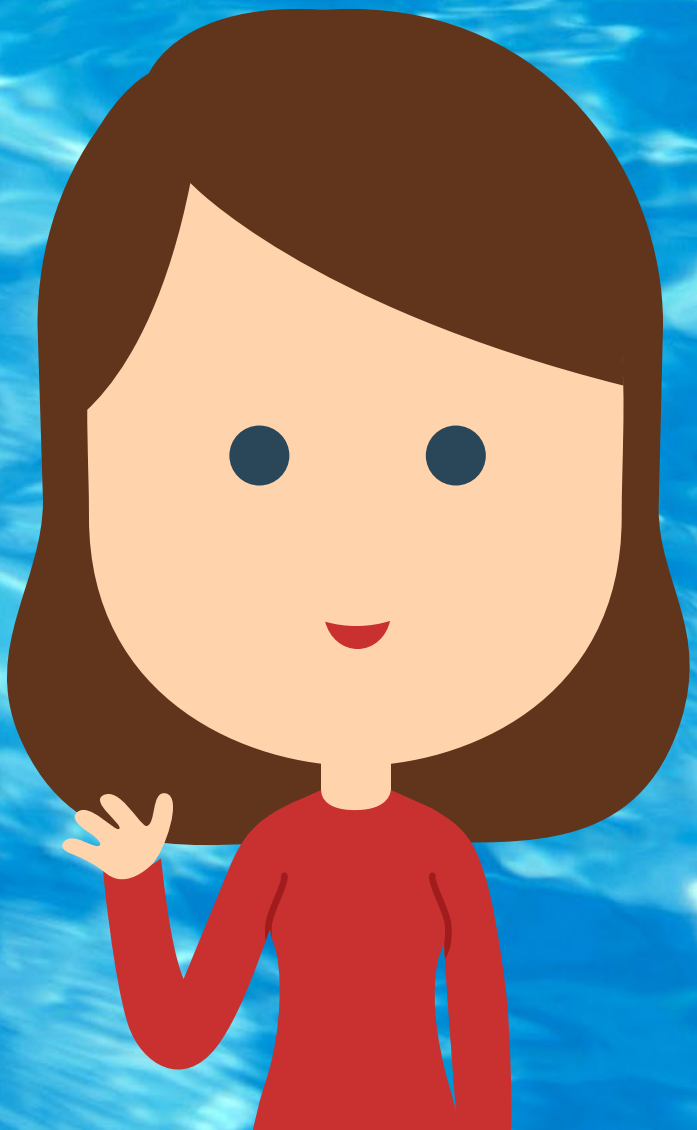
IGNITE ACTIVITY

THE PHYSICS BEHIND A VORTEX

STEM²D Topic: SCIENCE

Target Population:
Students, ages 10-14

The Physics Behind a Vortex is part of the STEM²D **Student Activities Series** developed by FHI 360 as part of Johnson & Johnson's WiSTEM²D initiative (**W**inning in **S**cience, **T**echnology, **E**ngineering, **M**ath, **M**anufacturing, and **D**esign). The series features interactive and fun, hands-on activities for youth.



The Physics Behind a Vortex

STEM²D Topic: Science
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ACTIVITY DESCRIPTION

In this Ignite STEM²D activity, students will apply their science knowledge and use critical thinking skills to explore the concepts of surface tension and centripetal force.

ESTIMATED TIME

This activity is intended to be done at a career fair, science fair, exhibit, or other type of "booth" event. It typically takes **8 to 10 minutes** to complete.

STUDENT DISCOVERIES

Students will:

- Apply their knowledge of science to solve a problem.
- Build important STEM²D skills, such as critical thinking, drawing conclusions, and problem solving.
- Have fun experiencing STEM²D.
- Be inspired to participate in other types of STEM²D experiences.

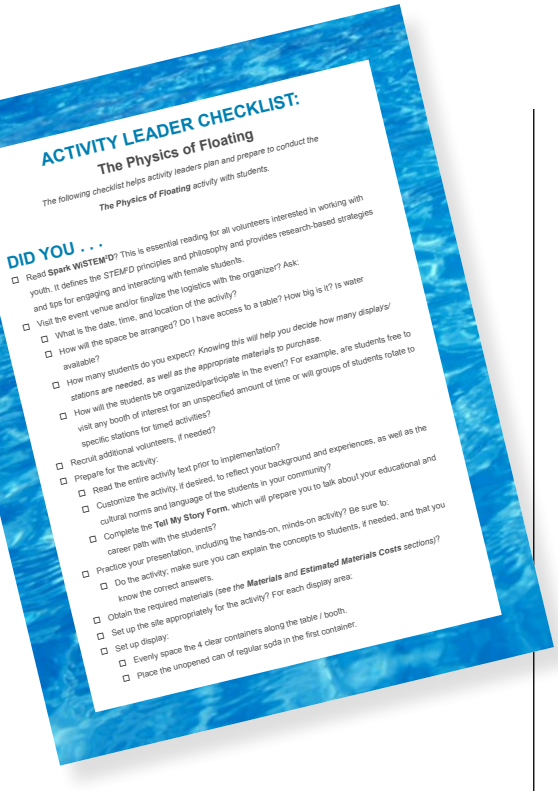
GETTING READY

Materials

- Pre-Activity Checklist
- Tell My Story Form, *optional*
- Student Handout: The Physics Behind a Vortex, *4–5 copies*
- Duct tape
- Hand wipes or paper towels (for cleanup)
- Tablecloths (number required depends on tables being used)
- Behind the Vortex materials, *1 set of the following items per display (4–5 displays recommended)*:
    - 2 empty 2-liter plastic bottles
    - 1 metal washer (either equal or slightly greater in size than

STEM²D Skills

- Communication
- Creative Thinking
- Critical Thinking
- Drawing Conclusions
- Problem Solving



ACTIVITY LEADER CHECKLIST:
The Physics of Floating

The following checklist helps activity leaders plan and prepare to conduct the *The Physics of Floating* activity with students.

DID YOU . . .

- ☐ Read **Spark WiSTEM²D**? This is essential reading for all volunteers interested in working with youth. It defines the STEM²D principles and philosophy and provides research-based strategies and tips for engaging and interacting with female students.
- ☐ Visit the event venue and/or finalize the logistics with the organizer? Ask:
  - ☐ What is the date, time, and location of the activity?
  - ☐ How will the space be arranged? Do I have access to a table? How big is it? Is water available?
  - ☐ How many students do you expect? Knowing this will help you decide how many displays/stations are needed, as well as the appropriate materials to purchase.
  - ☐ How will the students be organized/participate in the event? For example, are students free to visit any booth of interest for an unspecified amount of time or will groups of students rotate to specific stations for timed activities?
- ☐ Recruit additional volunteers, if needed?
- ☐ Prepare for the activity:
  - ☐ Read the entire activity text prior to implementation?
  - ☐ Customize the activity, if desired, to reflect your background and experiences, as well as the cultural norms and language of the students in your community?
  - ☐ Complete the **Tell My Story Form**, which will prepare you to talk about your educational and career path with the students?
  - ☐ Practice your presentation, including the hands-on, minds-on activity? Be sure to:
    - ☐ Do the activity; make sure you can explain the concepts to students, if needed, and that you know the correct answers.
  - ☐ Obtain the required materials (see the ***Materials*** and ***Estimated Materials Costs*** sections)?
  - ☐ Set up the site appropriately for the activity? For each display area:
    - ☐ Set up display:
      - ☐ Evenly space the 4 clear containers along the table / booth.
      - ☐ Place the unopened can of regular soda in the first container.

KEY WORDS

- **Centripetal Force**
- **STEM²D**
- **Surface Tension**
- **Vortex**

  the bottleneck of the 2-liter plastic bottle—approximately 28 mm in diameter)
  - 20-mL (4 teaspoons) colored lamp oil (recommended and available at most department stores where oil lamps are sold) or dish soap
  - 1-liter water
  - Glitter (optional)
- STEM²D brochures, flyers, or other informational materials, *optional*

Estimated Cost

Activity leaders can expect to incur less than $25.00 (excluding optional items) in materials costs for preparing four to five displays that will be used multiple times with large groups of students.

Activity Leader Preparation

1. Read **Spark WiSTEM²D**. This is essential reading for all volunteers interested in working with youth. It defines the STEM²D principles and philosophy and provides research-based strategies and tips for engaging and interacting with students. Download at www.STEM2D.org.
2. Review the **Physics of Floating Activity Leader Checklist** (at the end of this document) for details and specific steps for planning, preparing, and implementing this activity.
3. Set up "The Physics of Floating" display. See the Activity Leader Checklist for more information.
4. See the **STEM²D Student Activities Overview** for additional information.

STEP-BY-STEP INSTRUCTIONS: THE PHYSICS BEHIND A VORTEX

1. **Welcome & Introductions (1 minute)**
   - Welcome the students as they arrive at the table/booth.
   - Introduce yourself by saying your name, title, and your organization/company.
   - Explain that your career is one of many **STEM²D** careers. Indicate:

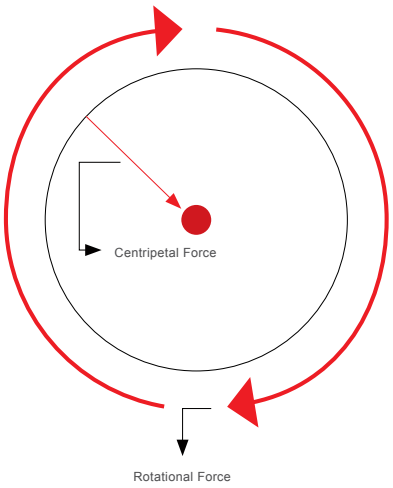
- STEM²D refers to: Science, Technology, Engineering, Math, Manufacturing, and Design.
- Individuals with an interest or degree in these areas are in demand.
- The STEM²D sector is expected to experience high growth over the next ten years.

- Ask the other volunteers and students to introduce themselves.

2. **Learning Activity: Behind the Vortex (2–4 minutes)**
   - Introduce the activity and gauge the students' knowledge by asking:
     - What is a vortex? (i.e., a **vortex** is a type of motion that causes liquids and gases to travel in spirals/rotates around a center line [an axis], typically with downward force.)
     - Where do you see vortexes in nature? (e.g., tornados, whirlpools, or dust devils)
   - Invite the students to look at the previously-assembled displays and ask them to predict (guess) what they think will happen when the bottles are inverted. Ask:
     - What do you think will happen when I turn the bottle over?
   - Do not point out that the water and oil do not mix—either initially or at the end. Do not point out that there is a washer in between the two bottles that keeps the water and oil from immediately pouring into the empty bottle when inverted.
   - Test the students' predictions. Quickly turn each display over – raising the bottle filled with water upright and making a swirling motion to initiate the vortex.
   - Stand the display(s) vertically on the table with the empty bottle on the bottom.
   - Have students observe the reaction.
   - Initiate a discussion. Pose open-ended questions that encourage students to share their ideas and explain what occurred:
     - Why don't the substances mix?
     - Why doesn't the water flow immediately?
     - What do you think holds the shape and rotation of the vortex?
     - What is centripetal force?
     - What keeps the vortex intact?

TIPS FOR WORKING WITH STUDENTS

- Check frequently for understanding by asking open-ended, topic-specific, or process questions.
- Ask students to talk about what they already know.
- Encourage students to ask questions to gain deeper understanding.



- If students cannot tell you why the substances do not mix, offer some brief background information, making one or more of the following points:
  - The vortex in this experiment is created when gravity pulls the water and oil through an opening to form a rotating tornado.
  - **Surface tension** affects how water works when it is in its liquid form. In this instance, the force of gravity that would otherwise make the water flow down is being counteracted by the property of surface tension holding the water molecules together and the air in the lower bottle exerting equal force back, keeping the system in a state of equilibrium.
  - A whirlpool is called an "orthodox" vortex because it has a downward stream. Hurricanes and tornadoes are called "unorthodox," because they have upward streams.
  - Oil is less dense than water. As a result, oil floats on the surface of the water.
  - When the display is swirled, mixing the oil and water, the less-dense oil travels down the vortex first and creates the spiral or tornado effect.
  - **Centripetal force** maintains the rotation of the vortex. Centripetal force follows a circular path and always points to the center of the axis of rotation. Point to the Student Handout, as needed, to explain centripetal force.

3. **Student Reflection (2 minutes)**
   - Wrap up the activity by asking any of the following reflection questions:
     - Can you think of any real-world applications for this experiment?
     - How do you think this might be relevant for someone in a STEM^{2}D profession?
     - What kind of careers do you think people with an interest/degree in this area would have?
   - Thank the students for joining you today.
   - Encourage the students to continue exploring STEM^{2}D subjects and careers.

Key Words

Centripetal Force: The force that keeps a body following a circular path; centripetal force always points to the center of the axis of rotation.

STEM²D: Science, Technology, Engineering, Math, Manufacturing, and Design.

Surface Tension: The property of a liquid that gives its perimeter an elastic 'solid-like' surface that allows objects of the same or greater density to float (or balance water).

Vortex: A type of motion that causes liquids and gases to travel in spirals or rotate around a center line (an axis), typically with downward force**.**

Resources and References

Activity concepts and real-life connections adapted from:

"Tornado in a Bottle," Steve Spangler Science. Accessed 17 Jul 2018. https://www.stevespanglerscience.com/lab/experiments/soda-bottle-tornado

TIPS ABOUT STEM²D CAREERS

Share with students that there are many different kinds of careers related to STEM2D. Some STEM2D careers related to this activity are:

- Applications Engineers
- Astronomer
- Laser Engineer
- Lab Technician
- Meteorologist
- Operational Forecaster
- Optical Physicist

ACTIVITY LEADER CHECKLIST:

The Physics Behind a Vortex

The following checklist helps activity leaders plan and prepare to conduct the ***The Physics Behind a Vortex*** *activity with students.*

DID YOU . . .

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- ☐ Visit the event venue and/or finalize the logistics with the organizer? Ask:
  - ☐ What is the date, time, and location of the activity?
  - ☐ How will the space be arranged? Do I have access to a table? How big is it? Is water available?
  - ☐ How many students do you expect? How will the students be organized/participate in the event? For example, are students free to visit any booth of interest for an unspecified amount of time or will groups of students rotate to specific stations for timed activities? *Knowing this will help you decide how many displays to create, as well as the appropriate materials to purchase.*
- ☐ Recruit additional volunteers, if needed?
- ☐ Prepare for the activity:
  - ☐ Read the entire activity text prior to implementation?
  - ☐ Customize the activity, if desired, to reflect your background and experiences, as well as the cultural norms and language of the students in your community?
  - ☐ Complete the **Tell My Story Form**, which will prepare you to talk about your educational and career path with the students?
- ☐ Practice your presentation, including the hands-on, minds-on activity? Be sure to:
  - ☐ Do the activity; make sure you can explain the concepts to students, if needed, and that you know the correct answers.
- ☐ Obtain the required materials? see the Materials and Estimated Materials Costs sections
- ☐ Make four to five “Physics Behind a Vortex” displays? For each display:
  - ☐ Start with 2 empty, 2-liter plastic soda bottles. Make sure the bottles are the same size.
  - ☐ Fill one bottle 2/3 full of water.
  - ☐ Add 20 mL (4 teaspoons) colored lamp oil (or dish soap).

- ☐ Place the metal washer securely on the mouth of the bottle.
- ☐ Take the remaining (empty) bottle and turn it upside down. Place the empty bottle on top of the metal washer, aligning the two bottle openings.
- ☐ Connect the two the bottles with duct tape to form an “hourglass.”
- ☐ Turn the display over, making sure there are no leaks.

☐ Practice your presentation, including the demonstration activity? Did you:

- ☐ Do the activity? *Make sure you can explain the concepts to students, if needed, and that you know the correct answers.*

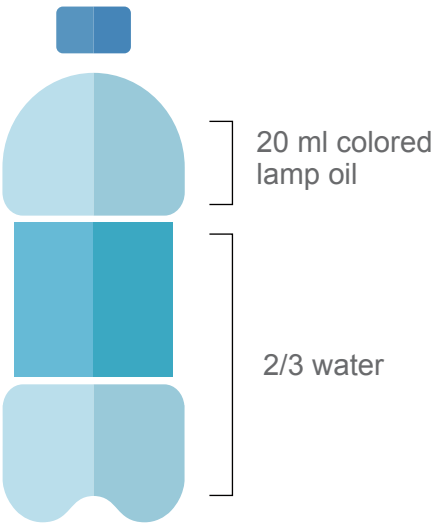
☐ Set up the site appropriately for the activity? Did you:

- ☐ Line table(s) with a tablecloth to contain spills or leaks and ease cleanup?
- ☐ Stand the previously-made “Physics Behind a Vortex” display/s vertically on the table with the empty bottle/s on the top?

☐ Bring a camera, if desired, to take photographs?

☐ Obtain and collect permission slips and photo release forms for conducting the activity, if applicable?

☐ **Have fun!**



Tell My Story Form

This form will help activity leaders and other volunteers prepare to talk about their STEM²D interests, education, and career path.

ABOUT YOU

Name: _____

Job Title: _____

_____

Company: _____

When/Why did you become interested in STEM²D? _____

_____

_____

What do you hope young people will get out of this activity?_____

_____

FUN FACT:

Share a little about your background. Ideas:

- Share a memory from childhood when you first had your “spark” or “interest” in STEM.
- Detail your journey, highlighting what you have tried, what you learned, steps to success, etc.
- Failures or set backs are also great to talk about—difficulties, and/or challenges, and how you overcame them.

EDUCATION AND CAREER PATH

What classes/courses did you take in secondary school and in college that helped or interested you most? _____

_____

How did you know you wanted to pursue a STEM²D career? _____

_____

What was your postsecondary path, including the institution you attended and your degree? *If you switched disciplines, make sure you explain why.* _____

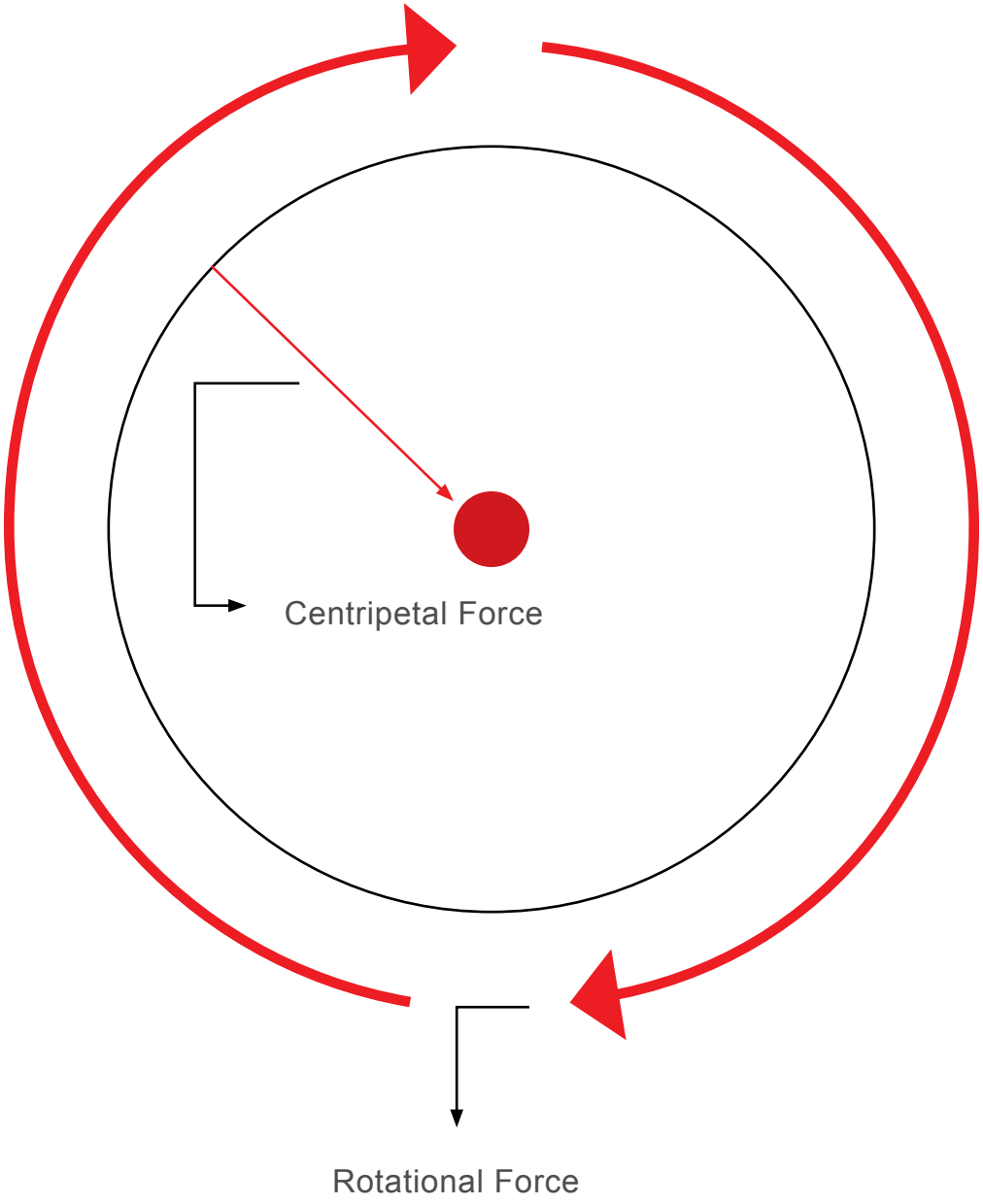
_____

What your current position entails. *Be sure to include how you use STEM²D during a typical work day.* _____

_____

The Physics Behind a Vortex

Student Handouts



This activity was written by Johnson & Johnson's Bridge to Employment (BTE)
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