Weighing Water

Container 1 Container 2 Container 3

The same amount of water is poured into three different-shaped containers with identical masses. Each container is placed on a bathroom scale. Circle the observation below that best describes what you would see when you looked at the weight reading on the bathroom scales.

A All three scales will have the same reading.

B Container 1's scale will have the highest reading.

C Container 2's scale will have the highest reading.

D Container 3's scale will have the highest reading.

E Container 1's scale and container 2's scale will have the same reading; container 3's scale will have a different reading.

Explain your thinking. What rule or reasoning did you use to select your answer?

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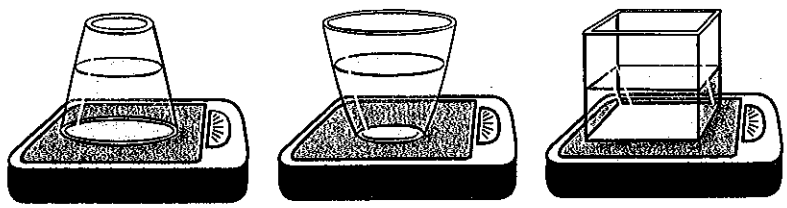
Teacher Notes



Container 1 Container 2 Container 3

Purpose

The purpose of this assessment probe is to elicit students' ideas about weight. The probe is designed to reveal whether students recognize that the weight of identical volumes of water is the same, regardless of the shape of the container.

Related Concepts

pressure, weight

Explanation

The best response is A: All three scales will have the same reading. The weight in all three containers is the same. Weight is the measure of gravitational force between the Earth and an object. In all three containers, the gravitational force is the same as long as all three containers are in the same location. While the weight stays the same, the pressure differs. Weight and pressure are not the same. When a force is spread out evenly over some surface, pressure is the amount of force exerted for each unit of area (e.g., centimeters^2 or inches^2). Pressure increases when the surface area decreases as long as the exerted force stays the same. In this case, the container with less surface area in contact with the scale exerts more pressure. However, less or more pressure does not change the weight.

Administering the Probe

This probe is best used with upper elementary, middle school, and high school students. Make sure students understand that the amount of water is the same in each container and that each of the containers has the same mass.

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

K–4 Properties of Objects and Materials

- Objects have many observable properties, including size, weight, shape, color, temperature, and the ability to react with other substances. Those properties can be measured using tools, such as rulers, balances, and thermometers.

Note: Pressure is not explicitly mentioned in the National Science Education Standards in the context of force and motion. However, it is a concept that is referred to in the context of weather (air pressure). In addition, pressure is related to phenomena that students will encounter in their curriculum materials (e.g., students learn that barometric pressure can be used to predict the weather; high pressure is generally associated with sunny skies and low pressure with storms) and is connected to key ideas about weight and forces that are in the National Science Education Standards.

Related Ideas in *Benchmarks for Science Literacy* (AAAS 1993, 2009)

3–5 Forces of Nature

- The earth's gravity pulls any object on or near the earth toward it without touching it.

Note: Pressure is not explicitly mentioned in the Benchmarks for Science Literacy. However, it is related to phenomena students will encounter in their curriculum materials (e.g., physical science courses often introduce students to Bernoulli's law that uses the law of conservation of energy to predict changes in pressure inside a fluid) and is connected to key ideas about weight and forces that are in the Benchmarks.

Related Research

- Research indicates that ideas about weight and ideas about gravity are separate from each other in the minds of most students (Driver et al. 1994).
- Most available research on pressure is in the context of air or water pressure. This probe is useful in finding out whether students have scientific conceptions of pressure that are different from their conceptions of weight.
- Researchers have found that children, from an early age, notice how objects differ in how they "press down." This "felt weight" is an early conception of the property of weight (Driver at al. 1994).
- Researchers have found that students rarely think of applying Newton's laws when asked questions about fluids or pressure (Heron et al. 2003).

Suggestions for Instruction and Assessment

- Students can further test this idea—that the weight of the same volume of water in containers with identical weights is the same, regardless of the pressure that the container of water exerts—by taking an object and weighing it in different positions. For example, they can weigh a log twice: when it is vertical and when it is lying down on its side. Then they can compare these two weights.
- This task is similar to questions used by noted child psychologist Jean Piaget during interviews with children. A simple version would be to ask students to predict how a scale reading would be different if two objects are sitting side by side or if they are stacked one on top of the other.
- To see if students recognize the effect of surface area on pressure, this probe can be followed up with, or preceded by, a similar probe. Present students with three different-shaped containers (e.g., like those on p. 153) and a piece of foam in place of the bath-

room scale. Ask them to think about what will happen when each container is placed on the piece of foam: A. All three containers will compress the foam the same; B. Container 1 will compress the foam the most; C. Container 2 will compress the foam the most; D. Container 3 will compress the foam the most; or E. Containers 1 and 2 will compress the foam the most, and Container 3 will compress the foam a different amount.

The correct answer is C: Container 2—the container with the smallest surface area touching the foam—will compress the foam the most.

- Ask students why someone can walk on top of deep snow with snowshoes but not with regular shoes. (The snowshoes distribute the weight over a greater surface area so the person does not sink in the snow.)
- An interesting classroom challenge is to ask students to construct a pair of shoes that could be used to walk on eggs (Adair and Loveless 1997).

References

Adair, L., and G. Loveless. 1997. Walking on eggs. *The Physics Teacher* 35: 28.

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

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