Archimedes was a great mathematician and scientist who was born in 287 B.C. It is said that while taking a bath one day, he got the idea for using the displacement of water to compare the densities of objects. In particular, he was able to use this method to determine that a crown made for the king did not contain the full amount of gold that it should have.

Summary

Students will conduct a simple experiment to see how the water level changes in a beaker when a lump of clay sinks in the water and when the same lump of clay is shaped into a bowl that floats in the water. They will notice that the floating clay displaces more water than the sinking clay does, a result that will probably surprise them. They will then determine the mass of water that is displaced when the clay floats in the water. A comparison of this mass to the mass of the clay itself should reveal that they are approximately the same.

Engineering Connection

Category 2. Engineering analysis or partial design  Engineers must determine the total amount of water displaced when designing boats. They must also consider this when designing waterways to determine the maximum sized boat that can pass through a man-made waterway such as the Panama Canal.

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Grade Level: 8 (7-9)
Time Required: 1 hours

Group Size: 3
Activity Dependency: Floaters and Sinkers, Determining Densities, What Floats Your Boat?, Clay Boats

Expendable Cost Per Group: US$ 0.50
Keywords: density, buoyancy, displacement
Related Curriculum:

subject areas: Measurement, Physical Science

curricular units: Floaters and Sinkers

lessons: What Floats Your Boat?

Educational Standards

- North Carolina Math
  - 2.02 Solve problems involving volume and surface area of cylinders, prisms, and composite shapes. (Grade 7) [2003]
  - 2.02 Apply and use concepts of indirect measurement. (Grade 8) [2003]

- North Carolina Science
  - 1.06 Use mathematics to gather, organize, and present quantitative data resulting from scientific investigations:
    - Measurement. (Grade 7) [2004]
  - 6.06 Investigate and analyze the real world interactions of balanced and unbalanced forces:
    - Sports and recreation. (Grade 7) [2004]
  - 1.06 Use mathematics to gather, organize, and present quantitative data resulting from scientific investigations:
    - Measurement. (Grade 8) [2004]

Pre-Req Knowledge (Return to Contents)

none, assuming students have completed the Floaters and Sinkers lesson and its associated activity, Determining Densities.

Learning Objectives (Return to Contents)

- Students will be able to describe a means to make a material that is denser than water (modeling clay) float.
- Students will be able to describe the parallels between the design process used to create a dense but floatable object, and the scientific method of inquiry.

Materials List

- balances accurate to at least 0.1 g (e.g., standard triple beam balances), one per team
- 500 mL beakers, one per team
- 50 or 100 mL graduated cylinders, one per team
- modeling clay, one-half stick (50-60 grams) per team
- pans or trays to catch water that overflows from the beakers during the displacement process, one per team
- funnels (optional, but they help limit the amount of spilled water), one per team
- sponges and/or dishrags (for wiping up drips and spills), one or two per team
- fine-point permanent markers or grease pencils that can be used to write on the beakers, one per team. (An alternative is to provide the type of transparent tape that can be written on with a pencil.)
- paper towels, several per team

Introduction/Motivation (Return to Contents)

Remind students that in the density experiments they completed earlier, they found that when they put an object such as a lump of clay into a full beaker of water, water spilled over the top. That was because in order for the clay to enter the water, it had to push some of the water out of the way, or displace it. The
only place the displaced water could go was up and over the top of the beaker. The amount of displaced water equaled the volume of the lump of clay.

Then, in the Clay Boats activity, they took a lump of clay and shaped it so that it floated on top of the water. Since the clay was more dense than the water in both situations, why was it able to float when it was molded into a bowl-like shape? Let students know that they will attempt to answer that question by taking a closer look at the relationship between floating objects and displaced water.

Vocabulary/Definitions (Return to Contents)

density: the mass per unit volume of a substance at a given pressure and temperature
buoyancy: the ability to float in a liquid (or rise in a gas)

Procedure

Divide students into teams of 3-4 students. Then provide students with the Instructions for Students page (shown below) and the materials listed above in the Materials List section.

Attachments (Return to Contents)

• Instructions for Students

Investigating Questions (Return to Contents)

• All scientific experiments start with a question. What was the question being asked in this experiment? (Which displaces more water - a sinking object or a floating object, when both are made of the same material and have the same mass?)
• What was the answer to the question? (The floating object displaced more water.)
• How did the mass of the water that was displaced compare to the mass of the floating clay? (They are approximately equal.)
• Did you get similar results when you repeated the experiment using a smaller lump of clay? (The results should be very similar: the floating clay displaces more water, and that displaced water has the same mass as the smaller lump of clay.)
• Why do you think you were asked to repeat the experiment, using a smaller lump of clay the second time? (To make sure the results of the first experiment weren't just some sort of coincidence having to do with the size of the clay used. In other words, to generalize the results about the relative quantities and masses of displaced water to other floating (or sinking) objects.)
• How many pounds of water does a fishing boat that weighs 80 tons displace (assuming it is afloat!)? (80 tons equals 80 times 2000, or 160,000 pounds of water.)
• How many gallons of water does it displace? (The answer depends on whether the fishing boat is floating in fresh water or sea water. A gallon of fresh water weighs 8 pounds, so 160,000 divided by 8 equals 20,000 gallons of water. Sea water, however, is more dense; a gallon of sea water weighs 8.2 pounds, so the sea water displaced by an 80 ton boat is 19,512 gallons.)

Assessment (Return to Contents)

• In a quiz or written assignment, ask students to predict the weight of water that would be displaced by an empty canoe weighing 120 pounds. Assume the canoe is afloat. Also, ask if the amount of water displaced by the same canoe would increase or decrease if the canoe tipped over, filled with water, and sank.

Activity Extensions (Return to Contents)
See the Lesson Extension Activities section for similar experiments students can conduct to explore the differences between buoyancy in fresh and salt water, and warm and cold water.

Other Related Information (Return to Contents)

Acknowledgement:

This activity was originally published, in slightly modified form, by Duke University's Center for Inquiry Based Learning (CIBL). Please visit the website http://www.biology.duke.edu/cibl for information about CIBL and other resources for K-12 science and math teachers.

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Supporting Program (Return to Contents)

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