Eureka! Archimedes & Water Displacement

Next Generation Science Standards: **MS-PS1-1**

Common Core Math Standards: **HSG-MG.A.2**

Objective: to find the volume of a solid using displaced water

Vocabulary

Volume is a measure of the amount of space an object takes up. When an object is submerged in the water it pushes water out of the way (**displacement**).

Archimedes discovered the **Hydrostatic Principle** which states that "a body completely or partially submerged in a fluid undergoes an upwards push equal to the weight of the displaced fluid."

The volume of the displaced water, when measured, will equal the volume of the object submerged in the water.

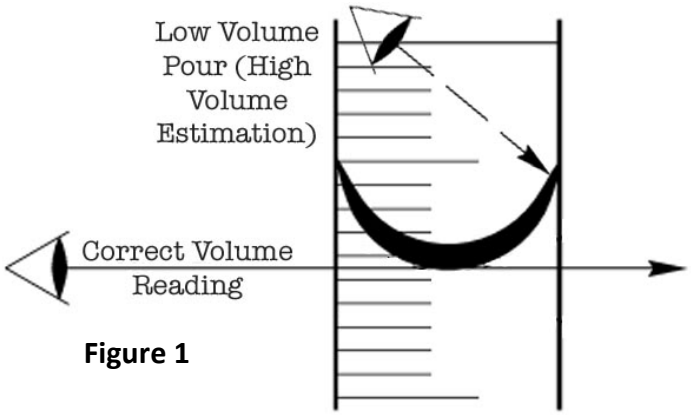


Figure 1

When measuring fluid volume you measure using the **meniscus line**. The meniscus line is caused by surface tension of a liquid. It's the curve in the upper surface of a liquid inside of a vessel, such as a graduated cylinder. [See Figure 1]

Background:

King Hiero, the second king of Syracuse, had a suspicion that the craftsman he had commissioned to create his new crown had stolen some of the gold, replacing it with silver when crafting it. The king sent for Archimedes in the hope the great scientist could uncover the truth.

Archimedes is said to have formulated the idea of how to solve the king's problem when he was taking a bath. Archimedes noticed the bath's water level raised and lowered when he got in and out which gave him the idea for his experiment.

Legend has it that upon devising the solution, Archimedes leapt from his bath to run through the town naked, victoriously shouting "Eureka! Eureka!" ("I've got it! I've got it!")

Supplies:

- Graduated cylinder or beaker (recommend 250 mL or greater) *A plastic or glass cup with graduated measurements will also work if lab ware is not available.
- Two dense objects (dense enough to sink in water and small enough to fit in your graduated cylinder or beaker opening) *Examples include rocks, nails, lead weights and/or marbles.
- Water (at least 50 mL)

Procedure:

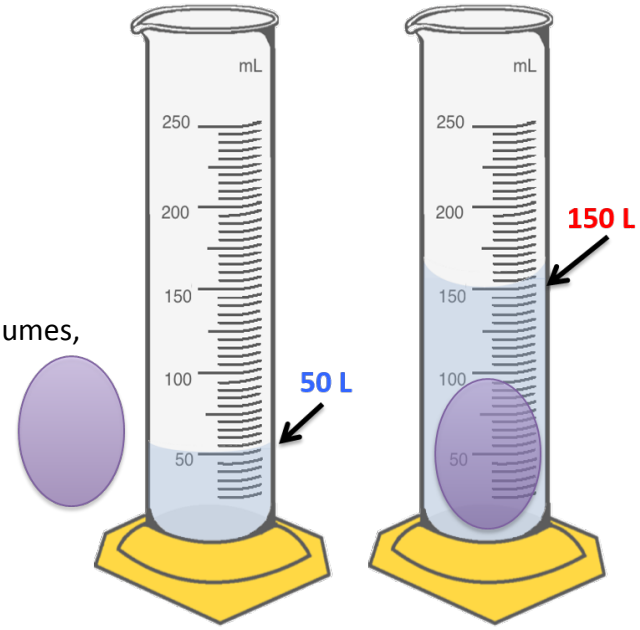
1. Fill the graduated cylinder or beaker to the 50 mL mark with water. To measure liquid volume accurately, observe the meniscus line to ensure 50 mL of water.
2. Carefully add one of your two selected objects to the graduated cylinder. Be sure not to splash any of the 50 mL of water out of the graduated cylinder or beaker.
3. Take note of the displaced water by measuring the new water level on the graduated cylinder or beaker. This volume measurement will be your final water volume measurement (v_f)
4. Take the final water volume (v_f) and subtract from the initial water volume (v_i). The initial water volume (v_i) is 50 mL. This will give you the objects total displaced water volume (v_d).

150 L – 50 L = 100 L

$$\mathbf{v_f - v_i = (v_d)}$$

First Object v_i	mL
First Object v_f	mL
Second Object v_i	mL
Second Object v_f	mL

5. Repeat steps 2-4 for the second object.
6. Compare the two objects' total displaced water volumes, and consider these two questions:
    a. Which object displaced more water?
    b. Would you consider the object that displaced the most water to be the densest?



How it works

Archimedes determined that an object placed into a body of water displaces its own volume of water. So by sinking a known quantity (volume) of gold into a vessel he could measure how much the water level rose and compare the result with an equal quantity (volume) of silver. By then measuring the crown in this way against an equal mass of gold, Archimedes could determine whether or not the crown was indeed crafted from pure gold or a gold and silver blend. By doing this, Archimedes created the first hydrostatic balance. The experiment successfully uncovered the truth that the craftsman had indeed stolen gold from the king, a very serious crime.

This lesson was designed by the U.S Space and Rocket Center