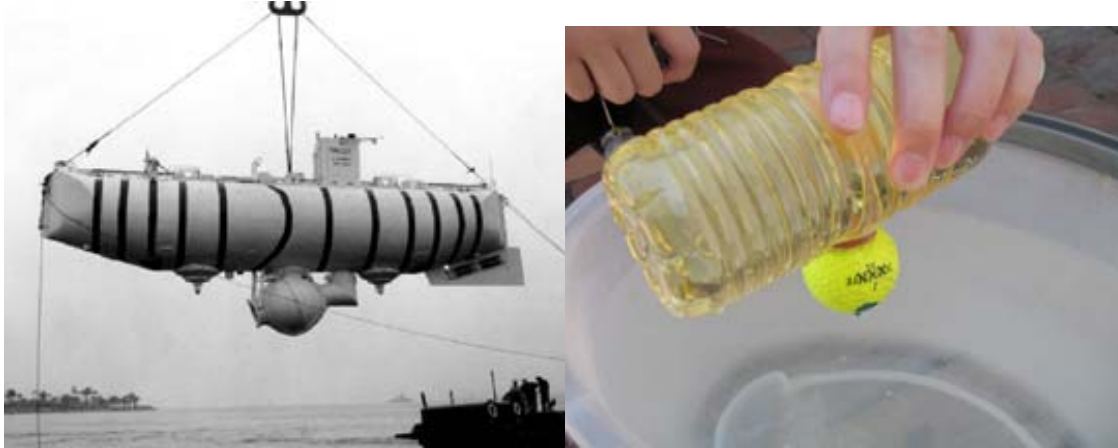


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Supplemental photographs and directions for:
Modeling the Trieste to Explore Density and Buoyant Force



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Introduction

Often we see students memorizing definitions for mass, volume, density, and buoyancy. And they are usually able to calculate density and buoyant force, but once they are able to apply these principles to a real life situation, the concepts take on new meaning. In this activity students use the context of the historic Trieste bathyscaphe to measure mass and volume, calculate density and build a working model of a submersible. After building the model, students develop hypotheses and test their model to observe it in action. Students are amazed to see and demonstrate some of the physics behind the Trieste submersible and the creative use of different densities to conquer the deep. Amidst their delight and total engagement in working with the models and testing their hypotheses, our middle school students began to make the important connections about density and buoyant forces.

Learning Objectives:

Practice measuring mass and volume as well as calculating density.
Explain how the density of an object determines whether it sinks or floats.
Describe the effect of buoyant force.
Demonstrate how the Trieste used differing densities to manage buoyant force.

Science Process Skills:

Students will: measure mass and volume of different substances, calculate density and buoyant force, build a model, make and test hypotheses, record and analyze data, and draw conclusions.

California Content Standards: Grade 8 – (2 a, b, c, d, e) (8 a, b, c, d) (9 a)
National Standards: (need to research)

Historic context:

In the 1930's there was a growing scientific and public interest in exploring the deep sea. The challenge of building a personnel sphere to withstand the high pressure was coupled with the challenge of how to float it. Auguste Piccard, the inventor of the Trieste, was a physicist and balloonist who looked at these challenges from a different perspective. He used differences in density to provide a creative solution to the challenge of ascending from great ocean depths. Piccard designed and built several bathyscaphs and in 1953, he completed his second bathyscaph, the Trieste. His goal was to go deeper than anyone had ever gone before. Using gasoline and iron shot the crew of the Trieste was able to adjust their buoyancy to successfully dive and return to the surface from depths greater than anyone had before.

Education Standards

Eighth grade Science Standards include that students know that a force has both direction and magnitude (2a) and that all forces acting on an object have a cumulative effect (2b). They must know that when the forces are balanced on the object, its motion does not change (2c) , but when the forces are unbalanced, the object's motion changes. (2e) Students must be able to identify the forces acting on an object (2d) . They must know that density is mass per unit volume, and that it can be calculated by dividing an object's mass by its volume. They must learn that floating or sinking can be predicted by comparing densities of fluids and objects within the fluids. Finally they must know that the buoyant force is equal to the weight of the displaced fluid. (8 a,b,c,d) In addition, they are expected to use and understand the scientific methods of investigation and experimentation (9a,f). It's no wonder that many of them find it somewhat difficult to grasp. It isn't until they are able to apply these things to what they enjoy and are familiar with that they really understand the concepts and how they are related. This activity does just that. It brings them to that "Aha!" moment when the light turns on.



Fig 1. Eighth grade students find neutral buoyancy for their model of Trieste.

Management

Before introducing this activity, the basic concepts of mass, volume, density, gravity and weight, buoyant force, and the scientific method for investigation and experimentation are introduced.

Students should be familiar with using the measuring equipment, and have done several activities calculating the mass, volume, and density of various objects. They should be familiar with the behavior of fluids of different densities, and should be familiar with why things float or sink. This can be done through several related activities that use all the learning modalities.

On the day of this activity, I introduce my students to the Trieste “bathyscaphe”. Photos and diagrams help the students to see the connection to the actual model they will be using. I ask the students what the designers needed to know about their bathyscaphe before they could be certain it was safe to put into the water. They suggest that they would need to know if it would float in the water, and I ask them how they could find this information without actually putting it in the water. When they determine that they could calculate its density and compare it to the density of the water, we move to the next question. I ask, if it does float, what needs to be done to it to make it sink. Most will quickly say add weight to it. Then I ask how they will know how much weight needs to be added. When they determine that they need to calculate its buoyant force, and then add more weight than the buoyant force, I ask the final question. What needs to be done to allow the bathyscaphe to return to the surface. By now, they can easily see that the weight needs to be removed.

- Bathyscaphes are independent, deep diving vessels for underwater exploration.
- The Trieste was the first bathyscaphe designed by the Swiss in 1953. It had a high pressure sphere and a very large tank filled with gasoline. Gasoline is less dense than water and does not compress, or squeeze, which allows it to keep its buoyancy.
- The Trieste displaced 50 tons of sea water and carried 9 tons of iron ballast.

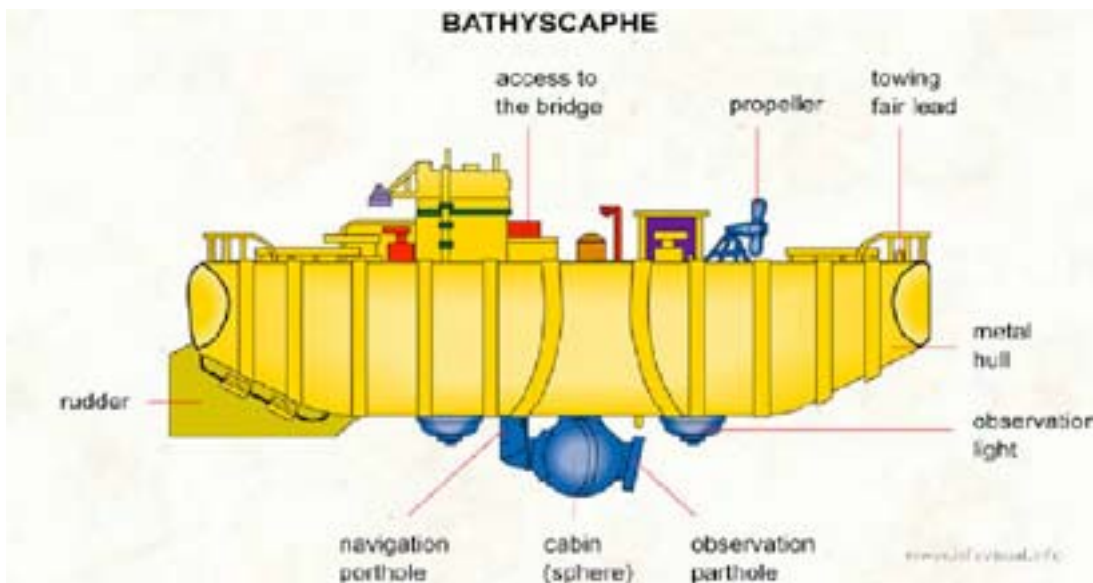


Fig. 2: A schematic drawing of the bathyscaphe Trieste, that carried explorers to the deepest place in the ocean.

Using a model of the Trieste filled with oil instead of gasoline, students determine its density, its buoyant force, and the amount of mass needed to make it neutral in tap water. Then they test their hypotheses by placing them in the tank. Finally they add more mass and a release mechanism to determine if it will sink to the bottom of the tank and then return to the surface.



Fig. 3: A working model of the bathyscaphe, demonstrating application of differences in density.

Further Explorations:

If time permits, students are encouraged to try other explorations with their models such as:

- Will you have the same results if you test your hypotheses in salt water?
- Will adding more mass slow the ascent time?
- Will adding more mass speed the sinking time?
- Can you think of any other release mechanisms for the Trieste model.
- Will it work in the deepest end of a pool?
- Will it work in saltwater, like off a dock in the bay?

Objective:

The objective for this activity is to explore how mass and volume affect density and buoyant force.

Materials, Lab Preparation / Assembly

Tools needed:

1. Hot melt glue gun with sticks
2. push pin
3. Needle nose pliers, 2 pair
4. diagonal small cutters
5. Drill
6. drill bits, 1/16", 1/8"
7. whisk broom, dust pan, trash can for clean-up
8. funnel
9. Magic Marker or Sharpie

Materials needed, for each bathyscaphe model:

1. Water bottle, 16.9 Fl. Oz, empty, with lid, remove label
2. washer, garden hose
3. screw eye, small
4. golf ball
5. vegetable oil, to fill water bottle
6. Alka Seltzer® tablets, 2 ea
7. paper clips, medium, 2 ea
8. rubber bands, 2 ea, medium
9. two lids from 35mm film canisters
10. paper towels
11. Sharpie indelible pen
12. Test tank. A 10"D x 24" glass cylinder is available from many wholesale flower shops for about \$50.
13. Siphon hose to drain test tank
14. buckets to fill/drain test tank
15. Large galvanized steel flat washers from the hardware store, total weight = 3 ozs
16. Tap water
17. Twist ties

Process: (Build the Parts!)

BATHYSCAPHE BODY

1. Plan construction in a place where if oil is spilled, the mess is contained, and doesn't become a bigger problem.
2. Plug in your hot melt gun and let it come up to temperature.

3. Place an empty water bottle on a sheet of paper towel or in a sink. Using a funnel, fill the water bottle with vegetable oil to full.



4. Screw cap loosely onto water bottle. Squeeze bottle slightly to remove any remaining air. Tighten cap. Clean exterior of bottle with dish soap to remove any oil on the outside.

5. Lightly gripping the center of the water bottle with your thumb and center finger like a teeter-totter, locate the center of mass of the filled water bottle. Mark the spot with a Sharpie pen.

6. Drop the oil-filled bottle into a bucket of water to see it float. This is what brings your bathyscaph back to the surface



7. Using the push pin, make a pilot hole in the golf ball for the screw eye. Install the screw eye into the golf ball. This will serve as the anchor attachment point later.



8. Using preheated glue gun, glue the garden hose washer to the side of the water bottle.

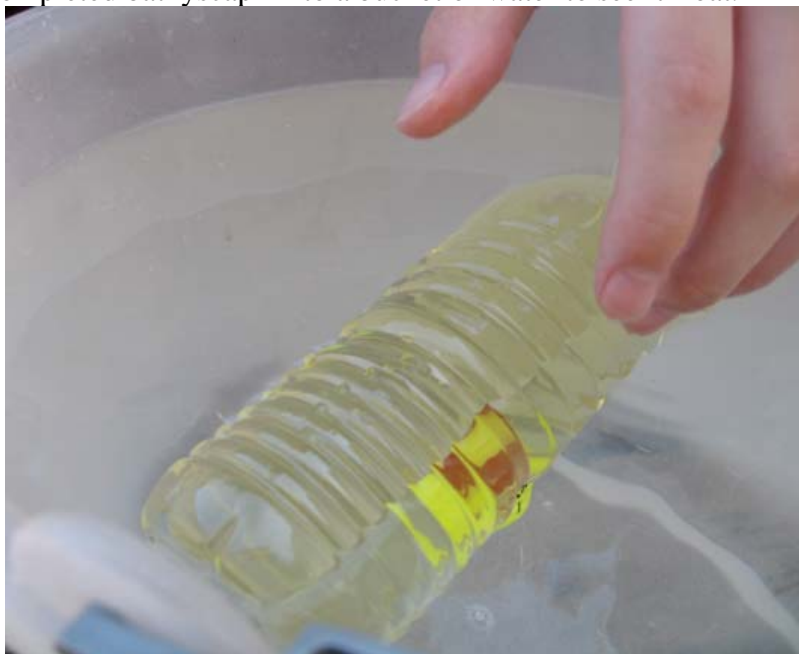


9. Fill the center of the hose washer with hot glue and stick in the golf ball with the screw eye pointing directly away from the water bottle.



Fig 4. Student glues “personnel sphere” to buoyancy tank.\\

10. Place your completed bathyscaph into a bucket of water to see it float.



The bathyscaph vehicle is now complete. Now let's build the anchor and anchor release.

ANCHOR

11. Weigh 3 ozs of washers (or mass determined by experiment as described). Run a twist tie through the center of the washers, plus one medium paper clip. The paper clip will be the hook to attach to the rubber band in the release later.



Fig 5. Fishing sinkers or flat washers work well for weights.

RELEASE

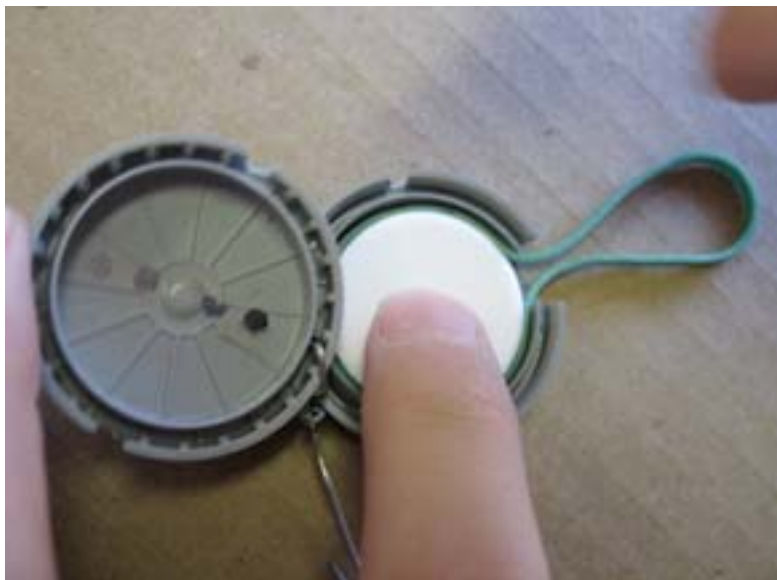


Fig 6. Assembly of the release. When seltzer tablet dissolves, rubber band falls out, releasing weight.

Each release uses two 35mm film canister lids and a paperclip bent to make a hinge. Drilled holes are done to both lids the same. Segments of the edges are clipped differently depending on which half it is.

- Layout 35mm film canister lids and medium size paper clips for the number of releases to be made.



- With Sharpie, make alignment mark to establish a “top” position on all lids

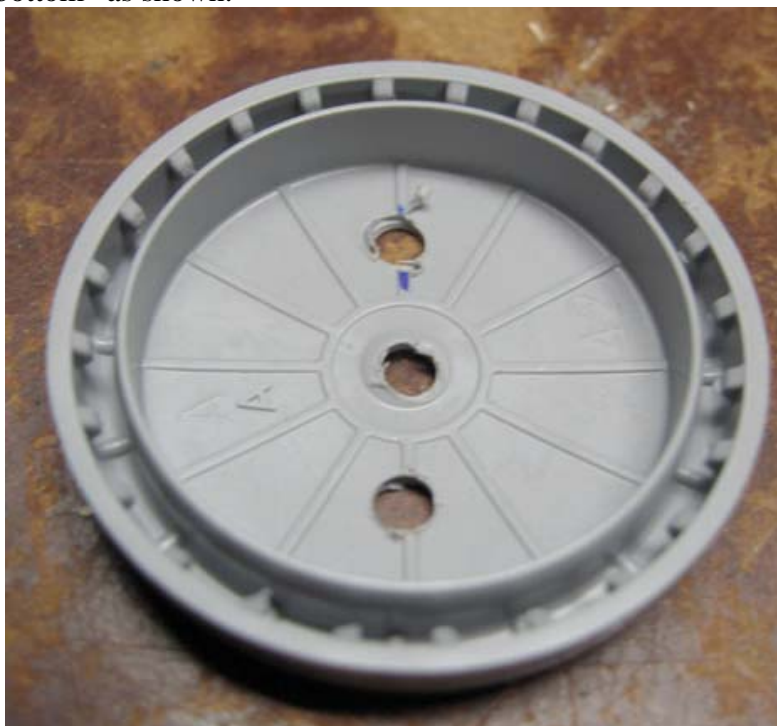


Important, this initial position will now be referred to as “top”. Other positions will be referred to as “bottom”, “Left,” and “right.” Note the two concentric “ridges” that make the snap seal when placed on the film canister.

14. Drill a single 1/16" diameter hole at the "top" between two ridges near edge as shown.



15. Drill three 1/8" diameter holes in a vertical line in the center section running from "top" to "bottom" as shown.



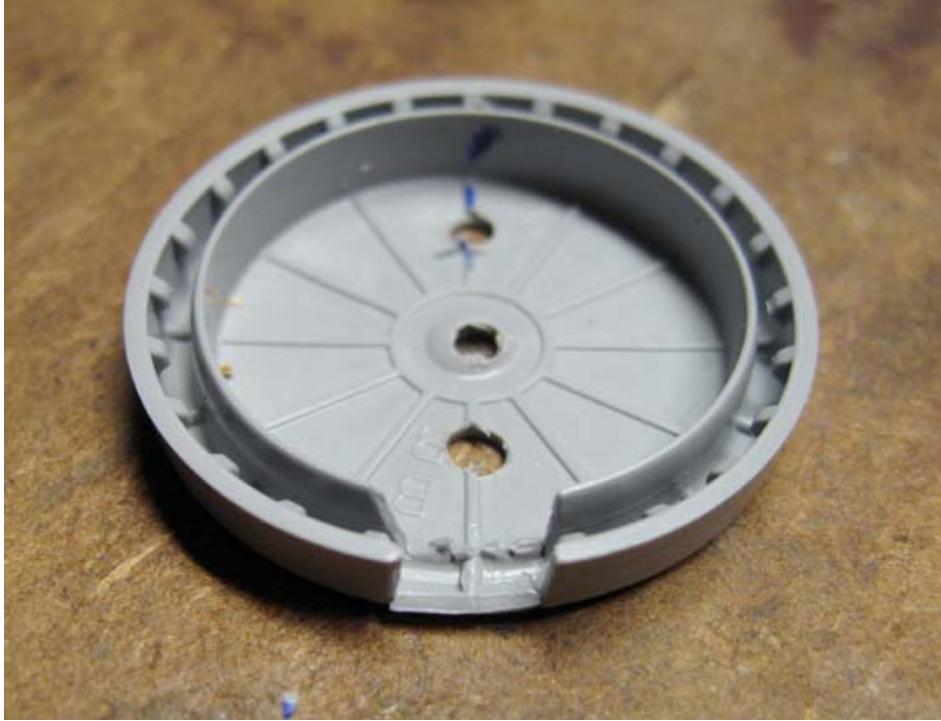
16. Modify all lids this way.



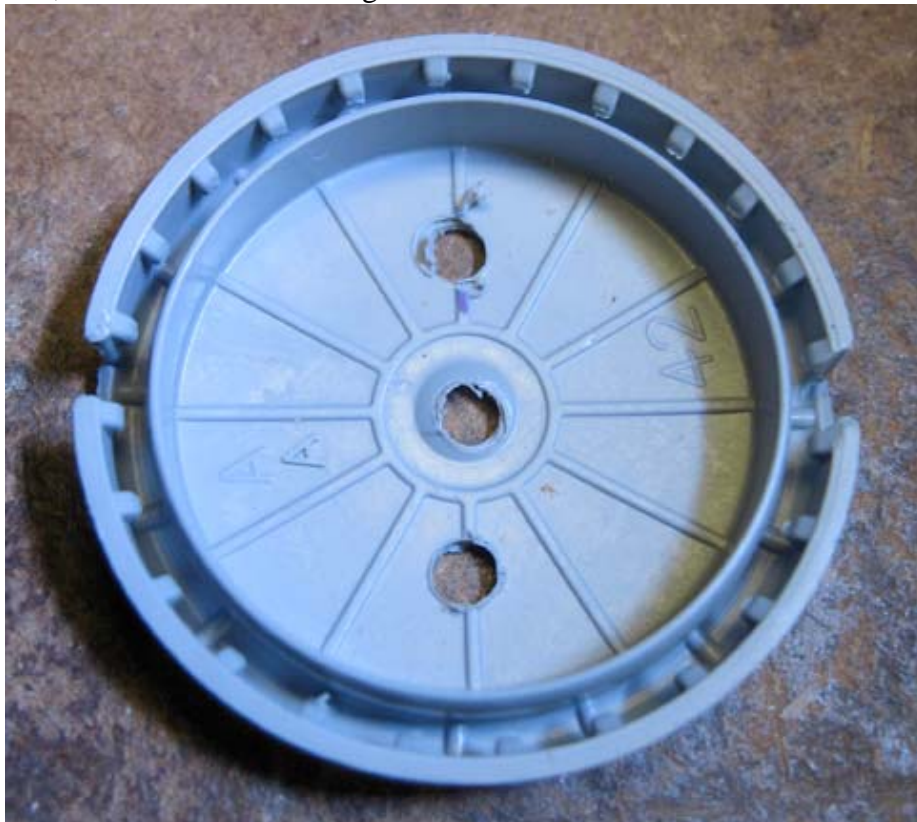
17. Separate lids into two equal groups.



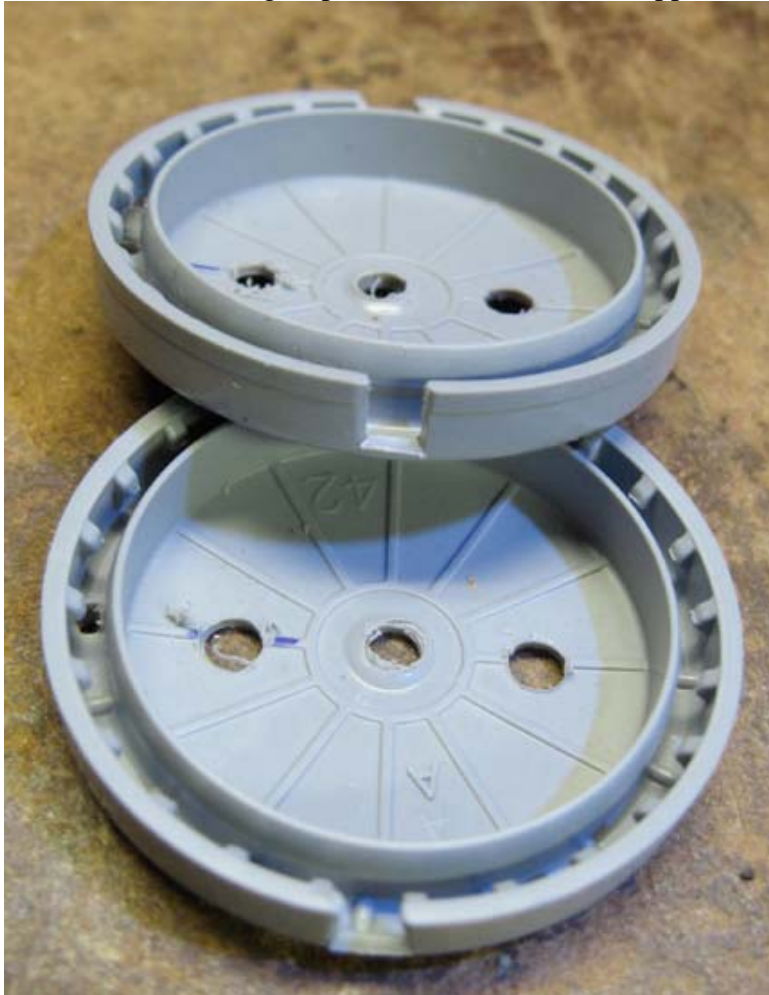
18. Modify one group by clipping a single 1/8" wide gap through both ridges at the "bottom" position (the side opposite the "top").



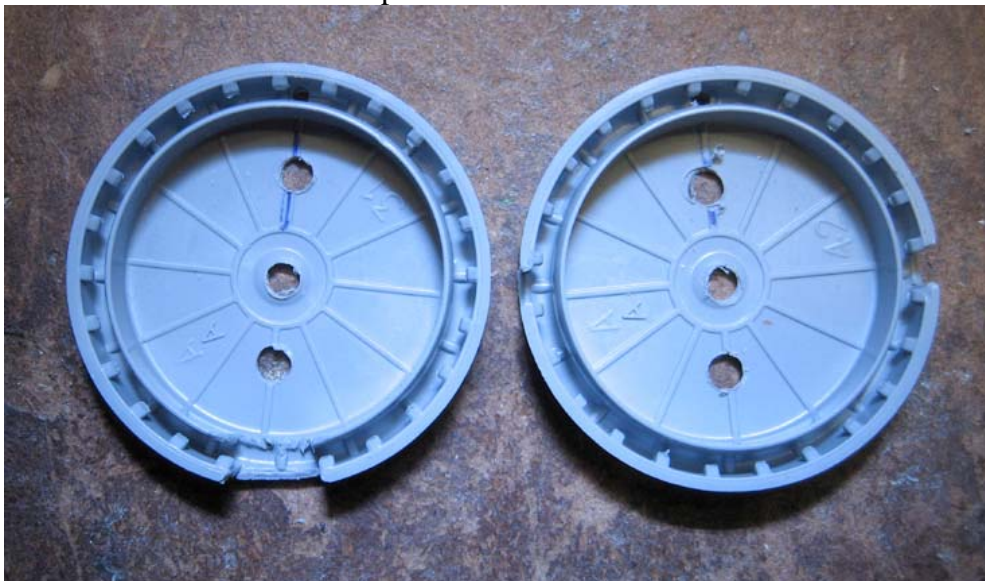
19. Modify the second group by clipping a 1/8" wide gap through the outer ridge at two locations, at the "left" and the "right" as shown.



20. Another view of modified second group. Note inner all is not clipped.



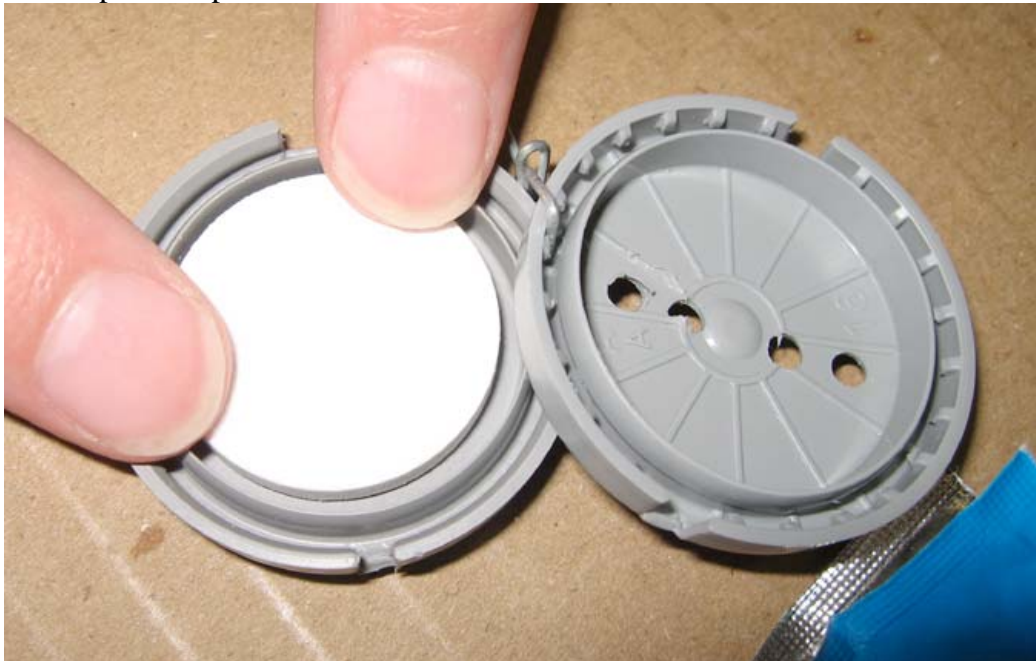
21. Release will use one lid from each group. Both are placed flat side down, ridges up, with 1/16" diameter holes at "top."



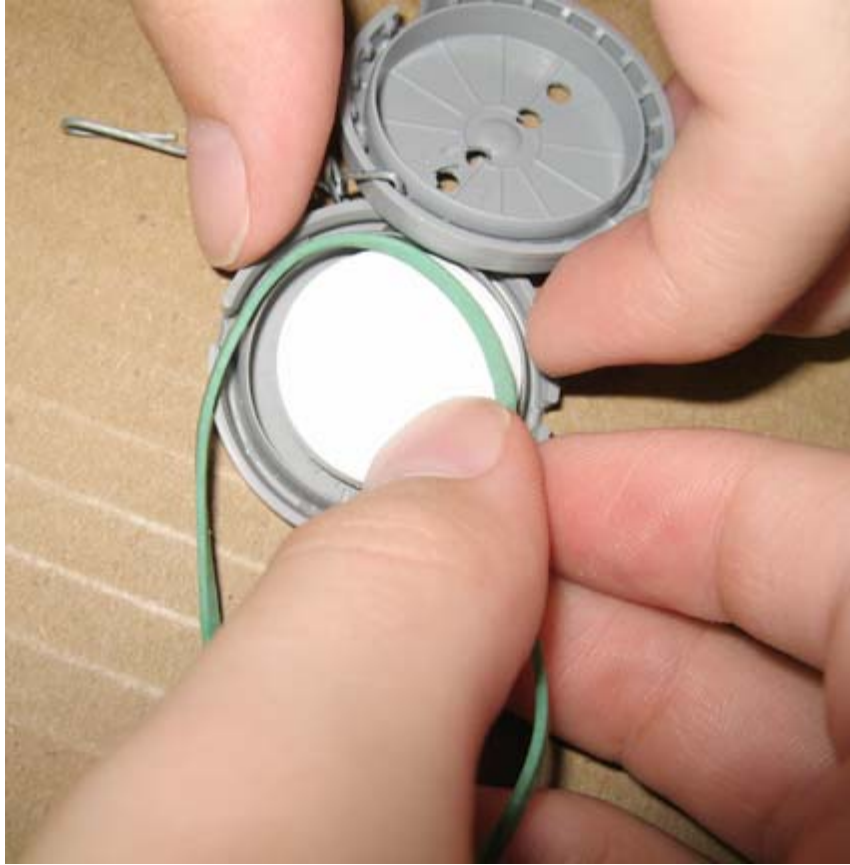
22. Using the needle nose pliers, bend the paper clip straight and make hinge by running the wire through the 1/16" diameter holes. Bend the wire at the top to make a "hook" like a Christmas tree ornament hander.



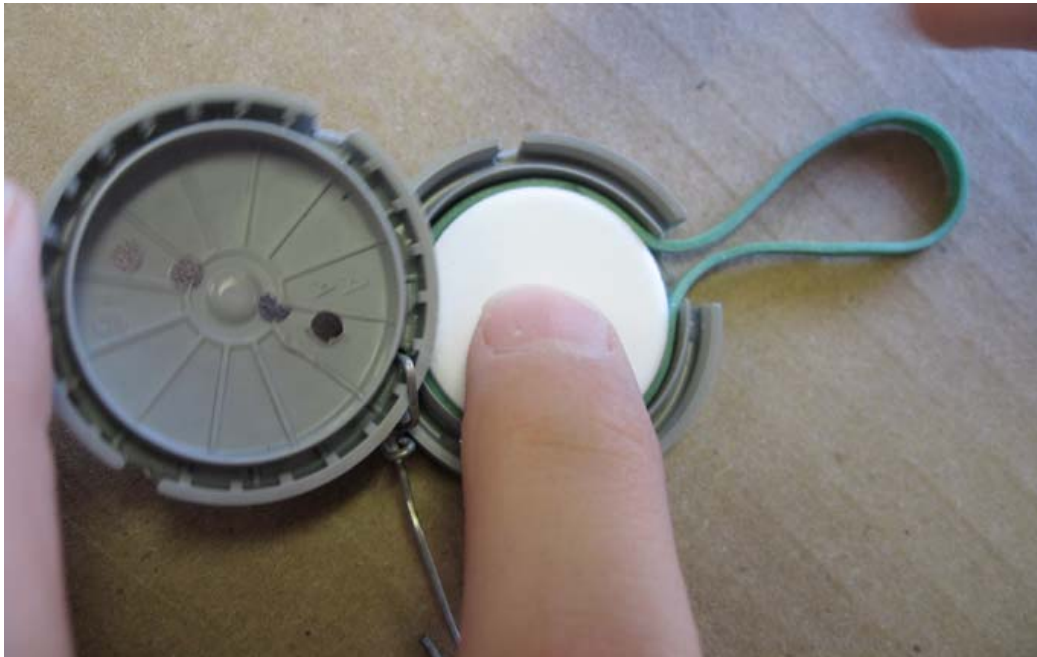
23. Slide lids apart and place Alka Seltzer® tablet in center of release.



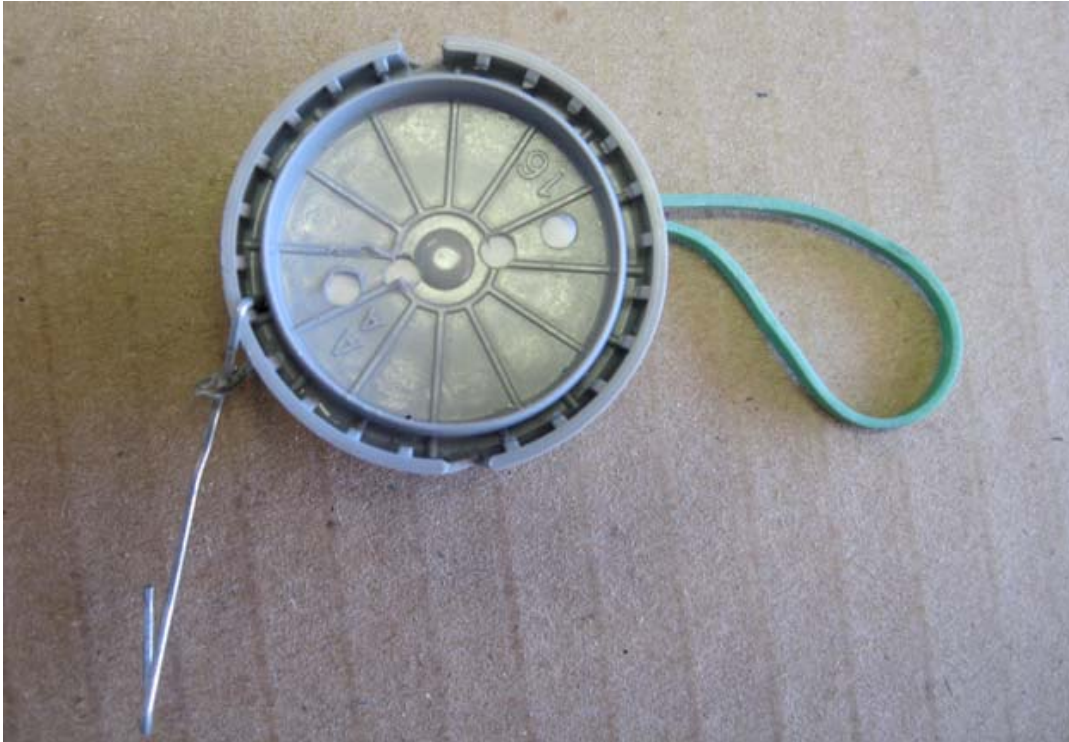
24. Place rubber band smoothly around Alka Seltzer® tablet, with excess brought through gap at bottom that was cut in step 7 above.



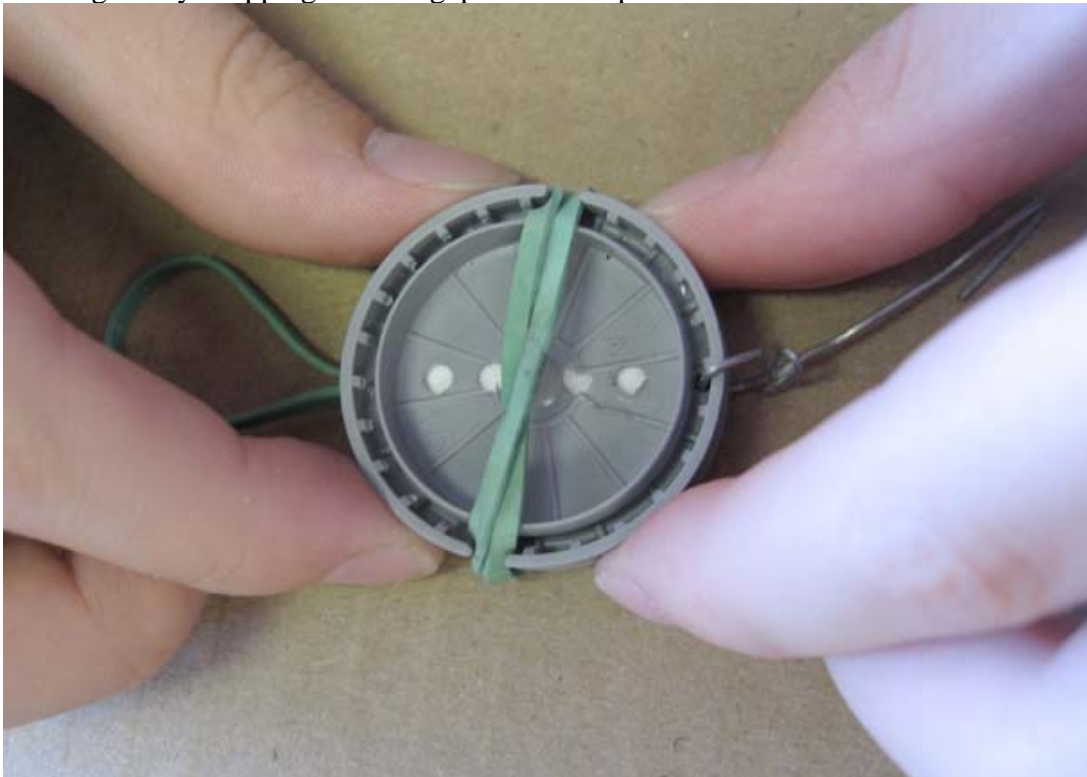
25. Close release by sliding the top lid over the bottom lid capturing the Alka Seltzer® tablet and rubber band inside.



26. Another view of release when closed.



27. Use second rubber band to hold release closed. Note rubber band is kept from sliding off by dropping into the gaps cut in Step 8 above.



28. Attach weights to rubber band coming out of bottom of release. Release is now ready for attachment to bathyscaphe screw eye using hook at top.



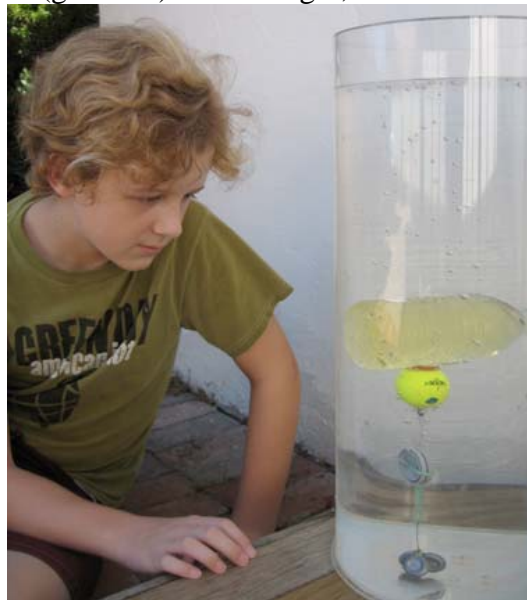
Fig 7. Anchor weights attached to rubber band of release.

ASSEMBLY

29. The hook at the top of the release connects to the screw eye on the bottom of the personnel sphere (golf ball). The hook on the weight clips onto the rubber band that comes out from the inside of the release at the bottom.



30. You can see your bathyscaph model floats with the buoyancy on top, and the weight is at the bottom. This is called “self-righting”, and will always tend to float this way. When the anchor is dropped, the personnel sphere (golf ball) is the weight, so the float will still stay on top.



Here's the bathyscaph in a pool. The pressure at the deeper depth doesn't change the way it floats.



Objective: Demonstrate by using the lab equipment provided how mass and volume affect density and buoyant force.

Observations (background information on Power Point) : We have a model of the Trieste bathyscaphe. It is not filled with gasoline, but it is filled with oil. We need to know if the Trieste Model is less dense than water, and therefore will float. To determine the **density** of the model, **divide its mass by its volume**. After determining the density, we will calculate the buoyant force on the model and determine the amount of mass needed to make it neutral in the water. (same density of water; 1 g/cc)

Finding Mass: Find the **mass** of the Trieste model with the **balance** and record this information on your Data Table below.

Finding Volume by displacement: Finding the volume of the Trieste model will require 3 steps because the model is too large to fit into our biggest graduated cylinder.

Step 1: Place the filled bottle of oil inside a 2-L graduated cylinder that has 1000 ml of water in it. Gently submerge the bottle using a pencil, so that the pencil does not go below the surface of the water. Read and record this new level of water with the bottle in it. Subtract the original 1000 ml from the new amount. This will give you the volume of the water displaced by the bottle of oil. Record this as the **volume of the oil filled bottle**.

Step 2: Use a filled displacement can at the sink to find the volume of the sphere (golf ball with attachments). Catch the displaced water with an empty graduated cylinder. This will be the volume of the sphere. Record this as **volume of sphere**.

Step 3: Add the volumes from steps 1 and 2. This should equal the total volume of the Trieste model. Record this as **volume of Trieste Model** on the Data Table.

Calculating Density: Now that we have determined the mass and the volume of the Trieste model, **calculate its density by dividing its mass (g) by its volume (cm³)**.

Record the density of the Trieste model on your Data Table. Is the model less dense than water (1.0 g/cm³)? _____ Will the model float in the water? _____

Ask a Question: What is the amount of mass that needs to be added to the Trieste model in order to make it neutral (1.0 g/cc)? Then after increasing the mass so that it will sink to the bottom of the tank, what needs to be done to return it to the surface of the tank? _____

Make a Hypothesis: To give a good possible answer to the question, you need to know how much buoyant force that the water has on the Trieste Model.

Calculating Buoyant Force: To determine the buoyant force, we will need to know the **weight of the displaced fluid**. In this case the fluid is water, which makes things easier, because the **weight (for which we will substitute mass) of the water equals its volume**. You have already determined the volume of the displaced fluid for the Trieste model when you were finding its density. So this volume is also the mass of the displaced water and, therefore, **the buoyant force** pushing up on the object. Record this as buoyant force on your data table.

Now you can make an educated guess, as some hypotheses, are called. You simply need to subtract the mass from the buoyant force. The result will tell you how much mass added to the Trieste model will make it **neutral (1 g/cc)** in water. Record this result as your hypothesis.

Test the Hypothesis:

Assemble the Trieste model with the **added mass from your hypothesis**. Take your prepared model to the tank of water and gently place it into the water. Observe what happens. Could you make your model neutral in the water? _____ Now add another weight to your model with a **release mechanism**.

Did the model sink? _____

What changed about the model to allow it to sink? _____

Did the model rise back to the surface? _____ What changed about the model to allow it to rise? _____

Conclusion:

Was your hypothesis correct? _____ How much mass made your model neutral? _____ sink? _____

Which changed in this experiment, the density of the model or the buoyant force on the model? _____

Data Table

Mass of Trieste Model = _____ gms

Volume of oil filled bottle = _____

Volume of sphere = _____

Volume of Trieste Model = _____

Density of Trieste Model = _____

Mass of displaced water = _____

Buoyant Force of water on model = _____

Your hypothesis of weight to make neutrally buoyant = _____

ASSESSMENT:

Compare data.

Discuss how it went!

INDEPENDENT STUDY

Let's try the deep end of the pool!



Fig 8. This bathyscaph explores the deep end of the pool.



Fig 9. Reflected in the surface, the bathyscaph returns from a deep dive.

MORE INFORMATION:

Go to <<http://www.materover.org>> and search for "bathyscaphe project." You'll find step-by-step photos showing how to make your own working Trieste model including the Alka Seltzer® release!

You can also search the web and learn about the amazing world of ocean engineering and undersea vehicles.

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