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Educational Innovations, Inc.®

Cartesian Divers

PP-222 / CD-3 / CDH-413 / CDH-422

What is a Cartesian Diver?

Cartesian divers are one of the oldest and most interesting toys you can build at home. While they are easy to construct, there is a lot of science behind this deceivingly simple toy. A Cartesian diver is an object whose density changes with pressure. In fact, most Cartesian divers become denser as pressure is increased. By constructing a Cartesian diver carefully, it is possible to make a diver that floats in water at atmospheric pressure, and sinks when the pressure is increased.

How does it work?

Water has a density of about 1 gram/ml. Objects that have a density of less than 1 gram/ml float, while objects with a density greater than 1 gram/ml sink. As pressure is increased, a Cartesian diver's density might increase from about 0.8 grams/ml to 1.2 grams/ml. When this happens, the diver sinks in the water.

Cartesian divers often change their density by changing the amount of water they displace (i.e., changing their volume). When the pressure is increased, the air inside the diver is compressed. This compressed air takes up less space, and thus displaces less water. As less water is displaced, the density of the diver appears to increase and, as a result, the diver sinks.

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Using Your Cartesian Divers

Materials (Required):

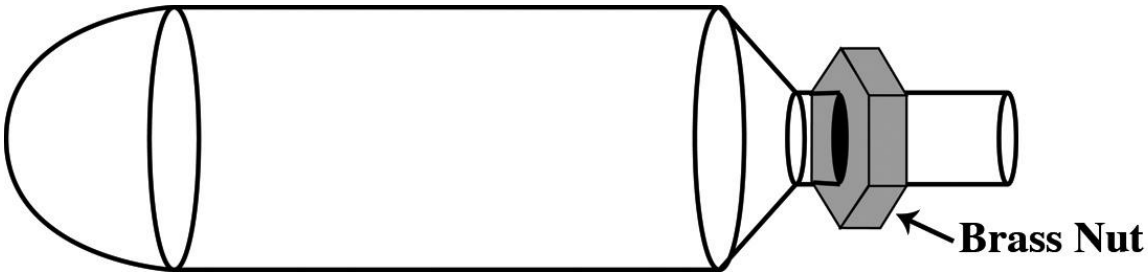
- 1 Plastic Pipet (PP-222)
- 1 Ballast Nut (CD-3)
- Plastic Soda Bottle with Top (BOT-600)
- Scissors
- Plastic Cup
- Water

Materials (Optional):

- Fizz-Keeper Pump Cap (CD-4)
- Food Coloring
- Candle
- Pliers
- Aluminum Foil
- Hot Melt Glue Gun

1. With scissors, snip off all but 2 cm of the neck of each pipet.

2. Screw one ballast nut onto the remaining 2 cm neck of each pipet.

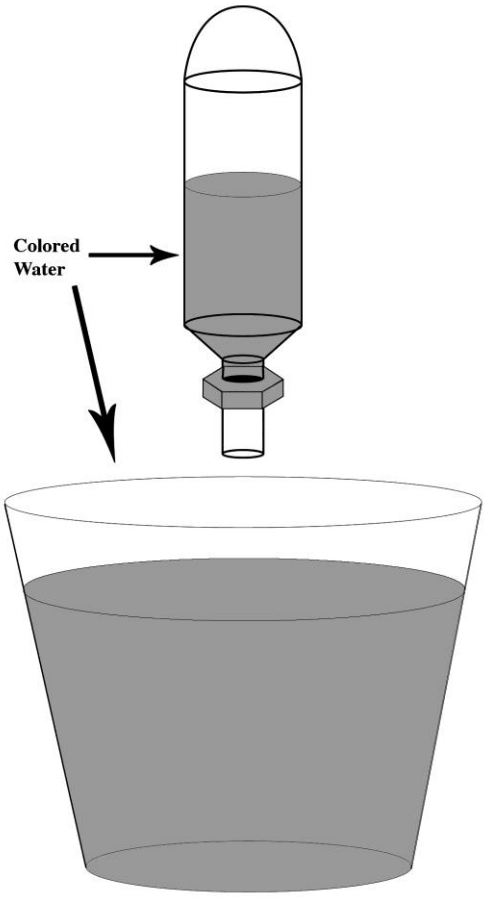


3. Fill each pipet bulb with colored water. Note that the bulbs must float when placed in a cup of water. Experiment with different amounts of water, making sure that the bulbs still float. Bulbs that float higher in a cup of water will make divers that are more difficult to sink.

Using Your Cartesian Divers

continued

4. Your Cartesian divers are ready! Fill a 1- or 2-liter plastic soda bottle almost to the top with water. Place your divers in the bottle and screw on the Fizz-Keeper pump cap. Try squeezing the bottle. Can you make your divers sink? Now pump the Fizz-Keeper and watch as your divers sink right to the bottom. Can you figure out how to get them back up to the top?



5. Remove the pump cap, pour out your divers, and try varying their buoyancy. Try filling them with different amounts of water. Put them back in the bottle, replace the pump cap and try sinking them again.

6. When you are satisfied with your divers and would like to make them permanent, you can seal them by sealing the open end of the bulb. This can be done with any waterproof glue or by melting the plastic slightly and squeezing it gently with small pliers. To seal the bulb by melting, first make sure your bulb floats. ***ONCE IT IS SEALED, ITS STARTING BUOYANCY CANNOT BE CHANGED!*** Make sure there is no water in the neck by holding it upside down and tapping or squeezing it slightly. Hold the neck about 1-2 inches above a candle flame until it becomes completely transparent (the change is very subtle). Immediately remove the neck from above the flame and squeeze the end gently with pliers to seal. Let cool. Return your divers to the bottle with clean water and they will last for many years.

There are literally hundreds of experiments you can try! For instance, try crumpling up a piece of aluminum foil into a small ball. Place this in your bottle. See if you can sink it by squeezing the bottle. How about pumping it?

Try numbering your divers and see if you can make them sink in order. Note that your divers are not yet sealed, and so they can be adjusted as many times as you like (colored water will leak out of them until they are sealed).

Take Your Lesson Further

As science teachers ourselves, we know how much effort goes into preparing lessons. For us, "*Teachers Serving Teachers*" isn't just a slogan—it's our promise to you!

Please visit our website for more lesson ideas:

TeacherSource.com/lessons

Check our blog for classroom-tested teaching plans on dozens of topics:

http://blog.TeacherSource.com

To extend your lesson, consider these Educational Innovations products:

One Dozen 1-Liter Bottles & Caps (BOT-600)

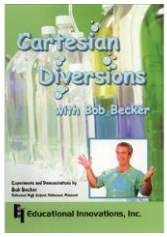
Brand new, clean soda bottles with caps are great for teacher workshops and classroom activities. They are perfect for making Tornado Tube Bottles, Cartesian Divers, Bottle Biology experiments, and storing aqueous solutions. Soda bottles for experiments are increasingly more difficult to get, as recycling machines now shred returned bottles on the spot!

Cartesian Diversions Class Kit (CDK-625)

The Cartesian Diversions Class Kit is a great hands-on way for students to learn about air pressure!

Each kit comes with 60 ballast nuts, 60 pipets, 1 Fizz-Keeper Pump, 1 sheet of acetate, 2 ft. of coated copper wire, 5 pipe cleaners, 3 permanent markers, 4 ft of fishing line, 3 sheets of colored craft foam, and 2 ft. of yarn—enough to make 60 divers! Your students will love creatively decorating their divers while learning all about what makes them tick! Includes 42 page instruction booklet.

Cartesian Diversions DVD (CD-900DVD)



Bob Becker, a pioneer in the field of Cartesian divers, demonstrates and discusses a plethora of fascinating diver designs. After seeing this DVD, we guarantee this is one subject your students will want to dive into. Includes DVD-ROM content for use in your classroom such as project guides and templates.

Fizz-Keeper Pump (CD-4)

Designed to keep the carbonation in one- and two-liter plastic soda bottles, these pumps are perfect for Cartesian Diver experiments. Simply place your diver in a plastic soda bottle filled with water, screw on a Fizz-Keeper Pump cap, and pump away! With the pump, even young children with small hands can easily operate the diver.

Pipets (PP-222)

At 25 drops per milliliter (40 microliters per drop), these pipets are perfect for approximate measurements up to one ml at 0.25 ml graduations. We have found that this size pipet is just right for making super Cartesian Divers! These pipets are so useful, it's always good to have a few around.