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Investigating Sinking and Floating

Background Information

When an object is placed in a fluid, the force of gravity causes part or all of the object to sink below the upper surface of the fluid. At the same time, the fluid exerts an upward push, or **buoyant force,** on the object. The part of the object below the surface displaces the fluid. The size of the buoyant force is equal to the weight of the fluid that the object displaces. Fluids exert a buoyant force on all objects, regardless of whether the objects sink or float.

Consider an object submerged in a fluid. If the object has the same density as the fluid, then the weight of the object will be equal to the weight of an equal volume of fluid. In that case, the buoyant force will be equal to the weight of the object. As a result, the object will remain at any depth where it is placed. If the object is less dense than the fluid, the buoyant force on the object will be greater than the weight of the object. In this case, the object will rise to the surface and float. If the object is more dense than the fluid, the buoyant force on the object will be less than the weight of the object, and the object will sink.

This principle explains why a grain of sand sinks in water, whereas a basketball that has a much greater weight can float. Sand is denser than water. Therefore, the weight of the sand grain is greater than the buoyant force it receives from the water. The buoyant force acting on the basketball is greater than the weight of the basketball. As a result, the basketball floats.

In this investigation, you will predict which objects will float in water. Then, you will perform experiments to test your predictions.

Problem

What happens to the ability of an object to float as its mass and volume change?

Pre-Lab Discussion

Read the entire investigation. Then, work with a partner to answer the following questions.

1. **Controlling Variables** Identify the manipulated, responding, and controlled variables in this investigation.

   a. Manipulated variables

   _____

   _____

   b. Responding variables

   _____

   _____

c. Controlled variables

_____

_____

2. Predicting Predict how adding BBs to the canister will affect the following variables.

a. The level of the canister in the water

_____

_____

_____

b. The level of the water in the beaker

_____

_____

_____

3. Predicting The bottle you will use in Steps 10 through 13 is larger than the canister. Which container do you predict will float at a lower level (more deeply) in the water? Explain your answer.

_____

_____

_____

_____

_____

4. Applying Concepts What factors determine whether an object sinks or floats in water?

_____

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_____

Materials *(per group)*

film canister	BBs
masking tape	paper towels
metric ruler	triple-beam balance
250-mL beaker	plastic bottle

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Safety

Put on safety goggles. Be careful to avoid breakage when working with glassware. Wipe up any spilled water immediately to avoid slips and falls. Note all safety alert symbols next to the steps in the Procedure and review the meaning of each symbol by referring to the Safety Symbols on page xiii.

Procedure

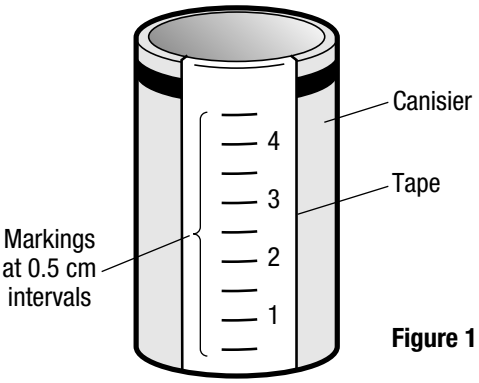

Figure 1

1. Attach a strip of masking tape to the side of the film canister, extending from the bottom to the top of the canister. Starting from the bottom of the canister, use the metric ruler and a pencil to accurately mark 0.5-cm intervals on the side of the canister, as shown in Figure 1.
2. Repeat Step 1, using the plastic bottle.
3. Fill the beaker approximately three-fourths full with water. Place 20 BBs in the canister. Place the canister in the beaker with its open end pointed upward. Add or remove BBs from the canister, one at a time, until approximately half of the canister floats below the surface of the water. **Note:** *To remove BBs, take the canister out of the beaker. To add BBs, leave the canister in the beaker while carefully placing the BBs in the canister.* Count the BBs as you add or remove them from the canister. In the first row of Data Table 1, record the number of BBs in the canister. Remember to include the first 20 BBs that you added.
4. Use the metric ruler to measure the level of the water in the beaker from the tabletop to the surface of the water. Record this measurement in Data Table 1. Also determine the level of the canister in the water and record this measurement in Data Table 1.
5. Predict how the level of the canister in the water and the level of the water in the beaker will change if you remove 10 BBs from the canister. Record your prediction as Prediction 1 in Data Table 1.
6. Now test your prediction. Take the canister out of the beaker, first tapping it gently against the inside of the beaker to minimize any water loss from the beaker. Remove 10 BBs from the canister and carefully place the canister back in the beaker. In Data Table 1, record the number of BBs in the canister, the level of the canister in the water, and the level of the water in the beaker.
7. Replace the 10 BBs that you removed from the canister. Predict how the level of the canister and the level of the water will change if you add 10 more BBs to the canister. Record your prediction as Prediction 2 in Data Table 1.

8. Test your prediction by carefully adding 10 BBs to the canister. In Data Table 1, record the number of BBs in the canister, the level of the canister in the water, and the level of the water in the beaker.
9. Carefully remove the canister of BBs from the beaker, while minimizing any water loss from the beaker. Use paper towels to dry the outside of the canister. Use the triple-beam balance to determine the mass of the canister and BBs. Record this mass in Data Table 2. Without changing the positions of the riders on the balance, remove the canister and set it aside.
10. Place the plastic bottle on the balance. Add BBs to the bottle until its mass is equal to the mass of the canister and the BBs it contains. Record this mass in Data Table 2.
11. Predict which container will float more deeply in the water by placing a check mark in the appropriate row below Prediction 3 in Data Table 2. Also predict which container will cause the greater rise of the water level in the beaker by placing a check mark in the appropriate row below Prediction 4 in Data Table 2.
12. Test your predictions by placing the canister into the beaker. In Data Table 2, record the number of BBs in the canister, the level of the canister, and the level of the water. Carefully remove the canister.
13. Repeat Step 12, using the plastic bottle.

Observations

DATA TABLE 1

Action	Number of BBs	Level of Canister in Water (cm)	Level of Water in Beaker (cm)
Float canister halfway below surface of water			
Remove 10 BBs			
Add 10 BBs			

Prediction 1 _____

Prediction 2 _____

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DATA TABLE 2

Container	Mass of Container and BBs (g)	Prediction 3 (Identify the container that will float more deeply in water.)	Level of Container in Water (cm)	Prediction 4 (Identify which container will cause the greater rise of the water level in the beaker.)	Level of Water in Beaker (cm)
Canister					
Bottle					

Analysis and Conclusions

1. **Analyzing Data** How did the number of BBs in the canister affect the level at which the canister floated in the water?

2. **Evaluating and Revising** Did your observations support your predictions of how the number of BBs in the canister would affect the level of the canister in the water and the level of the water in the beaker? Explain your answer.

3. **Comparing and Contrasting** Compare the volume of the canister containing the BBs to the volume of water that the canister displaced. Which was greater?

4. **Predicting** Assume that the canister is made of a material that is less dense than water. What would happen if you filled the canister with water and then placed it in the beaker of water? Explain your answer.

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5. **Drawing Conclusions** Explain why the canister and the bottle floated at different levels in the water.

6. **Comparing and Contrasting** Compare the water level when the canister was floating in the beaker to the water level when the plastic bottle was floating in the beaker in Steps 12 and 13. Explain your result.

7. **Applying Concepts** Suppose a boat is in a swimming pool. You are sitting in the boat and holding a rock. You drop the rock into the pool. The rock sinks to the bottom without splashing any water out of the pool. Using what you learned in this investigation, explain whether the water level in the pool will be higher, lower, or the same after you drop the rock into the pool.

Go Further

Use your knowledge of forces and buoyancy to predict the result of the experiment described below. Then, with your teacher's approval and supervision, carry out the experiment to test your prediction.

A beaker of water is sitting on a balance. The balance indicates the mass of the beaker of water. Taking great care not to touch the sides of the beaker, you dip your finger into the water. Does the reading on the balance change? If it does, will it increase or decrease?