Buoyancy

Consider: If I gave you an object that you had never seen before and it was made of unknown material and then asked you whether or not it would float in water, what would you base your guess on? (List at least 2-3 ways you might try to guess whether it could float.)

Will an item float or sink …

What determines whether an object will float or not? You might say it's the weight, but aircraft carriers are extremely heavy and they still float. You might say that it's if the density is less than 1 g/ml, but aircraft carriers are made out of steel that has a density much greater than 1 g/ml. The reason why objects float or sink in water actually depends upon the interaction of two forces**: Buoyant Force and Weight of Object (Gravitational Force).**

Displacement:

Buoyancy Force:

Size of buoyant force =

*Changing the amount of water displaced, changes the buoyant force. (Think about what this means in terms of changing the volume of an object.)

How do these two forces compare in a floating versus sinking object?

Floating: Sinking:

Understanding the concept of **buoyancy** allows us to build floating objects made out of materials that are denser than water. By increasing an object's volume, we can make the overall density of the floating object less dense than 1 g/ml, allowing it to float on the surface. These two ships were the first warships made of steel and fought each other to a tie during the Civil War.

U.S.S. Monitor   **C.S.S. Virginia   (Merrimac)**
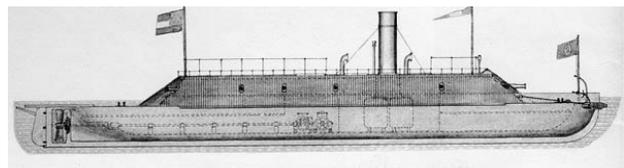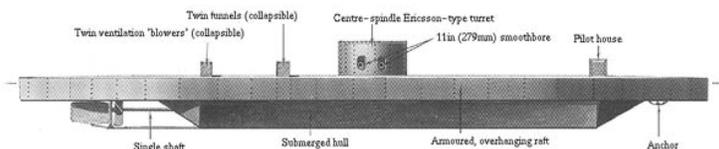
Buoyancy Lab-Mini Submarines

Why do some objects float while other objects sink? If the force of gravity pushing down is **bigger** than the Buoyancy Force pushing up, the object sinks until something pushes against it to stop moving (the bottom of the ocean).

If the force of gravity pushing down is **equal** to the Buoyant force pushing up, the object will float on the surface of the water because the two forces are equal.

The amount of force gravity can push on something is equal to its **weight**. A heavy dump truck pushes harder on the earth than you do. The amount of force Buoyancy can exert on an object is equal to the amount of water that object can move (displace) is the water. A ship is able to float when

Weight of displaced water = Weight of the ship

A ship sinks when water is taken onboard because the added weight of the water adds weight to the ship until the ship is heavier (and denser) then the water it is floating in.

Why is the *USS Wisconsin* able to float even though it is made of steel, even 12 inches thick in some places? (Remember, steel is denser than water so it should sink.) The trick is to form that steel in such a shape that it will make a big hole in the water. The force pushing up on the *Wisconsin* is equal to the weight of the water that was moved out of that hole. Since the *Wisconsin* is made of thick steel, it is very heavy and has to displace a lot of water so that the buoyant force is the same as the gravity force. Consequently the *Wisconsin* has a large draft (the amount of ship under the water), as much as 30 feet!

Submarine (Model!) Lab:

Question: How will you use the following materials: film canister with hole and string, pennies, Alka-seltzer tablet (1/2), water and a graduated cylinder to make a working submarine?

**Our definition of a working submarine is that it sinks to the bottom of the cylinder all by itself, sits there for a period of time, and then rises back to the top all by itself.

Measurements and calculations:
Procedure
        Your job is to make your canister sink to the bottom of the graduated cylinder, sit there for a few seconds and then rise to the top all by itself.

1. A canister that floats in water has a density (less than/greater than) that of water?

2. A canister that sinks in water has a density (less than/greater than) that of water?

3. First, figure out how many pennies are **just** needed to make a film canister (with air) sink to the bottom:
        _____ pennies.

4. Remove the canister, dry it off, and find the mass. Mass of canister + pennies = _____

5. Take two pennies out (now your canister should just float) and mass this canister = _____

6. Each film canister displaces about 40 ml of water. Water has a density of 1 g/ml. Use the density formula to figure out the density of each of the canisters. Fill in the table below.

	Mass	Volume	Density
Floating Canister		40 ml	
Sinking Canister		40 ml	
Water	1 g	1 ml	

7. In your own words, explain the relationship between an object that floats in water and an object that sinks in water in terms of their densities.

8. Now, try different thoughtful trials to help answer your question. Writing what you do and what happened will help you learn more about your investigation. Only change one variable at a time; keep the rest constant! Once your team has a working submarine, I will be over to observe it one more time.

Trial #	**What did you do?** (Sub characteristics)	**What happened?** (Sink, float, hover?)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		

Teacher's signature: _____

**When you are finished, please clean up your area and answer the questions.

Post-Lab Questions:

1. If a film canister has a volume of 40 ml and a mass of 8 grams, what is its density? [You must show your work!]

2. Describe what causes your sub to sink then float in terms of buoyancy force and the force of gravity.

3. Why did the gas from the tablet help the canister to rise to the surface?

4. Use the results of your experiments to explain how real submarines work.

5. Why do astronauts train for the weightlessness of space underwater?

6. Why does a boat sink down into the water when you get into it?

7. Why is it easy to pull up an anchor off the bottom of the lake when the anchor is underwater?

8. Why does an anchor get difficult to get into your boat once it is out of the water?

9. The density of silver is 10.5 g/ml. What is the mass of a piece of silver with a volume of 5 ml? [Show your work!]

10. Would an object float better or worse in salt water compared to fresh water? Why?

11. A ship is displacing 50,000 Kg of water. It's carrying 10,000 Kg of cargo. What is the mass of the ship? [Show your work!]

12. Cement has a density of 3.0 g/cm^3. You must pour a cement walkway with the measurements: 6 meters long by 1 meter wide by 10 centimeters thick. What is the mass of this walkway? (Be careful … notice that you will have to make some metric conversions!) [Show your work!]