

STEM ACTIVITY 1 CATAPULT CONTEST

HITTING A TARGET WITH A STRAW PROJECTILE

WHAT AFFECTS THE PATH OF A PROJECTILE?

Hannibal, Genghis Kahn, Archimedes, Alexander the Great—they all used catapults in warfare. Now the contestants of the Punkin Chunkin World Championship in Bridgeville, Delaware, build and use catapults for something very different than weapons. They hurl pumpkins insane distances—some close to a mile—in search of orange, pulpy glory (and to raise money for charities).

Now you get to do it, too! Instead of pumpkins, however, you are going to be using something more aerodynamic. You'll be launching projectiles with a catapult that your teacher will provide. You can refine your design to get better accuracy so you can emerge from your catapult competition as the victor.

DESIGN PARAMETERS

Note: Record all notes, designs, data, calculations, analyses, and conclusions in a project log.

Plan and build your projectile according to the parameters below. Play with your design so that you can achieve the greatest accuracy possible with your projectile.

- 1 One full-length straw for the fuselage
- 2 A lump of 2–5 grams of adhesive putty (sticky tac) or clay for the nose cone
- 3 Single paper clip with hook for rubber band even with the top end of the straw
- 4 No more than three layers of tape to secure the paper clip and fins in two sections each
- 5 Fins made of cardstock paper, maximum of four extending no more than 1 inch from the fuselage
- 6 There should be no fins lined up with the paper clip hook so that the fuselage can be next to the launch arm. There should be an extension of paper no more than 1.5 inches above and below the fins to be secured to the fuselage with tape.
- 7 Before you begin designing your own projectile, your teacher will tell you the distance to the target.

LAUNCH PARAMETERS

In order to figure out if you are improving your design, you need to make sure that you launch your projectile the same way every time. Follow the guidelines below.

- 1 The same rubber band should be used for all launches.
- 2 The distance for each projectile launch should be measured to the point at which the projectile first hits the floor/ground.

Key Questions

- » What is the relationship between force and the trajectory of a projectile regarding the distance it travels?
- » Does the mass of a projectile affect its flight?

Equipment

laboratory balance, accurate to 0.1 g
 stock projectiles
 plastic straw
 adhesive putty or clay
 paper clip
 rubber band
 cardstock paper
 launch apparatus
 long measuring tape
 cell phone with video analysis app
 adhesive tape
 project log

PROCEDURE

Planning a Design

To keep everyone involved, assign jobs to each person in your group. Choose who will launch the projectile, who will measure the time aloft, and who will measure the distance traveled. If you have the technology, record a video of the launch so you can analyze it later.

- 1 Your team will launch three stock projectiles provided by the teacher three times each from two different pull back points (total 18 launches). The three projectiles will each have a different amount of mass in the nose cone: 2 g, 3 g and 4 g. Each of these three launches should be at a different angle. The same three angles should be used for each of the three masses. The projectile should be pulled back to the point designated by the teacher for each of these launches. Your team should record the launch angle, the distance traveled, and time aloft for each of these launches.
- 2 Your projectile will travel a path that can be modeled by a parabola. Using the formula

$$v_h = d/t$$

plug in the distance your projectile traveled and the time aloft to determine how fast your projectile moved along the ground, v_h .

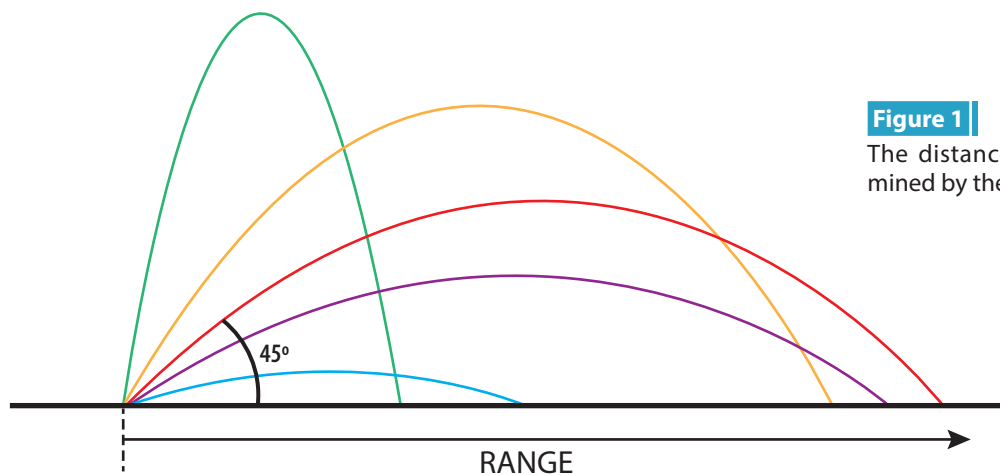


Figure 1

The distance your projectile travels is determined by the parabolic path that it takes.

- 3 Considering that the projectile spent roughly half the time aloft traveling upward and the other half of the time traveling downward, you can use half the time to compute the approximate height that the projectile reached. Use the formula

$$h = g(t_{\frac{1}{2}})^2$$

where $g = 9.8 \text{ m/s}^2$ (32 ft/s^2) which is the acceleration due to gravity.

- 4 Considering that the speed your projectile was traveling vertically at the peak of each flight is zero, compute the vertical velocity of the projectile at the end of its flight using the formula

$$v_v = gt_{\frac{1}{2}} \quad (t_{\frac{1}{2}} = \frac{1}{2} \text{ the time aloft})$$

- 5 Your team should share their data with the other teams by giving their data sheets to the teacher to make copies for the other teams.
- 6 Each team member should draw the trajectories of the five most successful flights and include the nose cone mass, height, and distance traveled for each.

Building the Design

- 1 Based on the data you collected with the stock rockets and the target distance provided by your teacher, each member of the team should design a projectile indicating the length and number of fins and the mass in the nose cone.
- 2 Compare designs and come to a consensus on which designs to build and which two projectiles will be tested.
- 3 The team should launch each of their projectiles twice while recording the launch angle, the distance traveled, the distance from the target, and the time aloft for each flight.
- 4 Compute the horizontal velocity, the height, and the vertical velocity for each launch.
- 5 Based on your results answer the following questions:

What seemed to be the most important factor affecting flight distance?

What seemed to be the second most important factor affecting the distance?

Besides the factors you were able to manipulate, what other factor(s) might affect flight distance?

Besides the direction, what was the difference between the vertical and horizontal components of the flights?

How could a scientist or engineer practically use what you have learned to help people or to wisely use God's world?
- 6 Based on testing your initial design, modify your projectiles and repeat the testing process.
- 7 After all data, calculations, justifications, conclusions, and answers to questions are recorded, turn in your project log with your data sheet.

Data Table

	Team	Launch Pullback Point	Mass of Nose Cone (g)	Launch Angle	Time Aloft (s)	Distance Travelled (m)	Horizontal Velocity (m/s)	Height (m)	Vertical Velocity at Impact (m/s)	Distance From the Target (m)
Stock Projectiles										
Test										
Retest										