

Tornado in a Bottle Inquiry

Teacher's Notes

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| Main Topic | Motion |
| Subtopic | Circular Motion |
| Learning Level | High |
| Technology Level | Low |
| Activity Type | Student |

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| Description: Explore and explain the motion of liquid poured out of a bottle and in the “Tornado in a Bottle.” Inquiry. |
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| Required Equipment | Plastic funnel, 2 empty soda bottles, stopwatch, materials for designing a funnel, water source, large tub or sink, Vortex Tube (also called a tornado tube). |
| Optional Equipment | Food Coloring |

Educational Objectives

- Explore and explain the motion of liquid poured out of a bottle and in the “Tornado in a Bottle.”

Concept Overview

We will use funnels, soda bottles, and a toy called a Tornado Tube to explore the concepts of moment of inertia, rotational motion, angular momentum, kinetic and potential energy, and air pressure in an attempt to discover and explain the physics of a rather complex hydrodynamic system.

The *moment of inertia* is a measure of how mass is distributed about an axis of rotation for things that spin. *Angular momentum* is a quantity that must be conserved at all costs! Examples of this phenomenon are a skater initiating a spin and the fact that the Moon's distance from the Earth is always increasing as the Earth's rotational speed is slowed by the friction of tides. Angular momentum is the product of the moment of inertia and angular, or rotational speed. Energy is something that nature also tries to conserve, but some may be converted into “useless” forms like heat when potential is transformed to kinetic. (*Think: falling objects transform the stored potential energy into kinetic energy as they speed up or rotate faster and faster.*)

In the case of the Tornado in a Bottle, we are not dealing with a solid object, but a falling *liquid*.

Acknowledgement

Adapted from “Twister! Tornado in a Bottle,” an Inquiry Exercise by J. R. Harkay. See www.PhenomenalPhysics.com for more information on the complete Guided Inquiry Curriculum.

Tornado in a Bottle Inquiry Name: _____

Class: _____

Materials:

Plastic funnel, 2 empty soda bottles, stopwatch, materials for designing a funnel, water source, large tub or sink, Vortex Tube

Commentary:

We will use funnels, soda bottles, and a toy called a Tornado Tube to explore the concepts of moment of inertia, rotational motion, angular momentum, kinetic and potential energy, and air pressure in an attempt to discover and explain the physics of a rather complex hydrodynamic system. You will also need a sink or bottle of water and a tub. The materials are cheap and the exercise is fun, so let's begin!

Inquiry:

1. Firstly, let's take a look at funnels. Place a plastic funnel on the neck of an empty bottle and try to fill it with water
 - a. Are you having a problem? Explain.

 - b. Measure the time required to fill the bottle. Can you make things go faster? Can you design a better funnel?

 - c. A race! The winner is the group who can fill their bottle in the least amount of time. They should report to all how they accomplished their feat. Record the winning design and why you think it was so much faster.

2. Emptying a bottle. Let's pretend you are a dishwasher who gets paid according to the number of bottles you can rinse during your workday. Time is money!
 - a. Fill a bottle with water and empty it into a tub or sink, and record the time required.

 - b. This time, let another group member try to see if he/she can empty it any faster. No fair using any tools or breaking the bottle! Record your observations as you proceed with each trial.

Tornado in a Bottle Inquiry Name: _____

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- c. Again, the winning group should share their “secret” with the class.
Record exactly WHY the winning technique works.

Now we look at a miniature tornado.

Firstly, let’s talk some physics. The *moment of inertia* is a measure of how mass is distributed about an axis of rotation for things that spin. *Angular momentum* is a quantity that must be conserved at all costs! Examples of this phenomenon are a skater initiating a spin and the fact that the Moon’s distance from the Earth is always increasing as the Earth’s rotational speed is slowed by the friction of tides. Angular momentum is the product of the moment of inertia and angular, or rotational speed. Energy is something that nature also tries to conserve, but some may be converted into “useless” forms like heat when potential is transformed to kinetic. (*Think: falling objects transform the stored potential energy into kinetic energy as they speed up or rotate faster and faster.*)

In this case, we are not dealing with a solid object, but a falling *liquid*.

3. Fill one 2-L soda bottle with water (adding color makes the effect much more cool), and connect this to an identical empty bottle with the little tornado tube. Now you have something that looks and acts like an hourglass with water rather than sand.
4. Turn the assembly upside down and observe CAREFULLY what happens! Record everything you see as this beautiful event unfolds before your eyes.
5. Do you see a relationship to what you did with funnels in part one? Explain fully.



