Flinkers

NC Standard ESS.8.2.2

Activity Description & Estimated Class Time

Over the course of one 50-minute class period, 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.

Correlations to NC Science Standards

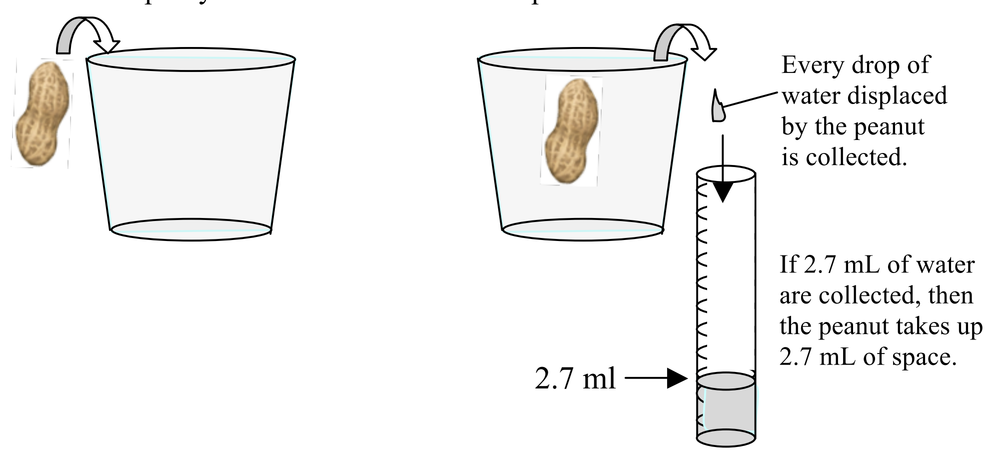
ESS.8.2.2 Use models to explain how temperature and salinity drive major ocean currents and how these currents impact climate, ecosystems, and the distribution of nutrients, minerals, dissolved gases, and life forms.

Learning Target

Students will demonstrate knowledge and understanding of density and its relationship to buoyancy.

Brief Science Background

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.

Brief Science Background cont.

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.

Part 1 — Volume Teacher Demo

Materials

Materials for the whole class demonstration

- tube, 1.5 cm in diameter, 3 cm long, with water-tight cap
- sand
- 50-mL graduated cylinder
- water (provided by the teacher)

Procedure

1. Fill the tube *almost full* of sand (2mm from the top) an cap it.
2. Fill the graduated cylinders about half way with water.
3. Ask students to predict what will happen when you put the tube in the graduated cylinder. Ask them to draw the graduated cylinder before and after.
4. State the volume of the water in the graduated cylinder and have students record the volume. Remind students that volume is that amount of space an object takes up. Drop the capped tube full of sand into it. What is the change in volume? Have students record the change in volume.
5. 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?
6. Take the tube out of the water and completely fill it with sand. Drop the tube into the graduated cylinder. Ask students "Would the tube take up less space if sand were taken out of it?
   The answer is "no" and most students should see this. Take out the sand and demonstrate the concept to students if needed.
7. Tell students that mass is how much "stuff" it is made of. Ask "Did the tube have more mass when it has more sand in it?
8. Write the equation for density on the board and explain to students that density is

Procedure cont.

mass per unit of volume.

9. Ask students "Which had a higher density? Half full tube or full tube? Why?"
   The full tube has a higher density because the mass of the full tube is greater.
10. Ask student "How does density relate to floating and sinking?
    If the object is more dense than the liquid it will sink (negative buoyancy). If the object is less dense than the liquid it will float (positive buoyancy). If the object has the same density it will neither float nor sink, it will be suspended (neutral buoyancy).

Part 2 — Flinker Challenge

Materials

Materials for the whole class

- tubes 1.5 cm in diameter, 3 cm long, with water-tight caps
- 9-oz squat cups
- metal scoops
- 1-oz cups
- sand
- salt
- food trays
- 1 electronic balance accurate to 0.1 gram
- Water Density by Temperature table (SD 1)
- newsprint or paper towels to cover work areas (provided by teacher)

Materials for groups of 2 students

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

Preparation
allow for approx. 30 min

1. Fill one 9 oz. cup 3/4 full of water for each group of two.
2. Fill one 1 oz. cup 3/4 full of salt for each group.
3. Set out all the remaining materials for groups of two.
4. 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.
5. Be sure that students either have newspaper or paper towels to cover their work areas, or that you have covered the work areas.

Procedure

1. 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.

Procedure cont.

2. 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 the mass of the flinker in grams, then weigh it on the balance. Have students find the density of the flinker in grams per cubic centimeter. Inform students that the density of freshwater is 1 g/cm^3.
3. 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, ask them to predict in their notebooks what will happen if they add the salt from the 1-oz cup into the water, and to give a reason why.
4. Have the students add the salt. Ask students to adjust the flinker to flink in the salt water. Have students explain what they did to make the tube flink in salt water and why they did it in their notebook.
5. Tell students to find the flinker's density. Have students compare the density of fresh-water to the density of saltwater based on the information gained from the flinker.

Content Connection

1. Ask students "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." #2 and #3 explain the answer in detail.
2. Display the Water Density by Temperature table (SD 1). Ask students "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.
3. 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.

SD 1

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