STEM on Site Summer Program

Designing Your Own Foam Rocket

Image Source: Jet Propulsion Laboratory

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Recommended for Grade Levels: 6-8

Content Notice

This activity has been put together as a free, open source resource from the Milwaukee School of Engineering STEM team for self-guided, at home learning. Unless otherwise noted, in person or live instruction is not provided and questions should be directed to stem@msoe.edu.

Curriculum has been adapted from Jet Propulsion Laboratory.

Safety Notice

Parents or guardians should review activity materials before students begin the activity. Some activities from MSOE may require cutting, hot gluing, electricity, manipulating sharp objects, and other tasks that may warrant adult supervision. MSOE is not liable or responsible for any injury, property damage, or other incidents that arise from completing these activities at home. If you have questions or concerns about any activities, please contact stem@msoe.edu

Note about this Activity

Welcome to the design your foam rocket kit! Below you will find learning outcomes, background knowledge, and questions to ask yourself to help guide you through problem solving!

Goals

- Understand the effect of air resistance/drag on an object
- Be able to manipulate hang time through design changes
- Be able to measure the impact a design change has on the variable we are measuring

Learning at Home

- While we have tried to select activities that utilize materials you might have around your home or able to procure without too much difficulty, we know that may not be the case for everyone.
- One of our favorite parts of engineering is the problem solving and critical thinking skills required, and we encourage you to consider the following question when looking at the materials list for this activity:
- **If I don't have a certain material, what is the material being used for in this activity?** Is there something else I could substitute that serves the same or a similar purpose? How can I modify this activity with what I have at home?

Materials List

Note that items marked with an asterisk (*) are not included in your kit if you ordered one from MSOE

	NAME
	30 cm- long piece of foam pipe insulation (for 1/2" size pipe)
	30 cm- long piece of foam pipe insulation (for 1" size pipe) (x2)
	Rubber Band size 64 (x9)
	Carboard or foam square approx. 9.5cm x 9.5cm (x3)
	Duct Tape (*)
	Tacky Glue (*) Optional
	Pre-cut string (3' in length) (x4)
	Parachute Paper (10 sheets)
	Washers
	Balsa wood sheets (*) *May not be included in MSOE kits; supplier is on backorder as of 7/1/2020*
	Bubble Wrap
	Assorted Balloons
	Zip Ties

REQUIRED TOOLS

	Scissors (*)
	Meter Stick (*) Not required but helpful
	Tape Measure (*) Not required
	Timer or Phone with timer app (*)

Background Knowledge

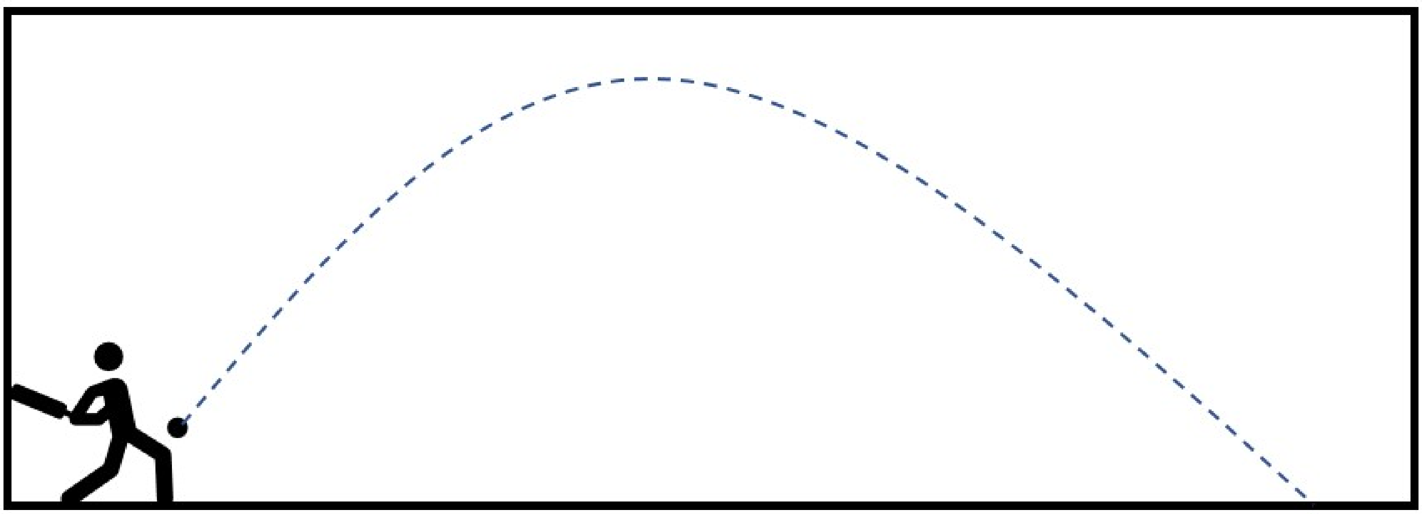
Introduction:

In this activity, we are going to build foam rockets and learn how we can change the design of the rocket to change the way it behaves when launched into the air. You will explore ways that you can increase or decrease the hang time and/or the distance traveled. In the end, you should have a rocket that can travel a far distance or a rocket that can stay in the air for a long period of time.

Background Knowledge:

Projectile Motion

Projectile motion is the term used to describe how an object behaves when thrown or launched into the air. When an object is thrown, there are only two forces acting on it, gravity and air resistance (also known as drag). When an object is thrown it will always travel in the same pattern and that pattern is illustrated by the dashed line in the image below.



The above image shows the general two-dimensional pattern that every thrown object will have. The rockets that we will make in this activity will have the same exact travel pattern as the ball in the image. Before we can discuss how when can change this pattern there is some terminology that we need to understand. In this activity we will need to define the following terms:

- Max Height
- Initial Velocity
- Trajectory
- Angel of projection
- Hang Time
- Final Position/ travel distance

Each term refers to specific location on the above image, which we will also need to define.

Before moving on try and define the terms on your own before we give our definition of each term. You can write your definitions below. Bonus if you can identify the location, on the above image, that each term is referring to. It is alright if you don't know what some of these terms mean.

- Max Height

- Initial Velocity

- Trajectory

- Launch Angle

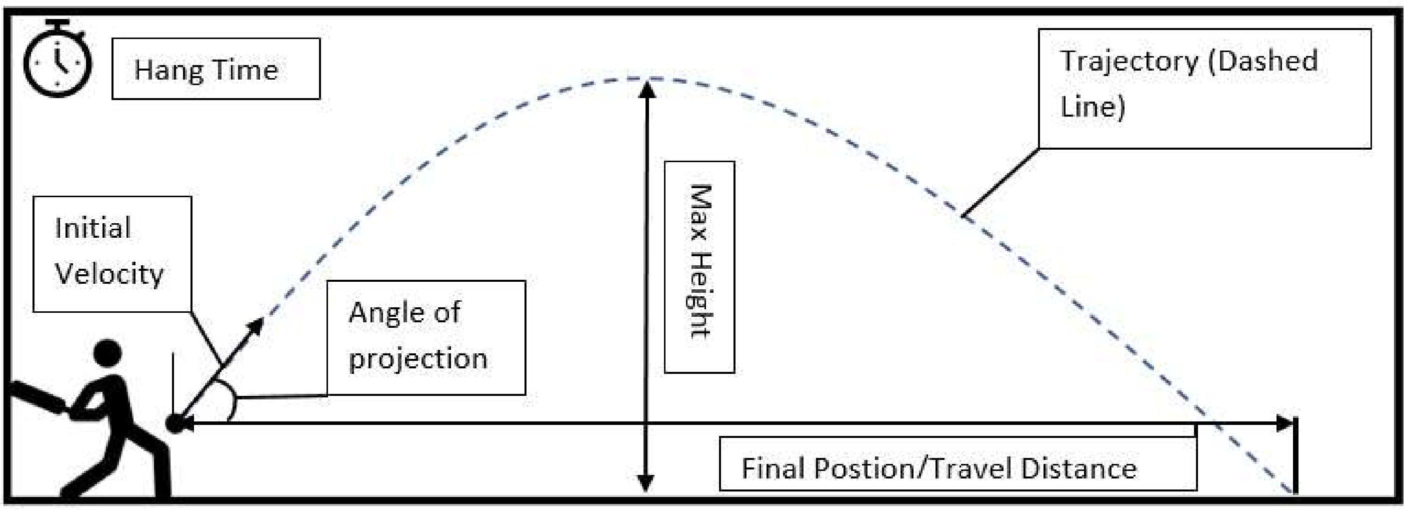
- Hang Time

- Final Position/travel distance

The general definitions for each of the terms are as follows:

- Max Height – the highest vertical distance that the object travels. This is where the object will stop traveling up and start falling back down to the ground.
- Initial Velocity – the speed that the object is launched or thrown.
- Trajectory – the path the object takes while in the air.
- Angel of projection – the angle, from the ground, that the object is thrown or launched.
- Hang Time – how long the object is in the air before hitting the ground.
- Final Position/travel distance – the location where the object hits the ground.

Now let's put the terms on the drawing, so we know what to look for when we are testing our rockets.



Be sure to keep all these terms in mind, because we will be using them later in this activity.

<u>Gravity and air resistance</u>

Before we can manipulate the hang time of our rocket, we need to understand the forces that are working on our object. The two main forces that are causing our rocket to come crashing back to the ground is the force due to gravity and air resistance.

We have all experienced gravity whether we like it or not. Gravity is what is keeping us on the ground, and it is what brings a ball back to the ground when dropped or thrown. Gravity not a force, but it is a constant acceleration that creates a force when an object has a mass. Meaning, the more mass an object has, the greater the force due to gravity is. The greater the force due to gravity is, the faster the object is going to come back to the ground. For example, if you were to drop a bowling ball and a feather from the same height the bowling ball would hit the ground first because it has a greater force due to gravity.

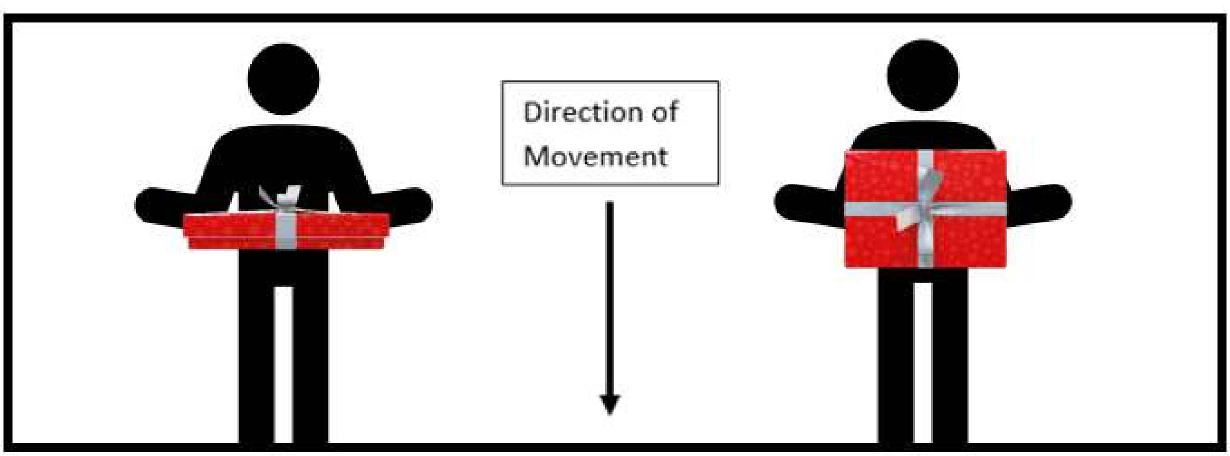
Challenge questions:

1) So far, we have been saying "force due to gravity" when referring to the effect of gravity on an object. What is the more commonly used term? HINT: it was one of the two forces talked about in the June activity.
2) If we were on the moon, which has less gravity than the earth, what would happen to a ball if we hit it with a bat? What would happen if we did the same thing on Jupiter, which has a more gravity than the earth?
    a. For each case, draw a two dimensional picture of the ball's flight pattern, similar to the images above.

Did you ever run, or ride your bike, on a windy day? If so, you might have noticed that it was harder to run when the wind was blowing at you. The reason it was harder for you is because of air resistance. Air resistance (also known as drag) happens when the tiny particles in the air collide with an object that is in motion. When we run, there are millions of air molecules that collide with us and these small collisions are what slow us down when we run. The same happens when a ball is hit and flying through the air, however the ball will experience less air resistance. Why?

Air resistance is dependent on the amount of surface area that is exposed to the forward moving direction. What the heck does that mean? First off, surface area can simply be described as how large an object is. In the image below we have a holiday present. We can see from the image that the top of the present has more surface area than the side of the present since the top is larger than the side.

If we were to drop this present with the top facing up, the present would experience more air resistance than if it was dropped on its side. In the image below, the same present is being dropped, however, the present on the left would experience more air resistance since the larger side is facing the direction of movement.



Apply what you learned:

1) How can we use surface area and air resistance to change the flight pattern of our rocket?

2) How can we manipulate the force due to gravity to change the flight pattern of our rocket?

Directions for Exploration:

1) Start with constructing a general rocket using this link.
2) When you have the rocket built, test out your rocket and collect your baseline data.
    a. Make sure you are launching your rocket at roughly the same angle of projection and the same initial velocity. For example, launch your rocket by pulling the rubber bands such that the tip of the rocket comes to your elbow, and launch the rocket at approximately 45 degrees.
3) On a sheet of paper, come up with several ways that you can increase **and** decrease the air resistance of your rocket.
    a. Hint: the more ways you come up with, the more options you have for testing.
4) On the same sheet of paper, come up with several ways that you can increase **and** decrease the force due to gravity on your rocket.
    a. Hint: the more ways you come up with, the more options you have for testing.
5) Create and test your designs while recording your data in the sheet below.
    a. Did your designs do what you expected? If not, repeat steps 3 and 4.
6) Study your data and determine how you will create a rocket that either travel a far distance or stay in the air for a long period of time.
    a. Challenge: Can you create a rocket that can do both?

Rocket Design Name	Hang Time	Travel Distance	Notes on Trajectory Pattern