

SICK!
science
insanely cool experiences

**CARTESIAN
DIVERS**
EXPERIMENT GUIDE



CARTESIAN DIVER

Is it mind control or just a clever science trick? It's a classic science experiment using an eyedropper, a soda bottle filled with water, and some great showmanship. Explore the science of Cartesian divers and density while amazing your friends.

WHAT YOU NEED

- 1 LITER BOTTLE WITH CAP
- WATER
- EYEDROPPER

1 Pour water into the 1 liter bottle so that it is mostly full.



Fill the glass eyedropper about 1/4 full with water. You may need to experiment with the amount of water in the eyedropper in a test cup, as it should be just enough water to make it so the eyedropper is barely floating.

3 Add the eyedropper to the 1 liter bottle.



4 Finish filling the bottle to the very top with water and put the cap on tightly.



Gently squeeze the sides of the bottle and notice how the eyedropper sinks. Release your squeeze and it floats back up to the top.





HOW DOES IT WORK

This activity is an updated version of the classic experiment named for the Frenchman, René Descartes (1596-1650). He made huge contributions to the fields of philosophy, math, and science.

When you have the water levels adjusted correctly in your eyedropper, you might see water levels inside it change. When you squeeze, the air trapped in the eyedropper compresses into a smaller space, water enters the eyedropper, the eyedropper's weight increases, and it sinks. When you release the squeeze, the compressed air expands and forces water out of the eyedropper, buoyancy is restored, and it floats back to the top of the water.

▶ TAKE IT FURTHER - FIVE DIVERS

- 1 Number the pipettes 1 through 5.
- 2 Screw a hex nut onto each of the pipettes.
- 3 Cut them each just below the hex nut.
- 4 Use a glass of water to fill each pipette about $\frac{1}{2}$ full of water by gently squeezing it with the tip submerged and releasing it. Each pipette should be the same and should just barely float. You may need to adjust the level by adding or releasing some of the water.
- 5 Fill up a 1 liter bottle with water so it is mostly full. Add pipette #1.
- 6 Squeeze 3 drops of water out of pipette #2 and add it to the bottle.
- 7 Repeat step 6 with the remaining pipettes, squeezing additional drops out from each one. Pipette #3 should lose 6 drops, pipette #4 should lose 9 drops, and pipette #5 should lose 12 drops.
- 8 Fill the bottle with water all the way to the top and screw the cap on tightly.
- 9 Squeeze the bottle and watch the divers sink one at a time.

WHAT YOU NEED

- SCISSORS
- GLASS
- WATER
- 5 PIPETTES
- 5 HEXNUTS
- PERMANENT MARKER
- 1 LITER BOTTLE WITH CAP

▶ TAKE IT FURTHER - HOOK

- 1 Wrap one end of the blue wire several times around the pipette stem stump of a Cartesian diver you've already tested. Make sure you wrap the wire between the bulb and hex nut. Shape the other end of the blue wire into a giant, J-shaped hook.
- 2 Wrap one end of the red wire around the stem stump of the second diver between the bulb and the hex nut. Loop it over the diver's bulb and wrap the other end around the stem stump, too. This diver will act as the sinker.
- 3 Set up a float test for the sinker in the large plastic cup, just as you did when you built the first Cartesian diver. This time, however, fill the sinker with enough water so it barely sinks to the bottom of the cup.
- 4 Pull the sinker out of the test cup and drop it into the top of the 1 liter bottle. Make sure the bottle is absolutely full with water (the diver won't work if there's any air in the bottle). Check the bulb to make sure that it hasn't lost any water and then drop the diver with the hook into the bottle. Top off the bottle with water. Screw the cap on the bottle as tightly as you can.
- 5 Squeeze the sides of the bottle. The hook will dive to the bottom. The object of the game is to catch the sinker with the hook and lift it to the surface. You may have to make some adjustments on both the hook and sinker to get this to work, but it's all part of the game!

WHAT YOU NEED

- 1 LENGTH OF RED COATED WIRE (LOOP)
- 1 LENGTH OF BLUE COATED WIRE (HOOK)
- 2 GRADUATED PIPETTE
- 2 HEX NUT
- 1 LITER BOTTLE WITH CAP

SCIENCE FAIR CONNECTION

Making an eye dropper move up and down is pretty cool, but it isn't a science fair project. You can create a science fair project by identifying a variable, or something that changes, in this experiment. Let's take a look at some of the variable options that might work.

- ▶ Try changing the size of the plastic bottle or eye dropper. Does the size affect how hard you have to squeeze to make the diver move?
- ▶ Try changing the water temperature. Do different temperatures affect the density of the diver?

These are just a couple of ideas, but you aren't limited to those! Try coming up with different ideas of variables and give them a try. Remember, you can only change one thing at a time. If you are testing different bottle sizes, make sure that the other factors remain the same!

TEACHER NOTES:

SCIENCE CONCEPTS OVERVIEW ▶ Density, Buoyancy

The learning experiences contained in the following Experiment Guide are designed to engage students and deepen understanding, not only of the underlying scientific concepts upon which these experiments/demonstrations are built, but also of critical thinking and problem solving skills. Teachers should allow students to actively participate in each activity as an investigation, where questions are being asked, hypotheses are developed and redeveloped, and where students own the discoveries. Vocabulary was included, assessments were created and critical thinking questions were designed with this underlying goal in mind.

The following are some suggested teaching points that could accompany this experiment/demonstration:

SICK Science Teaching Points: The SICK Science video can be utilized in a variety of ways. It can be used to introduce a scientific concept or in place of doing the demonstration/experiment if materials are unavailable. The video can also be used as a review or to help students complete the various learning experiences included in this guide. The video can also be used as a review or to help students complete the various learning experiences included in this guide.

Visit the landing page below to locate the appropriate video for this activity
stevespangler.com/sick-science-resources

Vocabulary: Students will enhance their science-content related vocabulary. You may choose to introduce the vocabulary words and explicitly teach the meaning of each. You may also use the vocabulary words as an investigation, where students may research the meanings of the words. Finally, students may develop their own meaning for each word through their experience with the experiments and critical thinking work.

Scientific Method: Students can complete a full lab report for the demonstration, including asking questions, identifying variables, forming a hypothesis, designing the experiment, collecting data, and drawing conclusions. Differentiation using the lab report is easy. For lower levels, complete the lab report as a class. As students are more independent, encourage students to work in partnerships or groups to complete the lab report. Eventually, students should be able to complete the lab report independently or design a new experiment using the lab report form based on the demonstration completed in class.

Paraphrase: Students will be able to restate the main idea of buoyancy in their own language.

Inference: Students will use knowledge gained from the demonstration to make judgements about outcomes and conditions of changing density.

Real World Application: Students will be able to apply their critical thinking strategies and scientific concepts to a real world scenario.

Literature Connections: The Pearl Diver by Julia Johnson is non-fiction chapter book about pearl divers in Dubai. This is a great text to engage intermediate students in the concept of diving.

Pete the Cat, Scuba Cat by James Dean is always a favorite for the primary grades. With this text, young students can get excited about the science of diving with one of their favorite characters of all time.

Writing Connections: Students can research how submarines or scuba divers control their own buoyancy and depth in the water. They should write an informational piece about how these buoyancy control devices work. They may present their findings to others in the form of a song, poster, poem, skit, etc.



Expert Vocabulary

NAME _____

WORDS AND DEFINITIONS —

Match the word on the left with the correct definition on the right by filling in the blank with the correct letter.

VOCABULARY WORDS

DEFINITIONS

1 ____ **Buoyancy**

 To press or squeeze together.

2 ____ **Compress**

 The ability of an object to float in water or air.

3 ____ **Expand**

 The force exerted on an object by something around it.

4 ____ **Density**

 Increases in size, range, or amount.

5 ____ **Pressure**

 The measurement of how much "stuff" is packed into a measured space.



Critical Thinking

NAME _____

PARAPHRASE —

Students will be able to restate the main idea of buoyancy in their own language.

Why does the eyedropper sink when you squeeze the bottle? Why does it float back to the top when you release the bottle? Explain using words or labeled diagrams to show your thinking.



Critical Thinking

NAME _____

INFERENCE —

Students will use knowledge gained from the demonstration to make judgements about outcomes and conditions of changing density.

What do you infer would change if you put more water into the eyedropper to start with? What if you used less water? Explain why you think this.



Critical Thinking

NAME _____

REAL WORLD APPLICATION —

Students will be able to apply their critical thinking strategies and scientific concepts to a real world scenario.

A submarine dives down into the water by filling ballast tanks with water while simultaneously releasing air from the tanks. The submarine continues this process until it has achieved the correct density, which allows it to travel at the desired depth. Explain how this is similar to or different from the Cartesian diver demonstration.



Assessment

NAME _____

ASSESSMENT QUESTIONS —

Read each question, then circle the letter next to the correct answer or write your response on the back of this page or in the box.

- 1 When the bottle is squeezed, the air inside of the eyedropper
 - a. expands.
 - b. compresses.
 - c. becomes more dense.
 - d. heats up.

- 2 As density increases, buoyancy
 - a. increases.
 - b. decreases.
 - c. stays the same.
 - d. compresses.

- 3 Why does squeezing the bottle cause the water to enter the eyedropper?
 - a. The squeezing heats the water inside of the bottle.
 - b. The squeezing decreases the pressure in the bottle.
 - c. The squeezing increases the pressure in the bottle.
 - d. The squeezing increases the density of the water.

- 4 Why is it important to have the bottle filled to the top with water before squeezing?

- 5 In your own words, explain how the density of an object affects its buoyancy.



Expert Vocabulary - Answer Key

WORDS AND DEFINITIONS —

Match the word on the left with the correct definition on the right by filling in the blank with the correct letter.

VOCABULARY WORDS

DEFINITIONS

1 **(B)** Buoyancy

(A) To press or squeeze together.

2 **(A)** Compress

(B) The ability of an object to float in water or air.

3 **(D)** Expand

(C) The force exerted on an object by something around it.

4 **(E)** Density

(D) Increases in size, range, or amount.

5 **(C)** Pressure

(E) The measurement of how much "stuff" is packed into a measured space.



Critical Thinking- Answer Key

PARAPHRASE —

Students will be able to restate the main idea of buoyancy in their own language.

Why does the eyedropper sink when you squeeze the bottle? Why does it float back to the top when you release the bottle? Explain using words or labeled diagrams to show your thinking.

Possible Answer:

The eyedropper sinks when you squeeze the bottle because more water is forced into the eyedropper, making it less buoyant. The space for the extra water comes from the air inside of the eyedropper compressing together. When you release the bottle, the air expands and pushes some of the water back out of the eyedropper. This makes the eyedropper more buoyant and it floats back to the top of the bottle.



Critical Thinking- Answer Key

INFERENCE —

Students will use knowledge gained from the demonstration to make judgements about outcomes and conditions of changing density.

What do you infer would change if you put more water into the eyedropper to start with? What if you used less water? Explain why you think this.

Possible Answer:

I think that if you started with more water in the eyedropper, the eyedropper would sink more easily. I think this because it would take less additional water inside the eyedropper to make it lose its buoyancy. If you started with less water in the eyedropper, it would make it more difficult to sink. You would probably have to squeeze the bottle harder to get more water into the eyedropper and make it sink.



Critical Thinking- Answer Key

REAL WORLD APPLICATION —

Students will be able to apply their critical thinking strategies and scientific concepts to a real world scenario.

A submarine dives down into the water by filling ballast tanks with water while simultaneously releasing air from the tanks. The submarine continues this process until it has achieved the correct density which allows it to travel at the desired depth. Explain how this is similar to or different from the Cartesian Diver demonstration.

Possible Answer:

Submarines are similar to our Cartesian diver in that they both use density to achieve their desired depth. Both the Cartesian diver and the submarine add water to increase density and lose buoyancy. However, the submarine is also able to release air which allows to to take in more water. The Cartesian diver cannot release air, so the air compresses, limiting the amount of water that can be taken in.



Assessment - Answer Key

ASSESSMENT QUESTIONS —

Read each question, then circle the letter next to the correct answer or write your response in the boxes.

- 1 When the bottle is squeezed, the air inside of the eyedropper
 - a. expands.
 - b. compresses.
 - c. becomes more dense.
 - d. heats up.

- 2 As density increases, buoyancy
 - a. increases.
 - b. decreases.
 - c. stays the same.
 - d. compresses.

- 3 Why does squeezing the bottle cause the water to enter the eyedropper?
 - a. The squeezing heats the water inside of the bottle.
 - b. The squeezing decreases the pressure in the bottle.
 - c. The squeezing increases the pressure in the bottle.
 - d. The squeezing increases the density of the water.

- 4 Why is it important to have the bottle filled to the top with water before squeezing?

Possible Answer:
It is important to have the bottle filled all the way to the top with water before squeezing to make sure that there is no extra air in the bottle. Extra air in the bottle would also compress when the bottle is squeezed, making it more difficult to squeeze hard enough to get extra water into the eyedropper.

- 5 In your own words, explain how the density of an object affects its buoyancy.

Possible Answer:
The density of an object determines its buoyancy in air or water. If the density of an object is higher than the density of its environment, it will have a low buoyancy (it will sink). If its density is less than the environment around it, it will have a higher buoyancy (it will float). When the eyedropper in the activity had more air and less water in it, it floated because it was less dense than the water. When the eyedropper had less air and more water it sunk to the bottom because it was denser than the water.

Common Core State Standards

Student Outcomes	Standards
Students will be able to ask and answer questions about key details about their observations and discussion to demonstrate their understanding of the scientific concepts presented through the experiment.	RI.K.1, RI.1.1, RI.2.1, RI.3.1, RI.4.1
Students will be able to ask and answer questions to help determine the meaning of vocabulary presented as part of an experiment.	RI.K.4, RI.1.4, RI.2.4, RI.3.4, RI.4.4, RI.5.4
Students will be able to explain the connection between scientific ideas presented in the experiment.	RI.1.3, RI.2.3, RI.3.3, RI.4.3, RI.5.3
Students will be able to retell key details presented in the experiment in order to understand/determine the main idea.	RI.K.2, RI.1.2, RI.2.2, RI.3.2, RI.4.2, RI.5.2
Students will be able to write an informative/explanatory text that includes facts.	W.K.2, W.1.2, W.2.2, W.3.2, W.4.2, W.5.2
Explain the procedure and ideas presented in a scientific experiment including what happened and why, including cause and effect, based on the information presented.	RI.3.3, RI.4.3
Students will be able to use information gained from observations of the experiment to demonstrate understanding of the concepts presented, including how a diagram can clarify understanding.	RI.2.7, RI.3.7
Students will be able to draw inferences from a specific scientific learning experience.	RI.4.1, RI.5.1