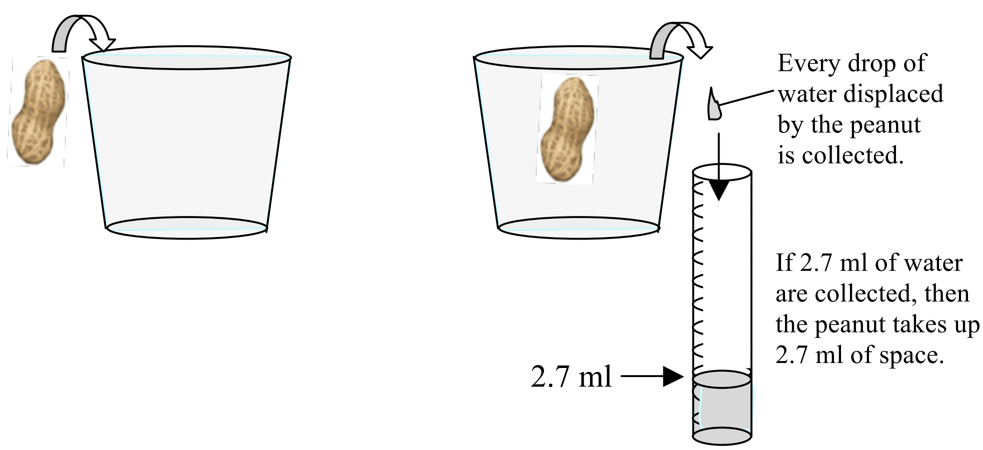
Flinkers

Overview

In this activity, students explore density and its relationship to buoyancy by making an object that neither floats nor sinks; we call it a flinker. It flinks because it has the same density as water. Students are challenged to add exactly the right amount of sand to a small tube to make it flink. They'll try to get the tube to flink by trial and error, trying their flinker repeatedly in a cup of water. Students will be surprised by the tiny amount of weight that makes the difference between floating, sinking, and flinking. They'll also predict whether their flinker in plain water will also flink in salt water. Students can apply these concepts to understand how tiny differences in density can drive ocean currents and cause lakes to "turn over" in the fall.

Background (Making Sense of Dense and Buoyant)

The amount of weight in a given amount of space is called **density**. You can measure the space that something takes up by measuring the amount of fluid it displaces when it is submerged. If you completely submerge a peanut in a glass full *to the brim* with water, water overflows. If you catch every drop of overflow water and measure its volume, that volume of water is pretty close to the volume of the peanut.



If you weighed the water that the peanut displaced and also weighed the peanut, you'd be weighing two things of about the same volume. If the peanut weighed less than the water it displaced, it would be less dense than water. Objects that are less dense than the fluid they are in float. If both weighed the same, they would have the same density. Objects of the same density as the fluid they are in neither float nor sink. They flink (a made-up word combining floating and sinking). If the peanut weighed more than the water it displaced, it would be denser than water. Objects that are more dense than the fluid they are in sink.

Archimedes said that a fluid exerts an upward "buoyant force" on whatever is in it. The upward force is equal to the weight of fluid that the object displaces. Think of the water that was pushed aside by the object. It has weight. That weight is trying to get back into the space it was pushed out of. The only force it has to exert is its weight. In this case, that weight pushes up. It pushes up the way squeezing a slippery watermelon seed between your fingers can shoot the seed straight up into the sky. That's the buoyant force.

Whatever is in the fluid is also pushing down according to its weight. So, there are two forces – one pushing down and one pushing up. It's a pushing match where the greater force wins. If the thing sitting in the fluid weighs less than the buoyant force, it floats. If the thing weighs more than the buoyant force, it sinks. If the thing sitting in the fluid and the amount of fluid displaced weigh the same, it's a tie. There is no net force either way. In that case, the thing doesn't rise up or sink down. It flinks.

In a lake or an ocean, the thing that's floating or sinking doesn't have to be solid. It can be a liquid. Less dense liquids like oil float in denser liquids like water. Even water that's warmer than the water around it will rise. Warmer water has expanded. The same weight takes up a little more space than the colder water it's displacing. So, it rises. The same goes for water with more or less salt. A cup of salty water is a little heavier than a cup of fresh water, so salty sinks in fresh, and vice versa. These differences are the main forces driving ocean currents.

Materials

*Materials to be supplied by the teacher or the students are marked with an asterisk.

Materials for the whole class

- 15 tubes 1.5 cm in diameter, 3 cm long, with water-tight caps
- 15 9-oz cups
- 15 metal scoops
- 16 1-oz cups
- sand
- salt
- 8 50-ml graduated cylinders
- 1 electronic balance accurate to 0.1 gram
- *newsprint to cover work areas

Materials for small groups (groups of 2)

- 1 small plastic tube 3 cm long, with a water-tight cap
- 1 9-oz cup ¾ full of water
- 1 metal scoop
- 1 plastic forceps
- 1 food tray of sand
- 1 1-oz cup of salt
- 1 50 ml graduated cylinder
- access to an electronic balance

Preparation (by the teacher)

1. Fill one 9-oz cup ¾ full of water for each group of 2 in your class
2. Fill one 1-oz cup ¾ full of sand for each group
3. Fill one 1-oz cup ¾ full of salt for each group
4. Set out all of the remaining materials for groups of 2
5. Place electronic balances where groups can use them efficiently. Plug them in and make sure they are zeroed. Avoid jams at the balances by letting each group know which balance to use.
6. Be sure that students either have newspaper to cover their work areas, or that you have covered the work areas with newspaper.

Procedure (for the teacher)

1. Ask students to fill their tubes *almost full* of sand (2 mm from the top) and cap them. When they have done this, ask them to fill their graduated cylinders about half way with water. Tell them NOT to put the tube in the graduated cylinder.
2. Ask students to predict in their notebooks what will happen when they put their tube in the graduated cylinder. Ask them to draw the graduated cylinder before and after.
3. Ask students to record the volume of water in the graduated cylinder and drop the capped tube full of sand into it. What is the change in volume? Ask students how much space they think the tube full of sand takes up. Ask if the tube would take up more space if more sand were put into it? Have students completely fill the tube and drop it into the graduated cylinder. Would the tube take up less space if sand were taken out of it? (No need to try this one; the answer is "no" and most students should see this.)
4. Challenge students to make a flinker. Give them 10 minutes. Say, "Using only sand to weight the tube, make a tube that neither floats nor sinks in the cup of water. Take care that no bubbles are on or under the tube." Students will not achieve neutral buoyancy on their first attempt. Nearly all tubes will sink or rise fairly quickly. Students will eventually be adding or subtracting just a few grains of sand, and trying their flinker over and over again.
5. Once a group has a flinker, ask that group to find the volume of the flinker in the graduated cylinder. Ask them to record that volume in their notebooks. Ask students to predict (estimate) the mass of the flinker in grams, then weigh it on the balance. What is the density of the flinker in grams per cubic centimeter?
6. Ask students: what do they think is the density of water in grams per milliliter? How would they find out? Ask students to devise a way to find out and try it. Give students 10 minutes to do this.
7. Ask students to put the flinker back in the cup. They might need to adjust it a little to get it to flink as well as before. Once they've got it, tell them you're going to

ask them to add the salt from the 1-oz cup into the cup of water with the flinker. Ask them to predict in their notebooks what will happen, and to give a reason why, then have them add the salt.

8. Ask students to adjust the flinker to flink in the salt water. Ask them to predict its density in their notebooks. Tell them to again find the flinker's density. What do they see? Ask them to write an explanation in their notebooks.

Reflection/Discussion

1. Ask: What made it difficult to get the tube to flink? Do you think that 1 grain of sand is enough to make the difference between floating and sinking? Why do you think that? (The answer is "Yes.")

   Look at the table of water density vs. temperature. What's the difference in density between water that feels cold (41 °F) and water that feels cool (59 °F)? This is a spread of 18 °F. The cool water will strongly rise up in the cold water even though the difference in density between the two is only 0.00081 g/cm^3. That's far less than a grain of sand's worth in a flinker tube, but it's enough to drive ocean currents.

Water Density by Temperature				
Temperature	Density		Temperature	Density
°F	g/cm3		°F	g/cm3
32.0	0.99982		66.2	0.99849
33.8	0.99989		68.0	0.99829
35.6	0.99994		69.8	0.99808
37.4	0.99998		71.6	0.99786
39.2	1.00000		73.4	0.99762
41.0	1.00000		75.2	0.99738
42.8	0.99999		77.0	0.99713
44.6	0.99996		78.8	0.99686
46.4	0.99991		80.6	0.99659
48.2	0.99985		82.4	0.99631
50.0	0.99977		84.2	0.99602
51.8	0.99968		86.0	0.99571
53.6	0.99958		87.8	0.99541
55.4	0.99946		89.6	0.99509
57.2	0.99933		91.4	0.99476
59.0	0.99919		93.2	0.99443
60.8	0.99903		95.0	0.99408
62.6	0.99886		96.8	0.99373
64.4	0.99868		98.6	0.99337

2. Review Archimedes' principle. The buoyant force is equal to the mass of the fluid displaced. For every cubic centimeter of cool water, 1 gram of cold water is pushing up and only .99919 grams are pushing down. The result of this little pushing match is that .00081 more grams are pushing up than pushing down on every cubic centimeter of the cool water. A grain of sand weighs a lot more than that. However, because there are a gazillion cubic centimeters of warm water out there, it adds up, and it's enough to move the whole body of warm water upwards.