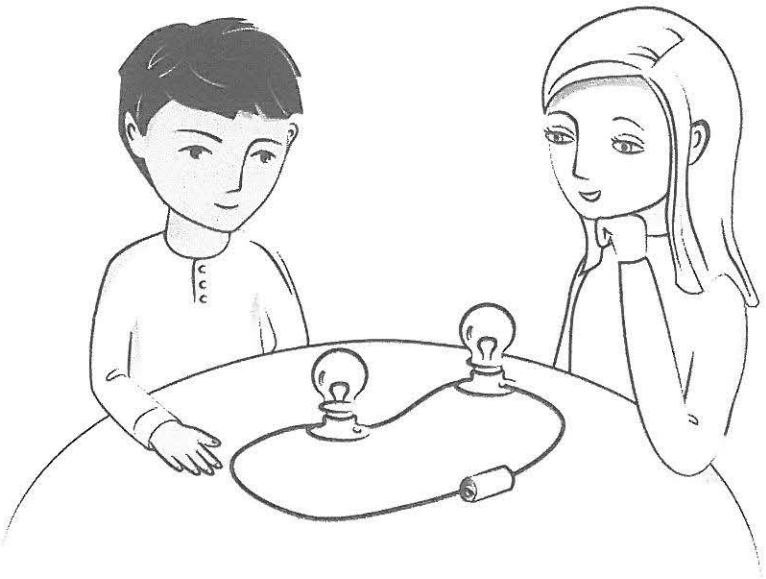
How Bright Will the Bulbs Be?



Two students made a circuit with a battery, wires, and two identical lightbulbs. Before they connected their circuit, they made a prediction about the brightness of the two bulbs. This is what they said:

Herman: I think both bulbs will have the same brightness.

Molly: I think one lightbulb will be brighter than the other.

With which student do you agree the most? _____ Explain why you agree with one student and not the other.

_____

_____

_____

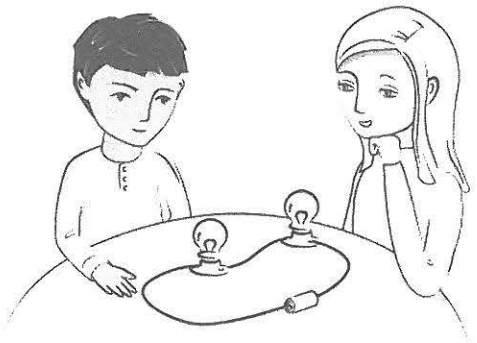
_____

_____

_____

How Bright Will the Bulbs Be?

Teacher Notes



Purpose

The purpose of this assessment probe is to elicit students' ideas about series circuits. The probe is designed to determine what students think will happen to the brightness of lightbulbs as more lightbulbs are added to a circuit.

Related Concepts

current, series circuit, resistance, circuit

Explanation

The best answer is Herman's: "I think both bulbs will have the same brightness." The circuit shown is a series circuit. A series circuit is a circuit in which resistors (i.e., the lightbulbs) are arranged in a chain, so the current has only one path to take. All the current that goes through the first bulb must also go through the second bulb, so the bulbs are the same brightness. (*Note:* It is important that the two bulbs must be identical for the same current to create the same brightness. Bulbs with different ratings could have a different brightness with the same current.) In a series circuit, every lightbulb (or other device) must function for the circuit to be complete. A burned out bulb in a series circuit breaks the circuit and acts like an open switch, which turns the circuit off. The concept of "current" in electric circuits refers to the number of electric charges that pass through the wire in a given amount of time. A lot of charges moving slowly or a few charges moving fast could be the same "current." This is different from the flow of water where "current" usually refers to the speed of the water.

Although the two bulbs will have the same brightness when compared to each other, they will be dimmer than the brightness of a single bulb circuit. This is because adding a second bulb in series will increase the resistance in the circuit, which decreases the current through the circuit.

Administering the Probe

This probe is best used with upper elementary, middle, and high school students. Make sure

students understand they are comparing the brightness of the two bulbs to each other, not to a bulb in a single bulb circuit. This probe can be used with the P-E-O strategy described on page xii (Keeley 2008).

Related Research

- Students who choose Molly tend to have a "consumption model" of current. They see some of the current being used up by the first bulb so there is less going to the second bulb (Driver et al. 1994).
- Several misconceptions related to the concept of current have been noted by researchers such as confusing current with electrical energy; current being used up as it flows through a resistor such as a lightbulb; a lack of recognition that all the parts of a circuit influence each other; and a belief that current flows "downstream" like a river, through the different parts of a circuit (Shipstone 1984; Borges and Gilbert 1999).
- Some students think current is actually something physical that flows through a circuit. This notion leads to the misconception that current gets weaker or used up as it moves from one part to another (Borges and Gilbert 1999).
- Student often confuse electric current and voltage. Student difficulties with voltage can often be traced back to their difficulty understanding the concept of energy. (Millar and King 1993).

Suggestions for Instruction and Assessment

- If using this probe with elementary students, the emphasis should be observational. At middle and high school, students can be asked to construct an explanation to describe what happens to the bulbs.
- Some researchers have suggested using the heart and blood circulation analogy to help move students away from the "consumption model." The blood circulates through the heart but does not get used up in the process (Osborne and Freyberg 1985).
- Although the probe does not ask for how the brightness of the single bulb changes when you add an additional bulb, students can also predict and observe that the bulbs are dimmer in a two-bulb series circuit than a single bulb in a circuit.. The correct inference is that the resistance to the flow must have increased by adding a second bulb in series.
- The probe can be extended by asking students what would happen if a third bulb is added to the circuit.
- One of the most effective models for a series circuit is a string tied into a large circle. Have three students stand in a circle and hold onto the string lightly. One student is the "battery." This student pulls the string around the circle. The other students let the string slide through their hands. The "flow" of the string is the same everywhere around the circle. If the "battery" always pulls the string around with the same "pull," the string slows down as more students are added to the circle. Students also feel the heat from the string sliding through their hands, which is like the resistance that each bulb adds to a series circuit.
- There are several inquiry-oriented curriculum guides that introduce the concept of electric current. One set of materials is the Electric Circuit Module of *Physics by Inquiry* (Pearson). This curriculum was designed specifically for the professional development of elementary school teachers. For a summary of these instructional strategies, see Shaffer and McDermott (1992).
- This probe can be followed by using "Which Burns Brighter," in which students compare the brightness of bulbs in a series circuit versus a parallel circuit.