Adapted to STEMAZing ECE Format by
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Density: Condiment Packet Cartesian Diver

NOTE: Children should always be given ample time to experiment, notice, and wonder before they are provided an explanation.

Always engage children with our two favorite questions:

What do you notice? What do you wonder?

Resist the urge to answer any questions children have while exploring. Instead, respond back with questions to children and let them make sense of the world. Sample questions you might use: What do you think? Do you notice any patterns? What could we change? Can we test something else? What can we try next? If children ask a testable question, which they could answer by doing an experiment, talk through with them how they might design a test to help answer their question. As much as possible and within reason, let them actually test their questions by trying the experiments they propose.

Learning Objectives

Children will…

- make a condiment packet Cartesian diver.
- use their senses to make observations about what happens when they squeeze the sides of the bottle.
- reinforce the idea of density.
- reinforce the rule for when something sinks and when something floats in a fluid.
- learn that applying pressure to an object can change its density.

Vocabulary (See **What the heck? Explanation of Science** at the end for definitions.)

Density	Gas	Buoyancy
Mass	Liquid	Weight
Volume	Sink	Gravity
Fluid	Float	Force

Materials

Empty 2-liter plastic bottle

Condiment packets (like ketchup, mustard, or mayonnaise from a fast food restaurant)

Water	Salt	Bowl

Key Question

Can you place a ketchup packet in a bottle of water and make it rise and fall at your command?

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Notice and Wonder Developmentally Appropriate Practice

1. Fill a bowl with water and put the condiment packets in the water. If any of them float, use that condiment packet for the diver. If they all sink, you will need to add salt to the water in the 2-liter to increase the water's density when you put everything together.
2. Put the condiment packet in the 2-liter bottle and fill it with water. If the condiment packet floats, skip to step 4. If the condiment packet does not float, continue to step 3.
3. If the condiment packet sinks, you will need to add salt to the water in the 2-liter bottle and dissolve it by putting the lid on and gently shaking the bottle. Don't add too much salt to the water. You want just enough to make the packet float.
4. Once the packet is floating in the water or salt water, fill the bottle up to the very top with no air gap. Put the cap on the 2-liter bottle and tighten it as much as you can. The condiment packet should still be floating once the 2-liter bottle is sealed.
5. Ask the leading question: Can you make this condiment packet rise and fall at your command?
6. Let children take turns squeezing the bottle and make observations about what happens.
7. Have children describe what they are doing to make the condiment packet sink. Ask them what they have to do to keep it at the bottom of the 2-liter bottle.
8. Reinforce the rule about sinking and floating by having children use the following language: When the packet is more dense than the water, it sinks. When the packet is less dense than the water, it will float.
9. Connect the pressure on the bottle to the changing density of the packet: Squeezing the bottle will increase the density of the packet. Relaxing your grip on the bottle, reducing the pressure, will decrease the density of the packet. If you have a stress ball, you could have students squeeze the stress ball and talk about how that makes it more dense. Then have them let the ball expand back out and talk about how it gets less dense.
10. Challenge the children to get the condiment packet to stay right in the middle without sinking or floating. Ask them why they think this happens and then share that when the density of the packet is the same as the density of the water, you can get it to stay suspended in the middle.

Extensions for Additional Learning

As always, ask the children throughout the experiment what they notice and what they wonder. If their wonder questions are testable, as much as possible and within reason, let them actually test their questions by trying new experiments.

Show children how they could pretend they are "magically" controlling the condiment packet. Have them tell the packet to go down and then squeeze as they say the words to make it seem like it is sinking on their command. Then, as they release the pressure, they can tell the packet to go up and it will! They can also tell it to hold steady as they keep it in the middle of the bottle suspended with just the right amount of pressure. Let

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them practice and show off their skills as they get better at making their voice commands match what the packet does. Explain how what looks like magic can be explained using science – their voice is really not making the packet move, the change in pressure which changes the density of the packet is making it sink, float, or stay suspended. You might also explain that while it is nice to fool people with our showmanship for a while, we always want to let them in on our secret so they can appreciate the real explanation.

Make a Cartesian diver using different materials. You can find a variety of designs online by searching for Cartesian diver. There are divers that use a pipette with a hex nut, an eye dropper, and other objects whose density can be varied with pressure.

AZ Early Learning Standards

Science Standard - Strand 1: Inquiry & Application - Concept 1: Exploration, Observation & Hypotheses
The child observes, explore, and interacts with materials, others, and the environment.

Science Standard - Strand 1: Inquiry & Application - Concept 2: Investigation
The child researches their own predictions and the ideas of others through active exploration and experimentation.

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Density: Condiment Packet Cartesian Diver

What the heck? Explanation of the Science (Vocabulary in bold.)

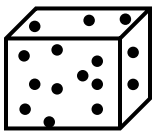
These phenomena can all be explained using density. What is density? Technically, **density** is the ratio of an object's **mass** to its **volume**. **Mass** is the amount of matter in an object. **Volume** is the size of the object.

IMPORTANT NOTE: Mass is not the same thing as the weight of an object. **Weight** is the **force** (pull) due to **gravity** on an object. For example, your mass (the amount of matter you are made up of) would not change if you were standing on the Moon's surface. However, your weight would change (it would be less) because the strength of gravity on the Moon is less than the strength of gravity on Earth. It should also be noted that the weight of an object does not determine whether it sinks or floats in a fluid. **Fluid** is a term used to describe either a gas or a liquid. So, air (a **gas**) is a fluid and water (a **liquid**) is a fluid. The density of an object compared to the density of the fluid it is in determines whether it will sink or float. More on this below.

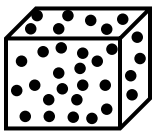
In equation form: $$density\ (\rho) = \frac{mass\ (m)}{volume\ (V)}$$

Density is a measure of how much matter is packed into an object. You cannot easily compare the density of two **solid** objects unless they are both the same mass or both the same volume (size).

Two solid objects with the same volume but different masses.



Less Dense



More Dense

If two solid objects are the same size, as shown above, then the one with less mass is less dense. The object with more mass packed into the same volume is more dense. The more matter packed into a certain volume or object, the greater its density. If it has less matter packed into a certain volume, then it is less dense.

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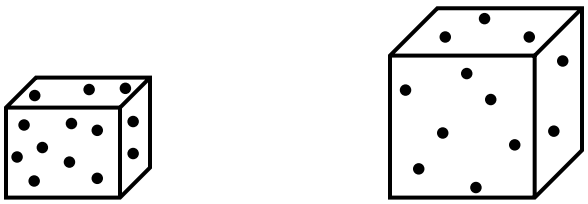
Two solid objects with the same mass but different volumes.



More Dense Less Dense

If two solid objects have the same mass, as shown above, then the one with a smaller volume is more dense. The object with the same amount of matter spread throughout a larger volume is less dense. If an amount of mass is packed into a smaller volume, the density is greater than the same mass packed into a larger volume.

So, what determines if a solid object will **sink** (fall to the bottom) or **float** (rise to the top) of a fluid?

Here is the rule:

A solid object will **SINK** if it is MORE DENSE than the fluid it is in.

A solid object will **FLOAT** if it is LESS DENSE than the fluid it is in.

Video Lesson: https://bit.ly/SciShowKidsSinkFloat

NOTE: An object DOES NOT sink or float because it is lighter or heavier. The weight of an object DOES NOT determine if it will sink or float. The object's density compared to the fluid it is in, as noted in the rule above, is what determines if it will sink or float. Just because an object is heavy, or weighs a lot, does not mean it will sink. Think about a big ship, which weighs a lot, and still floats. It floats because it is less dense than the water it is in. Just because an object is light, or weighs a small amount, does not mean it will float. Think about a small pebble, which weighs just a little, but will sink when placed in water. The small pebble sinks because it is more dense than the water. **PLEASE be careful to reference density and not weight when describing why something sinks or floats.**

What the heck? Explanation of Condiment Packet Cartesian Diver

Condiment packets have a small air bubble inside of them. This air bubble reduces the density of the condiment packet so it is less than the density of water. If this is the case, according to the rule above, the condiment packet will float because it is less dense than the water. This is ideal. You want a packet that will float when put in water.

If the packet doesn't float, you can add salt to the water to allow the packet to float. Adding salt to the water increases the density of the water. For a packet that initially sinks, because its density is greater than the water's density, adding salt allows for the salty water's density to become more than that of the condiment packet. Once the

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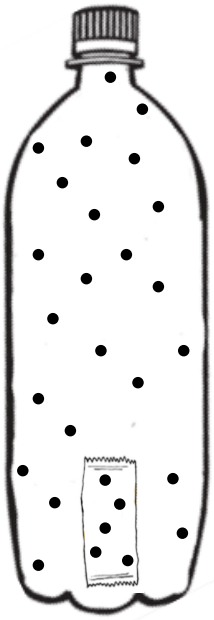
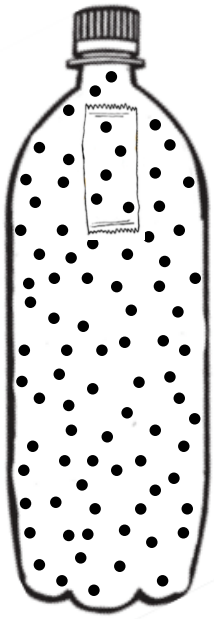
density of the condiment packet is less than the density of the salt water, it will float. The ability of an object to float on top of a fluid is called **buoyancy**.



Condiment packet
initially sinking in water



Condiment packet
floating in salty water

With the condiment packet now floating, the bottle is topped off with water to the very top and the cap is tightly secured. Water does not compress so when you squeeze the side of the bottle, it compresses the air bubble inside the condiment packet. Reducing the volume of an object, without changing its mass, makes it more dense. If you squeeze hard enough, the density of the condiment packet will become greater than the density of the water or salt water. When this happens, the packet will sink to the bottom. The pressure must be maintained on the bottle by squeezing it to keep the packet at the bottom of the bottle. If you release the pressure, the air bubble inside the condiment packet expands again, reducing its density. The condiment packet will then float back up to the top. If you squeeze with just the right pressure, you can get the density of the condiment packet to match the density of the water or salt water. In that case, the packet will neither sink or float but will hover in the middle of the water suspended. You must maintain the right amount of pressure to keep the condiment packet suspended.

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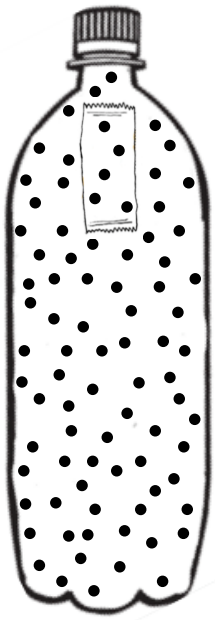
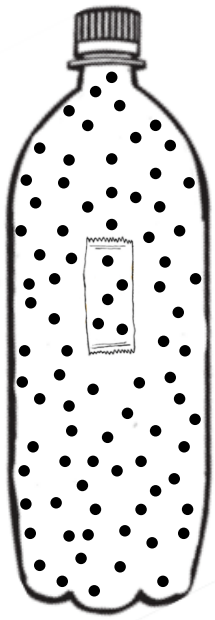
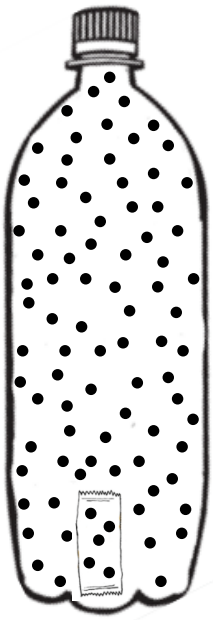


Condiment packet floating in salt water
(packet less dense than salt water)



Condiment packet suspended in salt water
(packet same density as salt water)



Condiment packet sunk in salt water
(packet more dense than salt water)

NOTE: The change in volume of the packet above when the pressure is changed by squeezing the bottle is exaggerated to demonstrate the change in density. In reality, the change in volume is not obvious or observable with the naked eye.