FINDING THE PERFECT SHOT

PART ONE – Testing Trajectories

Using catapults to investigate the trajectory – or curved path – a ball takes when it's thrown.

HERE'S WHAT YOU'LL NEED:

- **Craft stick**
- **Safety goggles**
- **Ping-Pong ball**
- **Tape measure or meter stick**
- **Masking tape**
- **Large plastic cup or bowl**
- **Notebook**
- **An open area, free of obstacles, for a test site**
- **Several friends to act as height and distance spotters**

WARMUPS

- Start by constructing a catapult using the directions provided.
- Use masking tape to mark a starting point on the ground and position your catapult behind it.
- For the first trial, position the lever arm so that the bowl of the spoon is resting on the craft stick

Suggestion: Perhaps state the cm that it should be on. From the picture it looks like the catapult is already constructed in the manner where the spoon is resting on the craft stick at the 2cm mark. Load the Ping-Pong ball onto the spoon. Place several fingers on either side of the crossbar, the catapult's fulcrum, to steady the catapult.

- Using your thumbs, pull back on the spoon until the lever arm touches the ground.
- Release the spoon and launch the ball.
- Have spotters mark and measure the highest point the ball reaches during its flight and the spot where it hits the ground. Record the results in your notebook.
- In your notebook, draw a diagram of the path the ball made from the time it was launched from the catapult until it hit the ground.
- Repeat the trial three more times, recording the height and distance each time.

What scientific explanation can you give for the shape of the ball's path?

Find the average for both the height and distance travel for your four test launches.

$$\text{Average} = \frac{\text{Sum of all the heights}}{\text{Total number of trials}}$$

- Try increasing the length of the catapult's lever arm by sliding the spoon up the craft stick to the next centimeter mark
- Adjust the rubber bands as necessary to hold the spoon steady.
- Create a new table and repeat the previous test with a new length and then discuss similarities and differences between the height and distance data.

How did the lever arm length affect the ball's performance?

Based on your results so far, predict what will happen to the ball's trajectory if you continued to increase the length of the lever arm.

- Test your prediction by sliding the spoon out to each centimeter mark on the craft stick. Record and average your results for each centimeter mark.
- Graph your results. Was your prediction correct? Did your prediction support what you thought would happen?

GAME TIME

Create a basket for your ball to land in by placing a plastic cup or bowl one meter in front of the starting line. Use a measuring tape or a meter stick as a guide.
Your engineering challenge is to determine the best lever arrangement for your catapult so that it consistently shoots the ball into the basket.

- Start by drawing a diagram of the catapult configuration you think will work. Label the parts and spoon's position on the lever arm. (See page 3 for reference)
- Create a table to record your test results and keep a log of any additional adjustments you make to your catapult.

ANALYZE THE REPLAY
What happened?

Once you've finished testing, take time to review all of the information you have collected through your tests and observations.

Did your experiments have the outcomes you expected?

Which lever arm configuration gave you the best results? Use the evidence found in your data to explain why this configuration worked the best.

What difficulties did you encounter during testing? How did you overcome them?

OVERTIME
Let's take it further

Now that you've tested the length of the lever, change a different variable to see how it affects the accuracy of the shot.

Possible Variables to Change:

- Varying the position of the fulcrum (the stacked cross-piece).
- Changing the number of craft sticks that make up the fulcrum.
- Changing how far back you pull the lever arm.
- Changing the weight or size of the ball.

CRAFT STICK CATAPULT

STEP #1

Using a ruler as a guide, mark a craft stick at 1 cm intervals.

Stack it on top of a second craft stick and wrap the pair together with a rubber band at one end.

STEP #2

Stack the remaining eight craft sticks together and wrap a rubber band around each end.

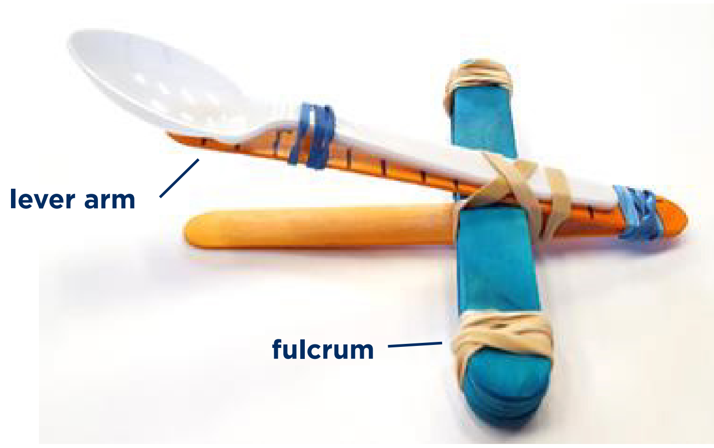
STEP #3

Slide the bundle of eight sticks in between the two sticks of the first bundle.

Criss-cross a rubber band where the two bundles meet to hold the two pieces together.

STEP #4

Slide a plastic spoon under the rubber bands on the top craft stick until the bowl of the spoon is resting on the stick. Secure with additional rubber bands as needed.



COACH'S CORNER
Additional information and explanations for parents and educators

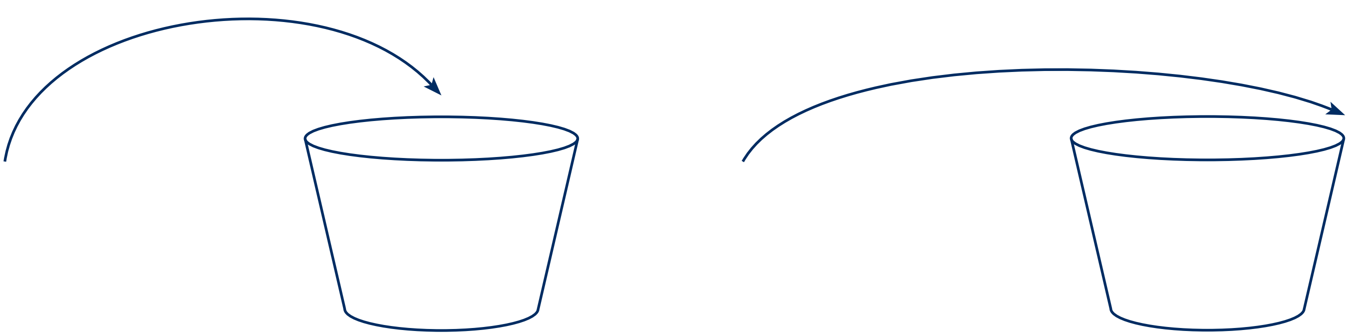
Slide a plastic spoon under the rubber bands on the top craft stick until the bowl of the spoon is resting on the stick. Secure with additional rubber bands as needed.

A lever is a simple machine that consists of a beam or plank that rests on and pivots around a stationary object called a fulcrum.

The crossbar of the catapult acts as the fulcrum that the catapult's lever arm pivots on. As the lever arm is pulled back, potential energy is gathered in the stretching rubber bands, the wooden craft stick and spoon as they bend. When the arm is released, the arm starts to return to its initial position and the gathered or stored energy is converted to movement. When the arm is unable to move any further, the ball leaves the spoon and launches forward. This behavior is a good example of Newton's First Law, which states that objects in motion tend to stay in motion, while objects at rest tend to stay at rest.

When the lever arm was released, the ball moved forward at the same speed as the arm. When the arm stopped, the ball continued to move forward at the same velocity until gravity brought it back to the ground. The speed of the ball combined with the angle at which it leaves the spoon determines the height of the ball's trajectory arc.

When shooting a ball into a basket, the higher the arc in a ball's trajectory, the bigger the percentage of available surface area inside the rim. If the ball drops into the hoop directly from above, the entire area inside the rim is open. If the ball's arc is flat it reduces the area within the hoop that is open to the ball's path.



CHECK OUT THESE WEBSITES FOR MORE INFORMATION

Basketball Training Grounds: Swish…How To Shoot A Basketball
http://www.basketballtraininggrounds.com/how-to-shoot-a-basketball.html

Catapult Crazy
http://www.stormthecastle.com/catapult/

OKLAHOMA ACADEMIC STANDARDS: MATHEMATICS

STANDARD	4TH GRADE	5th Grade	6th Grade
PS3-1 Energy	●		
PS3-2 Energy	●		
PS3-3 Energy	●		
PS2-1 Motion		●	
PS3-1 Energy			●
PS3-2 Energy			●