Buoyant Butter

Section **PROPERTIES OF MATTER** *Topic* **DENSITY**

Estimated Time Setup: 5 minutes; Procedure: 5–10 minutes

OVERVIEW

Students will discover the connection between density and whether an object will sink or float.

How can we determine if an object will sink or float in water? In this activity, students will calculate the density of butter and compare it to the density of water. They will make predictions about whether the butter will float or sink in the water based on their calculations and then test these predictions.

INQUIRY QUESTIONS

Getting Started:

- Do solids float or sink in liquids?

Learning More:

- How can we make predictions as to whether an object will sink or float in a liquid?

Diving Deeper:

- What forces cause an object to sink or float in a liquid?

CONTENT TOPICS

This activity covers the following content topics: instruments, measurement, precision vs. accuracy, density, displacement

This activity can be extended to discuss the following: environmental science (weather, oceans), engineering design, forces, buoyancy

NGSS CONNECTIONS

This activity can be used to achieve the following Performance Expectations of the Next Generation Science Standards:

- **2-PS1-1:** Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.
- **5-PS1-3:** Make observations and measurements to identify materials based on their properties.
- **MS-PS1-2:** Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

Fun Fact #1

The only soap that is known to float on the surface of water is Ivory soap! This is possible for Ivory because they whip air into the soap to decrease its density. Check out the Growing Soap activity to learn more!

MATERIALS

For one setup:

- 1 Stick of butter or margarine, with wrapper
- Metric ruler
- Large bowl or container
- Water

Optional materials:

- Scale

ACTIVITY NOTES

This activity is good for:

- Individuals
- Pairs
- Small groups

Safety Tips & Reminders:

- To reduce the mess, use a frozen stick of butter. Alternatively, you can use any rectangular prism that can be easily cut, such as paraffin wax.
- Only adults should handle the knives if the butter needs to be cut for the activity or modifications.
- There is no eating or drinking in the laboratory—even when we are working with normally edible materials.
- Review the Safety First section in the Resource Guide for additional information.

ENGAGE

Use the following ideas to engage your students in learning about density:

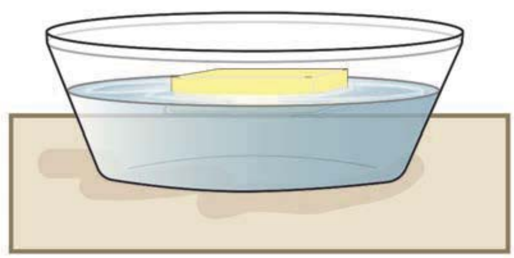
- Explain the concept of density using a visual. For example, use mini-marshmallows in a clear box to show how mass can change in a given volume.
- Collect different objects and ask the students if the objects will sink or float in water. Try to find objects of varying shapes, sizes, and densities. How can one predict floating or sinking accurately? What factors are important to making this determination?
- Ask students whether all rocks sink or float, or if it varies. Collect rock samples that are similar in volume and test it out! Include one rock that is pumice, which will float. This will help the students to understand that a variety of factors play into density.
- Place a piece of aluminum foil on top of the water as a flat sheet. Then crumple it slightly and put it in the water again. What happens? Now ball it up into a tight sphere and ask the students if it will still float. This will illustrate that the same mass but in a smaller space (more dense) will sink rather than float.

See more ideas for engagement in the Density Background section! You can also look at the Elaborate section of this activity for other ideas to engage your students.

EXPLORE

Procedure:

1. Determine and record the mass of the butter in grams (g). This can be measured on a scale or found on the wrapper label or box.
2. Using a ruler, measure and record the length, width, and height of the stick of butter in centimeters (cm).
3. Calculate the volume of the stick of butter by multiplying the length times the width times the height (V = l x w x h).
   - The answer will be in centimeters cubed (cm^3), which is equal to milliliters (mL). Record the volume in milliliters.
4. Calculate the density of the butter.
   - Density is the mass divided by the volume (D = m/V), so divide your answer from step 1 by your answer from step 3.
5. Determine the density of water. Make a prediction about whether the butter will float, hover in the middle, or sink in the water. Draw a model, and explain your thinking.
6. Fill the large bowl or container with water and place the butter in the bowl to determine whether your prediction was correct. Record your observations.



Fun Fact #2

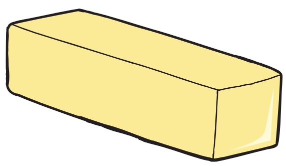
Over 2,000 years ago, ancient Greek mathematician Archimedes made a very useful measurement observation. As legend has it, Archimedes was tasked with determining whether a gold crown was a fake or not. It was known that sometimes goldsmiths would swindle their clients by mixing gold with a less expensive metal, like silver, to save money while still selling it at an exorbitant rate, but there was no known way to determine the amount of gold in a sample. On a trip to the public baths, Archimedes realized that the more he sank into the water, the more the water level rose and was displaced. He realized that different substances displace water different amounts, uncovering the forces of buoyancy and different densities of gold and silver! Realizing this discovery, the story goes that Archimedes leapt out of the bath and ran through the streets naked crying "Eureka!" ("I've found it!"), though the authenticity of this part of the story is up for debate!

DATA COLLECTION & ANALYSIS

Analyze and discuss the results of this activity using the following questions:

- Label this diagram (representative of the stick of butter) with your measurements and show the density calculation:

V = l x w x h



- What is the density of water? (This can be looked up online or in a textbook, or calculated by measuring the volume and mass.)
- We know that the density of water is 1 g/mL. Is the density of the butter less than, equal to, or greater than the density of water? Does this mean that the butter will float, hover in the middle, or sink if we put it in the bowl of water?
- Draw a model of where the butter will go when added to the water. Was your prediction correct?

Notes

EXPLAIN

What's happening in this Activity?

First review the Density Background section to gain a deeper understanding of the scientific principles behind this activity.

In this activity, we calculate the **density** of a sample and predict whether it will sink or float in water. Because density equals **mass** divided by **volume**, to calculate density the mass and volume of a substance need to be determined. The mass is calculated with a scale or by using the provided mass of the butter. The volume is calculated using the length, width, and height of the stick of butter. After calculating and recording these measurements, we determine that the density of butter is lower than that of water, indicating that the butter will float in the water.

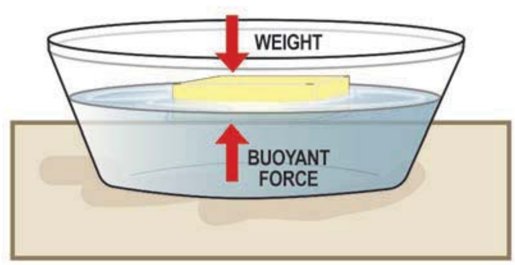
If many students are measuring the dimensions of the butter, you'll notice that not everyone gets the same measurements or calculations. Scientists are always striving to get measurements that are both **accurate** and **precise**.

- **Accuracy** means how close a measurement is to a known, standard value. In this case, we know that a stick of butter typically has a mass of 110 grams, a volume of 121 mL, and therefore a density of 0.911 g/mL. The closer your numbers are to these standard measurements, the more accurate they are.

- **Precision** is how close a measurement is to others that were taken, or how easy it is to get the same value multiple times. If you measure the length of a stick of butter multiple times and get very close to the same number each time, your answer is precise. It is best practice to repeat measurements until precision is reached. For example, if you measure the length of the butter three times and get the results of 8.1 cm, 9.6 cm, and 6.0 cm, your measurements are not very precise. If you get measurements of 8.2 cm, 8.1 cm, and 8.3 cm, your measurements are more precise. You can take the average of these numbers to use for your calculations. If your measurement is precise, it is less likely the result of experimental error, and more likely to be accurate.

The goal is always to get a measurement that is both accurate (close to the correct value) and precise (consistent in your measurements).

While conducting this experiment you might observe that when a stick of butter is added to water, some of it remains above the water line and some is below. The butter comes to rest in this position due to the force of buoyancy. **Buoyancy** is the upward force that a fluid (liquid or gas) exerts on an object.



The strength of the force of buoyancy of a fluid is dependent on its density: the denser it is, the stronger buoyancy is, too. An example of this is swimming in fresh water versus salt water. The Dead Sea is a body of water with a high salt content, which makes it easier for people to float in the water. The high salt content gives the liquid a greater density because there is more mass per volume in the water. This means a stronger buoyant—or upward—force, making it easier for people to float.

EXPLAIN continued

The force of **gravity**—which is dependent on the mass of an object and therefore on the density of the object—pulls objects to the Earth's center, and buoyancy pushes in the opposite direction. Depending on the strength of these forces, the object may sink, float, or rest at a specific place within the fluid. Ultimately, the force of gravity is directly related to the density of the object and the buoyant force is directly related to the density of the fluid, so both forces determine whether an object will float or sink in a fluid.

If you conducted this experiment in a narrow container, you might have noticed that the water level rose when the butter was added. If you push the butter deeper into the water you see that the water level continues to rise until the butter is fully submerged. This is a demonstration of **displacement**, which is when an object takes up space in a fluid and pushes the fluid that was there out of the way. As the butter moves into the space where the water used to be, the water is forced out of the way—or displaced—and the volume of the system (water and butter) increases.

Differentiation for Younger or More Advanced Students

You can differentiate this activity for students of different grade levels by focusing on the concepts outlined below.

GETTING STARTED

For younger students, emphasize the following concepts:

- Testing predictions
- Instruments and units of measurement

DIVING DEEPER

For more advanced students, emphasize the following concepts:

- Density of solids and liquids
- Buoyancy: buoyant forces and the force of gravity
- Displacement

ELABORATE

Elaborate on your students' new ideas and encourage them to apply them to different situations. The section below provides some alternative methods, modifications, and extensions for this activity.

- Skip the calculations and ask students to make predictions as to whether a variety of objects will sink or float. Do they notice anything that is similar between all of the objects that float and all of the objects that sink? What factors seem to cause something to sink or float?
- Cut the butter into various sizes so every sample is a different volume. Ask students to first make predictions as to which sample of butter will sink or float based on the size and shape. Use a scale to measure the mass and calculate the volume by calculating the height, width, and length of each sample. After they do some calculations they can make a prediction and test it by dropping their sample into water. Then have each group share the density they found with the whole class.
- Use a variety of objects that have the same volume but different masses (e.g., a cube of cream cheese, hard cheese, soft cheese, butter, margarine, various fruits, etc.; or inedible samples such as wooden and plastic blocks). What makes some of these objects float, and others sink?
- Have students calculate the density of water by measuring the mass and volume of a sample of water. How close are they to 1.00 g/mL? Ask them to brainstorm ways to make their measurements more accurate and precise.
- Use the data collected by the class to plot the mass versus volume of the stick of butter on a graph. Is there a pattern? Now do the same but with sticks of butter of different sizes (and shapes for more complicated volume calculations!). Is there still a pattern? Do you see a constant slope on the graph? What does that mean for the density of each sample? Remember that density is a ratio of mass to volume ($D = m/V$), so for any given sample of butter the density should be the same, which is why you see a constant slope (density) on the graph.
- Conduct the activity in a variety of liquids (e.g., oil, milk, soda water) or try different samples of water with a different amount of salt dissolved in each. Students can calculate the density of each liquid or just observe whether the butter floats or sinks. Ask students to design a method to make the butter sink in a liquid. Hint: If they can't find a liquid that is less dense than butter, is there a way to increase the mass per volume of the butter? Can they add a heavy object to the butter to make it sink? Ask students to calculate the new density.
- Get an air-tight container that can float in water. Have a variety of objects to put inside to change the overall mass. Ask the students to hypothesize which objects will cause the container to sink to the bottom of the water. Can they make a calculation that accurately predicts how much more mass needs to be added for it to sink? You can also have two containers with different surface area but the same internal volume. Ask the students if the shape of the container will affect its ability to remain afloat. How do buoyancy and displacement change as more objects are added?

CHEMISTRY IN ACTION

Share the following real-world connections with your students to demonstrate how chemistry is all around us.

Real-World Applications

Challenge your students to determine how huge boats made of metal can float. Then, explain that the massive weight of the boat is spread out over a large area, thus it has a large volume, making it possible to float in water. The concepts of density and buoyancy are vital to the development of large ships such as aircraft carriers, cargo ships, and cruise ships.

Life jackets are made in different sizes to accommodate different sized people. As your mass increases you want to have the right jacket on to keep you buoyant in the water.

Single-stream recycling processes rely on different densities to separate each type of material, or different plastics from one another. Machines move objects to different parts of the process based on their densities so they can be recycled and reused in the appropriate way.

Buoys are used in the water as anchored floats to help with navigation or to mark hazards in the water, among other uses. A floating buoy must be designed so that part of it stays below water, and other parts above water. Different shapes, materials, and masses are used to achieve the ideal density and buoyancy.

Careers in Chemistry

- Soap manufacturers use chemistry to figure out if their soap will sink to the bottom of a tub or float on the surface. Some soap has extra air whipped into the formula so it will float in water and it is easier to retrieve dropped soap from a tub!
- Anything that goes in the water is designed by scientists with density and buoyancy in mind: boats, buoys, submarines, floating piers or docks, diving equipment, and more. An example is a "buoyancy compensator," which is a piece of equipment used for professional underwater diving. The device has a bladder that can hold air, and the diver adjusts the bladder to establish the right amount of buoyancy during a dive so they can either descend into the water or float to the top.

EVALUATE

- Provide students with a series of rectangular prisms or cubes. You can use matchboxes with different objects in them, various wood samples, or anything else that can readily be measured for mass and volume. Ask students to conduct their measurements, calculate density, and see if they can accurately predict whether the objects will sink or float in water.
- Challenge students to go home and make a list of objects that sink, float, or hover around the middle of a glass of water. They can draw their answers in a diagram and label the picture, or make it into a matching or fill-in-the-blank game they can play with a partner in class the next day. Were there any that surprised them? Why?
- Design a research project to better understand how engineers create ships that stay afloat in the water. Ask students to research the materials used on ships and the properties of the materials. What are the densities of the metals used? Where can this information be found online? What precautions are taken to ensure that the ship stays afloat in the water? Challenge them to design their own ship that can carry a 1 kg weight without sinking. Who can do this using the cheapest materials? The least amount of materials? With the smallest ship?

Fun Fact #3

Sulfur hexafluoride (SF_6) is a gas that is almost five times as dense as air. It is so dense that a solid sheet of aluminum can float on top of it!