INNOVATION GENERATION
Making an Impact

VOLUNTEER-LED ACTIVITY: ANGLED LAUNCH

ACTIVITY

What is the best angle for launching a catapult?

Objective

In this activity, students will utilize principles from geometry and physics to build and test their own catapults.

Materials

- Rubber bands (20–30 per group)
- Plastic spoon (1–2 per group)
- Popsicle sticks (5–10 per group)
- Glue (1 bottle per group)
- Clay (2–3 blocks per group)
- Ping pong ball (1–2 per group)
- Protractor (1 per group)

How-to

1. Get students curious by asking a series of questions (you can add in your own if you'd like!):
    - **a.** How and why were catapults used in the Middle Ages?
    - **b.** Can you think of examples of catapults used today (slingshots, crossbows, etc.)?
    - **c.** What do you need to make a catapult work?
2. Explain that a successful catapult relies on a few basic principles of physics: tension, torsion, and gravity.
    - **a.** Provide a quick definition for each:
        - i. Tension is a force that occurs along a flexible medium, like a rope or cable. The word "tension" comes from a Latin word that means "to stretch"[1].
        - ii. Torsion is the same as twisting. When you use a drill to tighten a screw, you are using torsion[2].

[1] https://phys.libretexts.org/Bookshelves/College_Physics/Book%3A_College_Physics_(OpenStax)/04._Dynamics%3A_Force_and_Newton's_Laws_of_Motion/4.5%3A_Normal%2C_Tension%2C_and_Other_Examples_of_Forces

[2] https://engineeringinsider.org/torsion-meaning-torsion-force/

iii. Gravity is the force that tries to pull two objects towards one another. It's what keeps us walking on the ground and brings a ball we throw up into the air back to the ground[3].

3. Have students think back to a catapult from the Middle Ages for a minute. Explain that the most common example of a catapult that they would have seen in a movie or learned about in history class would be the mangonel—this is a catapult that is set up like a slingshot[4]. Let's look at how tension, torsion and gravity make the mangonel catapult work:

    a. The mangonel catapult uses either tension or torsion to create potential energy in the catapult's launcher. Tension results when the builders use ropes or cables pulled in opposite directions (one towards the ground, one towards the target)[5]. Torsion results from using ropes that are twisted really tightly to hold down the launcher[6].

    b. When the rope is cut, the potential energy stored in the launcher propels the projectile forward. Once the projectile is launched, it's at the mercy of gravity. If gravity didn't exist, the projectile would keep going in the same direction and have a straight trajectory[7]. Because the force of gravity compels the projectile to fall towards the ground, it doesn't have a straight trajectory. It has a curved, or parabolic, trajectory[8].

    c. Just like when a pitcher throws a baseball, a catapult launcher has to think about the angle and potential energy required to get a projectile to hit its intended target. A steeper angle means a steeper curve, so the projectile will fly higher but will not go as far. The more a pitcher winds up, the more potential energy they're storing, and the more energy they'll transmit to the baseball when it's released.

4. Now, it's time to get hands-on![9]

    a. Divide students into groups of 4 or 5.

    b. Provide each group with a good amount of the materials listed (to save time, you can work with your educator to set up the classroom and distribute materials before students arrive).

    c. Tell students that the objective of the activity is to determine the best angle for maximizing the range of a mangonel catapult made from the given materials.

    d. Inform students that they can use the given materials to design their catapult in any way they'd like. There are just a few ground rules:

    i. The rubber bands are to be used to create potential energy through tension or torsion.

    ii. The spoon is to be used as the launcher

[3] http://coolcosmos.ipac.caltech.edu/ask/300-What-is-gravity-

[4] https://sciencing.com/a-catapult-work-4586404.html

[5] https://sciencing.com/a-catapult-work-4586404.html

[6] http://people.cs.ksu.edu/~nhb7817/ScratchCurriculum/Catapult/Physics%20Calculations%20for%20a%20Mangonel.pdf

[7] https://www.physicsclassroom.com/class/vectors/Lesson-2/Characteristics-of-a-Projectile-s-Trajectory

[8] http://people.cs.ksu.edu/~nhb7817/ScratchCurriculum/Catapult/Physics%20Calculations%20for%20a%20Mangonel.pdf

[9] Adapted from http://people.cs.ksu.edu/~nhb7817/ScratchCurriculum/Catapult/Physics%20Calculations%20for%20a%20Mangonel.pdf

iii. The ping pong ball is to be used as the projectile

iv. The popsicle sticks, clay, glue and remaining materials can be used to build the structure of the catapult.

e. Provide students with 20–25 minutes to construct their catapults.

f. As students work, walk around the classroom to assist as needed and call out any especially creative designs you see!

5. When a critical mass of groups have at least the beginnings of a mangonel catapult in front of them, it's time to test their designs (helpful hint: this part is best done outside or in a large room like a gym!):

a. Instruct groups to line up their catapults in a horizontal line. Check in with your educator to ensure any appropriate safety gear is in place.

b. One designated group member will be the launcher. One will load and hold the projectile in place, one will measure the angle with the protractor and 1–2 will record the distance that the projectile travels after launch.

c. Inform students that they are going to test their designs and see which angle allows the projectile to travel the furthest.

d. Have students prepare their catapults for their first launch, which should be set to 30 degrees.

e. On your cue, students will release the projectile!

f. When the projectiles have been released, have the distance recorders walk to the location of their group's ping pong ball, measuring distance by counting the number of steps they take to reach the ball. Have them write down the number of steps on a piece of paper.

g. Repeat this process twice more, adjusting the angle to 45 degrees and 60 degrees, respectively.

6. When the tests are complete, synthesize learning by asking students the following reflection questions:

a. Which angle launched the projectile the farthest. Why do you think that is?

b. If the goal of the catapult was to send a projectile over a tall enemy wall, how would your approach change?

c. What are some other ways you could build a catapult?