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# Vortex Bottle Connectors

SS-1 / 120 / 125 / 130

## What is a Vortex Bottle Connector?

The Vortex Bottle Connector is a plastic adapter fitted so that two plastic soda bottles can be held together in order to create a vortex in the top bottle. It works by flipping and then spinning the top bottle so that air begins to replace the water in the top bottle, forming a vortex shape. This phenomenon may have originally been discovered when soda fountain managers poured the syrup out of gallon jugs in order to clean them. They found that by spinning the top bottle, the liquid would flow more quickly. Our Vortex Bottle Connectors can be used to demonstrate the properties of a nearly frictionless liquid within a bottle and to show how two substances cannot take up the same space.

# Elementary / Middle School Student Experiments:

## Let's Race!

### Materials:

Two Vortex Bottle Connectors
Four 1-liter Plastic Bottles (BOT-600)
Two MyChron Student Timers (TIM-700)
Water

### Procedure:

Before class, set up two dual bottle systems with the same amount of water in each. Give one set to a student (your competitor) and keep one for yourself. Explain to the class that you and your competitor will be racing to see who can completely empty the water from the top bottle first. Give MyChron timers to two other students (your time keepers) so that they can keep track of how long it takes for you and your competitor to empty your top bottles. Position yourself back-to-back with your competitor so you each can't see what the other one is doing. Ready, set, go—flip the bottle over, and let the race begin! Briefly spin your top bottle once you flip it over in order to create a vortex. This will cause your water to flow faster than your competitor's.


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# Replacing Air

## Materials:

One Vortex Bottle Connector
Two 1-liter Plastic Bottles (BOT-600)
Water

## Procedure:

1. Start by using clear water in the bottles. Fill up one bottle almost completely, around five-sixths of the way full. Then attach the adapter and the second bottle.
2. Ask your students, "What's in these bottles?" They will most likely say water.
3. Now flip the bottles *without* spinning the top one. The water should hold in place (mostly). Ask your students, "If water is the only thing inside these bottles, why isn't it moving down into the lower bottle?" Explain that each bottle also contains air, which takes up space—even if we cannot see it. In order for the water to go from the top bottle to the bottom one, first some air must move up into the top bottle and make room.
4. Next, disconnect the system and empty out a little of the water so that one bottle is halfway filled with water. Then reconnect the system. Now flip the bottle again so the water is on top. Shake the bottles slightly. This will cause some air bubbles to float upward, and allow some water to drip down.
5. Ask your students what's happening. Explain to them that the air is replacing the water in the top bottle. Remind them that two substances cannot occupy the same space at once. Essentially, the two fluids are trading spaces: each little bubble of water is displacing a little bubble of air.
6. Now disconnect the system again and add water so that one bottle is about two-thirds filled. Then close the system again and flip the bottles and spin them until a vortex forms within the top bottle. **Do this several times because the students will be too amazed by this to answer any questions at first.**
7. Ask the students what's happening again. Explain to them that it's the same basic idea as before—the water is replacing the air and vice versa—but this time, the fluid is draining in a way that allows the water and the air to both keep trading spaces at the same time.
8. Put the bottles on the floor and encourage your students to look down the center of the bottles and point out the 'hole' in the water in the center. Explain to them that this is where the air is coming up. Even though the air is invisible, the water can be used to see the outline of the air's movement.

### Discussion:

- Two substances can't take up the same space.
- The water is heavier (denser) and wants to be closer to the ground more than the air.
- The vortex allows both the air and the water to trade places at the same time.

### If you're planning to display your bottles:

Use Alka Seltzer Tablets in order to create pressure in the bottles so they will keep their form. Just put two tablets in the bottle without water, tighten the connector and turn the bottles over so the water drains into the lower bottle, thereby reacting with the tablets to form $CO_2$ and pressurize the bottles.

**Warning:** If you unscrew the bottles, the pressure will be released and you will have to put in two more tablets the next time you close it.

## A New Spin in Technicolor

### Materials:

One Vortex Bottle Connector
Two 1-liter Plastic Bottles (BOT-600)
One Pack of Color Splash Tablets (CSP-100)
Water

### Procedure:

1. Try it with color! Put three Color Splash Tablets in one of the bottles and fill it with about two-thirds water. (Warm water works best.) Let the tablets dissolve completely. This might require some shaking of the bottles. Now try the experiment in style with new colorful water. Combine tablets in order to get other colors. Let your students experiment!
2. For extra interest, start with clear warm water in one bottle and several undissolved Color Splash Tablets in the bottom of the other. Connect the two bottles and then turn the bottle with the water on top. Spin it to create a vortex. The water will remain clear in the top bottle but it will change colors by the time it reaches the bottom.

# Hydrodynamics in a Bottle

## Materials:

One Vortex Bottle Connector
Two 1-liter Plastic Bottles (BOT-600)
One Bottle of Rheoscopic Fluid (RH-100)
Water

## Procedure:

This is a great demonstration of fluid dynamics. Fill one bottle with a mixture of Rheoscopic Fluid and water, aiming for a ratio of one part Rheoscopic Fluid to three parts water. Invite your students watch the fluid travel down into the lower bottle. Ask them, "What is this experiment demonstrating?" Hopefully they will have noticed that the liquid moves faster at the neck of the bottles and in the center of the vortex, and that the liquid tries to stay on the edge of the bottom bottle once it passes through the Vortex Bottle Connector and the neck of the lower bottle. Explain that the reason the fluid moves faster at the neck is because it is trying to remain in equilibrium. How does the fluid accomplish this? It must exchange water with air equally, meaning the flow of air has to be equivalent in volume to the flow of water. Since the bottle's neck has a smaller diameter than its body, the water must flow faster around the neck in order to keep the same amount of water flowing overall in equilibrium.

## Talking Points:

Ask the students to explain why the fluid is moving faster in the center of the vortex than on the outside. The reason is actually a trick: the particles are moving at the same rate of speed, but the ones in the center just seem like they are moving faster because they have less distance to travel. The liquid actually started with the same momentum because the shake you gave the bottle was equal throughout the bottle. Since the mass of the particles are approximately the same, the overall momentum must remain the same due to the Conservation of Momentum laws ($M_1V_1=M_2V_2$).

If the mass remains the same, the velocity must also remain the same. The particles in the center of the vortex *appear* to be moving faster because they have less distance to travel around the circle of the vortex and therefore they go through more revolutions in the same amount of time, even though the particles are all traveling the same speed. It may help to use a sports analogy: when a figure skater spins tightly in a circle, she often bring her arms and legs closer together, which makes her appear to spin faster. In reality, by narrowing the span of her body, she is actually decreasing the distance she must travel in order to make one complete revolution.

Ask the students to explain why the liquid tries to stay on the walls of the bottle once it passes through the Vortex Bottle Connector. The answer is due to the surface tension that exists between the water and the bottle wall. Make sure students understand that the liquid will try to remain in the most energy efficient form possible in order to avoid expelling any energy. In this case, the most energy efficient form for the water after it passes through the Vortex Bottle Connector is to remain in contact with the walls.

# NGSS Correlations

Our Vortex Bottle Connectors and these lesson ideas will support your students' understanding of these Next Generation Science Standards (NGSS):

## Elementary

**K-ESS3-2**
**3-ESS3-1**

Students can use the Vortex Bottle Connectors to obtain information about severe weather.

## Middle School

**MS-ESS2-5**

Students can better understand how the motions and complex interactions of air masses result in weather changes when using the Vortex Bottle Connectors in an investigation of tornados.

## High School

**HS-S&E**

Develop and use models to predict and show relationships among variables between systems and their components in the natural world.

## Suggested Science Ideas

**K-ESS3-1**
**K-ESS3-3**
Use the Vortex Bottle Connectors to demonstrate the actions that take place during a tornado. Questions and conversations regarding weather forecasting to prepare for and respond to severe weather.

**MS-ESS2-5**
Make data collection relevant by allowing students to conduct investigations creating their own vortex weather chambers.

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# 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:

**Dozen 1-Liter Bottles and 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. These bottles are new and completely clean. They have no label to clean off and no worry about what had previously been in the bottle.

**Fountain Connection** (SS-10)
Connected to two clear 2-liter soda bottles, a fountain erupts every time the bottles are turned over. This is the modern version of Hero of Alexandria's 2,000-year-old fountain. Comes complete with explanation. A proven winner on your Science Table and as amazing as the familiar 'tornado in a bottle.'


**Pet Tornado** (AIR-260)
Spin the Pet Tornado clockwise and watch a mini tornado form before your eyes. The vortex forms and fades just like a real tornado.

**Rheoscopic Fluid** (RH-100)
Captivate your students with this unique fluid. Its suspended pearly crystals show current movement continually, without settling out. This non-toxic, pearly white substance is a water-based suspension. When warmed or cooled, strong convection currents appear. Appropriate for all grade levels K-college. Although the fluid ships colorless, it may be easily tinted with food coloring.