Cartesian Diver Lab Pack

F09L

Contents

Soy sauce fish container	24
Stainless steel flat washers (3/16")	50

You will also need

- Clear, plastic soft drink bottles 600 mL to 1.5 L
- Tall plastic glasses or tubs with water
- Paper towel

In Japan & Australia most sushi shops supply their traditional soy sauce in small plastic fish-shaped containers. These make excellent cartesian divers in the classroom as they have clear walls and screw-on caps. And of course they are fish shaped!

PROCEDURE (for 24 students)

1. Each student gets a fish and two washers and should have access to a water tub or tall plastic glass filled with water. And a waste cup too.

2. Unscrew the red lid from the fish and carefully squeeze **25 drops** of the sauce from the fish into the waste cup.

3. Screw **two** of the washers to the threaded mouth of the fish without losing more sauce! Then screw the lid on tightly.

4. Note: The fish first has to be calibrated in a glass of water so its density is close to that of water. Only then can it be transferred to the soft drink bottle.

   Place the fish in the water in the glass or tub, head first. It will probably go to the bottom of the tub or glass, showing that it is denser than water. If this is the case, take it out, unscrew the lid and squeeze another 3 drops of the soy sauce from it. Let air in, screw the lid back on and try to float it in the water again.

5. Keep doing this until the fish barely floats, squeezing 2 to 3 drops at a time. The object is to barely float the fish **just below the surface** of the water. This is when its density will be close to that of the water.

6. If the fish floats partially above the water it means too much sauce (liquid) has been squeezed out and its density is now less than that of the water. The fish then needs to take in more water. Do this by holding the fish under water and squeezing 2 or 3 air bubbles from it. Then relax the sides under water so it takes in water. Screw the lid back on.

7. When its density is fine you can transfer the fish to the empty bottle and then fill the soft drink bottle **right to the brim** with water and seal it tightly.

8. The fish should float at the top. And now to test it: Squeeze the bottle and the fish should dive!

Notes

★ If you only use one washer then the little ones in the class will need to squeeze much harder to make the fish dive as it will have less air in it.
★ Very important to fill the bottle to the brim so there is no air trapped in the bottle.
★ The students should be able to see the movement of the sauce in the fish as it moves up and down. As for the air in the fish: When the pressure goes up, the volume goes down . . .
★ If the fish does not dive, its density is too low. Suck more water into it.
★ If the fish stays at the bottom, its density is too high. Squeeze a few drops of water from it.
★ If you have stored the bottle, first release the air from the bottle, fill it to the brim with water and seal it again.

Extensions

✦ Change the number of washers.
✦ Let older students discover themselves how to manipulate the fish's density.
✦ Increase the water's density: Dissolve sugar or salt in the water.
✦ Study the temperature effect: Place the bottle in the fridge and then in the sun.
✦ Make a density column diver. Layer several liquids with differing densities inside the bottle. Try the following: corn syrup, dishwashing liquid, water, vegetable oil and rubbing alcohol (order of decreasing density). Drop in divers with different buoyancies. A diver will choose its location according to its density and that of the liquid.
✦ Find out how all of this relates to the functioning of a submarine. (It uses water and compressed air to facilitate the dive and surface motion.)
✦ Look up Boyle's Gas Law and explain how the air in the diver obeys this Law. (When the pressure goes up, the volume goes down . . .)

The Science of the Diving Fish

This is a Cartesian Diver and **two principles** apply here:

A. The first is about the **density** of the two objects: water & fish.

Density is simply a result of an object's spread of mass:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

An object that is less dense than water, such as a log, can float in water. An object that is more dense, such as a rock, will sink. Initially with the fish barely floating, the fish's density is about that of the water.
When we squeeze the bottle, pressure is exerted on the water and this is transferred to the fish. The fish's body is flexible and thus its volume decreases (the mass stays constant) and consequently its density increases and it dives.

Likewise, if we release the squeeze, the fish's air volume increases and the density decreases. This causes the fish to surface. The fish is essentially a **barometer**, indicating the outside pressure on the bottle.

B. There is a second principle too which is basically just an extension of the above:

More than 2000 years ago, Archimedes found that an object weighs less in water than in air because of the upwards thrust of the water, called **buoyancy.** This partly supports the object. He simply found that a boat will float *when the weight of water that it displaces equals the weight of the ship (**Archimedes' principle**).*

Acknowledgements

Our sincere thanks to Jenny Kelly & Julie Stallwood of Ivanhoe Grammar School in Melbourne for sharing the idea to use a Sushi fish shaped container.