

1. Archimedes' Principle

Eureka! It's Buoyancy.

Driving Question

What is the buoyant force?

Materials and Equipment

For each student or group:

- | | |
|---|--|
| <input type="checkbox"/> Data collection system | <input type="checkbox"/> Balance |
| <input type="checkbox"/> Force sensor with hook | <input type="checkbox"/> String (10 to 20 cm per object) |
| <input type="checkbox"/> Objects to be suspended in water | <input type="checkbox"/> Bucket or tub |
| <input type="checkbox"/> Water | <input type="checkbox"/> Towel |

Safety

Add this important safety precaution to your normal laboratory procedures:

- Do not apply a pushing or pulling force greater than 50 newtons to the force sensor (doing so will damage the sensor).

Thinking about the Question

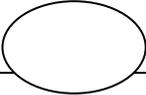
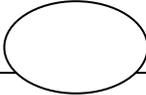
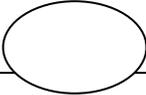
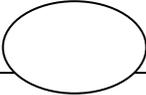
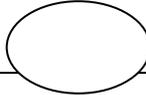
Gravity pulls on everything on Earth, from the smallest particle of dust to the largest jumbo jet flying over the earth's surface. Gravity even does its best to keep the space shuttle from launching at Cape Canaveral and escaping into orbit. Whales however, despite their enormous size, do not feel the pull of gravity quite so strongly – at least not as much as they would if they lived on land.

Have you ever been in a swimming pool and dove below the water? Have you ever tried to pick someone up in the swimming pool? You can easily carry people in water that you would not be able to lift on land. Water makes the creatures swimming in it seem lighter.

Discuss with your lab group members whether a whale (or a person) can really get lighter in water. What is meant by “getting lighter?” What is the difference between weight and mass? What do you think water has to do with this phenomenon? Discuss within your group the meaning of the term buoyancy.

Sequencing Challenge

The steps below are part of the Procedure for this lab activity. They are not in the right order. Determine the proper order and write numbers in the circles that put the steps in the correct sequence.

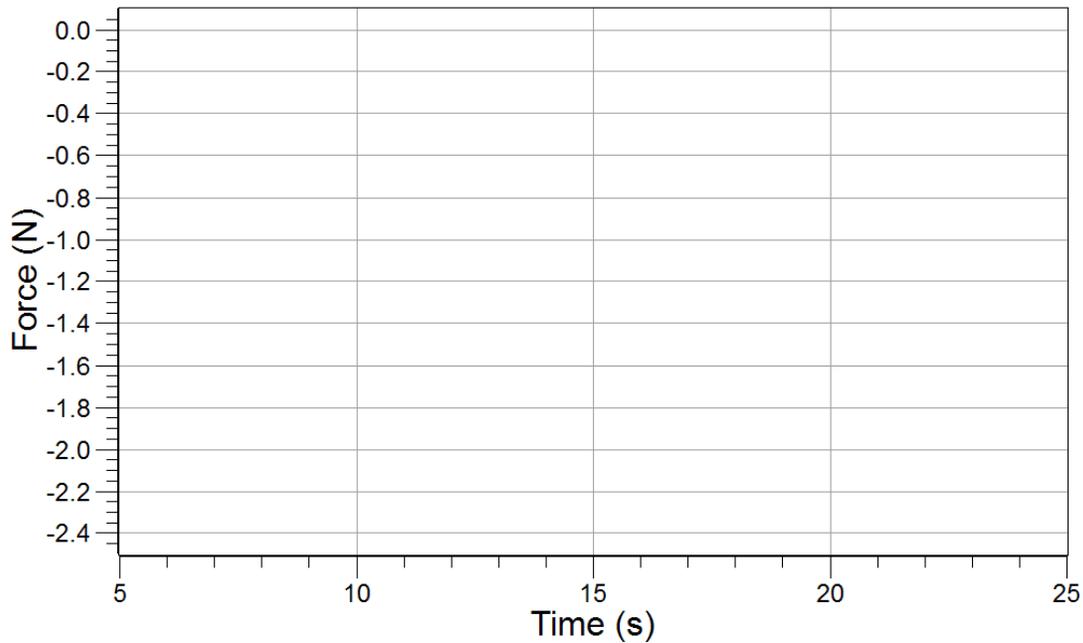
				
Attach object to be submersed to the hook of the force sensor. Submerge and measure the force.	Make sure each lab group member is aware of safety rules and procedures for this lab.	Zero the force sensor by pushing the "zero" button on the side.	Find the mass of each object.	Fill container with enough water to submerge objects.

Investigating the Question

Note: When you see the symbol "♦" with a superscripted number following a step, refer to the numbered Tech Tips listed in the Tech Tips appendix that corresponds to your PASCO data collection system. There you will find detailed technical instructions for performing that step. Your teacher will provide you with a copy of the instructions for these operations.

1. Write your predictions for the following:
 - a. How will a graph of force versus time look when you hang an object from the hook of the force sensor and hold it steady for a few seconds?
 - b. How will a graph of force versus time look when you put a heavier object than the first one on the hook of the force sensor and hold it steady for a few seconds?
 - c. What will happen to the graphs of both objects when you suspend each object in water?

2. In the space below, sketch a force versus time graph that reflects your predictions.



Part 2 – Investigating the pull of gravity on objects in air

3. Find the mass in grams of each of your two objects, and record that mass below.
 Mass of Object 1 _____ grams
 Mass of Object 2 _____ grams
4. Start a new experiment on the data collection system. ♦^(1.2)
5. Connect a force sensor to the data collection system. □^(2.1)
6. Display Force with pull positive on the y-axis of a graph with Time on the x-axis. □^(7.1.1)
7. Begin data recording. □^(6.2)
8. Hold the force sensor with its hook down, and press the “zero” button. Why do you think this is important?

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9. Gently attach the first object to the hook of the force sensor, and hold the entire system steady until the force reading stabilizes. Why do you think that moving the force sensor, even a little bit, results in variations in the force data?

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10. Stop data recording. ^(6.2) Remove the first object from the force sensor's hook.

11. Start data recording for a new run of data. ^(6.2)

12. Gently attach the second object to the hook of the force sensor and hold the entire system steady until the force reading stabilizes.

13. Stop data recording. ^(6.2) How can you tell by looking at your data which object was the heavier one? How is the force of each object related to its mass?

Part 3 – Investigating the buoyant force

14. Fill your bucket or other container with water. Fill it with enough water so that you can fully immerse the objects without causing the water to overflow. How is the amount of water displaced or pushed aside related to the size and mass of your object?

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15. Start a new experiment on the data collection system. ^(1.2) Display force (push positive) versus time on a graph. ^(7.1.1)

16. Hold the force sensor with its hook down, and press the “zero” button.

17. Attach the first object gently to the force sensor's hook.

18. Begin data recording. ^(6.2)

19. Holding the container of water underneath the object, raise it until the object is either floating or is submerged in the water. Allow the force reading to stabilize. Observe the graph and record your observations.

20. Stop data recording ^(6.2) and set the bucket of water down. Remove the first object from the force sensor's hook.

21. Attach the second object gently to the force sensor's hook.

22. Begin data recording. ^(6.2)

23. Holding the container of water underneath the object, raise it until the object is either floating or is submerged in the water. Allow the force reading to stabilize. Observe the graph and record your observations.

24. Stop data recording. ^(6.2)

Answering the Question

Analysis

1. How did your predictions from Part 1 compare to the results in Part 2?

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2. Archimedes' principle of buoyancy states that an object immersed in a fluid such as water is acted upon by an upward force equal to the weight of the fluid that is displaced. This upward force is called *buoyancy*. How does your data from Part 3 provide evidence for buoyancy? Explain your reasoning.

3. How could you re-state or paraphrase Archimedes' principle in your own words?

Multiple Choice

Circle the best answer or completion to each of the questions or incomplete statements below.

- What is the force that determines an object's weight on Earth?
 - Mass
 - Gravity
 - Volume
- Which force pushes on an object in an upward direction, opposite the pull of gravity?
 - Buoyancy
 - Volume
 - Weight
- Weight is measured with a force sensor while mass is measured with
 - A gravitational sensor.
 - A graduated cylinder.
 - A balance.
- If you were on the Moon, which quantity would be less than it is on Earth?
 - Your mass
 - Your weight
 - Your volume

5. Which of the following is a pull of Earth's gravity on objects close to the earth's surface?
 - A. Weight
 - B. Buoyancy
 - C. Mass

6. An object fully under water is said to be:
 - A. Balanced
 - B. Less massive
 - C. Submerged

7. Which term describes the amount of space an object takes up?
 - A. Volume
 - B. Buoyancy
 - C. Weight

8. The buoyant force on an object acts in which direction?
 - A. Opposite the force of gravity
 - B. In the same direction as gravity
 - C. At a right angle to the force of gravity

9. In order for an object to experience a buoyant force, it must:
 - A. Have a very large mass
 - B. Have a very large volume
 - C. Displace some type of fluid

10. What fluid is displaced by a helium balloon tied to a child's wrist by a string?
 - A. Air
 - B. Helium
 - C. No fluid is displaced