

Build a Binder Clip Catapult

Introduction

Catapults have been used to launch projectiles during battles from the time of the ancient Greeks to World War I. Make a catapult using simple materials and then test the machine to see what variables affect launch distance. Improvements may then be made to increase the accuracy of the launch.

Concepts

- Levers
- Mechanical advantage
- Potential and kinetic energy
- Engineering design
- Projectile motion

Materials

- | | |
|-------------------------------|--|
| Binder clip, medium | Scissors or pliers |
| Bottle cap, plastic | Tongue depressors, 4 |
| Cable ties, 4 | Velcro® dot tape |
| Meter stick or measuring tape | Projectile (e.g. small cork, pom-pom, table tennis ball, etc.) |

Safety Precautions

Use caution when launching projectile. Do not aim the Binder Clip Catapult at anyone. Catapult launching should be performed only in the area specified by your instructor. Wear safety glasses. Follow all laboratory safety guidelines.

Procedure

Part A. Assembling the Catapult

1. Align one tongue depressor on top of a second one and fasten them together with a cable tie 2.5 to 3 cm from one end. See Figure 1. Pull the cable tie as tight as possible.



Figure 1.

2. Insert one metal arm of the binder clip between the two tongue depressors past the cable tie. Since the cable tie is very tight, the arm will fit snugly between the tongue depressors. See Figure 2.



Figure 2.

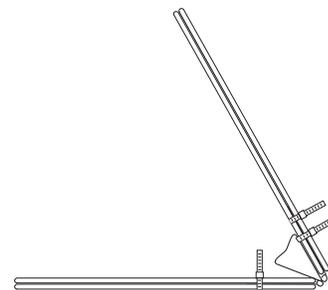
3. Repeat steps 1–2 with the other two tongue depressors and the second metal arm.
4. Insert a third cable tie through the binder clip and around the two tongue depressors, pulling the cable tie as tightly as possible. See Figure 3 on next page.
5. Repeat step 4 with the fourth cable tie on the other side of the binder clip.
6. After making sure all four cable ties are as tight as possible, cut off the excess plastic. Alternately, grasp the excess cable tie near the fastener with pliers and twist several times until the plastic breaks off.
7. With both sides stuck together, attach a Velcro dot on top of one tongue depressor about 1 cm from the free end.
8. Attach the matching Velcro dot to the plastic bottle cap and press the bottle cap firmly to the tongue depressor. See Figure 4.
9. The arm of the catapult with the bottle cap is the lever arm and the other is the base of the catapult.

Build a Binder Clip Catapult *continued*

Part B. Testing the Catapult

Be sure to wear safety glasses when any team is testing the catapult. Do not launch the projectile toward anyone.

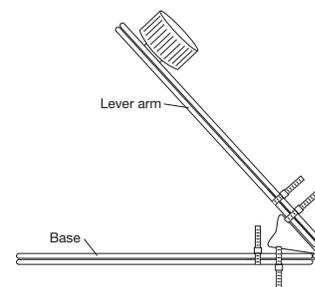
1. Choose a projectile from those approved by your instructor.
2. Set the catapult on the floor and hold down the base.
3. Press down the lever arm of the catapult and place the projectile in the bottle cap.
4. Making sure no one is in the path of the projectile, release the lever arm.
5. Note where the projectile lands and measure the distance from the catapult to that spot.
6. Repeat launch with the same projectile several times.



Part C. Design Challenge

Choose one of the options below.

1. Form a working group with other students and make a list of variables that may affect the distance the projectile travels. Write out a step-by-step procedure for testing a specific variable. After testing several variables, propose improvements to the basic design to generate a greater launching distance.
2. Consider the accuracy of the launches from Part B. How consistent were the distances? Brainstorm ways to improve the design of the catapult to increase the accuracy of the launch. For example, how would you design a catapult to launch a specific projectile to consistently hit a target 3 meters away?



NGSS Alignment

This laboratory activity relates to the following Next Generation Science Standards (2013):

Disciplinary Core Ideas: Middle School

MS-PS2 Motion and Stability: Forces and Interactions

PS2.A: Forces and Motion

PS2.B: Types of Interactions

MS-PS3 Energy

PS3.A: Definitions of Energy

PS3.B: Conservation of Energy and Energy

Transfer

PS3.C: Relationship between Energy and Forces

MS-ETS1 Engineering Design

ETS1.A: Defining and Delimiting Engineering Problems

ETS1.B: Developing Possible Solutions

ETS1.C: Optimizing the Design Solution

Disciplinary Core Ideas: High School

HS-PS2 Motion and Stability: Forces and Interactions

PS2.A: Forces and Motion

PS2.B: Types of Interactions

HS-PS3 Energy

PS3.A: Definitions of Energy

PS3.B: Conservation of Energy and Energy

Transfer

HS-ETS1 Engineering Design

ETS1.C: Optimizing the Design Solution

Science and Engineering Practices

Asking questions and defining problems

Developing and using models

Planning and carrying out investigations

Analyzing and interpreting data

Constructing explanations and designing solutions

Crosscutting Concepts

Patterns

Cause and effect

Energy and matter

Structure and function

Tips

- This binder clip catapult model was specifically chosen to eliminate the need for hot glue or sharp cutting tools. If students are allowed to make improvements on the basic design, consider the experience and maturity of your students and set specific design constraints accordingly.
- Twisting the excess cable tie off with pliers leaves a smoother edge than cutting with scissors, which can leave a sharp edge. Sharp edges may be sanded smooth.
- Many small, lightweight objects may be used for projectiles. Students may consider the advantages and disadvantages of shape, texture, mass, etc. when choosing a projectile.
- A large open space such as a gymnasium or even outdoors works best for this activity. Student groups may form a large circle with their catapults facing outward to avoid projectiles interfering with one another or hitting other students.
- Some smart phones have a slow motion video feature. Allow students to record their launches in order to better analyze the motion of the catapult and projectile.

Discussion

A catapult is based on the simple machine known as a lever. The binder-clip catapult is a first class lever, with the base of the clip acting as the fulcrum, or pivot point, which is in between the load and the effort force. The load or resistance force is provided by the “jaws” of the clips that open. The effort force is applied to the tongue depressors that are an extension of the metal arms of the clip. By extending the length of the lever arm, an increase in mechanical advantage is obtained, which is the ratio of the output force to the force applied. In general, a reverse relationship exists between mechanical advantage and both the amount and speed of movement. When the lever arm of the catapult is compressed, less force is required to open the jaws of the binder clip than using the metal arms alone, but the force must be applied over a greater distance. The energy used to open the binder clip is stored as elastic potential energy. This energy is then released as kinetic energy when the force holding the lever arm down is removed. Since the closing jaws of the binder clip have a short distance to travel, the trade-off is more speed and distance of the lever arm as it snaps upward. The projectile moves with the lever arm and continues on when the lever arm stops as predicted by Newton’s first law of motion.

Materials for *Build a Binder Clip Catapult* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP4412	Tongue Depressors, Pkg. of 500
AP6842	Velcro Dot Tape
AP6996	Caps for Mini Soda Bottles, Pkg. of 30

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.