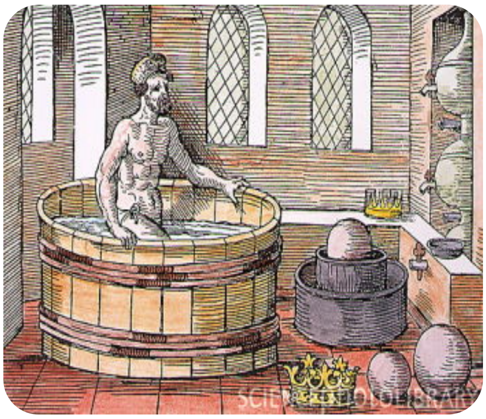
Raising the Titanic: Buoyancy and Density



Archimedes Principile:

Any object, wholly or partially immersed in a fluid, is buoyed up by a force equal to the weight of the fluid displaced by the object

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FOCUS

Physics

GRADE LEVEL

Primary (UK); 3-5 (US)

FOCUS QUESTION

How is it possible to make heavy objects that normally sink, float using physics?

LEARING OBJECTIVES

Students begin to understand the principles of buoyancy and objects sinking and floating. Students will understand fluid displacement as well as how to lift heavy objects off of the ocean floor. Additionally, students will learn more about dive science.

MATERIALS NEEDED

- An aquarium
- Water
- A number of weights (10-20 grams works best!)
- Paper clips
- Packing peanuts, ping pong balls, tennis balls (objects that have air pockets)
- 20-40 pieces of 2 cm x 2cm pre-pierced neoprene (old cut up wetsuit works great!)
- probes (1 for each group)
- Analytical balance

- corks

AUDIOVISUAL MATERIALS NEEDED

Diving science movie Explorer 2012

TEACHING TIME

One 45-minute period

SEATING ARRANGEMNET

Groups of three to four students

KEY WORDS

Mass- measure of the amount of matter in an object

Density- the mass per unit volume of an object

Volume- The amount of space occupied by a three-dimensional object

Buoyancy- is a force exerted by a fluid that opposes an object's weight

Archimedes' Principle- Any object, wholly or partially immersed in a fluid, is buoyed up by a force equal to the weight of the fluid displaced by the object.

Artefact- Discarded objects that have been made or changed by people Examples: bones with cut marks, pottery, stone tools or coins.

Shipwreck- What remains of a ship that has wrecked, either sunk or beached

Liftbag- an item of diving equipment that is an airtight bag with straps, used to lift heavy objects underwater by means of the bag's buoyancy.

Buoyancy Compensation Device- a piece of diving equipment that controls a diver's overall buoyancy, allowing a diver to achieve neutral buoyancy while remaining at a constant depth. The device, which looks like a vest, uses air from the dive cylinder (SCUBA tank) to inflate and deflate the vest for the proper amount of buoyancy.

BACKGROUND INFORMATION

In ancient Greece, the scientist Archimedes began to prepare his bath after a long day of pondering. For quite some time he had not been able to figure out the mathematical formula for his principle of displacement. Although he had visions of it in his dreams, upon waking up he was never able to fully remember. Because he was thinking for so long, he let the bath run a little long and the water was higher than it usually was. Right as he sat down in the bath, he saw the water level rise over the edge and spill onto the ground. "EUREKA!!!!" he had figured out the principle of displacement!

According to Archimedes, "a body immersed in a fluid is buoyed up by a force equal to the weight of the displaced fluid." This means that as a person sits in a bath, he displaces (or pushes out of the way) a certain amount of water. That amount of water has a corresponding amount of weight, so the buoyant human could hypothetically 'lift' the weight of the amount of water he or she displaces in a bathtub.

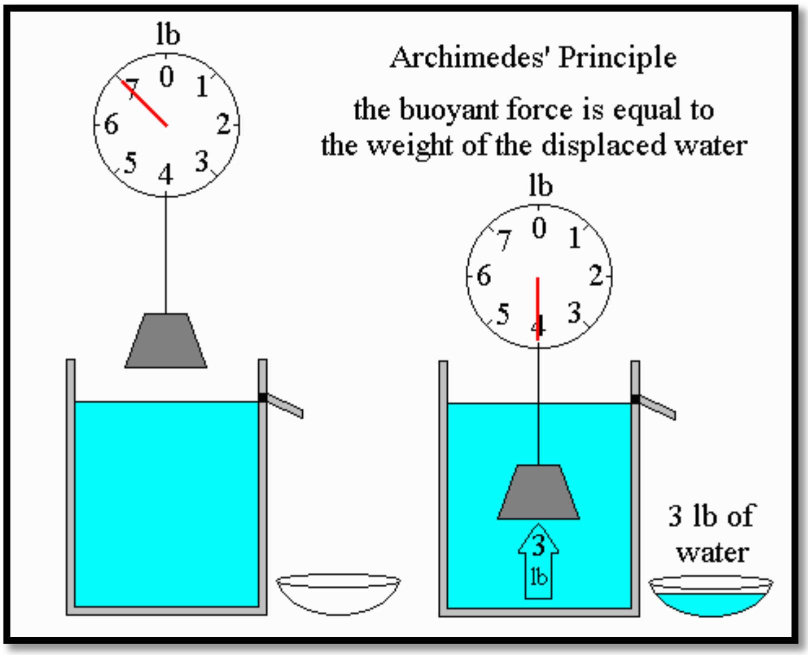

Figure 1: Archimedes' Principle (glogster.com)

So what does some guy's bath rising in 212 BCE have to do with anything in our lives?

Bermuda is an island surrounded by over 400 shipwrecks. While most of these wrecks will remain on the bottom of the ocean and serve as artificial reefs, let's say we wanted to salvage one of these sunken ships—how on earth would we do that? As a Note: The Historic Wrecks Act 2001 protects Bermuda's Underwater Heritage. It provides protection for all shipwrecks in Bermuda's territorial waters. The law states that it is illegal to interfere with or remove anything from a Shipwreck or Marine Heritage Site without obtaining a licence. For more information please see the Department of Conservation Services. http://www.conservation.bm/shipwreck-legislation-overview/

Archimedes' Principle explains why boats made of heavy steel can float, why life preservers will keep humans afloat, and why some people have a much easier time floating on their back than others.

Also, Archimedes' Principle can be used to determine how much buoyant material is needed to lift an object off the bottom of the sea! Just as Archimedes' body displaced a certain weight of water, other objects, too, can displace water. And when enough buoyant material is connected to a weight, the buoyant objects can 'lift' the weights from the bottom of the sea! …and you thought I was just trying to give you a history lesson!

Freshwater is less dense than seawater because it contains fewer dissolved salts. Because freshwater and seawater have different densities, a given volume of these types of water will differ in weight. Taking this into account, an object that is just able to lift a weight in seawater might not be able to lift that same weight in freshwater. Typically, a buoyant object that displaces 1mL of freshwater will be able to lift 1g of weight in freshwater. When doing this experiment, take into account the differences in water densities and consider if your lifting mechanism would work in both freshwater and saltwater, or just freshwater.

Similarly, when diving, the deeper you descend, the more dense the water around you becomes due to the increasing pressure of the water above you. When lifting major objects off the bottom of the ocean (like a shipwreck), divers will use 'lift bags' (http://www.youtube.com/watch?v=v4FYtE8_v8I). The weight of a certain volume of water displaced at depth will be greater than the weight of that same amount of water displaced at the surface. So, why doesn't the lift bag sink midway up the water column? This is a good question for you to think about as you complete this experiment! One hint: consider the initial size of the lift bag.

In this experiment, we will be testing the buoyant capacities of a few household items, and lifting our own version of the Titanic (that just happens to be a fishing weight!).

LEARNING PROCEEDURE

Prelab Reading:

http://www.doowin-dooflex.com/info-en/The-Theory-of-Lifting-Bags.html

http://en.wikipedia.org/wiki/Archimedes'_principle

http://www.relaxnswim.com/physics/buoyancy.htm

http://www.infoplease.com/ce6/sci/A0804583.html#ixzz1T3EvHSPM

Standard Procedure: see video for any clarification

Displacement Preparation/Calculations

- Fill a 50ml graduated cylinder with 20 ml of water
- Pierce a 2cm x 2cm piece of neoprene
- Calculate how much volume it displaces
- Subtract the $Volume_{after}$ from $Volume_{before}$ to calculate the total displacement of the various objects.

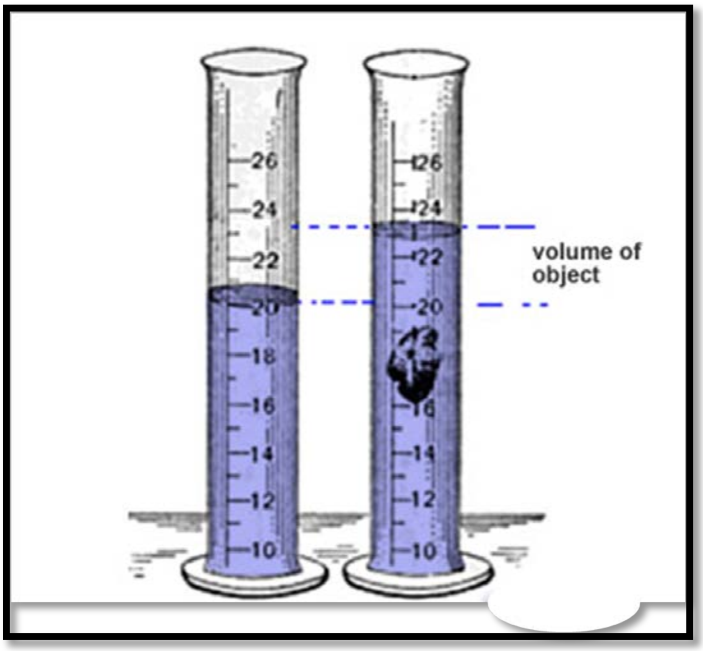

Figure 2: Volume displacement graphic (UC Irvine Distance Learning)

Weighing of Weights:

- Using an analytical balance, weigh a number of different fishing weights (other solid, lead weights will work too).
- Record the weight of each of the fishing weights in grams.

Hypothesis Formation:

- Give each student a certain amount of neoprene pieces and a few different weights with known weights in grams, and have students guess how many pieces of neoprene it will take to float a 10 gram weight.

Buoyancy Testing:

- With one end of the paper clip add one piece of neoprene at a time (as pictured below)
- To the other end of the paper clip, affix the fishing weight.
- Place the contraption in the aquarium, and note if it floats or not.
- If it doesn't float, students will add another piece of neoprene
- Record how many neoprene pieces it takes to float the weight

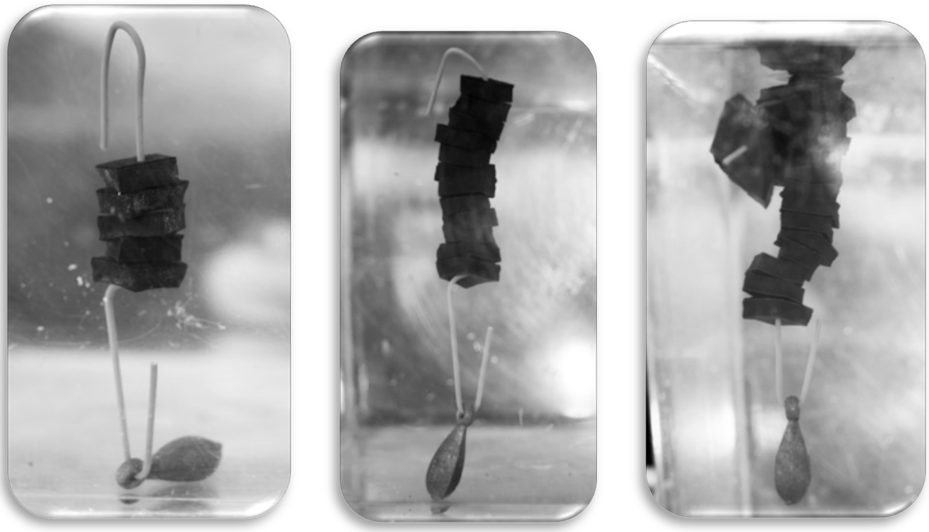

Figure 3: 10 gram weight on paper clip and students can continually add neoprene pieces

Further Testing

- Fill a 50ml graduated cylinder with 20 ml of water
- Piece a cork with the probe and calculate the water displacement
- Attach the 10 gram weight
- Will the cork float the 10-gram weight?
- If no, how many neoprene pieces do you have to then add to make it float (see Figure 4)

Figure 4: 10 gram weight floating with cork and pieces of neoprene

Further Discussion Questions:

1. How many pieces of neoprene were required to lift your fishing weight?
2. How many pieces of neoprene were required to lift your fishing weight when you added the cork?
3. What was the total amount of water displaced by your buoyant materials in your second experiment ((number of corks)x(mL water displaced by a cork))+((number of neoprene pieces)x(mL water displaced by a 2x2 cm neoprene pieces)).
4. What connection do you see between grams of the weight, and the required mL of water displaced by the buoyant materials?
5. With that in mind, how many mL of water do you think would be required to lift a 2lb (.9kg) weight?
6. How is this type of experiment applicable to the bodies of water nearby? What types of items do you think can be lifted by buoyant ascents?
7. Envision a 5000 kg. shipwreck at the bottom of the sea. You're in charge of lifting it off the bottom. Explain how you would complete such a task. (Hint: it might not be feasible to lift the entire shipwreck in one go—you may need to split it up). Make sure to note how much water you would need to displace, and how you would displace it.
8. I lifted a 50 pound weight with 5 gallons of displaced water in saltwater, but I can't seem to lift that same 50 pounds with my 5 gallons of displaced water in freshwater. Why is this?
9. Why will life preservers keep humans afloat?
10. Why do some people have a much easier time floating on their back than others?
11. What will be the difference in floating if you use saltwater verses fresh water? Will it take more or less neoprene?

Images:
http://www.sciencephoto.com/image/223082/350wm/H4010136-Coloured_artwork_of_Archimedes_in_his_bath-SPL.jpg
http://bernews.com/wp-content/uploads/2010/02/GE-Bermuda-shipwrecks.jpg
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