




COTTON BALL CATAPULT

STEM²D Topic

Design,
Engineering

Target Population:
Students, ages 14–18

Cotton Ball Catapult is part of the **STEM²D Student Activities Series.** This activity was 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 includes more than ten interactive and fun, hands-on activities for youth globally.

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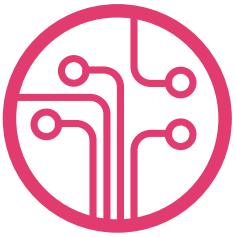
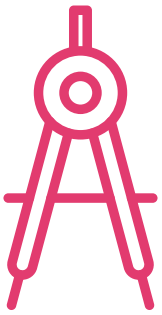




ACTIVITY DESCRIPTION

In this team-based, hands-on activity, students will learn about the product development process by designing and testing a cotton ball catapult.

ESTIMATED TIME

This session typically takes **60 minutes** to complete and should be conducted in **one** session.

STUDENT DISCOVERIES

Students will:

- Learn about the product development process.
- Participate in a team-based learning experience.
- Build important STEM²D skills, such as creative thinking, critical thinking, problem solving, testing, and teamwork.
- Realize that STEM²D offers diverse and exciting career opportunities.
- Have fun experiencing STEM²D.

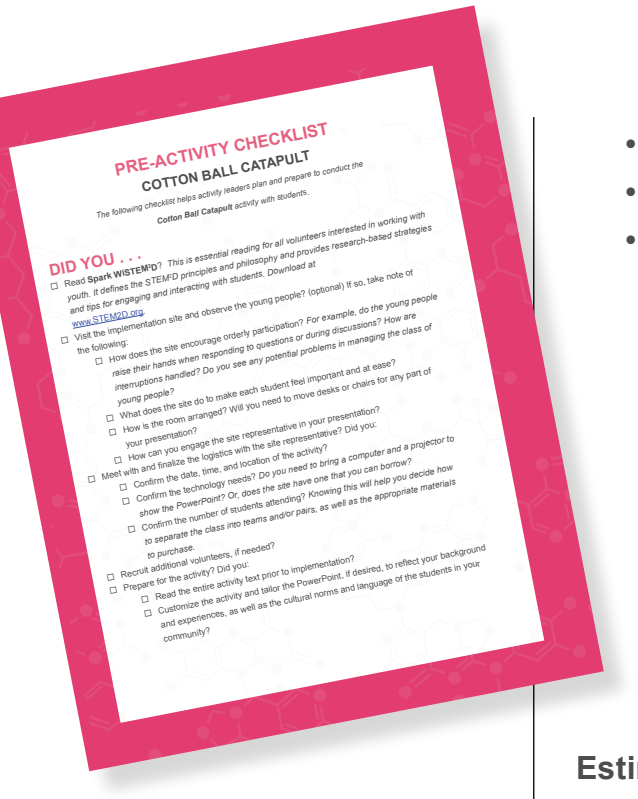
GETTING READY

Materials:

- Pre-Activity Checklist
- Tell My Story Form
- Computer with projector
- PowerPoint: Cotton Ball Catapult
- Student Handout: Cotton Ball Catapult Challenge, *1 per student*
- 1 yard stick, meter stick, or tape measure

STEM²D Skills

- Collaboration
- Communication
- Creative Thinking
- Critical Thinking
- Decision Making
- Teamwork
- Testing



PRE-ACTIVITY CHECKLIST

COTTON BALL CATAPULT

The following checklist helps activity leaders plan and prepare to conduct the **Cotton Ball Catapult** 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 students. Download at www.STEM2D.org.
- ☐ Visit the implementation site and observe the young people? (optional) If so, take note of the following:
  - ☐ How does the site encourage orderly participation? For example, do the young people raise their hands when responding to questions or during discussions? How are interruptions handled? Do you see any potential problems in managing the class of young people?
  - ☐ What does the site do to make each student feel important and at ease?
  - ☐ How is the room arranged? Will you need to move desks or chairs for any part of your presentation?
  - ☐ How can you engage the site representative in your presentation?
- ☐ Meet with and finalize the logistics with the site representative? Did you:
  - ☐ Confirm the date, time, and location of the activity?
  - ☐ Confirm the technology needs? Do you need to bring a computer and a projector to show the PowerPoint? Or, does the site have one that you can borrow?
  - ☐ Confirm the number of students attending? Knowing this will help you decide how to separate the class into teams and/or pairs, as well as the appropriate materials to purchase.
- ☐ Recruit additional volunteers, if needed?
- ☐ Prepare for the activity? Did you:
  - ☐ Read the entire activity text prior to implementation?
  - ☐ Customize the activity and tailor the PowerPoint, if desired, to reflect your background and experiences, as well as the cultural norms and language of the students in your community?

- 2 black permanent markers
- Pen/pencil, *1 per student*
- Catapult Kit, *1 set of the following materials per team of two students:*
  - 10 cotton balls
  - 1 ruler
  - 5 popsicle sticks/wooden sticks
  - 1 roll of masking tape
  - 10 rubber bands
  - 2 plastic teaspoons
  - 2 pipe cleaners
  - 6’ 6” (2 meters) of string

Estimated Cost:

Activity leaders can expect to incur less than $20.00 in materials costs when completing this activity with 20 students organized into teams of two students.

Activity Leader Preparation

- 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.
- Review the **Pre-Activity Checklist** (at the end of this document) for details and specific steps for planning, preparing, and implementing this activity.
- See the **STEM²D Student Activities Overview** for additional information.

STEP-BY-STEP INSTRUCTIONS: COTTON BALL CATAPULT

1. **Welcome and Introduction (5 minutes)**
   - Welcome the students.
   - Introduce yourself by saying your name, title, and your organization/company.
   - Share that students will be learning about STEM²D careers and will be applying STEM²D skills during the session.

- **(What is STEM²D? Slide)** Explain that **STEM²D** refers to: Science, Technology, Engineering, Math, Manufacturing, and Design.
- Ask students and other volunteers to introduce themselves and state their favorite area of STEM²D.
- **(Today's Plan Slide)** Review the agenda. Explain that today students will learn how designers and engineers work through the design and testing process before a product is submitted for approval (if necessary) or introduced directly into the marketplace.
- Share that they will be able to put their own skills to use in a team design activity.

2. **Career Awareness: Design and Engineering in the World of Work (10 minutes)**
   - **(STEM²D in the World of Work Slide)** Initiate an opening discussion and brainstorming activity. Consider asking:
     - How do you think design and engineering are used every day in the workplace?
     - What do kinds of careers do you think people with an interest, aptitude for, or degree in design or engineering would have?
   - **(Tell My Story Slide)** Talk about your educational and career path. Use the Tell My Story form as the basis for your remarks. Be prepared to describe your job or a typical day, and provide information about your background including:
     - When/why you developed an interest in design and engineering.
     - The classes/courses you took in secondary school.
     - Your postsecondary path, including the institution you attended and your degree. *If you switched disciplines, make sure you explain why to the students.*
     - What your current position entails. *Be sure to include how you use design and engineering and what you do on a typical work day.*
   - Weave in facts about design and engineering and STEM²D careers:

KEY WORDS

- **Catapult**
- **Commercialization**
- **Concept design**
- **Patent**
- **Strategy**

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:

- Analytical Scientist
- Biomedical Engineer
- Chemist
- Computer Scientist
- Materials Engineer
- Physicist
- Product Designer
- R&D Scientist

TIPS FOR MAKING CONNECTIONS

Encourage students to:

- Ask questions if they don't understand.
- Summarize what they have learned.
- Explain their thinking process aloud.
- Talk about the five stages of development and/or describe the stages that they may have used.

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    - Tell the students that your career is only one of the many careers available in the STEM²D disciplines.
    - Explain that STEM²D careers are high-demand, high-growth careers and are predicted to remain in demand over the next ten years.
    - Share a few Johnson & Johnson job titles and careers

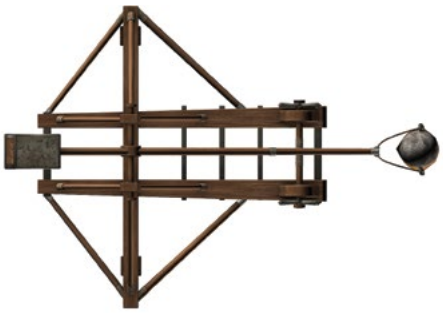
3. **Content Presentation: Learning About Product Development (10 minutes)**
    - **(What is Product Development? Slide)** Explain that product development is the overall process of strategy, organization, concept generation, product and marketing plan creation and evaluation, and commercialization of a new product. Define:
        - **Strategy:** a carefully developed plan or method for achieving a goal or skill.
        - **Concept generation:** brainstorming ideas in order to meet a specific need or specification.
        - **Commercialization:** the process of introducing a new product or service to the general market.
    - **(5 Stages of Product Development Slide)** Indicate that there are five main stages of product development:
        - **(Generating Ideas Slide).** The first stage is creating an idea and developing it for commercial sale. Brainstorming is a technique used for generating ideas. This is also called concept generation.
        - **(Evaluating and Screening Ideas Slide).** Next, ideas for inventions and innovations are assessed for their commercial potential. While some ideas may seem great in theory, it may not be possible for the designs to be brought to life, or the cost to bring the designs to life may be too high.
        - **(Protecting Ideas Slide).** The third stage is making sure your idea is protected. This can be done through acquiring patents or using trade secrecy. **Patents** are rights granted to inventors that exclude others from making, selling, or using the invention for a period of time. Trade secrecy is simply a matter of keeping knowledge of the ideas, designs, processes, techniques, or any other unique

component of the creation limited to a small group of people. The formula for Coca-Cola is one of the best-recognized and most successful trade secrets.

- **(Research and Development or R&D Slide).** Research and development (or R&D) is the process by which a company works to obtain new knowledge that it might use to create new technology, products, services, or systems that it will either use or sell. R&D often takes place in an internal department in a company but can also be outsourced. R&D is often an expensive part of product development.
- **(Marketing, Promotion, and Distribution Slide)** The final stage of product development is marketing, promotion, and distribution. Examples of marketing and promotion are television and radio commercials, billboards, and magazine and newspaper ads. Distribution is the system for making the product available for consumers to purchase.

- Consider providing information on product development at Johnson & Johnson or its focus on scientific innovation at the JLabs and Innovation Centers.

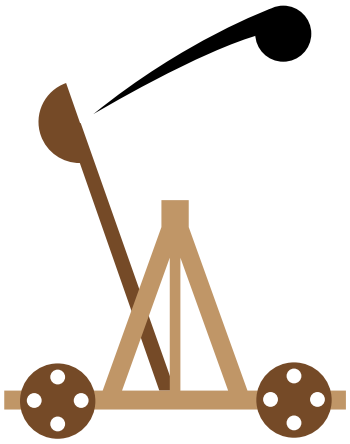
4. **Learning Activity: Cotton Ball Catapult Challenge (15 minutes)**
   - **(Cotton Ball Catapult Challenge Slide)** Introduce the challenge. Explain that students will work in teams to perform three of the five stages of product development: Generating Ideas, Evaluating and Screening Ideas, and R&D. The product the teams are designing is a cotton ball catapult.
   - **(Catapults Slide)** Show students pictures of catapults. Explain that a catapult is a device that is used to hurl an object some distance. Point out the parts of the catapult.
   - **(Cotton Ball Catapult Challenge Instructions Slide)** Give the following instructions:
     - As a team and using the Student Handout, generate ideas and sketch possible designs for your cotton ball catapult. Keep in mind your design may only use the materials provided.



- Next, choose the design to build and test.
- Use the materials provided to build the selected catapult based on your design.
- Test your catapult and make changes as needed in order to get the cotton ball to fly as far as possible. Do not launch the cotton ball at other students or teams.
- You have 15 minutes to build your catapult as a team. Keep an eye on the time.
- Once all catapults are built, we will test the catapults as a large group to see which design works the best.

- Break the group into teams of two students.
- Distribute the Student Handout and a Catapult Kit to each team. If there are additional volunteers, ask them to assist with distribution.
- Facilitate group work by walking around the room observing and asking students questions about their design. Do not give suggestions—this will ensure that students maintain ownership of their designs. Provide support and answer questions as needed.
- Ensure all students are participating in the team task; give encouragement to students who may not be as involved/engaged.
- Remind students that they may make as many alterations to their design, and test as often as needed, before the time deadline.
- Inform the group when time is up and explain that they will now be moving on to testing their catapults. All students must observe the testing; no further work can take place on catapults during testing.

5. **Cotton Ball Catapult Testing (15 minutes)**
   - Ask teams to bring their catapults to the testing area (an area on the floor with a designated starting line).
   - Once all catapults are in the designated area, inform the teams that they cannot remove their catapults from the area or make any alterations. Ask all students to position themselves behind the starting line so they will not be in the way of the cotton balls being launched.



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- Choose a team at random to test their catapult. Tell them they are Team #1. The team will set up and test their own catapult with one cotton ball. All parts of the catapult must be placed on the ground behind the starting line before testing. You may choose to have the group count down from 3 to 1 before the cotton ball is launched.
- After the cotton ball has been launched by the team and has landed on the ground, measure the distance the cotton ball traveled from the starting line to the landing point, using the yard stick, meter stick, or tape measure. After measuring, state aloud to the group the distance the cotton ball traveled. It is important to be precise in the measurements.
- Use the masking tape to create a small "X" on the ground under the cotton ball. Use a permanent marker to write the distance traveled on the masking tape and "Team #1." Remove the cotton ball from where it landed and give back to the team.
- Randomly choose the next team to test their catapult. Tell them they are Team #2. The team is to set up and test their catapult. Repeat the process of measuring and marking where the team's cotton ball landed.
- Repeat this process until all teams have tested their catapults by launching cotton balls.
- Once all testing has been completed, announce the distance the cotton balls traveled, from shortest to longest. Example: Team #3's cotton ball flew 9 ft. (2.7 meters).
- Ask students the following questions:
    - Why did some cotton balls fly farther than others? What was different about the catapults?
    - What would you change about your design if you were to do it again?
    - What was difficult about designing and building your catapult?

TIPS FOR WORKING WITH STUDENTS

- Encourage students to be creative in their designs and generate multiple ideas before choosing the design to build.
- Ask open-ended questions to encourage student reflection and discussion. For example:
    - Can you tell me about your design?
    - What do you think you need to do to make the cotton ball fly a longer distance?
- Encourage all students to participate in the different stages of the challenge.
- Move around the learning space and provide support when necessary.
- Reassure students that it is okay to make changes to the design.
- Help students stay on track with time during the group challenge.

TIPS FOR STARTING CONVERSATIONS

- What area of STEM²D is your favorite?
- Why did you choose that area of STEM²D as your favorite?
- What would your dream job be?
- Where do you see yourself in 5–10 years?

- Provide a recap of learning for the students. Give your own or use the following as a guide:
  - Today, we explored three important stages of product design: Generating Ideas, Evaluating and Screening Ideas, and R&D.
  - The R&D stage is often the most expensive stage of product design, as it can mean the difference between a product that is successful and a product that is a failure, or a product that is helpful, or a product that is harmful.

6. **Student Reflection (5 minutes).**
   - **(Reflection Slide)** Ask students to reflect on the activity. Have students spend a few minutes thinking about the following questions and then ask some of the following:
     - What did you learn about product design?
     - How do you think this activity relates to a career in design or engineering and/or working at Johnson & Johnson?
     - Can you see yourself as a STEM²D professional? In what role? Why or why not?
     - What would you need to do to make that happen?

Extended Learning

Here are a few ways to extend the learning:

- **Supersize it!** This activity can be done on a larger scale. Materials may include wooden boards, hammers, and springs to launch objects like tennis balls.
- **Integrate R&D.** Research the design and use of specific catapults currently in service or used historically around the world.
- **Bring it to life**. Use all stages of the product design process to bring an idea to life as a new product or improvement to an existing product.

Key Words

- **Catapult—**a device that is used to hurl an object some distance.
- **Commercialization—**the process of introducing a new product or service to the general market.
- **Concept design—**brainstorming ideas in order to meet a specific need or specification.
- **Patent—**rights granted to inventors that exclude others from making, selling, or using the invention for a period of time.
- **Strategy—**carefully developed plan or method for achieving a goal or skill.

Resources and References

The following resources provide additional information or activities:

- "Building a Catapult for Kids." http://pbskids.org/video/design-squad-nation/2365918833
- "Catapult History Video." https://www.youtube.com/watch?v=0MHJvsXHLy0
- "PBD Design Squad." http://pbskids.org/designsquad/
- "Product Development." https://www.entrepreneur.com/encyclopedia/product-development
- "What is a Patent?" https://smallbusiness.findlaw.com/intellectual-property/what-is-a-patent.html

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    - ☐ Confirm the number of students attending? *Knowing this will help you decide how to separate the class into teams and/or pairs, as well as the appropriate materials to purchase.*
- ☐ Recruit additional volunteers, if needed?
- ☐ Prepare for the activity? Did you:
    - ☐ Read the entire activity text prior to implementation?
    - ☐ Customize the activity and tailor the PowerPoint, 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? *If desired, include key points about your story on the PowerPoint (see Tell My Story Slide).*

☐ Photocopy the Student Handout?

☐ Obtain the required materials? Assemble a Catapult Kit for each team? *Pre-assembly will speed the distribution process. See the Materials and Estimated Materials Costs sections.*

☐ Practice your presentation, including the hands-on, minds-on activity? Be sure to:

- ☐ Do the activity! Make sure you are able to explain the concepts to students, if needed, and that you know the correct answers.

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

- ☐ Create a designated area for testing the cotton ball catapults? *The designated area should be an open space where cotton balls can be easily launched without hitting walls/ceiling/other students. Create a starting line with masking tape on the ground in the designated area; allow 3 ft (1 meter) of open space, minimum, from the starting line for the cotton ball to travel.*
- ☐ Make sure tables and chairs are arranged to accommodate teams of 2 students?
- ☐ If additional volunteers are available, assign adults to specific teams?
- ☐ Set up the computer and projector for the PowerPoint presentation?

☐ 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 had your first 'spark' or 'interest' in STEM²D.
- Detail your journey—highlight what you've 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 to the students.*

_____

_____

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

_____

_____

COTTON BALL CATAPULT CHALLENGE

Student Handout

CHALLENGE

As a team, design and build a catapult that will launch a cotton ball. The winning team will launch the cotton ball the farthest distance.

INSTRUCTIONS

As a team:

1. **Generate Ideas.** Brainstorm possible ideas and draw potential designs for your cotton ball catapult. Use the attached graph paper to sketch your ideas. Keep in mind you may only use the materials provided when building your design.
2. **Choose a Design.** With your partner, choose one design to build.
3. **Build the Catapult.** Use the materials provided to build your catapult based on your design. You have 15 minutes to build your catapult as a team. Keep an eye on the time
4. **Test the Catapult.** Test your catapult and make changes as needed in order to get the cotton ball to fly as far as possible. Do not launch the cotton ball at other students or teams.
5. **Determine the Winning Team.** After 15 minutes, we will test the catapults as a group to see which design works the best.

MATERIALS

- 1 ruler
- 5 popsicle sticks/wooden sticks
- 5 cotton balls
- 1 roll of masking tape
- 10 rubber bands
- 2 plastic teaspoons
- 2 pipe cleaners
- 6 ft. 6 in. (2 meters) of string

CATAPULT DESIGN

Content and graphic layout courtesy of FHI 360.

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