LAB - Chapter 21.2 Severe Weather

Activity A. Tornado Tube

The purpose 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 water flows downward into the lower bottle.

This interesting phenomenon of vortex action can also be observed in everyday occurrences. Examples include the way water swirls as it drains when the plug is pulled in a bathtub drain, and miniature rotating tornadoes called dust devils are produced by gusty winds. 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 the vortex drops rapidly and a funnel cloud, or tornado, appears.

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

Concepts

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

Materials

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

Procedure

1. Fill one plastic soda bottle approximately two-thirds full with water.
2. Screw the Tornado Tube onto this bottle.
3. Attach the other empty plastic soda bottle to the other end of the Tornado Tube.
4. Invert the assembly so that the water-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.
6. Answer the questions in the *Observations and Results* section.

Observations and Results

1. Describe the motion of the water as it enters the lower bottle.

2. What is causing the vortex to form?

3. How does the formation of the vortex compare to how tornadoes occur?

4. Repeat the procedure once again without swirling the bottles. Compare the results with the original procedure.

Activity B. Pet Tornado and the Fujita Scale

The Fujita scale is a scale for rating tornado intensity based on damage caused by the tornadoes on human-built structures and vegetation. When a tornado occurs, the official Fujita scale rating is determined by meteorologists after a ground or aerial damage survey. Eyewitness and media reports are also considered when determining the Fujita scale rating. The Fujita scale, which was introduced in 1971 by Dr. T. Theodore Fujita, is broken down into 6 categories as shown in Table 1.

F Number	Wind Speed (mph)	Frequency of Occurrence in United States
F0	40–72	38.9%
F1	73–112	35.6%
F2	113–157	19.4%
F3	158–206	4.9%
F4	207–260	1.1%
F5	261–318	<0.1%

Table 1. Fujita Scale

Some of the original wind speed numbers have since been found to be higher than the actual wind speeds required to cause the damage described in each category. The wind speed numbers were found to be increasingly inaccurate as the F# category increases. Therefore another scale called the Enhanced Fujita (EF) scale was created and, as of early 2007, it is now considered to be the standard for rating tornadoes. The EF scale accounts for degrees of damage that occurs to an extensive list of structures, both man-made and natural. The expanded and refined damage indicators provide a better estimate for wind speeds and set no upper limit for the wind speeds of the strongest level tornados, EF5. The wind speeds are defined at a three-second gust (mph) in the EF scale. See the refined EF scale in Table 2 below. The back of the Pet Tornado model lists the types of damage that typically result from each type of tornado.

EF Number	Wind Speed (3-second gust—mph)
EF0	65–85
EF1	86–110
EF2	111–135
EF3	136–167
EF4	168–200
EF5	> 200

Table 2. EF scale

Concepts

- Tornadoes
- Fujita Scale

Materials

Pet Tornadoes,™ 2

Procedure

1. Shake the Pet Tornado vigorously.
2. Let the bottle settle until the viewing area is clear.
3. Hold the bottle upright and shake briskly a few times in a circular motion. See Figure 1.
4. Observe what happens in the viewing area.
5. Repeat steps 1–4 as desired.
6. Answer the questions in the *Observations and Results* section.

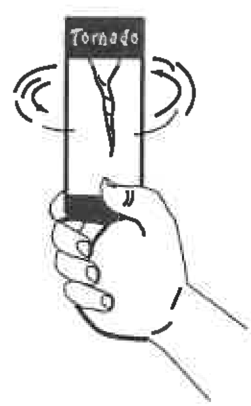

Figure 1.

Observations and Results

1. Describe what occurs when the Pet Tornado is shaken.

2. Once Activities A and B have been completed, compare and contrast the vortexes formed in each device.

3. Describe the principles of the Fujita Scale.

4. How does the Enhanced Fujita Scale (EF) differ from the Fujita Scale?

Activity E. PolySnow™

Snow is a type of precipitation in the form of crystalline ice consisting of numerous snowflakes that fall from clouds. Snow is composed of small ice particles and is a granular material. It has an open and soft structure, unless packed by external pressure.

Snow forms when water vapor condenses directly into ice crystals, usually in a cloud. These crystals typically have a diameter of several millimeters and have six lines of symmetry. A snowflake is an aggregate of these ice crystals and may be several centimeters large. The individual ice crystals are clear, but because of the amount of light reflected by the numerous individual crystals, snowflakes usually appear white in color unless contaminated by impurities.

In this activity, an artificial snow made of a chemical known as PolySnow will be studied. PolySnow is an example of a super absorbent polymer. Superabsorbents operate on the principle of osmosis—the passage of water through a membrane permeable only to water. In PolySnow, osmotic pressure results from a much greater concentration of sodium ion inside of the polymer lattice membrane than in the solution in which it is immersed. This osmotic pressure forces water into the solid polymer lattice in an attempt to equilibrate sodium ion concentration inside and outside the polymer membrane. The electrolyte concentration of the water will affect the osmotic pressure, subsequently affecting the amount of water absorbed by the polymer. For example, PolySnow will absorb approximately 500–800 times its own weight in distilled water, but will only absorb about 300 times its own weight in tap water, due to the high ion concentration of tap water.

Chemical Concepts

- Polymers
- Super absorbent
- Osmosis
- Cross-linking

Materials

PolySnow,™ [redacted] Cap Full

Sodium chloride, NaCl, 1 g

Water, distilled or deionized, 150 mL

Balance, 0.1-g accuracy

Cups, plastic, 2

Procedure

1. Add 3 g of Polysnow to a plastic cup.
2. Add approximately 150 mL of distilled or deionized water to another plastic cup.
3. Slowly add the water to the cup containing the 3 g of PolySnow. The PolySnow will turn white and start to grow. Within a minute, it will overflow the cup.
4. Add a small amount (1 g) of sodium chloride to the cup of PolySnow. The PolySnow will release the water and transform it to a slurry.
5. Answer the questions in the *Observations and Results* section.

Observations and Results

1. Explain why the artificial "snow" forms when the water is added to the PolySnow powder.

2. Compare and contrast PolySnow to real snow.

3. What happens when salt is added to the PolySnow? Give an example of how this process is commonly used.