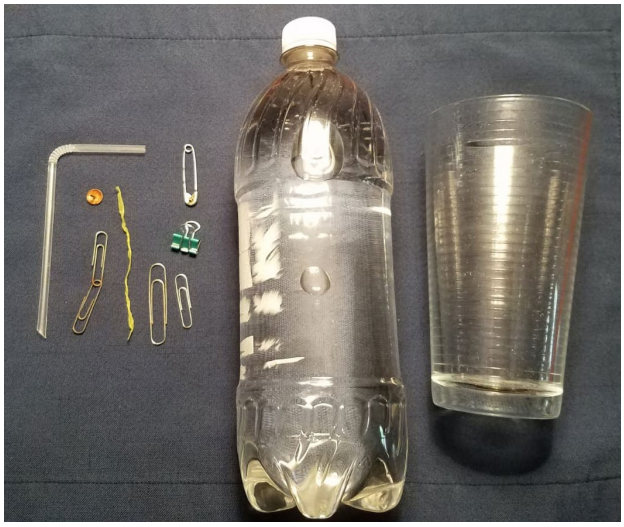
Build Your Own Cartesian Diver Using a Juice Box Straw

A Cartesian Diver is a toy based on scientific principles that you can make yourself using things found around the house. The Cartesian Diver sinks or floats when gas pressure (and volume) change inside the diver. A Cartesian Diver toy can be made using any object that contains air, can be compressed to reduce the volume of air, and can have ballast attached. (Ballast is weight in addition to the weight of the diver itself.) Some options for a diver are an eye dropper, an unopened ketchup, mustard, or mayo pack that floats in a glass of water, a balloon minimally filled with air, a pen with the ink cartridge removed, and a bent soda straw/juice box straw with bobby-pin or paperclip ballast.

This activity provides directions for making a Cartesian Diver with a juice box straw. ICE has at least one other Cartesian-Diver activity as an alternative if you don't have the materials for this one.

Materials

- A 1-L (quart-sized) or 2-L (half gallon) plastic bottle. You need to be able to see the diver inside this bottle, so try to find one that is clear and colorless and remove the labels.
- Paper clips, safety pins, and/or bobby pins to be used as ballast weights.
- A clear plastic cup that is tall enough to contain the diver (the straw standing vertically). (A glass will work but be careful not to break it.)
- A twist-tie.
- Water. (It is a good idea to do this in the kitchen because the water can be spilled.)



This activity is courtesy of ICE, the Institute for Chemical Education at UW-Madison's Chemistry Department. This activity was adapted from the ACS Celebrating Chemistry Cartesian Diver Activity found here: https://www.acs.org/content/dam/acsorg/education/resources/k-8/science-activities/solidsliquidsgases/gases/cartesian-diver-science-for-kids.pdf

Construct the Cartesian Diver

1. Fill a clear cup with water. This is your test site for the diver before you put it into the 1-L or 2-L plastic bottle.

2. Bend the juice box straw at the bend section. Add ballast to your straw, using the paper clips, safety pins, and/or bobby pins.

3. Use a twist-tie to tie the two straight sections of the straw together.

Step 2

Step 3

4. Make sure there is air in the straw. Then place the diver into the water in the cup, open ends down. Add ballast until the diver sinks and then remove one paperclip or bobby pin. The diver should barely float in the water.

Step 4

5. Make sure the labels have been removed from the 1-L or 2-L plastic bottle and fill the bottle with water.

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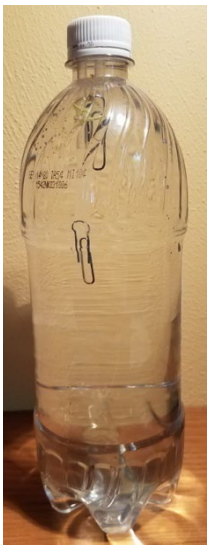
6. Add your Cartesian Diver to the bottle and then close the cap tightly. The bottle should be full enough that water runs down the side of the bottle when the cap is tightened.

7. Squeeze the bottle. The Cartesian Diver should sink when the bottle is squeezed and rise when you let go.



Step 6

Step 7

Troubleshooting

- *The straw diver keeps sinking with weights added…*

Test many combinations of ballast (weights). Depending on the size of the straw, more or fewer may be needed.

- *The straw diver does not dive when the bottle is squeezed…*

This is the most difficult part of the activity to troubleshoot. Make sure your bottle is filled completely and that the cap is on tightly. If these two suggestions do not solve the setback, add additional ballast to the straw. The diver should readily dive when the bottle is squeezed. Some bottles are made of stronger plastic than other bottles. A 2L bottle is the easiest to squeeze.

What Happened? What Are the Scientific Principles?

- *Why does the Cartesian Diver sink when the bottle is squeezed?*

  Carefully observe the soda straw when it is floating in the water. How high is the water level inside the straw when it is floating? What occupies the space above the water inside of the straw? Now squeeze the bottle and watch the water level inside the straw as the diver sinks. What changes?

  Initially, the density of the juice box straw, ballast, and air in the diver system is less than that of the water, so the diver floats. When the bottle is squeezed, water compresses the air pocket inside the juice box straw. This decreases the

volume of straw + ballast + air, but the mass stays the same. Thus, the density of the straw + ballast + air increases and the diver sinks.

- *What kinds of experiments were needed to get the Cartesian Diver to work?*
- Trial and error is a major part of what researchers do! Researchers learn from both successes and failures in the laboratory. Even if initial attempt to make a Cartesian Diver sinks directly to the bottom of the glass of water, you can learn something and make a better, more informed decision about how to design a diver that works. The activity is all about testing different combinations of ballast and air inside the soda straw. Which work, which don't, and why?

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