GRADES: 3 – 6

Displace In Your Face

OVERVIEW:

This lesson focuses on applications of Archimedies Principle of buoyancy and displacement to determine why some things float and others sink. Students will use clay models and simple household objects to test and see how a change in shape will change the amount of fluid displaced. In addition, using these two principles, they will participate in a design competition to create an aluminum foil boat to hold the most cargo without sinking.

ITV SERIES:

Dr. Dad's Ph^3: Buoyancy

LEARNING OBJECTIVES:

Students will be able to:

❖ define the term density
❖ explain the meaning of the term displacement.
❖ predict which materials will displace the most fluid.
❖ describe the difference between density and buoyancy.
❖ measure an object's volume using displacement.

VOCABULARY:

displacement
density
buoyancy

MATERIALS:

Single Items:

- gram scale or balance
- roll of aluminum foil
- large dishpan
- 200-300 marbles

Per group of four students:

- 500 ml plastic beaker or large plastic cup
- water
- small wooden block (must fit in beaker)
- small pebble
- plastic button
- penny
- paper clip
- red and green crayons
- lump of waterproof modeling clay that weighs the same amount as the wooden block.
- 9" aluminum pie plate
- 100 ml graduated cylinder or measuring cup

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BACKGROUND:

The ability of an object to float is controlled by the amount of the fluid it displaces. If an object can displace more than its own weight of the fluid, it becomes buoyant and floats. This phenomena is known as Archimedies Principle in honor of the Greek philosopher who first described it.

Somewhere around 250 B.C. Archimedies, who was credited with numerous inventions and mathematical theorems, discovered that a submerged object would displace some of the water around it. As the story goes, he discovered this while stepping into a bathtub that was filled to the top. As he watched the water spill on to the floor, he shouted Eureka! which meant "I found it!" What he discovered was not only that objects would displace water, but that they also appeared to lose some of the their weight when they were submerged. In other words, they were buoyed up by the surrounding water.

By carefully comparing the weights of objects to the weight of the water they displaced, Archimedes determined that those objects that naturally floated, like wood, always displaced a volume of water that weighed more than they did. Those objects that sank, like the king's golden crown, displaced far less water. By changing the shape of non-floating objects so they displaced more water, he discovered that he could significantly increase the amount of water they displaced.

Today ship builders create huge vessels out of different types of high density material which are capable of carrying enormous amounts of cargo. Using steel and other alloys, they often use computer programs to help design shape to get maximum displacement. In many cases, these vessels must displace in excess of 100,000 tons of water in order to float.

PRE-VIEWING ACTIVITIES

Pose the following question to the students: "Why do some objects float while others sink?" Their responses will vary. Some will suggest that it has to do with how heavy the object is or the type of material it is made from. Others may feel that it has to do with how large the item is or how it is shaped. Allow the students to discuss it for a few minutes; then, without reaching a formal conclusion, ask them to do the following experiment:

Give each group of 4 students the same collection of 5 or 6 objects. Include things like a penny, a paper clip, a pebble, a plastic button, and a small wooden block. All of the items should be about the same size. Explain that they are going to test which items sink and which float. Before testing, have them record their predictions. Working in their groups, have the students test each of the objects by placing them in the plastic beaker and record what happens. Ask them to observe what happens to the water level each time they put a different object in.

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Allow them a few minutes to test each item, then compare the results to the predictions. After discussing the results, explain that the reason some objects float and some sink has to do with the amount of water the objects displace. Ask if the students noticed what happened to the water lever when they placed the different objects in. The water should have gone up with each of the items. Define the term displacement.

Give each student group a lump of waterproof modeling clay that has the same weight as the wooden block they have been using. You can either weigh these out beforehand and demonstrate that they weigh the same using a balance or, if time permits, have the students weigh the wood block and adjust the size of the clay so that it weighs the same. Have them make the following predictions: Which item will float: the wood, the clay or both? Which will displace more water: the wood, the clay or will they displace the same amount? After discussing their predictions, have the students conduct the following experiment:

Give each student group a red and a green crayon. Have them mark the water level on the outside of the beaker with the red crayon. Carefully, so as not to splash any of the water out, have them place the wooden block in the beaker. Since the block will float up in the water, one student must push the top of the block down so that it is submerged in the water right to the top. They must be careful so they don't actually displace any water with their finger. After the water has settled, have them mark the level to which the water rose. Have them remove the wood and check the water level so that it is the same starting point. If need be, they can add some more water to adjust the level. Have them place the clay in the water and observe what happens. Have them record the level to which the water rises, using the green crayon. Discuss the results with the class. If all goes according to the design, the clay should sink and displaced less water than the wood.

FOCUS FOR VIEWING:

Explain to the students that even though the clay and the wood weighed the same, the clay had a smaller volume. That meant that it was more compact, or in science lingo, it's more dense. The greater the density of a material, the less water it will displace. In order to get something to float, it must displace enough water to equal it's own weight. This is called Archimedies Principle of buoyancy. Define buoyancy as the upward force that a fluid places on an object causing it to float. Before turning on the video, ask the students if it would be possible to get an object that is denser than water, like a block of concrete, to float. Invite them to look for some clues to the mystery while they watch the video.

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VIEWING ACTIVITIES:

Start the video. Pause immediately after “Dr. Dad” asks the girls why they think a steel nail sinks but an ocean liner floats. Have the students offer some suggestions as to why a nail sinks and an ocean liner floats. Remind them to think about Archimedies Principle and water displacement. Start the tape after the discussion so the class can see what the girls came up with.

Resume viewing and pause again when “Dr. Dad” removes the wooden block from the container of water. To test for comprehension, ask the students how much the water that splashed over the side of the bowl should weigh. Resume viewing and watch as the answer is revealed. Continue the tape and pause when “Dr. Dad” places the sinker into the water. Ask the students to explain why the sinker displaced so little water compared to the wooden block. Do they have any suggestions how they might get the sinker to displace more water? Discuss their ideas and resume viewing. Stop the tape when “Dr. Dad” talks about going to the University of New Orleans for the concrete canoe races.

Review the sinker experiment with the class. Why did flattening the sinker get it to displace more water? Would it ever be possible to get the lead sinker to float? What about the original challenge? Did the students think of any ways to get a concrete block to float?

To emphasize how important shape is to displacement, have the students return to the beaker of water with the block of clay. Have them fill the beaker to the very top and place it in the center of the pie plate. Have the students carefully drop the lump of clay into the beaker and watch the water that overflows into the pie plate. After the water stops dripping, have them pour the displaced water into the graduated cylinder or measuring cups to see how much was pushed out. Record this volume then put the water back into the beaker. Re-set the beaker on the dry pie plate.

Ask the students to flatten the block of clay so that it is shaped like a pancake and place it flat into the water. Does it displace more or less water than before? Have them measure using the cylinder to find out. Have them repeat the procedure one more time flattening the clay and turning up the edges until it floats. Have them check the displacement again. How does it compare with the first amount? As the students continued to flatten out the clay, the amount of water displaced should have continued to increase.

After discussing the outcome of the experiment, return to the video. Start the tape and play to the conclusion.

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POST-VIEWING ACTIVITIES:

Have students review the different elements that went into the design and construction of the concrete canoe. What design changes might be made if they wanted the canoe to haul cargo instead of race? If possible, show some slides or photos of different types of vessels including barges, oil tankers, ferry boats, Coast Guard cutters and speed boats. Discuss how the designs are similar and different.

ACTION PLAN:

Have the students take Olivia's Challenge. Get each student a piece of aluminum foil approximately 12" x 12" square. Using the concepts presented in the video and discussed in class, have them each design and build a boat that will hold the most weight. Use a large dish pan to float the boats and either pennies or marbles as the ballast to calculate weight holding capacity.

Invite an engineering student from a local university to discuss some of the techniques used in modern ship design and construction. What new materials are being introduced to help get even more cargo on board?

EXTENSIONS:

TECHNOLOGY: Ship building isn't the only area where buoyancy is used. The sport/science of hot air ballooning also depends on buoyancy. Have students research the early history of ballooning including the contributions of Jacques Charles and the Montgolfier Brothers. To extend the concept, review the Dr. Dirt's Ph^3 show on Gas Laws.

MATH: Archimedies was not only famous for taking baths, but he was also an excellent mathematician. He was the first one to seriously explore the mechanical advantage supplied by levers and discovered the relationship between the circumference of a circle and it's area, a value we now call Pi. Using a metric ruler, a graduated cylinder and number of different irregularly shaped solids, have students try to calculate volumes first by measuring, them by using water displacement. Have the students research the origins of the metric system, which is based on the density and displacement of water.

ART: Many cultures have their own unique designs for boats including Native American dug out canoes, Egyptian reed boats and Polynesian outriggers. In many of these cultures, boat building is viewed more as an art form than a science. Have students research some of the designs used by different cultures and have them draw their own designs or copy some of the classic designs.

LANGUAGE ARTS: Many of the common phrases that we use today in the English language had their origins in shipping. Terms like "Mark Twain" and a "Plimsoll Line" actually come from the early days of hauling cargo. Have students research some of these terms and discover why they came about.