Grade 6-8 STEM Challenge

Catapults!

Inspired by Gabi, an Electrical Engineer in the Indiana Uplands.

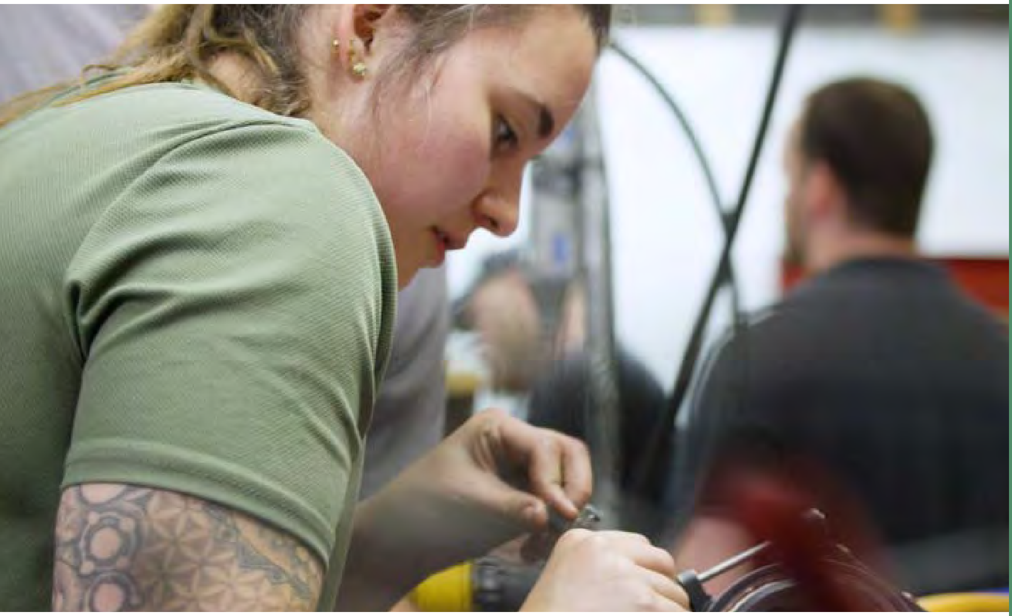
Published by Regional Opportunity Initiatives

GRADE 6-8 STEM CHALLENGE

Catapults!

Inspired by Gabi, an Electrical Engineer in the Indiana Uplands.

Students will design and build a catapult to launch a ping pong ball.



CAREER CONNECTION AND LESSON OVERVIEW

Engineers who work for the Navy, like Gabi, are given unique challenges to solve every day. All engineers use the engineering design process as a blueprint for solving problems and devising solutions. Like real engineers, students will be given criteria (what the design must do) and constraints (resources and limitations.)

In this challenge, students will design a catapult that will launch a ping pong ball. Gabi works on guidance systems to ensure objects that are launched land in the correct place. Small errors at launch (in direction or power) can result in the payload being off target by large distances once it reaches its destination. The catapults will not only have to launch the ball a long distance but they will also need to launch along a specific line. This means students will need to devise a way to aim their catapult.

LESSON TIMELINE

DAY 1
- Show the inspiration video, "Gabi - Electrical Engineer" (10 minutes)
- Introduce (or review) the Engineering Design Process (10 minutes)
- Introduce the challenge (5 minutes)
- Brainstorm, Design, and Build (rest of class period)

DAY 2
- Finish catapult designs and building (if not finished on day 1)
- Test and refine designs (15 -45 minutes, depending on time allowed)

DAY 3
- Final design performance evaluation (10 minutes)
- Report out (35 minutes)

Recommended Supplies

General supplies per group (3-4 students):
- 1 plastic spoon
- 8 craft sticks
- 2 rubber bands
- 2 straws
- 1 piece foam board
- 10 inches of string
- Scissors
- Mousetrap
- Hot glue
- Ping pong ball

For challenge assessment: range supplies
- Measuring tape
- Masking tape (for marking distance and center line)

IN THIS CHALLENGE, STUDENTS WILL:

- Create a catapult design that will launch a ping pong ball the furthest distance while also launching it in a straight line.

Standards

Science & Engineering Process Standards
SEPS.1 Posing Questions (for science) and defining problems (for engineering)
SEPS.2 Developing and using models and tools
SEPS.4 Analyzing and interpreting data
SEPS.6 Constructing explanations (for science) and designing solutions (for engineering)
SEPS.8 Obtaining, evaluating, and communicating information

Preparing for College and Careers
PCC-2.1 Determine roles, functions, education, and training requirements of various career options within one or more career clusters and pathways
PCC-2.2 Analyze career trends, options and opportunities for employment and entrepreneurial endeavors for selected career clusters and pathways
PCC-2.3 Evaluate selected careers and pathways for education requirements, working conditions, benefits, and opportunities for growth and change
PCC-2.4 Use appropriate technology and resources to research and organize information about careers

6th Grade Science Standards
6.PS.3 Describe how potential and kinetic energy can be transferred from one form to another

7th Grade Science Standards
7.PS.7 Construct a device that uses one or more of Newton's laws of motion. Explain how motion, acceleration, force, and mass are affecting the device
7.PS.8 Investigate a process in which energy is transferred from one form to another and provide evidence that the total amount of energy does not change

Standards
(continued)

Engineering

6-8.E.1 Identify the criteria and constraints of a design to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions

6-8.E.2 Evaluate competing design solutions using a systematic process to identify how well they meet the criteria and constraints of the problem

6-8.E.3 Analyze data from investigations to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success

6-8.E.4 Develop a prototype to generate data for repeated investigations and modify a proposed object, tool, or process such that an optimal design can be achieve

Engineering Design and Development

ETE-4.1 Apply the steps of the design process

ETE-4.2 Use the design process to create a product that addresses a real world problem

ETE-4.3 Create a technical sketch of a design with appropriate notation

ETE-4.4 Develop a product using the design process, while maintaining appropriate documentation

ETE-4.5 Develop various types of models (graphical, physical, or mathematical) that hep communicate solutions to peers

Grade 6-8 Employability Skills

6-8.M.2 Engage in feedback with peers to seek growth and learning opportunities from others

6-8.WE.4 Understand failure as an opportunity for growth

6-8.LS.1 Communicate information to audiences in a variety of formats (i.e., large and small group presentations, e-mail communication, interview setting, etc.)

6-8.LS.4 Identify possible career choices and high school course selection using self-assessment (including an appraisal of strengths, interests, and values)

6-8.LS.12 Use prediction and evaluation skills to develop potential solutions

Planning and Implementation

CATAPULTS!

Essential Vocabulary

- NEWTON'S FIRST LAW OF MOTION: An object at rest stays at rest and an object in motion stays in motion until acted upon by an outside force.
- VELOCITY: The speed at which an object moves.
- FORCE: A push or pull on an object that transfers energy to the object.
- GRAVITY: Attraction between two objects with mass, i.e. a marble and the Earth.
- ACCURACY: The state of being close to a known or expected point or value.
- PRECISION: The reproducibility of results from a given device.
- ENGINEERING DESIGN PROCESS: A series of steps that a student or engineer follows to come up with an optimal solution to a problem.

In this challenge, students will:

- Create a catapult design that will launch a ping pong ball the furthest distance while also launching it in a straight line.

Before Class:

- Read the activity outline sheet and leader notes to become familiar with the activity.
- Gather necessary materials. Be sure that you have enough materials and space for students to work in groups of 3-4.
- Introduce students to the relevant vocabulary and the idea of the engineering design process.
- Set up a testing range for students. This should include distance markers and a line parallel to the launch trajectory. Students will be assessed by how far their balls travel and how far the deviate from the line.
- Create an example catapult if needed. However! Be mindful of how much guidance you provide. Some students will see an example as the "right" solution and this can stifle creativity.

Guiding Questions

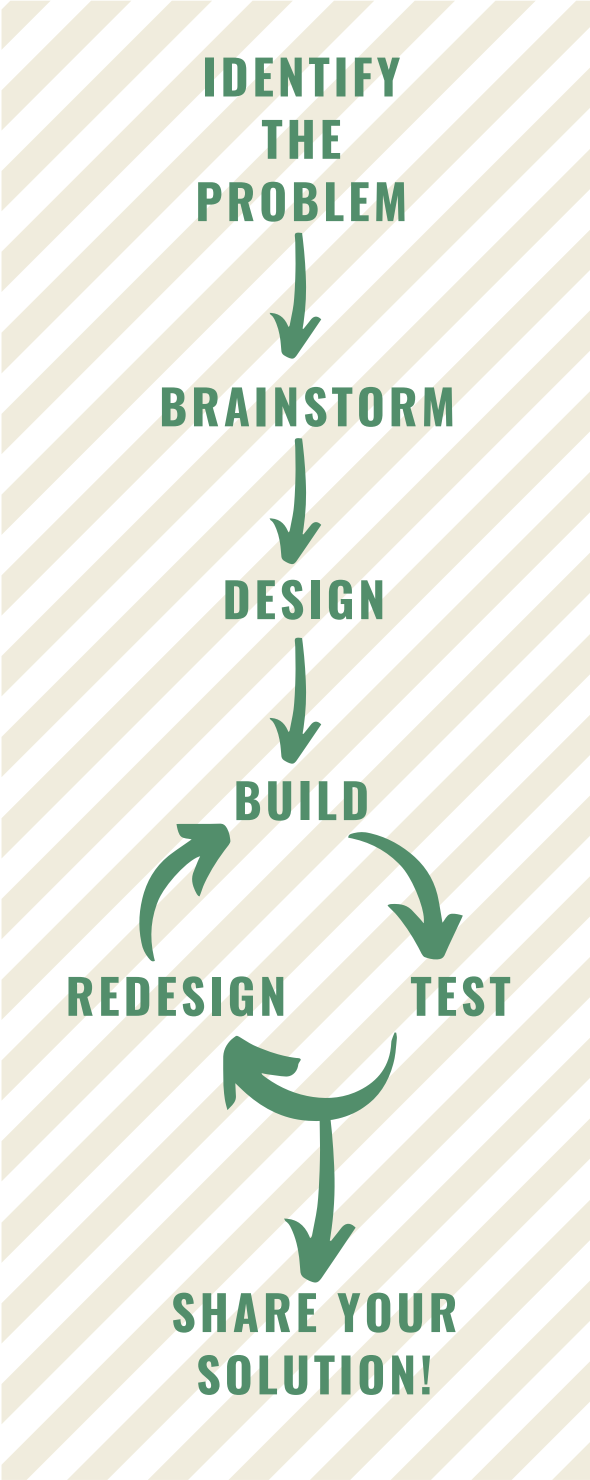
1. What is the engineering design process?
2. What is a catapult? How does it work?
3. What kind of energy is at work in a catapult?
4. Where is energy used and/or stored in a catapult?
5. How do engineers design complex structures and solutions?

Day 1

Introduction

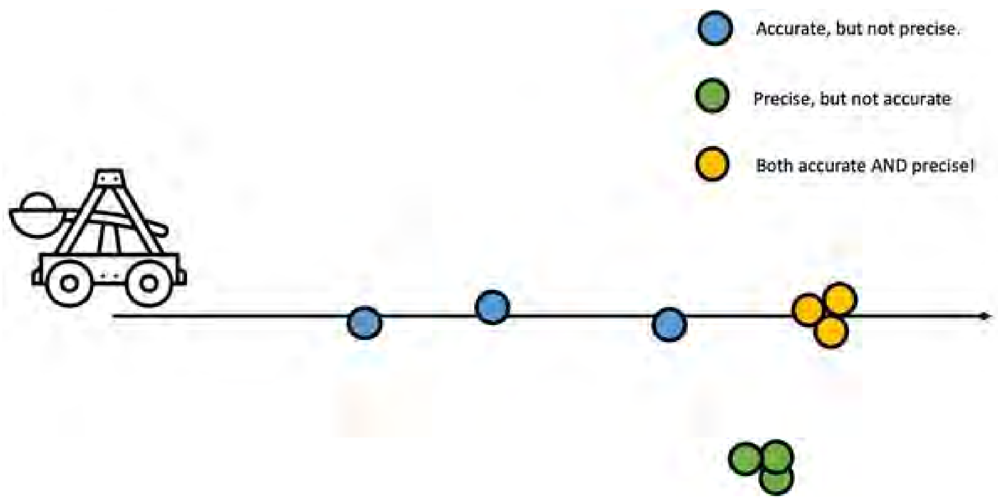
Show students Gabi's career shadow video. Talk about what engineers do and outline the engineering design process. There are many versions of the EDP that include more or fewer steps but each should include some variation of:

- Identify the Problem
- Brainstorm
- Design
- Build
- Test & Evaluate
- Redesign (if needed)
- Communicate Solutions



Catapults are a great way to explore ideas like velocity, energy, and force. Newton's First Law of Motion states that objects at rest remain at rest and objects in motion will continue in a straight line unless acted upon by another force. The launched ball has velocity when it leaves the catapult but students will see that its path is definitely NOT a straight line. As they plan and build, encourage students to think about how energy and gravity interact to affect the flight path and velocity of their ping pong balls.

This activity is also an excellent opportunity to discuss the ideas of accuracy and precision. As an electrical engineer, Gabi is tasked with developing guidance systems that ensure that whatever the Navy launches lands where it should. Her results, like those of the student engineers must be accurate. That is, they must hit or land extremely close to the target. They also must be precise—the launches should be able to reliably and reproducibly land in roughly the same place over and over again. When accuracy and precision come together you can hit the target every time.



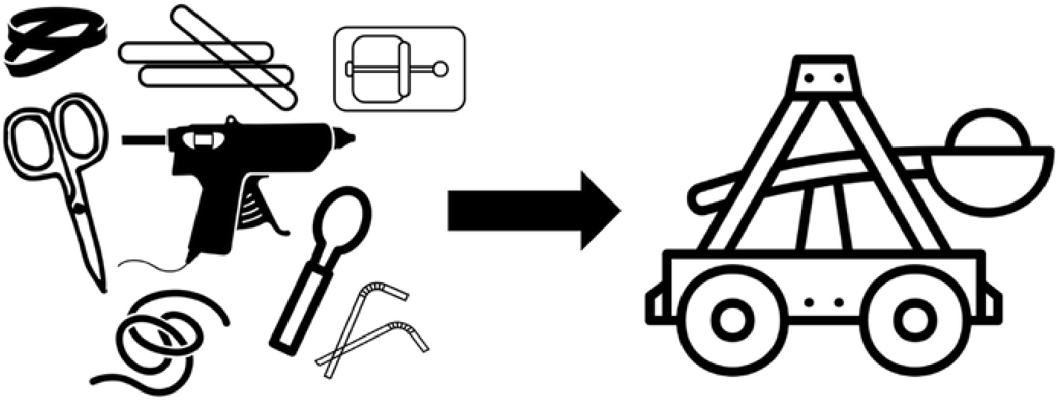
Explain to student the challenge and outline what materials they will have. Explain the criteria for successful designs (distance launched) and constraints (it must use the materials provided and travel along a center line.) Students will be building a catapult to launch a ping pong ball. Their designs will need to meet the following criteria and constraints.

Criteria

1. The ball must be launched a distance. The launcher will be judged by the distance the ball flies before hitting the ground.
2. The ball must be launched in a straight line. Each foot the ball deviates from the set line will result in a penalty.

Constraints

- Student engineers may use only the materials provided. They do not need to use all the materials.
- The launcher must be portable.
- The engineers will not be able to touch the ball while launching. The ball may not be pushed, pulled, or thrown by the engineers.
- Engineers may use only two fingers when launching.



Brainstorm and Design

Share the challenge and give your student engineers time to think through and plan, both on their own and in small groups. Discuss the questions as well as the criteria and constraints of the challenge. Encourage students to think about:

- Energy! How will your device store potential energy? How will you release this energy and convert it into kinetic energy?
- Newton's First Law of Motion states that objects at rest remain at rest and objects in motion will continue in a straight line unless acted upon by another force. How do you predict your ping pong ball will move when you launch it? Will it continue in a straight line forever? Why or why not? If not, what is affecting its motion?
- How will you hold the ping pong ball in the launcher?
- How will you aim your launcher?
- Accuracy and precision are linked ideas but not similar. How will you be able to tell your catapult is accurate? How will you be able to tell if it is precise?

Build, Test, Evaluate, and Revise

Students should be fairly self-directed but be prepared to trouble shoot. Each group will have three shots to demonstrate their catapult but they should be allowed unlimited testing and redesign prior to assessment.

Discuss and Report

Each student group should share out their initial designs as well as any revisions or modification. Ask them to describe their approach either verbally or in writing.
In addition to the planning worksheet, ask students to briefly answer the following questions in complete sentences:

- Where did energy play a role in your design? How did you store it? How is it released?
- What changes or revisions did you make to your design after your initial tests? Why?
- Newton's First Law states that an object in motion continues in straight line motion until acted upon by a force. How did your ping pong ball's flight demonstrate this?
- Was your team's catapult accurate? Were you able to land a ping pong ball close to the center line every time?
- Was your catapult precise? Could you reproduce your results each time?
- How is your system similar to the tracking and guidance systems soldiers use? How is it different?

Career Exploration and Extension

Prompt students to think about and research what a career as an electrical engineer might entail.

- What does an electrical engineer do all day? What does Gabi do?
- What kind of training would a student need to become an electrical engineer? What about an engineer in general? What other types of engineers are there?
- Are jobs like Gabi's in high demand? Will more people be hired to be engineers in the future?
- What kind of education is needed to be an engineer? Where could a student be trained locally for a career in engineering? What types of classes are important?

Name: ______________

Catapults!

Student Data Sheet

IDENTIFY THE PROBLEM What are we trying to do?
BRAINSTORM Imagine solutions to the problem above. Record your ideas in words or pictures.

Name: ________________

DESIGN

Create a blueprint of the prototype you will build. What materials will you use?

BUILD

You will have ________minutes. Use this time to build the prototype you planned.

Name: ________________

TEST AND REDESIGN

Improve the prototype that you created. How can you make it better?

SHARE AND COMMUNICATE

Share your marble run with the class or a classmate.

What was the most difficult part of this challenge?

What was your biggest success?

ACKNOWLEDGEMENTS

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IMAGE AND CONTENT CREDITS

Images

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- Catapult by BGBOXXXDesign from Noun Project
- Spoon by dewadesign from Noun Project
- Mousetrap by Pham Tran Loc from Noun Project
- Straw by Juan Pablo Bravo from Noun Project
- Glue Gun by Julia Bridge from Noun Project
- String by Carol Cost from Noun Project
- Scissors by Olga from Noun Project

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