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.)



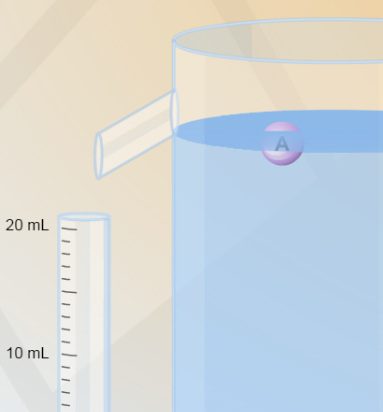
A ship floats by an iceberg as shown.

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

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

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**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? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Which object do you think is densest? \_\_\_\_\_\_\_\_\_\_\_\_ Least dense? \_\_\_\_\_\_\_\_\_\_\_\_

Explain: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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| **Activity:**  **Finding density** | Get the Gizmo ready:   * Click **Reset**. | DensityWaterSE3 |

**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?**

1. 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).
   * 1. How much water is displaced by object **A**? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
     2. Water has a density of 1 gram per milliliter (1 g/mL). Based on its density, what is the mass of the displaced water? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
     3. Use Archimedes’ principle to determine the mass of object **A**: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. Measure: The volumes of solid objects are measured in cubic centimeters (cm3). 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.
   * 1. Does object **F** float or sink? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
     2. How much water is displaced by object **F**, in mL? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
     3. What is the volume of object **F**, in cm3? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
     4. What is the volume of object **A**? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. Calculate: The density of an object is equal to its mass divided by its volume: *D* = *m* ÷ *V*. The density of solids is measured in grams per cubic centimeter (g/cm3).

What is the density of object **A**? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. 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**?

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**(Activity continued on next page)Activity (continued from previous page)**

1. 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** |  |  |
| **E** |  |  |

|  |  |  |
| --- | --- | --- |
| **Object** | **Volume of displaced water** | **Floats or sinks?** |
| **C** |  |  |
| **D** |  |  |

1. 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: \_\_\_\_\_\_\_\_

1. 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? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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1. 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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1. 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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