46 Sink or Swim

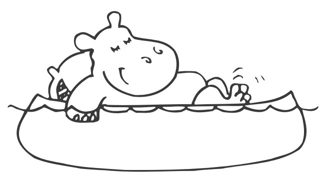
Purpose

To introduce Archimedes' principle and the principle of flotation.

Required Equipment/Supplies

spring scale	water
triple-beam balance	masking tape
string	chunk of wood
rock or hook mass	modeling clay
600-mL beaker	toy boat
500-mL graduated cylinder	50-g mass
clear container	2 100-g masses

Discussion



An object submerged in water takes up space and pushes water out of the way. The water is said to be displaced. Interestingly enough, the water that is pushed out of the way, in effect, pushes back on the submerged object. For example, if the object pushes a volume of water with a weight of 10 N out of its way, then the water reacts by pushing back on the object with a force of 10 N. We say that the object is buoyed upward with a force of 10 N. In this experiment, you will investigate what determines whether an object sinks or floats in water.

Procedure

Weigh an object in air and submerged in water.

Step 1: Use a spring scale to determine the weight of an object (rock or hook mass) first in air and then underwater. The difference in weights is the buoyant force. Record the weights and the buoyant force.

weight of object in air = ____________

apparent weight of object in water = ________

buoyant force on object = ____________

Measure the water displaced.

Step 2: Devise an experimental setup to find the volume of water displaced by the object. Record the volume of water displaced. Compute the mass and weight of this water. (Remember, 1 mL of water has a mass of 1 g and a weight of 0.01 N.)

volume of water displaced = __________

mass of water displaced = ____________

weight of water displaced = __________

1. How does the buoyant force on the submerged object compare with the weight of the water displaced?

Float a piece of wood.

Step 3: Find the mass of a piece of wood with a triple-beam balance, and record the mass in Data Table A.

NOTE: To keep the calculations simple, from here on in this experiment, you will measure and determine masses, without finding the equivalent weights. Keep in mind, however, that an object floats because of a buoyant force. This force is due to the *weight* of the water displaced.

Measure the volume of water displaced when the wood floats. Record the volume and mass of water displaced in Data Table A.

Data Table A

OBJECT	MASS (g)	VOLUME OF WATER DISPLACED (mL)	MASS OF WATER DISPLACED (g)
WOOD			
WOOD AND 50-g MASS			
CLAY BALL			
FLOATING CLAY			

2. What is the relation between the buoyant force on any floating object and the weight of the object?

3. How does the mass of the floating wood compare to the mass of water displaced?

4. How does the buoyant force on the wood compare with the weight of water displaced?

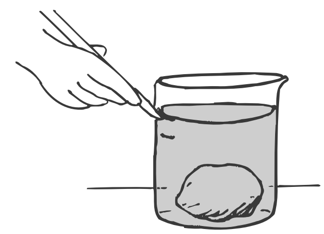
Step 4: Add a 50-g mass to the wood so that the wood displaces more water *but still floats*. The 50-g mass needs to float on top of the wood. Measure the volume of water displaced and calculate its mass, recording them in Data Table A.

Float wood plus 50-g mass.

5. How does the combined buoyant force on the wood and the 50-g mass compare with the weight of water displaced?

Step 5: Find the mass of a ball of modeling clay. Measure the volume of water it displaces when it sinks to the bottom. Calculate the mass of water displaced, and record all volumes and masses in Data Table A.

Measure dipslacement of clay.



6. How does the mass of water displaced by the clay compare to the mass of the clay?

7. Is the buoyant force on the submerged clay greater than, equal to, or less than its weight in air? Explain.

Step 6: Retrieve the clay from the bottom, and mold it into a shape that allows it to float. Sketch or describe this shape.

Mold the clay so that it floats.

Measure the volume of water displaced by the floating clay. Calculate the mass of the water, and record in Data Table A.

8. Does the clay displace more, less, or the same amount of water when it floats as it did when it sank?

9. Is the buoyant force on the floating clay greater than, equal to, or less than its weight in air?

10. What can you conclude about the weight of water displaced by a floating object compared with the weight in air of the object?

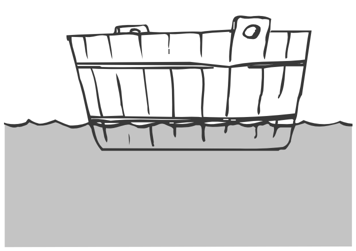
Predict new water level in canal lock.

Step 7: Suppose you are on a ship in a canal lock. If you throw a ton of bricks overboard into the canal lock, will the water level in the canal lock go up, down, or stay the same? Write down your answer *before* you proceed to Step 8.

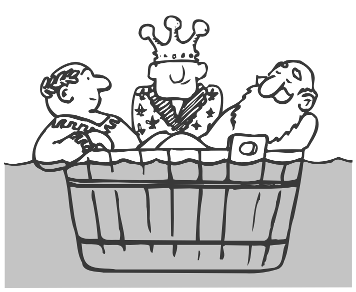
prediction for water level in canal lock: ____________

Step 8: Float a toy boat loaded with "cargo" (such as one or two 100-g masses) in a container filled with water deeper than the height of the masses. Mark and label the water levels on masking tape placed on the container and on the sides of the boat. Remove the masses from the boat and put them in the water. Mark and label the new water levels.

11. What happens to the water level on the side of the boat when you place the cargo in the water?



12. If a large freighter is riding high in the water, is it carrying a relatively light or heavy load of cargo?



13. What happens to the water level in the container when you place the cargo in the water? Explain why it happens.

14. What will happen to the water level in the canal lock when the bricks are thrown overboard?