecture of a lightbulb. Building complete circuits is primarily observational at this level and provides students with an opportunity to systematically test out their ideas and make observations.

Middle School Students

In middle school, students build a variety of different circuits to trace the path of electricity. At this level, they are able to understand why the lightbulb is designed the way it is in order to build a circuit. They also begin to build an understanding of the direction in which the electric current flows. Students build on their earlier experiences with complete circuits to understand the transfer of energy that is involved in a circuit designed to accomplish a task such as lighting a lightbulb.

High School Students

Students at the high school level have begun the study of particles smaller than atoms, and their study may begin to link particles such as electrons to the notion of charge and to ideas of current and electric circuits. However, it is important to remember that many students may have had little experience with electric circuits themselves or that their experiences involved prefabricated circuit boards and light sockets that prevent them from seeing how the current flows through a lightbulb.

Administering the Probe

Make sure students know what you mean by a "strip" of wire. Show them a battery, a bulb, and a coil of wire. Cut a strip off that is long enough to make the circuit so they know what is meant by a strip of wire. Or, show a handful of cut strips, but do not show just one, because it might cue them to the answer. Note that if students choose more than one wire, it is not necessarily incorrect in terms of making a complete circuit. However the probe is not asking how many wires are needed to make a complete circuit but rather what the minimum number of wires is. It is important to emphasize drawing as a way of supporting the students' explanation in this probe.

Related Ideas in *National Science Education Standards* (NRC 1996)

K–4 Light, Heat, Electricity, and Magnetism

★ Electricity in circuits can produce light, heat, sound, and magnetic effects. Electric circuits require a complete loop through which an electric current can pass.

5–8 Transfer of Energy

- Electric circuits provide a means of transferring electric energy when heat, light, sound, and chemical changes are produced.

Related Ideas in *Benchmarks for Science Literacy* (AAAS 1993)

6–8 Structure of Matter

- Materials vary in how they respond to electric currents, magnetic forces, and visible light or other electromagnetic waves. (Note: This is a new benchmark. It can be found in AAAS 2007, p. 27.)

9–12 Forces of Nature

- Different kinds of materials respond differently to electric forces. In conducting materials such as metals, electric charges flow easily, whereas in insulating materials such as glass, they can move hardly at all.

Related Research

- Studies by Shipstone (1985), Arnold and Millar (1987), and Borges and Gilbert (1999) show that, before instruction, many K–8 students are not aware of the bipolarity of batteries and lightbulbs. They do not recognize the need for a complete circuit and have difficulty making a bulb light when provided with a battery and wires. Furthermore, even high school and university students have shown difficulty with this task (AAAS 2007).
- Many students will use a source-consumer model in which the battery gives something to the bulb. In this context, younger students will often draw a single wire going from the top of the battery (unipolar model) to the bulb. Another similar model

★ Indicates a strong match between the ideas elicited by the probe and a national standard's learning goal.

held by younger and older students involves two wires, each one going out of an end of the battery (bipolar model) and touching the bulb with the electricity going from the battery to the bulb in each wire (Driver et al. 1994).

- Some students will regard one wire as the "active" wire and the second wire as a "safety wire" (Driver et al. 1994).

Suggestions for Instruction and Assessment

- This probe lends itself to a follow-up inquiry investigation. Provide a battery, bulb, and single wire, and ask students to figure out whether it is possible to light a bulb with just one wire. Have them explain the path of the complete circuit once they figure out how to light the bulb.
- The metal casing around the base of a bulb prevents students from seeing what the structure of a lightbulb actually is. Before students can explain the complete circuit, they need to see the arrangement of the wires in the bulb. Use an enlarged cutaway diagram of a lightbulb to show students what the wires look like behind the casing. (Note: Do not break the glass of a lightbulb to show students the structure of a bulb. Students can be injured by shards of broken glass that may still be on the bulb casing.)
- Ask middle school and high school students to draw arrows to show the direction of the current. Sometimes their drawings with two wires will reveal a "clash model" in which current flows from both ends of the battery and ends up lighting the bulb when the currents clash. This can provide further assessment information to inform instruction on how students think about electric current and complete circuits.
- Extend the probe to have students show how to light the bulb with two wires or with two batteries and one wire.
- Challenge students to find as many different ways as they can to light the bulb with one or two wires and explain the path of the current.
- Many students have trouble with batteries/bulbs/wires questions because they have only encountered them when they are part of a kit that includes "housing" for the batteries—with clips—so they are easier to manipulate and set up in a series. It is important to give students an opportunity to explore batteries, bulbs, and wires *without* the casings or clips so that they can understand how the current flows through each of the components.

Related NSTA Science Store Publications and NSTA Journal Articles

American Association for the Advancement of Science (AAAS). 1993. *Benchmarks for science literacy.* New York: Oxford University Press.

American Association for the Advancement of Science (AAAS). 2007. *Atlas of science literacy.* Vol. 2, "electricity and magnetism," 26–27. Washington, DC: AAAS.

Driver, R., A. Squires, P. Rushworth, and V. Wood-

Robinson. 1994. *Making sense of secondary science: Research into children's ideas.* London and New York: RoutledgeFalmer.

Keeley, P. 2005. *Science curriculum topic study: Bridging the gap between standards and practice.* Thousand Oaks, CA: Corwin Press.

National Research Council (NRC). 1996. *National science education standards.* Washington, DC: National Academy Press.

Robertson, W. 2005. *Electricity and magnetism: Stop Faking It! Finally Understanding Science So You Can Teach It.* Arlington, VA: NSTA Press.

Stein, M. 1998. Toying with science. *Science and Children* (Sept.): 35–39.

Related Curriculum Topic Study Guide

(Keeley 2005)

"Electrical Charge and Energy"

References

American Association for the Advancement of Science (AAAS). 1993. *Benchmarks for science literacy.* New York: Oxford University Press.

American Association for the Advancement of Science (AAAS). 2007. *Atlas of science literacy.* Vol. 2, "electricity and magnetism," 26–27. Washington, DC: AAAS.

Arnold, M., and R. Millar. 1987. Being constructive: An alternative approach to the teaching of introductory ideas in electricity. *International Journal of Science Education* 9 (5): 553–563.

Borges, A., and J. Gilbert. 1999. Mental models of electricity. *International Journal of Science Education* 21 (1): 95–117.

Driver, R., A. Squires, P. Rushworth, and V. Wood-Robinson. 1994. *Making sense of secondary science: Research into children's ideas.* London and New York: RoutledgeFalmer.

Keeley, P. 2005. *Science curriculum topic study: Bridging the gap between standards and practice.* Thousand Oaks, CA: Corwin Press.

National Research Council (NRC). 1996. *National science education standards.* Washington, DC: National Academy Press.

Shipstone, D. 1985. Electricity in simple circuits. In *Children's ideas in science,* eds. R. Driver, E. Guesne, and A. Tiberghien, 33–51. Milton Keynes, UK: Open University Press.