

# CARTESIAN DIVER (1 Hour)

Addresses NGSS

Level of Difficulty: 2

Grade Range: K-2

## OVERVIEW

In this activity, students will build a Cartesian diver and discover how compression and changes in density cause the diver to mysteriously move up and down.

**Topic: Density and Buoyancy**

### Real-World Science Topics

- The floating and sinking of fish
- Buoyancy control devices used by divers
- Submarines
- Life jackets

### Objective

Students will explore factors that affect buoyancy by constructing and experimenting with a Cartesian diver.

### NGSS Three-Dimensions

#### Science and Engineering Practices

##### Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in K-2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions.

- Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena

##### Scientific Knowledge is Based on Empirical Evidence

- Scientists look for patterns and order when making observations about the world.

#### Disciplinary Core Ideas

##### PS1.A: Structure and Properties of Matter

- Different kinds of matter exist and many of them can be either solid or liquid, depending on temperature. Matter can be described and classified by its observable properties. Different properties are suited to different purposes. A great variety of objects can be built up from a small set of pieces.

#### Crosscutting Concepts

##### Patterns

- Patterns in the natural and human designed world can be observed.

##### Cause and Effect

- Events have causes that generate observable patterns. Simple tests can be designed to gather evidence to support or refute student ideas about causes.

# CARTESIAN DIVER

## Background Information

Buoyancy is the phenomenon (discovered by Archimedes) that an object less dense than a fluid will float in the fluid. More specifically, Archimedes' principle states that a fluid will exert an upward force on an object immersed in it equal to the weight of the fluid displaced by the object.

Why does a cruise ship float? According to Archimedes' Principle, if a boat weighs 50,000 tons, it would sink until it displaces 50,000 tons of water. Ships are designed so that they are less dense than water. Extra-strength steel is more dense than water, so the hull (or body) of the ship actually contains a lot of empty space. Engineers make the hull rounded, wide and deep.

Life jackets contain foams that trap air in pockets when submerged. The air pockets give them a lowered density which makes them buoyant. When a scuba diver submerges deep into water, the air bubbles in his wet suit become compressed. This causes the diver to become denser. To compensate, a scuba diver wears a buoyancy control device called a BCD. It is an inflatable life vest that inflates as the diver goes deeper. This adjusts the density of the diver so he neither floats nor sinks at any depth. When the diver rises to the surface, he becomes less dense as air bubbles in his wet suit expand. This causes him to rise faster and faster towards the surface. To slow down the ascent, the BCD releases air slowly.

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## Key Vocabulary

**Buoyancy**- the ability or tendency to float or the power of a liquid to keep something afloat

**Density** - how much mass is contained in a unit of volume

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## Materials Needed for the Student Activity

### For warm-up demonstration:

- Ping-pong ball
- Golf ball
- Tennis ball
- Orange
- Volleyball
- Large clear storage container of water

### For the activity, each group will need:

- One clear 2-liter soda bottle per group (label removed)
- Sink or pitcher of water
- Cup
- Half of a straw
- One paperclip
- 5 small washers (size #8 works well)



# STEPS FOR *CARTESIAN DIVER*

## Teacher Preparation

One week in advance of activity, ask students to bring in empty 2-liter soda bottles (with the caps). Remove the labels.

Obtain all other materials. Practice the demonstrations to make sure they go as planned.

Cut straws in half. Build a Cartesian diver with the washers that you obtained. Follow the instructions on the handout. Adjust the number of washers needed in the procedure if your washers are bigger or smaller than size #8.

## Steps

**1. Warm-up Activity:** Tell the class you are going to play SINK or FLOAT! Hold up a ping pong ball. Let students yell if they think it will SINK or FLOAT. Ask one student for their reasoning. Then place the ping pong ball in the water and see what happens. Repeat for a golf ball, tennis ball, orange, and a volleyball. The golf ball will be the only one that sinks. Discuss the results with the class. The students may think the golf ball sinks because it is the heaviest. Ask, can heavy objects float? Yes, for example, a cruise ship can float. Be sure to highlight that size (volume) and weight (mass) play a role. Lead the students to the conclusion that the density of an object helps to determine whether or not it floats.



Density is how much matter is in a certain volume. An object that is small and heavy (such as a shot put) is very dense. An object can also be very large, but light (like a giant balloon). It would therefore not be very dense. Objects that contain air are often not very dense.

Now peel the orange. Ask the class if it will float or sink. Listen to several responses. Place the peeled orange in the water. It sinks. Elicit from the students that the orange must be denser after you peel it. The peel traps air and decreases the overall density of the orange.

- 2.** Tell the class they will be making a Cartesian Diver – a science toy they can use to amaze their family! Distribute the Student Handout. Demonstrate to the class how to make the diver. Divide students into groups and let them begin the activity.
- 3. Wrap-up Activity:** Propose the question: How do fish float and sink in water? They have a small sac inside their bodies. This small sac contains a small air bubble. Ask the class, what does a fish need to do to sink? When they squeeze the sac with their muscles, it makes the bubble smaller. The fish becomes denser, and it sinks. What does the fish need to do in order to float upward? When the fish relaxes his muscles, the air bubble gets bigger, the fish becomes less dense and he floats upward.

This is the same idea used to raise and lower a submarine. Water is pumped into tanks inside the submarine to make it sink. Water is pumped out of the tanks to make it rise.

# STEPS FOR *CARTESIAN DIVER*

## What Goes Down, Must Come Up Extension Activity

Students can make predictions and then test them for the following questions:

- How does changing the temperature of the water in the bottle affect the diver?
- What happens if the bottle is not completely full of water?
- What if fluid with a different density is used in the bottle?
- How will the diver react if two different fluids (of different densities) are in the bottle (such as vegetable oil and water)?

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## Sources

<http://physics.about.com/>

<http://science.howstuffworks.com/>

<http://www.ehow.com/>

<http://www.fatlion.com/science/>

<http://www.ncsu.edu/>

<http://www.sciencekids.co.nz/>

# CARTESIAN DIVER

STUDENT HANDOUT

Name:

Date:

## Step 1: Build and Get to Know Your Diver

Build a diver:

Fold the piece of straw in half.

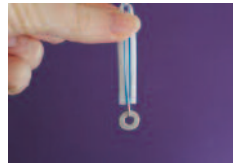


Use a paperclip to hold straw in this position.

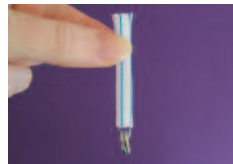


Place diver in a cup of water. What happens?

Remove paperclip, slide one washer onto paperclip.  
Slide paperclip back onto straw.  
Place the diver in a cup of water. What happens?



Add 2 more washers. Now there are three washers on the diver. Place the diver in the water. What happens?



Add 2 more washers. Now there are five washers on the diver. Place the diver in the water. What happens?



# CARTESIAN DIVER

## STUDENT HANDOUT

### Step 2: See Diver in Action

Take off two washers. There should be three washers on the diver.

Fill a soda bottle to the top with water.

Put diver in the bottle.

Put cap on the bottle.

Squeeze the bottle. What happens?

Where do you think some of the water goes when you squeeze the bottle?

Does the diver become lighter or heavier?

Does the diver become more or less dense?

Stop squeezing the bottle. What happens?

Why do you think that happens?

Try to make the diver hover in the middle of the bottle. Can you do it? Describe how.

# CARTESIAN DIVER

## TEACHER HANDOUT

### Step 1: Build and Get to Know Your Diver

Build a diver:

Fold the piece of straw in half.



Use a paperclip to hold straw in this position.



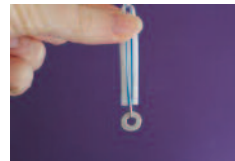
Place diver in a cup of water. What happens?

It falls on its side and floats

Remove paperclip, slide one washer onto paperclip.  
Slide paperclip back onto straw.

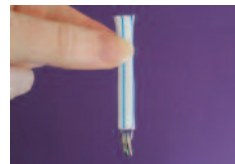
Place the diver in a cup of water. What happens?

It stands up right and sinks  
a little into the water



Add 2 more washers. Now there are three washers on the diver. Place the diver in the water. What happens?

It sinks farther down into the water but  
It is not all the way into the water



Add 2 more washers. Now there are five washers on the diver. Place the diver in the water. What happens?

It sinks all the way down to the bottom



# CARTESIAN DIVER

## TEACHER HANDOUT

### Step 2: See Diver in Action

Take off two washers. There should be three washers on the diver.

Fill a soda bottle to the top with water.

Put diver in the bottle.

Put cap on the bottle.

Squeeze the bottle. What happens?

The diver goes down

Where do you think some of the water goes when you squeeze the bottle?

Into the straw (diver)

Does the diver become lighter or heavier?

Heavier

Does the diver become more or less dense?

More

Stop squeezing the bottle. What happens?

The diver goes up

Why do you think that happens?

Water goes out of straw (diver) and it becomes lighter and less dense

Try to make the diver hover in the middle of the bottle. Can you do it? Describe how.

Answers will vary