Buoyancy

When an object is immersed in water, it pushes water aside. The buoyant force of water on the object reduces the weight of the object. In this experiment, you will determine and compare the buoyant force on an object and the weight of the water pushed aside (displaced) by the object for three objects. The Greek mathematician Archimedes first studied this relationship during the third century B.C.

OBJECTIVES

- Use a force sensor to measure the weights of objects in and out of water.
- Determine the weight of water displaced by each object.
- Compare buoyant force to weight of water displaced for each object.
- Use the results of the experiment to explain why objects sink or float.

MATERIALS

Chromebook, computer, **or** mobile device
Graphical Analysis app
Go Direct Force and Acceleration
metal rod included with Force Sensor
ring stand
right-angle clamp
string
metal mass with a hook
50 g piece of clay
wooden pencil
100 mL graduated cylinder
water

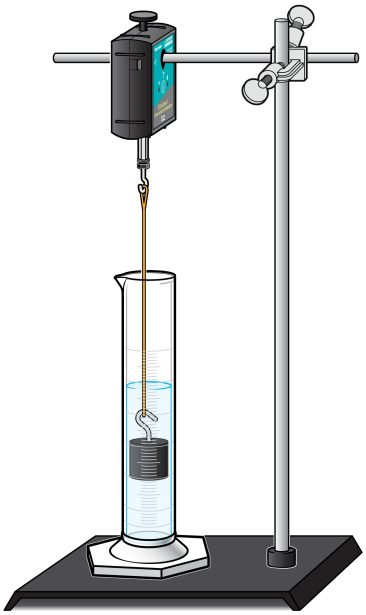

Figure 1

PROCEDURE

1. Obtain a metal mass, a 50 g piece of clay, and a pencil. Roll the piece of clay into a hot-dog shape that will fit into the 100 mL graduated cylinder.
2. Launch Graphical Analysis. Connect the Force and Acceleration Sensor to your Chromebook, computer, or mobile device.
3. Click or tap View, ⊞, turn on Meters, and turn off Graph. Then, dismiss the View menu.
4. Zero the force sensor.
   a. Fasten the sensor to a ring stand as shown in Figure 1.
   b. When the readings on the screen stabilize, click or tap the Force meter and choose Zero. When the process is complete, the readings for the sensor should be close to zero.

5. Measure the weight of the object in air.
   a. Hang a loop of string from the hook of the sensor, and then hang the metal mass from the string.
   b. When the readings stop changing, record the weight in the data table.

6. Collect data in water.
   a. Fill the graduated cylinder with enough water to cover the object.
   b. Read and record the volume of the water alone (to the nearest whole mL).
   c. Lower the object into the graduated cylinder.
   d. If the object sinks, lower it until it is covered with water but not touching the bottom. If the object floats, let it float.
   e. Record the weight of the object in water.
   f. Read and record the volume of the water plus object.

7. Repeat Steps 5 and 6 for the clay and the pencil. Change the amount of water, if necessary.

DATA

Table 1			
Object	Metal	Clay	Pencil
Weight in air (N)			
Weight in water (N)			
Volume of water alone (mL)			
Volume of water + object (mL)			

PROCESSING THE DATA

1. Calculate the buoyant force on each object by subtracting its weight in water from its weight in air. Show your work, and record the results in the table in Question 3.

2. Find the volume of water displaced by each object. Subtract the volume of water alone from the volume of the water + object. Show your work, and record the results in Table 2.

3. Find the weight of water displaced by each object. Multiply the volume of displaced water by 0.01 N/mL, giving you an approximate value for the weight of the water in Newtons. Show your work and record the results in Table 2.

Table 2			
Object	Metal	Clay	Pencil
Buoyant force (N)			
Volume of displaced water (mL)			
Weight of displaced water (N)			

4. How does buoyant force compare to the weight of water displaced for each object? **Note**: The answer to this question is known as Archimedes' Principle.

5. For which objects was buoyant force less than the weight in air? For which objects was buoyant force equal to the weight in air?

6. Explain how buoyant force determines whether an object sinks or floats in water.

EXTENSIONS

1. Repeat the experiment using saltwater. Compare your saltwater results with the results of your first experiment.

2. Investigate why boats float when made of materials that would normally sink. Shape and float a boat made from your clay. Measure the volume of water that it can hold. Compare this volume to volume it displaced as a lump of clay. Explain your results.

3. Have a contest with your classmates to see whose clay boat, described in Extension 2, can hold the most mass without sinking.