Tornado Tube®

Introduction

Create a vortex in a bottle with the amazing and fun-filled Tornado Tube®.

Concepts

- Air pressure
- Fluid motion
- Kinetic energy
- Vortex action

Materials

Tornado Tube®
Plastic soda bottles, 1-L or 2-L, 2
Tap water

Safety Precautions

Do not use glass bottles with the Tornado Tube for safety reasons. The materials used in this activity are generally considered nonhazardous. Please follow all standard laboratory safety guidelines.

Procedure

1. Fill one plastic soda bottle approximately two-thirds full with water.
2. Screw the Tornado Tube onto this bottle.
3. Attach an empty plastic soda bottle of the same size to the other end of the Tornado Tube.
4. Invert the assembly so that the filled bottle is on top.
5. Holding the assembly securely, swirl the bottles briefly in a small circular motion to create tornado action, or a vortex. (*Note:* The direction of rotation may be either clockwise or counterclockwise.) Observe the resulting fluid motion.

Disposal

The Tornado Tube may be used over and over. If disposal is necessary, dispose of the bottles in the solid waste disposal.

Tips

- You may wish to add food coloring or glitter to the water to create special effects.
- Allow students to experiment with the Tornado Tube assembly. See if they can figure out the best and fastest way to get the liquid from the top bottle to the bottom bottle. Many will discover that the most efficient technique is to create a vortex, which is a swirling motion in the fluid.
- Compare the fluid transfer rate with and without a vortex in the Tornado Tube. To do this, time how long it takes for the liquid to fall when the assembly is inverted and simply set on the table (like a sand timer). Then repeat, but this time swirl the assembly to create the tornado action.
- To demonstrate the importance of a vortex, simply compare the rate at which water will flow out of a single swirled versus non-swirled plastic soda bottle. Again, water flows out and air must flow in—the vortex allows this to happen quicker.

Discussion

The object of the Tornado Tube is to cause the water in the top bottle to empty into the lower bottle as quickly as possible. The lower bottle, however, is not empty—it is filled with air. Air takes up space, so in order for the water to flow from the upper bottle into the lower bottle, the air has to be displaced to the upper bottle. The way to do this is to create a vortex in the water. A *vortex* is a tornado-like, swirling motion that causes a liquid or a gas to travel in a spiral around a center line. Because the center of a vortex is hollow, the air from the lower bottle flows through the vortex into the upper bottle as the

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water flows downward into the lower bottle.

This interesting phenomenon of vortex action can also be observed in everyday occurrences—such as when the plug is pulled on the bathtub drain and the water is seen spinning with vortex action, or when gusty winds produce miniature tornadoes called dust devils that move with rotating action. And then there is the most commonly known example—a fierce windstorm or powerful rotating column of air known as a tornado.

Vortex action results from a concentration of *kinetic energy*, or motion, within a fluid. In the atmosphere, the kinetic energy in a tornado vortex arises from varying air temperatures and strong winds. A tornado usually forms during a severe thunderstorm when a cold front meets a warm front. Cold air is forced downward as warm air is forced upward at great speed, causing very low pressure at the Earth's surface. Strong winds approaching the center of the low-pressure system collide from different directions and begin to rotate violently. When this happens, the air pressure inside drops rapidly and a funnel cloud, or tornado, appears.

With the Tornado Tube, the initial small rotation of the bottles creates a similar-type vortex. The vortex forms a valve where the displaced air can escape quickly as the rotating liquid falls through the opening. Gravity is the force that pulls the liquid into the hole, forming a continuous vortex, which will continue naturally until something occurs to stop it.

Extensions

The Liquid Race

Have three or four tornado tubes connected to pairs of two-liter bottles. Select several students to demonstrate the best method of transferring the liquid from one bottle to the other. Give them a limit of 10 seconds. Be sure to point out that they may only handle the bottle for 10 seconds. At the end of that time, wait one minute to make sure all the liquid that is going to fall from the top bottle has fallen into the bottom bottle. Measure the volume of liquid in each bottle. Then demonstrate how you would transfer the liquid. The best and fastest way is to create a vortex by swirling the bottles. If you like, you can challenge them to transfer more liquid than you can in 10 seconds. The best they will ever be able to do is tie.

The Tornado Tube Density Bottle

Make a density bottle using a one-liter bottle to which you add about 500 mL of corn oil and 500 mL of colored water. Connect this to a second one-liter bottle with a Tornado Tube and invert. Swirl the liquid to transfer the liquid from the top to the bottom. If you do not swirl too hard, all of the water will fall through the hole (since water is more dense than oil), vortex action will stop, and the liquid will stop transferring. This may be explained in terms of attractive forces between molecules. Since the water molecules are polar and the corn oil molecules are nonpolar, they have little influence on each other. The vortex is the result of the attraction of water molecules to each other and, once set in motion, they pull other water molecules along. This pull is not transferred to the corn oil. When the interface is reached between the two liquids, the transfer stops.

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Materials for the *Tornado Tube* are available from Flinn Scientific, Inc.

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Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.