

Name: \_\_\_\_\_ Date: \_\_\_\_\_

## Student Exploration: Determining Density via Water Displacement

**Vocabulary:** Archimedes' principle, density, displacement, mass, volume

**Prior Knowledge Questions** (Do these BEFORE using the Gizmo.)

A ship floats by an iceberg as shown.

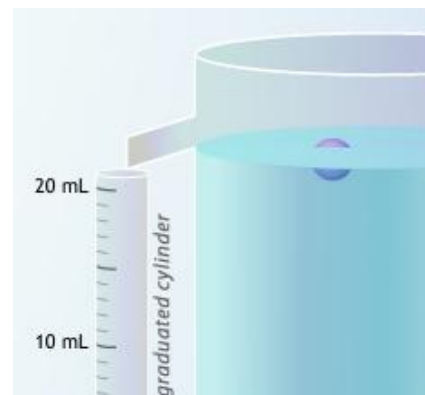


1. Based on the picture, which object is denser, the iceberg or the ship?  
\_\_\_\_\_

2. How do you know? \_\_\_\_\_  
\_\_\_\_\_

### Gizmo Warm-up

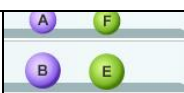
Have you ever gotten into a bath and noticed the water level rise? Have you added potatoes to a full pot of water and had water spill over the sides? If so, you have witnessed a phenomenon called **displacement**, in which water or another fluid is pushed out of the way when a solid object is submerged in the fluid.



The *Determining Density via Water Displacement*

Gizmo™ allows you to calculate the **density**, or mass per unit volume, of an object using nothing but a graduated cylinder and a container of water.

1. Place object **A** into the water. Does it float or sink? \_\_\_\_\_
2. Click **Reset**. Add each object to the water, one at a time. (Click **Reset** after each trial.)  
Which objects float? \_\_\_\_\_ Which objects sink? \_\_\_\_\_
3. Which object do you think is densest? \_\_\_\_\_ Least dense? \_\_\_\_\_  
Explain: \_\_\_\_\_

<b>Activity:</b>	<u>Get the Gizmo ready:</u>	
<b>Finding density</b>	<ul style="list-style-type: none"> <li>Click <b>Reset</b>.</li> </ul>	

**Introduction:** Over 2,000 years ago, the Greek mathematician Archimedes discovered that an object in water is pushed up by a force equal to the weight of the displaced water. This law, called **Archimedes' principle**, has two consequences:

- If an object floats, its **mass** is equal to the mass of the displaced water.
- If an object sinks, its **volume** is equal to the volume of the displaced water.

**Question: How do you find the density of an object without using a balance?**

- Measure:** Drop object **A** into the water. Notice the water displaced into the graduated cylinder to the left of the container. The unit of volume is the milliliter (mL).
  - How much water is displaced by object **A**? \_\_\_\_\_
  - Water has a density of 1 gram per milliliter (1 g/mL). Based on its density, what is the mass of the displaced water? \_\_\_\_\_
  - Use Archimedes' principle to determine the mass of object **A**: \_\_\_\_\_
  
- Measure:** The volumes of solid objects are measured in cubic centimeters (cm<sup>3</sup>). One cubic centimeter is exactly the same volume as one milliliter. Click **Reset**. Notice that object **F** has the same volume as object **A**. Drag object **F** into the water.
  - Does object **F** float or sink? \_\_\_\_\_
  - How much water is displaced by object **F**, in mL? \_\_\_\_\_
  - What is the volume of object **F**, in cm<sup>3</sup>? \_\_\_\_\_
  - What is the volume of object **A**? \_\_\_\_\_
  
- Calculate:** The density of an object is equal to its mass divided by its volume:  $D = m \div V$ . The density of solids is measured in grams per cubic centimeter (g/cm<sup>3</sup>).  
 What is the density of object **A**? \_\_\_\_\_
  
- Analyze:** Click **Reset** and drop object **A** back into the water. About what percentage of object **A** is under the water? How is this percentage related to the density of object **A**?  
 \_\_\_\_\_  
 \_\_\_\_\_

**(Activity continued on next page)**

**Activity (continued from previous page)**

5. Gather data: Click **Reset**. Find how much water is displaced by objects **B**, **C**, **D**, and **E**. Record your measurements below. Include units.

Object	Volume of displaced water	Floats or sinks?
<b>B</b>		
<b>E</b>		

Object	Volume of displaced water	Floats or sinks?
<b>C</b>		
<b>D</b>		

6. Calculate: Use your data to find the mass, volume, and density of the two floating objects, **C** and **E**. Recall that the mass of a floating object is equal to the mass of displaced water, and the volume of a sinking object is equal to the volume of displaced water. Assume objects **B** and **E** have the same volume, as do objects **C** and **D**.

Object **C**:                      Mass: \_\_\_\_\_                      Volume: \_\_\_\_\_                      Density: \_\_\_\_\_

Object **E**:                      Mass: \_\_\_\_\_                      Volume: \_\_\_\_\_                      Density: \_\_\_\_\_

7. Analyze: Drag objects **C** and **E** into the water. Estimate the percentage of these objects that are submerged below the waterline. List these estimates below:

Object **C**: \_\_\_\_\_                      Object **E**: \_\_\_\_\_

How do these estimates relate to the densities you calculated above? \_\_\_\_\_

\_\_\_\_\_

8. Think and discuss: Why can't you use this Gizmo to measure the densities of objects **B**, **D**, and **F**? If possible, discuss your answer with your classmates and teacher.

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\_\_\_\_\_

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9. Challenge: What can you say about the densities of objects **B**, **D**, and **F**? Is there a way to compare the relative densities of these three objects? Explain.

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