SCIENCE FAIR CENTRAL

Maker Corner Activity

CATAPULT COMPETITION!

Grade Level: High School

MAKE. CREATE. EXPLORE.

www.ScienceFairCentral.com #ScienceFairCentral

Do you know the difference between a catapult and a trebuchet?

Overview

Students will investigate different kinds of catapults as they explore how counterweights and levers work to launch projectiles into the air. They will then apply what they have learned as they experiment with building a mini-catapult, and they will work in teams to optimize its design and maximize the distance and accuracy that its projectile can be launched. The class will then participate in a class-wide catapult challenge, and a catapult competition champion will be crowned at the end!

Have you ever wondered...

Who invented the first catapult?

The catapult was invented by Dionysius the Elder of Syracuse: a Greek tyrant who had conquered Sicily and Southern Italy[1]. He developed the catapult in about 400 BC so it could be used as a siege machine that could throw heavy objects with immense force and for long distances. His design remained popular throughout medieval times. Some catapults that evolved from Dionysius's invention could throw rocks that weighed up to 350 pounds more than 300 feet![2]

What is the different between a catapult and a trebuchet?

Trebuchets are a type of catapult. In fact, they are the French version of a catapult! The type of catapult that most people are familiar with is actually called a Mangonel catapult.

This activity focuses on the **"Designing Solutions"**, **"Creating or Prototyping"**, **"Refining and Improving"**, and "**Communicating Results"** stages of the Engineering Design Cycle.

Engineering Design Cycle

- Defining the Problem
- **Designing Solutions**
- **Creating or Prototyping**
- **Refine or Improve**
- **Communicating Results**

Objectives

Students will be able to:

Understand the goal of a simple machine.

Compare how two different kinds of catapults function.

Design and create a mini Mangonel catapult, and explain the force behind its launch system.

Both catapult versions are similar in that they use stored energy to launch a projectile. Whereas a Mangonel catapult relies on one long arm that launches objects when its tension is released, a trebuchet functions more similar to a seesaw and relies on gravity and the energy of a falling counterweight to launch its projectile[3].

What is a simple machine?

Simple machines are mechanical devices that help increase the force that someone can apply to an object so it requires less work to move it. There are six kinds of simple machines: pulleys, wheel and axles, inclined planes, wedges, screws, and levers. Catapults are examples of levers. Levers are made up of a rigid object like a board that moves on a turning point called a fulcrum. (Picture a see-saw!) The fulcrum could be in the middle of the lever or closer to one of the ends. When you use a lever, you need a smaller force to move something a longer distance.

Materials

- Catapult and Trebuchet images, to project
- Projectile Brainstorm Handout, one per student
- Mangonel Catapult Build Handout, enough for 1/3 of the class
- How to Build a Trebuchet video, to project
- Paper bags, one pack
- Measuring tape
- Painter's tape
- Marker

Mangonel Catapult Materials: Divide your class groups of 3 or 4 students, and then distribute the following:

- Craft sticks, 8 per group
- Strong rubber bands, at least 6 per group
- Ping pong balls, one per group
- Recycled plastic bottle caps, one per group
- Hot glue gun and hot glue, at least 2 or 3 for the class to share

Make connections!

How does this connect to students?

The catapult is an example of a simple machine. Though catapults were invented centuries ago, simple machines are still constantly used today!

From chopping fruit to building skyscrapers and riding a bike, simple machines are all around us and engineers continue to use them on a daily basis. Though many of today's innovations now rely on elements of technology, the root of today's tools is still centered on simple machines. It therefore remains important to have a working understanding of the fundamentals of simple machines in order to understand the tools we use in our everyday lives.

How does this connect to careers?

Mechanical Engineers apply math and science as they design solutions to problems. Some engineers in this field design machines such as engines, elevators, and escalators! Many of the machines they develop rely on a combination of simple machines[4].

Aerospace Engineer: For students who enjoy catapults because they project items through the air, aerospace engineering may be of interest! These engineers help design and create machines that fly, and they create and test prototypes to make sure they function effectively[5].

Toy Designer: As a toy designer, the sky's the limit! Toy designers must have creative ideas for toys that children would like to play with, and they need to create models of the toy that demonstrate exactly how the toy will function before it can be manufactured[6].

How does this connect to our world?

The six kinds of simple machines are used around the world today. While some continue to function alone as simple machines, others combine two or more simple machines into a move complex tool.

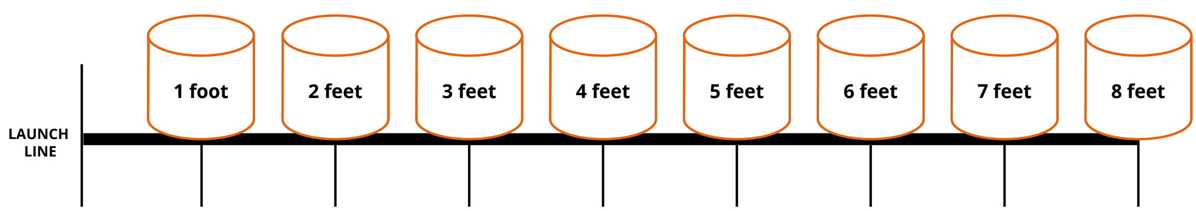
Consider water use and access around the world, for example. Some developing countries still rely on pulleys to draw water from wells. A round water faucet is based off a wheel and axel, and most pipes are an example of inclined planes. A modern water pump is even based on the combination of two simple machines: a screw that turns and moves water up an incline to a basin[7].

By building an understanding of simple machines and how they conserve energy, students are gaining skills that can be used to further engineering problems worldwide.

Blueprint for Discovery

Prior to class arriving

- Prepare the Catapult projection images or print out several copies of the images for students to examine in groups.
- Copy both handouts, so there are enough for each student.
- Assemble the Catapult materials so they are ready to distribute.
- Prepare for the Catapult Competition by completing the following:
    - Find an area in the classroom that has at least eight free feet of space.
    - In this space, place an eight-foot line of tape on the floor.
    - Go back and mark every foot along the vertical line with horizontal lines, starting at the very beginning of the line.
    - Use the marker to label the first horizonal line “Launch Line”.
    - Then label eight paper bags with “1 foot, 2 feet, 3 feet...8 feet”.
    - Place the bags on the corresponding horizonal lines, so they indicate how far each bag is from the Launch Line.
    - Secure the bottom of each bag to the floor with a piece of tape.
    - Your final set-up should resemble the following:



During class

1. Project these two images (Mangonel catapult and trebuchet) side by side and encourage students to share their observations. What do they see?
2. Explain that both images show examples of simple machines. In ancient times, people relied heavily on simple machines because there was no electricity like there is today. Simple machines helped increase the force that someone could apply to an object so it required less work to move or launch it. Today, many of our more complex machines are made up of several simple machines!
3. Distribute a Projectile Brainstorm Handout to each student and bring their attention to the two images provided. Explain that these are simpler versions of the Mangonel catapult and

trebuchet portrayed in the historical images. Encourage students to look back and forth between the handout and the projected images in order to find similarities.

4. Tell students that the Mangonel catapult and trebuchet are both types of catapults. Each one relies on potential energy (stored energy) to launch projectiles—but they store this energy and convert it into kinetic energy (energy of motion) in different ways. Encourage students to Write/Pair/Share* where they think each simple machine stores its potential energy and how this stored energy converts to kinetic energy in order to launch its projectile. They should record their thoughts in the first column of their handout.

   *In a Write/Pair Share, students should write independently, discuss their thoughts with a partner, and then share their thoughts with the class.

5. Tell students that you are about to play a MythBusters video that demonstrates how to build a model trebuchet. Students should take notes in the second column of their handout as they learn how a trebuchet actually functions.

6. Play the [How to Build a Trebuchet]() video. When the video is complete, review: How does the trebuchet work? What does the lever do? What is the role of the counterweight? How is potential energy converted into kinetic energy?

7. Next, explain that student teams will work together to brainstorm how Mangonel catapults work and then construct one of their own. To prepare for this:
   - Divide students into teams of three or four and distribute the Mangonel Materials to each group.
   - Pass out one Mangonel Catapult Build Handout to each group, and review the instructions together. Explain that the instructions are vague for a reason…How each group builds their catapult is up to them!

8. Finally, share one additional challenge: Students will be competing to see which team can achieve the farthest catapult free-throw shot, using the ping pong ball. It's therefore important that their catapults focus on both distance and accuracy! Show the class the Catapult Competition set-up so they understand what they are working towards.

9. Then share the amount of time students will have to build their catapult, and encourage students to get to work.

10. When there are about 10–15 minutes left, give groups a two-minute warning and then assemble students near the Catapult Competition Line. Explain that each group will have three shots to see how far and how accurately they can launch their ping pong ball!

11. Before each team shoots, the group should explain how their catapult works and where the ping pong ball's energy comes from. Ensure students understand that by creating tension in their catapult, they are adding potential energy. When the tension is released, the potential energy is transformed into kinetic energy and the ball launches forward.

12. On the board, keep track of the score by recording the farthest distance at which each team was able to successfully make a “basket.”
13. Before class wraps up, crown one group as the Catapult Competition Champions!

Take action!

Possible Extension Activities:

1. Hold a class debrief in which you compare and contrast the groups’ different catapult designs in relation to how each one performed. What takeaways could be learned? Students may even optimize their design based on this initial round and then compete a second trial!
2. Students can perform further research on how to build a trebuchet and construct a mini-version at home. Students can then share their projects with the class, either through a video or by bringing their design to school. Students can consider why these designs may be able to project items farther and with more accuracy than the Mangonel catapults.

National Standards

Science

Next Generation Science Standards

MS-PS3-5. Energy
Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object

MS-ETS1-4 Engineering Design
Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Technology Education

International Technology and Engineering Educators Association

Students will develop an understanding of Design. This includes knowing about:

- Attributes of design.
- Engineering design.
- The role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

English Language Arts

Common Core

CCSS.ELA-LITERACY.CCRA.SL.1
Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.

CCSS.ELA-LITERACY.CCRA.SL.4:
Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.

Sources

1. Dionysius the Elder. The Columbia University Press. encyclopedia.com/people/history/ancient-history-greece-biographies/dionysius-elder.
2. Stone-Hurling Catapult, Greece, 400 BCE. Museum of Ancient Inventions: Smith College History of Science. smith.edu/hsc/museum/ancient_inventions/hsc11b.htm.
3. How Does A Catapult Work? HowStuffWorks. science.howstuffworks.com/transport/engines-equipment/question127.htm.
4. What Do Mechanical Engineers Do? Southern New Hampshire University. snhu.edu/about-us/newsroom/2018/10/what-do-mechanical-engineers-do.
5. Aerospace Engineers. Bureau of Labor Statistics. bls.gov/ooh/architecture-and-engineering/aerospace-engineers.htm.
6. Five Top STEM Toy Careers. STEM Jobs. stemjobs.com/5-top-stem-toy-design-careers/.
7. How to Combine 2 Simple Machines. Sciencing. sciencing.com/combine-2-simple-machines-6147271.html.

Projectile Brainstorm Handout

Directions: Label the drawings below and/or write notes in the space provided as you brainstorm how these simple machines work. Be sure to consider: 1) Where each one stores potential energy, 2) How they convert this stored energy into kinetic energy when they launch their projectile.

Catapult Type	How do you *think* it works?	How does it *actually* work?
Trebuchet 		
Mangonel Catapult 		

Image Source: forestry-suppliers.com

Mangonel Catapult Build Handout

Group Instructions:

Step 1: Read the background information below. Then examine the picture of the Mangonel catapult on your Projectile Brainstorm Handout and record a description of how this catapult *actually* works. Be sure to include the word "tension" in your new description.

Background Information: Mangonel catapults are different than trebuchets. While trebuchets rely on counterweights, Mangonel catapults rely on tension. Tension is the force that occurs when you pull/stretch an object. (Picture a rubber band!) When the object is stretched out, it contains tension. An object that has tension wants to return to its regular state, and it will as soon as its tension is released.

Step 2: Review the materials you have available to build your own Mangonel catapult. Then brainstorm how you could create a catapult that uses tension to launch a ping pong ball. Your catapult won't look exactly like the image on your Projectile Brainstorm Handout, but it should work similarly! Use the space below to sketch your ideas.

Step 3: Begin building! As you construct your catapult, continuously test your launch design for both distance and accuracy. (Accuracy means: Does the ping pong ball land where you want it to land?) If not, think about how you can change the design to make it work better!