FUTURE U.

Buoyancy Exploration

Objectives

Students will investigate and explain factors that contribute to positive, neutral, and negative buoyancy.

Overview

In this activity, students will pretend they have been invited to join the maritime team at Boeing for an internship that focuses on unmanned undersea vehicles. Before students start their internship, they will investigate the principles of density and buoyancy as they may apply to deep ocean research vehicles. Student groups will rotate through three stations as they investigate negative, positive, and neutral buoyancy in order to prove they are ready for their internship!

Grade Range

5–8

Timing

60 minutes

Materials Needed

- Large bowl or container filled with water, one
- Orange, one
- Echo Voyager image, to project or print
- Buoyancy Note Sheet, one per student

Neutrally Buoyant Station

- 3 sets of the following:
    - Neutrally Buoyant Directions, two copies
    - Large bowl or container (filled two-thirds with water), one
    - Large film canisters, pill containers, or anything with a top of a similar size, three
- Towel or washcloth (for cleanup), one to share
- Assortment of other items for the groups to share, such as:
    - Balloons
    - Tape
    - String
    - Corks

- Small masses to give the boats weight such as marbles, pebbles, coins, washers, etc.
- Sponge (cut into small pieces)
- Sandwich bags

Negative Buoyancy Station

- 3 sets of the following:
  - Negative Buoyancy Directions, two copies
  - Small container (recommend solo disposable cups but other food storage containers, empty hummus or cream cheese containers, etc. work), one
  - Large container (at least four times larger than the small container), one
  - Marbles, several*
  - Pitcher of water, one
  - Marker
  - Beaker with milliliter measurements

    *In advance, test how many marbles it will take to sink the small container. Then give students a few more than this amount.
  - Scale, at least one for the station to share

    Note: If this is not available, weigh one marble in advance and be ready to share this with students.
  - Towel or washcloth (for cleanup), one to share

Positive Buoyancy Station

- 3 sets of the following:
  - Positive Buoyancy Directions, two copies
  - Container of water that is deep enough for an apple to float in

    Note: It should be able to hold at least four cups of water.
  - Apple
  - Small inflated balloon
  - Paper clip
  - Play dough, one palm-sized ball
- Towel or washcloth (for cleanup), one to share

Preparation

- Check with the classroom teacher about projection capabilities. In some cases, it may be easiest for you to send the image link to the teacher in advance. In other cases, you may be able to easily connect your laptop.
- Copy all handouts.
- This lesson requires a variety of materials. Try to organize the materials in advance, and place the station materials in three different areas around the classroom before the class session begins.

Next Generation Science Standards

Engineering Design

- MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

Motion and Stability

- MS-PS2-2: Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

Procedure

1. **Warm-Up:** Begin by telling students that they are about to imagine they have been invited to join the ocean team at Boeing for an internship that focuses on unmanned undersea vehicles. Buoyancy, which is the ability to float, will be a key part of their work.

   Hold up the orange and ask students to predict—through a show of hands—whether the orange will sink or float. Then place the orange in the bowl of water and observe what happens.

   Next, peel the orange and ask students to predict through a second show of hands whether the orange will now sink or float. Then place the peeled orange back in the water and observe what happens.

   Finally, ask students to consider: Why do you think the original orange was buoyant and floated, while the peeled orange sunk? Don't yet confirm or deny their responses.

2. Tell students that before they can begin their work with the Boeing team, they'll need to gain a better (or—if students predicted the orange demonstration correctly—even stronger) understanding of buoyancy.

3. Display the image of the Echo Voyager and explain that Boeing's underwater team will be focusing on the development of additional submarine-like ocean vehicles. In order to join this team, the class needs to be able to prove that they understand why objects float, sink, and remain neutrally buoyant in water.

   Note: It's okay if students don't yet know what "neutrally buoyant" means.

4. Divide the class into groups of four, and distribute one Buoyancy Note Sheet to each student. Explain the following:

   - Each group is about to rotate through three stations to investigate three different kinds of buoyancy: positive, negative, and neutral.
   - Groups must read the step-by-step instructions at each station before they do or touch anything.
   - There will be more than one group at each station, but students should work only with their own group members.
   - Students should use their Buoyancy Note Sheet to record what they learn about each type of buoyancy. They will be prompted to do this during the Discuss and Record step in each station's directions.

- The class will then regroup at the end of the session and try to prove they have learned enough to begin their internship.
- Groups will have about 10 minutes at each station.

5. Show students where each of the stations is set up, and distribute the groups evenly among the stations. Then instruct groups to read the instructions and begin!
6. Rotate around the classroom as groups work and answer questions as needed.

   Once about seven to eight minutes have passed at each station, encourage students to move on to the Discuss and Record step if they have not done so already.

   Once a total of 10 minutes have passed at each station, instruct all groups to complete the last step and then move clockwise to the next station.
7. **Wrap Up:** Bring the class back together once students have visited all three stations. Challenge students to use their Buoyancy Note Sheet to prove to you that they have learned enough about buoyancy to begin their internship. Lead the discussion with questions such as:

   a. What factors cause objects to sink?

   b. What factors cause objects to float?

   c. Explain that density is the weight of an object divided by its volume. In other words, it is how compact an object is.

      Then ask: Why does density matter? And (if students were stumped during the warm-up): What does density have to do with the orange demonstration?

   d. How can neutral buoyancy be achieved?

   e. How may sea vessels, like submarines, move between positive, neutral, and negative buoyancy?

   Conclude by congratulating the class on their buoyancy understanding and tell them that it seems they would all be ready for an internship! Be sure to also tell students that while an actual internship may not exist right now, they should keep STEM careers in mind as they look toward their own futures. There are a wide variety of careers focused on marine, terrestrial, and space exploration—and high school and college internships are a great way to explore these fields!

Buoyancy Note Sheet

Directions: As you complete the three buoyancy stations, note your findings below. Your key takeaways should include notes about positive buoyancy (floating), neutral buoyancy (hovering below the surface), and negative buoyancy (sinking). You will use these notes to help prove you are ready for an internship with Boeing's maritime team!

Key Takeaways

✓ _____

_____

✓ _____

_____

✓ _____

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✓ _____

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✓ _____

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✓ _____

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✓ _____

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✓ _____

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Station: Neutral Buoyancy

Directions: Buoyancy is the force of a liquid pushing up on an object. When an object has neutral buoyancy, it hovers in the water and doesn't fully sink or float. Complete the investigation below to see what conclusions you can make about what it takes for something to be neutrally buoyant.

Materials Needed:

- Water bowl or container
- Submarine model: One small container with cap
- Assortment of materials to share with the other groups: Take only as needed

1. A submarine must be able to float, sink, and be neutrally buoyant. First, experiment with your submarine model:
    - Test: Does it float?
    - Consider: How could you make it sink?
    - Experiment: Use the station materials to make it sink to the bottom.

2. Now think about neutral buoyancy. If you know the conditions in which the submarine will sink and the conditions in which it will float, how could you get the submarine to hover partway between the two? Use the station materials to construct a submarine that has neutral buoyancy. If you quickly succeed, try once more with different materials.

3. Discuss & Record: Think about the differences between your sunken submarine, your floating submarine, and your neutrally buoyant submarine. Then record: How may an actual submarine achieve neutral buoyancy and hover in the water? You may want to consider how it could be built or what capabilities it should have in order to achieve this.

4. Clean up, dry off, and return the materials to where you found them so this station is ready for the next group.

Station: Negative Buoyancy

Directions: Buoyancy is the force of a liquid pushing up on an object. When an object has negative buoyancy, it sinks! Complete the investigations below to see what conclusions you can make about negative buoyancy.

Materials Needed

- Smaller container, one
- Larger container, one
- Marbles, several
- Pitcher of water
- Marker
- Beaker
- Scale

1. **Volume** is the amount of space that something takes up. Imagine that your smaller container is your boat. Measure the volume of this boat by filling it with water. Once it is filled to the top, carefully pour the water into the beaker.

   What is your boat's volume? _____ milliliters

2. Now calculate the weight of the water that your boat can hold.

   One milliliter of water = 1 gram. Therefore, your boat can hold _____ grams of water.

3. Fill the larger container halfway with water. Use the marker to draw a small line inside the container, as close to the water as you can.

4. Place marbles carefully in your boat, one at a time.

5. As soon as your boat fully sinks, remove it from the container, and dump out any water. Then place the container (still filled with marbles) on the scale and record its weight:

   Boat's "sinking" weight: ____ grams.

6. Discuss & Record: What does it take to make a boat sink?

7. Clean up, dry off, and return the materials to where you found them so this station is ready for the next group.

Station: Positive Buoyancy

Directions: Buoyancy is the force of a liquid pushing up on an object. When an object has positive buoyancy, it floats! Complete the two investigations below to see what conclusions you can make about the force of buoyancy.

Materials needed:

- Container of water
- Apple
- Palm-sized ball of play dough
- Paper clip
- Small inflated balloon

Investigation #1

1. Line up the apple, small balloon, and paper clip according to estimated weight, and record them in the first column of the chart below.
2. Complete the second column's hypothesis with your group.
3. Test your hypothesis and record your results in the third column.
4. **Discuss & Record:** Other than weight, what are some other differences among these three objects? How might this affect their buoyancy?

   Tip: Think about how compact (or dense) each object is!

Objects (lightest to heaviest)	**Hypothesize:** Will each object float or sink? Circle one.	**Results**
	Float Sink	Float Sink
	Float Sink	Float Sink
	Float Sink	Float Sink

Investigation #2

1. Form a compact ball with your play dough and place it in the water container. What happens?
2. Dry off the ball of play dough. Then mold it into a bowl-shaped boat and place it back in the water. What effect did this have on its buoyancy?
3. **Discuss and Record:** Based on Investigations one and two, what factors affect whether a boat floats?
4. Clean up, dry off, and return all of the materials to where you found them so this station is ready for the next group.