Marshmallow Catapults

Lesson Type: Engineering/Building
Target Grade: Elementary School
Authors: Eddy Wang (based on Marty Gelenter and Akshay Belur's Spring 2015 lesson)
Semester: Spring 2016

Introduction

This lesson is designed to be an exciting start to the semester. At the beginning of the lesson, there will be time for ice breakers, name games, and other activities to introduce the students to BEAM, to their mentors, and to each other. Afterwards, students will build their own individual marshmallow catapults using popsicle sticks, plastic spoons, tape, and rubber bands. By the end of the lesson, the mentors/mentees should know each other's names and also a little bit about projectile motion and the engineering design process.

Teaching Goals

- Learning the names of all mentors and mentees
- Understanding the engineering design process
- Strength of triangles
- Understanding projectile motion

Agenda

- **Introduction to BEAM / Icebreakers (15 min)**
- **Marshmallow Catapults (30 min)**
  - Introduction to Marshmallow Catapults (5 min)
  - Building the Catapults and Testing (25 min)
- **Conclusion and Clean-up (10 min)**

Module 0: Introduction to BEAM / Icebreakers

For this lesson (and the next couple of lessons), it is a good idea to have the mentors and mentees make/wear their own name tags so that everyone can learn each other's name. Learning names is especially important for developing good relationships with the mentees because they are a lot more receptive when you call them by their name (as opposed to pointing to them or using some other generic identifier). You should play some name games to break the ice and allow everyone to get to know each other in a fun way. Here are a couple options:

- Animal Name Game: Have everyone stand in a circle (**be sure to have mentors evenly distributed in the circle!**). Then, go around the circle and have each student/mentor (1) say their name and (2) an animal that starts with the same letter as their name (ex: Eel Eddy, T-rex Tiff).
    - If you really want to reinforce the names, you can also have each mentor/mentee repeat the name/animal of each person before them.
        - Ex: say we have a circle of 3 people: Eddy, Tiff, and Varun.
        - Eddy says ‘Eel Eddy’, Tiff will say ‘Eel Eddy, T-rex Tiff’, Varun will say ‘Eel Eddy, T-rex Tiff, Viper Varun’
- Name Dance Game: Have everyone stand in a circle (**be sure to have mentors evenly distributed in the circle!**). Then, go around the circle and have each student/mentor (1) say their name and (2) do a little dance move.
    - If you really want to reinforce the names, you can also have each mentor/mentee repeat the name/dance move of each person before them (see the name game above if you’re confused)
- Animal Dance Name Game: Basically, combine the two aforementioned name games into one!

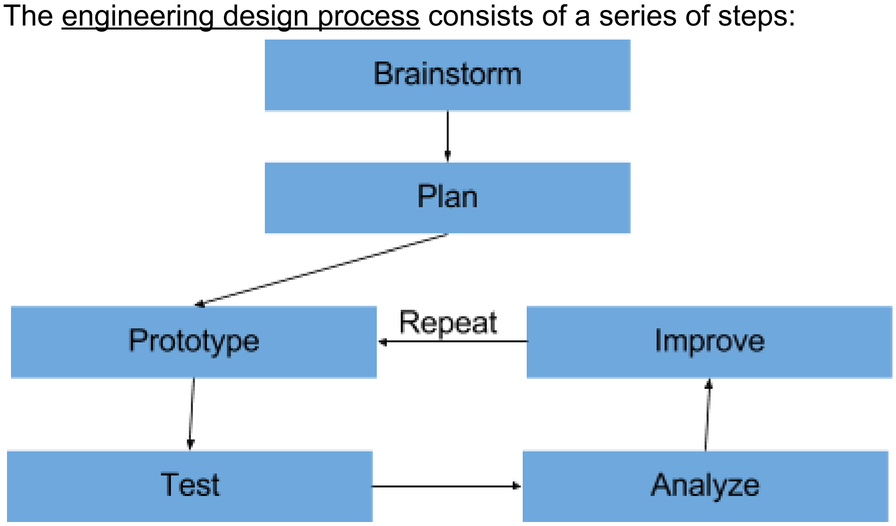
Module 1: Marshmallow Catapults

Introduction

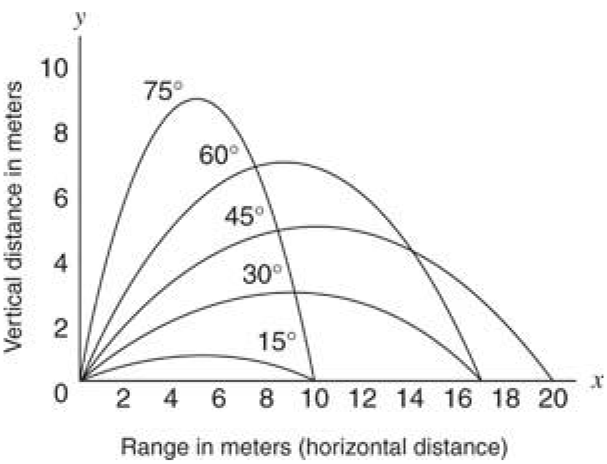
In this module, the mentees will use popsicle sticks, plastic spoons, tape, and rubber bands to make small catapults that will launch marshmallows into the air. Catapults will be judged by their range (how far the marshmallows are launched) and by their accuracy. During the building process, mentees will learn about the engineering design process and the importance of prototyping. Furthermore, they will learn a little bit about the basics of projectile motion to understand how to maximize the range of their catapult.

Background for Mentors

The engineering design process consists of a series of steps:



During each step of the process, remember to **ask the kids what they think they should do next**. Don't tell them what to do! Let them explore for themselves and have a discussion with them about why their plan might or might not be the best way to proceed.



Projectile motion refers to the arc that you commonly see when projectiles like cannonballs (or for the purpose of this lesson, marshmallows) take when they are launched into the air and affected **by one single force: gravity**. For the purposes of this lesson, we will neglect air resistance. Notice in the diagram to the left that the **angle of the launch affects two things: (1) how high the projectile goes (y-axis) and (2) how far the projectile goes (x-axis).**

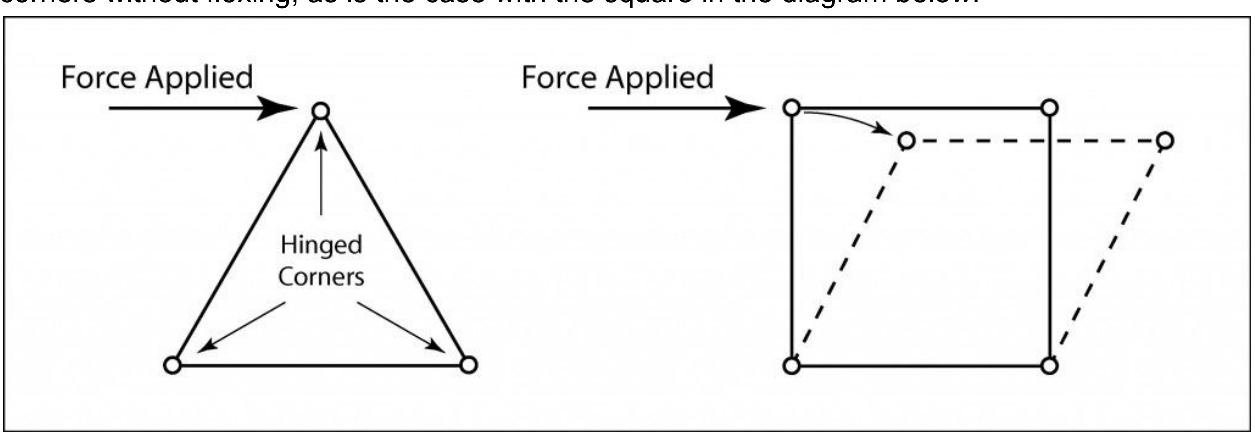
Also, notice that:

- 45 degree angle launch gives you **maximum range**
- 90 degree angle launch gives you **maximum height** (not shown in diagram, but this is equivalent to throwing a ball straight up into the air)

In other words, steeper launch angles enable the marshmallow to go higher, but if the angle is *really* steep (> 45 degrees), the increase in the height will come at a cost by **decreasing the horizontal distance**. The 45 degree angle maximizes range because it optimizes the balance between horizontal speed and vertical speed. You can think of vertical speed as how much time a projectile spends in the air.

Triangles

Another concept that will be covered is the strength of triangles. Triangles are stronger and more rigid than squares and other shapes (like hexagons) because any force (tensile or compressive) that is applied to one end of the triangle is evenly distributed to the other hinged corners without flexing, as is the case with the square in the diagram below:



This makes triangles indispensable in buildings, bridges, or any other object that must be strong and rigid. In the case of the catapult, using triangles as the sides of the catapult will help make the catapult stronger.

Materials

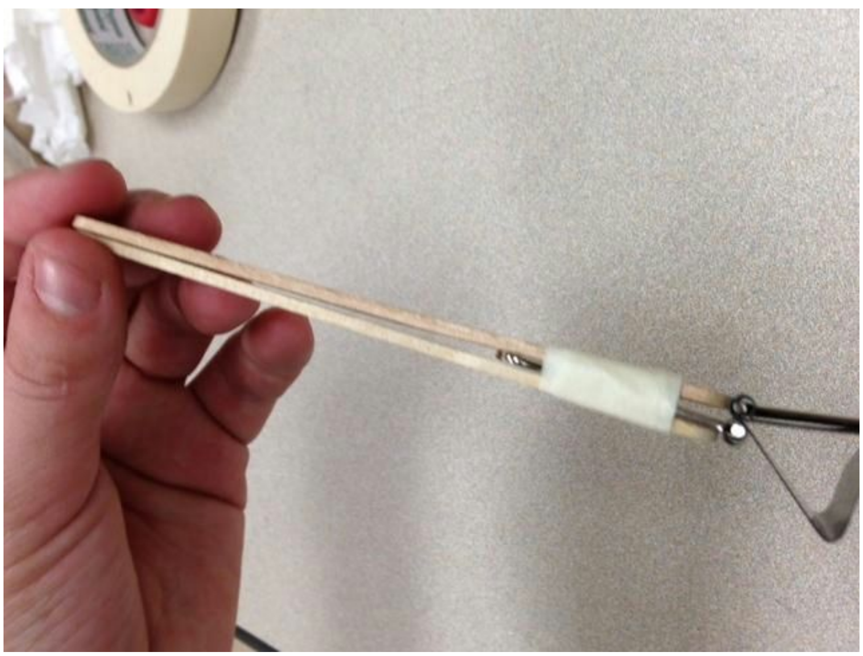
- See table at end of lesson

Procedure

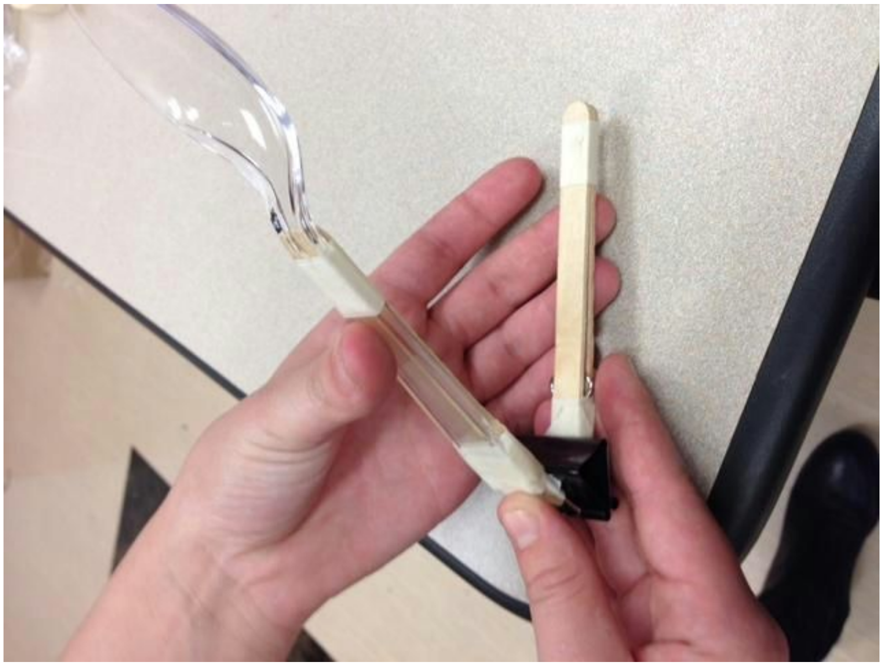
The most important procedure about this lesson is to **let your students build the catapults themselves.** Let them build the catapult through trial and error. Pay attention to what they are building and ask them why they are building it that way. The following are simply **GUIDELINES** in case a student is stuck and cannot proceed.

<u>Binder clip catapult</u>

- It takes a lot less time to build and works really well but it does not look as cool
- Start off with a binder clip and tape two popsicle sticks around the arm of the binder clip



- Make sure it is securely taped to the metal arm (you can tape one popsicle stick on first then tape the other)
    - Tape it both around the arm and around the other end of the popsicle sticks



- On the other arm, tape a spoon and a popsicle stick to the binder clip arm
    - **MAKE SURE THE SPOON IS TAPED ON THE CORRECT SIDE!**
    - The final product should look similar to the picture above
- If the catapult as a whole seems unsteady, you can use more tape to secure it
- Load up a marshmallow in the spoon and launch!

Or, you can go for something more complex using just popsicle sticks, spoon, tape, and a rubber band:

To build the above catapult:

- Build 2 equilateral triangles by taping 3 popsicle sticks together (for each triangle)
    - BUT, before building the triangles, ask the students if they want their sides to be squares or a triangle
    - Which one is stronger? (Refer to “material to teach” for the answer)
- Connect the two triangles to each other using two cross beams on the bottom of the catapult
    - Notice that these bottom 2 cross beams need to lay flat on the table
    - Taping these will be difficult, so the students may need help!
- Attach the spoon to the fulcrum stick
    - Hold the fulcrum stick in “front” (closer to you) of the spoon with the spoon also facing you (the pen below represents the spoon)

    - Put the spoon through a rubber band and let the rubber band hang over the front (over the fulcrum stick)

- Stretch the rubber band over the bottom of the spoon, bring it behind the head of the spoon spoon, and pull it over the spoon (see video: https://youtu.be/0flx1Ede3VU)
- Tape the fulcrum/spoon/rubber band to a different side of the triangle (not the same side as the cross-beams)
    - Make sure to leave enough room for the spoon to be pulled back
- Tape the tip of the handle of the spoon on the FRONT of a stabilizing stick below the fulcrum stick (on the triangle) (see the original picture of the catapult for clarification)

Here are some challenges that might be fun for the students:

- Target practice: try to get the students to accurately hit an inanimate object (like a backpack)
- See whose catapult can launch a marshmallow the farthest
- See whose catapult can launch a marshmallow highest into the air

References

- http://www.ctgclean.com/tech-blog/2012/10/the-strength-and-mystery-of-triangles/
- https://youtu.be/0flx1Ede3VU
-

Summary Materials Table

Material	Amount per Student	Expected $$ per site	Vendor (or online link)
Popsicle Sticks	10-15		
Spoons	2-3		
Marshmallows	1 bag per site		
Rubber bands	2-3		
Tape	1 roll per site		
Binder Clips	1-2		