

The Intimate Machine

Activity 1: Grades 5-8

Weighing In

As you observed in "[Getting to Know You](#)", researchers have developed a floor that allows them to identify and track individuals by their weight. The floor includes sensors that trace the impact of footsteps. Entered into a database, the collected impacts can be used to construct a specific individual's movement history. This "intelligent floor" is so precise that it can detect when you've added a cup of milk to a recipe!



How do YOU measure quantities such as fluid ounces? Most likely you use a measuring cup or a similar device that measures volume. Things are about to change. The following activity will allow you to emulate the weighing technique associated with an intelligent floor. It will also examine the difference between "accuracy" and "precision," important considerations when using any measuring technique.

The "accuracy" of a device describes how close its readings are to the actual value. If a scale measures the weight of a 5-pound sack as five pounds, it is very accurate. If it produces a reading of 6 pounds, it is less accurate. The "precision" of a device refers to the repeatability of the measure. Will the scale always give a reading of precisely 5 pounds? Will it produce a narrow range of values, thus making it "high precision"? Or will it present a wide range of values associated with "poor precision"?

This activity page will offer:

- Insight into the relationship between volume and mass
- An opportunity to differentiate between accuracy and precision
- An arena for creating a strategy to measure volume
- A chance to emulate the action of the pressure sensitive floor in measuring quantities

MATERIALS

- Bathroom scale (digital works best)
- Measuring cup
- Water
- 2-liter container
- 5-pound bag of rice
- Clean kitchen bowl

TEACHERS: Please see the Teacher's Note on the [Answers Page](#)

PROCEDURE

1. Identify the bathroom scale that you will use in this activity. Is the weighing device digital or analog? Does the scale include any information about the reliability of its measure (such as $\pm .2$ pounds)?
2. Stand on the scale. Note and record your weight shown on the scale display. Step off the scale. Weigh yourself two more times and average the three readings.
3. Place an unopened five-pound bag of rice on the scale. Determine and record the weight of this bag and contents as measured by the scale. Reweigh this bag twice more and average the three readings.
4. Make a prediction. Suppose you were to stand on the scale holding the bag of rice. How much weight should the scale read?
5. Weigh yourself with the 5-pound bag. Was your prediction correct? Why or why not? Explain any differences.
6. Using the value you obtained in step 3, determine the approximate weight of one fluid ounce of rice. (Divide the total weight of package by its volume in ounces)
7. Develop a strategy that you could use to remove twenty fluid ounces of rice from the bag without using a volumetric tool. Then, using clean utensils and a bowl, test your strategy. Check your results with a measuring cup. Did your strategy work? Explain. When you are finished, return the rice to its bag.
8. Fill a 2-liter container with water. Obtain and record the weight of the water-filled container.
9. Apply the strategy you developed in step 7, to measure out 0.5 liters from this 2-liter container. By what percentage must the container's original weight be decreased in order to remove 0.5 liters? When you are done, use a measuring cup to test the accuracy of your procedure.

Questions

1. Why did you need to repeat the weighing measurements?
2. Would the weight of the container in which the rice or water is stored affect the accuracy or precision of the measurement? Explain.
3. Make a prediction. How would using molasses instead of water affect the weight of the measured and removed liquid?

EXTENSIONS

High Heel Pressure

In most schools, spiked high-heeled shoes are not allowed on a wooden gym floor. The reason for this ban has to do with science - not sociology! When you stand on a mostly flat sole, your body weight is distributed over the entire area of the contact surface. So if you weighed 150 pounds and you stood on one foot that contacted 30 square inches of surface, you'd produce a pressure of about 5 pounds/square inch. Suppose you only made contact with the spike of a high-heeled shoe. How would this effect pressure? Explain. Use a ruler, scale and a variety of shoes with various heel contours to determine variance in a person's walking pressure.

Between You and a Door

Imagine a "smart door" like the one you saw in the program, only one with an attitude. How might this device reply to different individuals? Would it show a bias in its communication regarding gender, profession, or a visitor's motives? Think about it. Then apply your creative writing skills to creating a humorous essay about an hour in the life of this communication interface.

Intelligent Elevator

How might the footstep profiles captured by an "intelligent floor" be used to improve elevator service? Should this intelligent floor be placed inside or outside of the elevator, or both? Explain the benefits of each approach. Could it address pranksters who might press all of the floor buttons? If so, how? How might the floor address a car that was overloaded?

Freedom of Movement

The ability to track individuals on a floor might be interpreted as a challenge to a person's right to anonymity. Do you think this violates a person's rights as guaranteed by the constitution? Should a person need to sign a release in order for his/her footstep profile to be recorded? Suppose you were a lawyer who challenged the legality of this process? How would you present your case?

WEB CONNECTION

Accuracy and Precision

<http://www.flatsurv.com/accuprec.htm>

Learn more about accuracy and precision in measurement.

Self-Organizing Elevators

http://www.halfbakery.com/idea/Self-Organizing_20Elevators

A fun and informative site that describes intelligent floors and uses in elevator environments.

The Smart Floor

<http://citeseer.nj.nec.com/271128.html>

This article describes the use of a smart floor as a means of tracking

individuals by footprint profiles.

The activities in this guide were contributed by Michael DiSpezio, a Massachusetts-based science writer and author of "Critical Thinking Puzzles" and "Awesome Experiments in Light & Sound" (Sterling Publishing Co., NY).

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TEACHING GUIDE



www.pbs.org/saf/1303

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Answers

PROCEDURE

4. Make a prediction. Suppose you were to stand on the scale holding the bag of rice. How much weight should the scale read?

(Answers will vary but this should be the sum of the student's weight and the weight of the rice bag.)

6. Weigh yourself with the 5-pound bag. Was your prediction correct? Why or why not? Explain any differences.

(Scale may not retain its accuracy over a range in weight measurements).

9. Apply the strategy you developed in step 7, to measure out 0.5 liters from this 2-liter container. By what percentage must the container's original weight be decreased in order to remove 0.5 liters?

(About 25%).

Questions

1. Why did you need to repeat the weighing measurements?
(In order to assure repeatability, the weighing was repeated. This repeatability was a measurement of the precision of the weighing device. The final average was a more reliable number than any of the individual values.)
2. Would the weight of the container in which the rice or water is stored affect the accuracy or precision of the measurement? Explain.
(The weight of the container will offset the recorded value by a small, fixed value. This affects the accuracy of the measures. If we assume that the container's weight does not interfere with the scale's mechanism, we should observe the same repeatability of measure (precision) in all readings.)
3. Make a prediction. How would using molasses instead of water affect the weight of the measured and removed liquid?
(Since molasses is a thick, sugar-rich solution, the observed weight measurements will be greater.)

EXTENSIONS

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(The heel's smaller contact area will assume the entire weight. Therefore, this single but small area contact point would produce a large increase in pressure - often strong enough to produce "dings" in the wooden floor surface.)

CURRICULUM LINKS

General Science:

Experimental Design

Chemistry:

Physical Properties (mass, volume, density, pressure),
Measurement (accuracy and precision)

NATIONAL SCIENCE STANDARDS (Grades 5-8)

Science as Inquiry- Content Standard A

Students will learn to formulate questions, design an investigation, execute this investigation, interpret the data and use the evidence to generate explanations. By evaluating the accuracy and precision of their experimental setup, students will acquire an understanding of the benefits and limitations of technology used to gather data.

History and Science - Content Standard G

Students will learn that the newest areas of scientific research many times lack experimental evidence and understanding.

Students will understand that disagreement does exist in the scientific community.