SINK, FLOAT, HOVER– DESIGN A SUBMARINE!

QUICK PEEK

Students will learn about density, buoyancy, and how submarines dive.

SUGGESTED GRADE LEVELS: 4–8

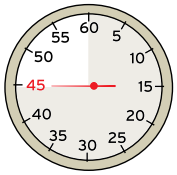
ILLINOIS STATE LEARNING GOALS

SCIENCE
11.A, 11.B, 12.D, 13.A, 13.B

LANGUAGE ARTS
3.A, 3.B, 3.C, 4.A, 4.B

OBJECTIVES

- ★ Students will learn about density and buoyancy and how manipulating one affects the other.
- ★ Students will design and create and object that is able to sink, hover, and float.



PACE YOURSELF:
45 MINUTES

PREPARE YOURSELF

1. Make enough copies of the worksheet for each student in your class.
2. Get one small container with lid for each group.
3. Get all the heavy and light objects you will need for your class.
4. Divide materials, heavy and light, evenly for the number of groups you will have in your class. Students will work in groups of 2-4, depending on your class size.
5. Fill one container per group with water.

MATERIALS

Per Group:

- ☐ Small Containers with Lid (film canisters work best)
- ☐ Variety of small, heavy objects (coins, washers, marbles, screws, etc)
- ☐ Variety of small, light objects (paper clips, corks, beads, Styrofoam, etc)
- ☐ Rubber bands or string
- ☐ Large containers of water

Per Student:

- ☐ Worksheet
- ☐ Writing utensil

WHAT YOU NEED TO KNOW...

Density is the mass of a substance compared to its volume. The formula is **Density = Mass/Volume**. It may help students if they think of density as the amount of stuff in a space. Something crammed with a lot of stuff (mass) in its space (volume) has a high density. Conversely, something with only a little stuff in its space has a lower density.

Buoyancy is the upward force that a fluid exerts on an object less dense than itself. Think of buoyancy as the ability or tendency to float. Objects less dense than water float while objects more dense than water sink.

WARM UP!

Get two cans of the same brand of soda but one diet and one regular (example: Coke and Diet Coke). Fill a large clear container with water and place it in the front of the room. Ask your students what they think will happen: Will the cans sink or float? Put the cans in the water. The regular soda will sink while the diet soda will float. Ask your students if they have any hypotheses why this happened. Tell them it is because the regular soda has more sugar/sweetener in it, making it denser than the diet soda. Because it has a higher density, the regular soda sinks. The diet soda has a lower density and remains buoyant. Introduce the terms and meanings of density and buoyancy to your students. Explain to your students that they will be experimenting with density and buoyancy today.

THE HOW TO

1. Divide students into groups. Pass out materials, water, and worksheets.
2. Tell students they will be working in teams to complete a challenge by designing "submarines" that will float, hover, and sink.
3. Show them the film canister. Tell them this is going to be their submarine.
4. Explain that each group will have the same materials and can use any supplies they have—so they should not trade or take another group's supplies.

PROVIDE THESE CHALLENGE GUIDELINES TO YOUR STUDENTS:

To be successful:

1. Each team member should participate in the challenge.

2. A floating submarine is on top of the water.

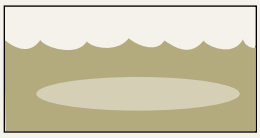
3. A sinking submarine is at the bottom of the water container.

Density and Buoyancy have an inverse relationship. As density increases, buoyancy decreases. As density decreases, buoyancy increases.

Density ↑ Buoyancy ↓

Density ↓ Buoyancy ↑

Hovering means the entire "submarine" is completely underwater, and nothing is touching the bottom of the container.



4. A hovering submarine is completely underwater, in the middle of the container. This means that no part of the container or any object you are using can be touching the surface of the water or the bottom of the container.
5. You can do anything you want to get the submarine to sink, float, and hover—attach things to it, or put things inside it, but the lid must be on it.
6. When you get your submarine to complete one of the challenges, fill out that section of the worksheet.

WHAT'S GOING ON HERE?

In the students' "submarines," the volume (size of the container) stays constant. The density changes by adding or taking away the different objects. In a real submarine, the volume also stays the same but instead of adding or taking away different objects, a submarine changes its density by adding water to its ballast tanks.

A ballast tank is a compartment on a boat or ship that holds water. On the U-505, the ballast tanks are between the two hulls. As the ballast tanks are filled with water, the submarine dives.

When two or more forces act on an object, the result is the cumulative effect of those forces. The buoyant force is the net upward force (or uplift) exerted by a fluid on a submerged object. Gravity counters this force by pulling down on an object while the buoyant force pushes the object up. If an object's density is more than that of the liquid, it will sink (force of gravity is greater than the buoyant force). If an object's density is less than that of the liquid, then it will float (force of gravity is less than the buoyant force). If an object's density is the same as that of the liquid, it will hover (force of gravity is equal to the buoyant force).

DID THEY GET IT?

Have the students share what they did in a whole group discussion.

Gravity > Buoyancy is Negative Buoyancy (sinking)

Gravity < Buoyancy is Positive Buoyancy (floating)

Gravity = Buoyancy is Neutral Buoyancy (hovering)

1. What did you do to get the submarine to float? To sink? To hover? *answers will vary*
2. What is similar about the subs that floated? *they are light, not much inside/ attached*
3. What is similar about the submarines that sank? *they are heavy, had a lot of stuff in them*
4. Did anyone use water to complete the challenges? *Some students may use water in addition to the materials provided and some students may figure out that they can complete the challenges with only water. This is important because submarines dive by adding water to their ballast tanks.*

Consider asking your students these questions. They may not know the exact answers so you might guide them and facilitate discussion.

1. What is the downward force acting on the submarine? *Gravity*
2. What is the upward force acting on the submarine? *Buoyant force or buoyancy*
3. If the submarine is floating, what might we call that type of buoyancy? *Positive buoyancy*
4. If the submarine is sinking, what would we call that type of buoyancy? *Negative buoyancy*
5. When the submarine is hovering, what is that type of buoyancy? *Neutral buoyancy*
6. Which of the 3 challenges was most difficult? Why? *Hovering is most difficult because you are balancing both forces- gravity and buoyant force.*

ET CETERA

DENSITY COLUMN

Have your students experiment with the density of different liquids and the density/buoyancy of different objects in those liquids.

Here are the different liquids and the order they are added to a large glass graduated cylinder (or similar container):

1. Vegetable Oil: will go to the bottom
2. Light Corn Syrup: will go through the oil, settle on the bottom.
3. Water (colored blue with food coloring): will go between the vegetable oil and the corn syrup.
4. Rubbing Alcohol (colored red with food coloring): will go on top of the vegetable oil. Make sure to add it slowly so it doesn't mix with the water through the oil.
5. Baby Oil: will float on top of the rubbing alcohol.

On a piece of paper, have your students draw and label the different layers of their density column and rank the liquids according to density.

Give your students a variety of small objects—pieces of cork, small plastic toys, pennies, nuts/bolts, Styrofoam, etc. Tell your students they will now participate in a challenge. They will try to guess where the objects will float when dropped into the density column.

RULES OF THE GAME:

1. You must make a prediction and give a reason for the prediction before dropping any objects.

2. 1 in a row = 1 point
   2 in a row = 2 points
   3 in a row = 3 points
   MISS = 0 points

Points start over after a miss- ie: 1 in a row = 1 point, 2 in a row = 2 points, etc.

3. Use a privacy curtain!

4. Prizes for the winners!

Have your students make and record their predictions and observations on a chart like this one:

Object	Predicted Level	Why?	Actual Level	Points
1.	Above: Below:		Above: Below:	
2.	Above: Below:		Above: Below:	

DESIGN A SUBMARINE!

Name: _____

Draw a picture of what your "submarine" looks like and make a list of the materials you used to complete the tasks.

FLOATING

Materials Used:

SINKING

Materials Used:

HOVERING

Materials Used:

How is density related to buoyancy? _____

_____

_____