

Educational Innovations[®]

PP-222

CD-3

Cartesian Divers

Instructions

Materials (Required):

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

Materials (Optional):

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

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 the workings of this deceptively 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.

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 .8 grams/ml to 1.2 grams/ml. When this happens, the diver sinks in 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 the diver sinks.



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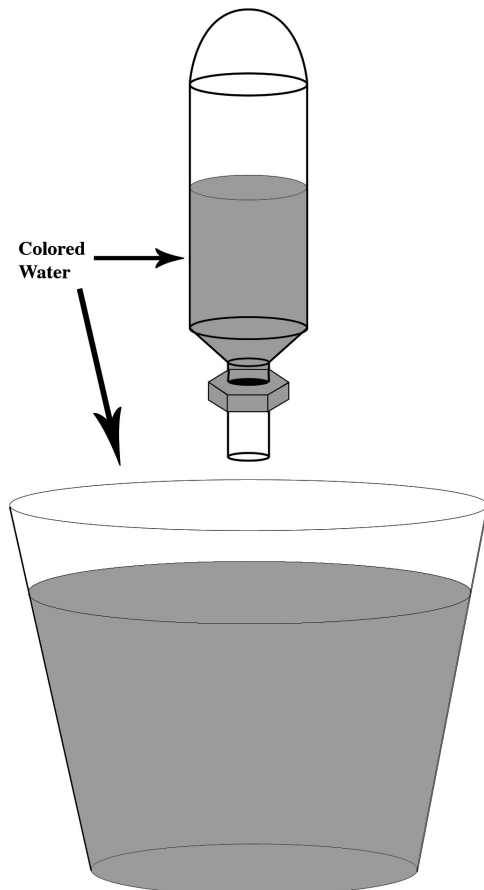
1. With scissors, snip off all but 2 cm of the neck of each pipet.



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.



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).