WAMC Lab Template

Math Concept(s): Measurements and charting

Source / Text:

Developed by: Aaron J. McDonald and Modified by J. David Sandefur

E-Mail: dsandefu@cloverpark.k12.wa.us

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Attach the following documents:

Lab Instructions

Student Handout(s)

Rubric and/or Assessment Tool

Short Description (Be sure to include where in your instruction this lab takes place):

In this Lab, students build rockets that are powered by a 2-liter bottle and can explore how mass and angle affects performance of the rocket.

Lab Plan

Lab Title:

- Stomp Rockets! (*Adapted from www.exploratium.edu)*

Prerequisite skills: (i.e., vocabulary, measurement techniques, formulas, etc.)

- Rocketry Vocabulary, measurement

Vocabulary

- Proper use of an Inclinometer, measuring in degrees with a protractor

Lab objective:

- Each team will build a rocket out of materials and fire for distance using a launcher built from a 2-liter bottle.

Standards:

CCSS-M:

- A-CED.2: Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
- A-REI.1: Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method.
- A-REI.6: Solve systems of linear equations exactly and approximately (e.g., with graphs), focusing on pairs of linear equations in two variables.

- A-REI.10: Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane, often forming a curve (which could be a line).

Standards for Mathematical Practice:

- 1. Make sense of problems and persevere in solving them.
- 2. Reason abstractly and quantitatively.
- 4. Model with mathematics.
- 5. Use appropriate tools strategically.
- 7. Look for and make use of structure.
- 8. Look for and express regularity in repeated reasoning.

Next Generation Science Standards:

HS-ETS1-3.	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.
HS-ETS1-4.	Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Writing:

- 3.3 Knows and applies writing conventions appropriate for the grade level,

Leadership/21st Century Skills:

21st Century Interdisciplinary themes (Check those that apply to the above activity.)

☐ Global Awareness
☐ Financial/Economic/Business/Entrepreneurial Literacy
☐ Civic Literacy
☐ Health/Safety Literacy
☐ Environmental Literacy

21st Century Skills (Check those that students will demonstrate in the above activity.)

LEARNING AND INNOVATION

Creativity and Innovation
☒ Think Creatively
☐ Work Creatively with Others
☐ Implement Innovations

Critical Thinking and Problem Solving
☒ Reason Effectively
☐ Use Systems Thinking
☒ Make Judgments and Decisions
☒ Solve Problems

Communication and Collaboration
☐ Communicate Clearly
☐ Collaborate with Others

INFORMATION, MEDIA & TECHNOLOGY SKILLS

Information Literacy
☐ Access and Evaluate Information
☒ Use and manage Information

Media Literacy
☐ Analyze Media
☐ Create Media Products

Information, Communications and Technology (ICT Literacy)
☐ Apply Technology Effectively

LIFE & CAREER SKILLS

Flexibility and Adaptability
☐ Adapt to Change
☒ Be Flexible

Initiative and Self-Direction
☐ Manage Goals and Time
☒ Work Independently
☐ Be Self-Directed Learners

Social and Cross-Cultural
☐ Interact Effectively with Others
☐ Work Effectively in Diverse Teams

Productivity and Accountability
☐ Manage Projects
☒ Produce Results

Leadership and Responsibility
☐ Guide and Lead Others
☐ Be Responsible to Others

Teacher Preparation: (What materials and set-up are required for this lab?)

Materials

- ***See Making Rockets Sheet for all materials***

Set-Up Required:

- This lab is a multi-day investigation that can be done as a way to move from CORD Unit 1 Lesson 1(Scale Drawings and Measuring).

Lab Organization Strategies:

Grouping/Leadership/Presentation Opportunities:

- Students work in “firing teams”, but are expected to report work individually
- Teams have three positions of responsibility – Launcher (stomper on bottle); Angle setter; and spotter of flight.

Cooperative Learning:

- All of the students will work together to determine which student is doing what responsibility they have. All of the students need to work together to complete the lab.

Expectations:

- Even though each student will work in a team, they will be individually responsible for turning in their own lab results.

Timeline:

- Day 1 – Introducing the Activity
- Day 2 – Building and Practicing with Inclinometer and Rocket
- Day 3 – Launching Rockets and figuring out how high Rockets flew
- Day 4 – Lab write up and further experimentation

Post Lab Follow-Up/conclusions:

Discuss real world application of learning from lab

- Where would being able to measure correctly be useful in a real world situation?
- Why is charting important in the real world?

Career Applications

- Coordinating equipment drops in the military
- Ballistics calculations
- Blood-splatter analysis
- Other forensic techniques

Optional or Extension Activities

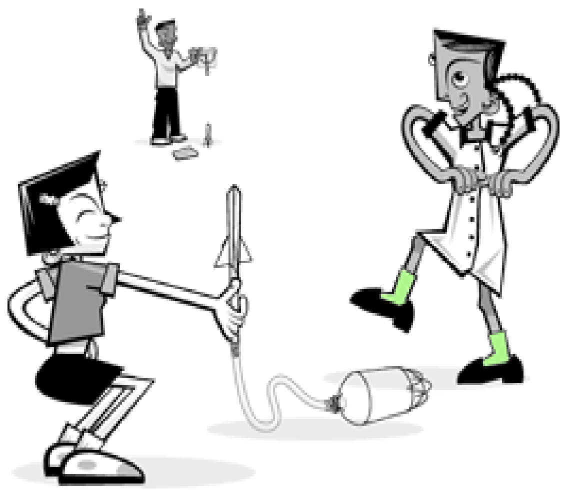
- Shooting for greatest distance
- Calculating optimal angle for launch
- Explore alternative materials for construction of rockets
- Explore how the difference in mass affects performance of the rocket

Bottle Blast-Off!

Tips for leaders

It's easy to build a simple rocket launcher from an old plastic soda bottle—and launching paper rockets is a lot of fun. Experimenting with these simple rockets and measuring how high they fly will also help your group understand concepts that they'll encounter in math class.

Before you do this activity with your group, you need to complete [Height Site.](Height Site) *In that activity, people build inclinometers, devices that will enable them to measure how high their rockets fly. We suggest you plan to spend one session doing How High? and two doing Bottle Blast-Off! That's a lot of time, but Bottle Blast-Off! is a lot of fun.*



Preparation and Materials

Find a place to launch your rockets. On a day that's not very windy, a playground or park is a fine launch site. You can also launch rockets in a gym with a high ceiling.
You will also need to build two rocket launchers, a task that takes five to ten minutes.

Planning chart

Building rockets	about 30
Practicing with inclinometer and rocket	about 20
Launching rockets	depends on size of group: about 30 for 20 kids
Figuring how high the rockets flew	about 20
Continued experimentation	open-ended

To build two rocket launchers, you will need:

- Two empty 2-liter plastic soda bottles from the recycling bin
- About 1 meter (3 feet) of clear flexible vinyl tubing with 1/2 inch inner diameter and 5/8 inch outer diameter (the type of tubing doesn't matter, as long as you can tape one end to the neck of the soda bottle and the other end to the PVC pipe)
- Duct tape

- About 60 centimeters (cm) of PVC pipe with 1/2 inch inner diameter

To make rockets, launch rockets, and calculate the height of the rockets' flight, you will need:

- Two sheets of 8 1/2" x 11" paper for each person (recycled paper is OK)
- About 30 cm (1 foot) of PVC pipe for every group of five people (the same type of PVC pipe you used for your rocket launcher)
- Clear tape
- Scissors (at least one pair for each group of three)
- A 3" x 5" card for each person
- Pens or pencils
- A meter stick or some way to measure one meter
- A ball of string
- Rulers (at least one for each group of three)

Options

Often, after an initial session of rocket launching, people want to improve their rocket designs. A Leader's Guide includes suggestions for continued experimentation.

Height Site

Tips for Leaders

Bottle Blast-Off! *combines science and math in an exciting activity. This activity involves making and launching rockets, using an inclinometer to measure each rocket's flight, and figuring out how high each one flew.*

Your group will discover that math can be useful for judging how well a particular rocket performs. They will learn the value of representing the real world with a diagram, because drawing a diagram lets them figure out the height of the rocket's flight, something that's hard to measure directly.

Before you do this activity with your group, you need to complete Height Site. In that activity, people build inclinometers, devices that will enable them to measure how high their rockets fly.

Building a Rocket Launcher

You can build rocket launchers by following the directions on Building a Rocket Launcher. Or you can have a few members of your group build rocket launchers as a project. Building a launcher is easy; once you have gathered the materials, the project will take five to ten minutes.

A group of fifteen people can use one rocket launcher, but we suggest you make two—in case one breaks. We also recommend having an extra soda bottle handy just in case you need a quick replacement.

Introducing the Activity

After launching the rocket, blow into the PVC pipe to reinflate the soda bottle so you are ready to launch again. We suggest that you put your hand around the end of the pipe to make a mouthpiece and put your lips against your hand.

Before you begin building rockets, you might check to see that all members of the group have the inclinometers that they made in the *Height Site* activity. They'll need their inclinometers to measure how high their rockets fly.

Making Rockets

Have your group follow the instructions on Making Rockets or lead them through the steps to make a rocket.

While everyone is making rockets, we suggest you establish a launch order. We suggest that you have people sign up for launch order only after they have completed a rocket. You could say something like: "Come up and show me your rocket, and I'll sign you up for a launch time."

It's important to establish who is launching when before you go to the launch site. (At the launch site, things can get a little chaotic.) Have everyone fill in the names, in order, on their data sheets before going to the launch site.

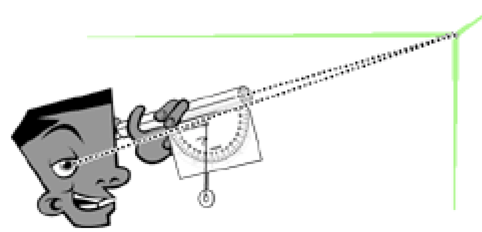
Before You Go to Your Launch Site

Here are a few preparations that will make it easier to keep track of what's going on at the launch site.

Review how to use the inclinometer

If you need help remembering how to use it, see Height Site.

When people are using their inclinometers to follow a rocket's flight, it's important that they keep both eyes open. This makes it possible to track the rocket in flight. They can either sight through the tube with both eyes open or sight along the top of the tube. Either method will work. The important thing is to keep both eyes open.



Mention this to your group. Tell them that you'll do a couple of trial runs, so that everyone gets a chance to practice.

Designate an Aimer and a Launcher

Each time a rocket is launched, you'll need an Aimer and a Launcher. The Launcher stomps the bottle with *one foot* to launch his or her own rocket. We suggest that you have each person be the Launcher for his or her rocket.

Aimers are responsible for holding the PVC pipe straight up and making sure the rocket doesn't hit anyone (including themselves). We suggest you appoint responsible people to be Aimers, so that rockets are not aimed or fired at people.

The Aimer also reinflates the soda bottle after each launch by blowing into the PVC pipe.

Tell Everyone How the Launching Will Work

Here are the steps you will follow at the launch site:

- First, you will mark the launch site.
- Then you will mark part of a circle that's 10 meters from the launch site. Everyone who is measuring the rocket's height will stand on this arc, so each person is 10 meters from the

launch site.

- Each person will launch his or her own rocket with the help of the Aimer.
- Everyone else will watch to see how high the rocket goes and will mark the results on a Rocket Launch Data Sheet.

(Marking the launch site and the 10-meter distance from the site could be done ahead of time as part of preparation, before you take your group to the launch site.)

Launching the Rocket

Here's What to Take to the Launch Site

Each member of your group needs a Rocket Launch Data Sheet on which he or she has written the launch order. Each person also needs a rocket, an inclinometer, and a pen or pencil.
You also need your rocket launcher and a spare bottle or two, your 10 meters of string, and some way to mark the launch site and a circle that's 10 meters from the launch site. You can mark with chalk if you're on asphalt, with tape if you're in the gym, with sticks or rocks if you are on grass.

Getting ready

First, mark the launch site. To accurately measure the rocket's height, people need to view the rocket launching from a specific distance away. Have someone hold one end of your 10-meter string on the launch site while someone else stretches out the other end and marks an arc that is exactly 10 meters from the launch site. Everyone watching the launch will stand on the edge of this arc.

Then do a trial launch. Have everyone do a countdown, chanting together: *"3, 2, 1, Launch!"* On "Launch!" the Launcher stomps down on the 2-liter bottle, sending the rocket flying. Have everyone use inclinometers to measure the height of the rocket's flight.

Have people compare their inclinometer measurements. It will take some practice before people are comfortable using their inclinometers to track a rocket.

Blast Off!

Start launching rockets, in the order that you previously established. Ask everyone to measure the height of each rocket's flight and record it on his or her data sheet. If you can, measure the height of each rocket yourself—so you can check the readings of others. When we do this activity at the Exploratorium, we stop after each launch and announce the measurement we got.

If you have time, you might want to have everyone launch his or her rocket twice, then use their best height.

After you finish launching rockets, go back inside to figure out how high the rockets flew.

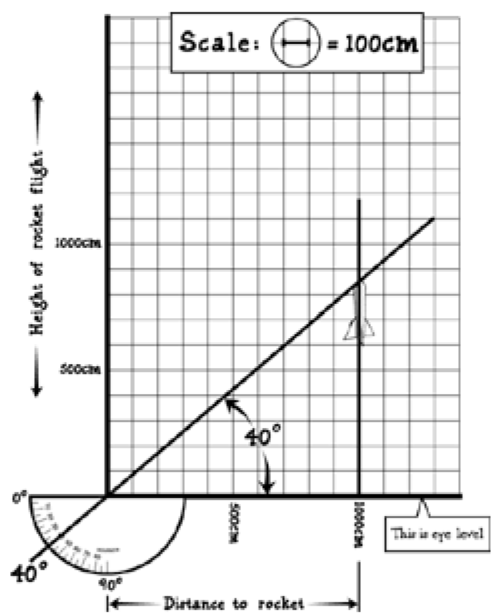
Figuring Out How High Each Rocket Flew

Have people use the [Rocket Height Calculator] to figure out how high each rocket flew. The procedure here is very similar to the procedure you followed in [Height Site.]

The height of the triangle is how high the rocket flew above eye level. To get the height the rocket flew above the ground, people need to add on the distance from the ground to the eye. We've provided an average value for this number. People could get a more accurate measurement by measuring the eye level of all their measurers and figuring out the measurers' average eye level. But that's more accurate than people probably need to get!

Why Use an Average Angle Measurement?

Some people may ask why they had to average three measurements. People often think of measuring as exact, but it isn't really. Every measurement is an estimate, a best guess at an answer. When you are using a new tool, like an inclinometer, different people will come up with different estimates. Averaging these measurements improves the accuracy of your results.



Going Further—Building a Better Rocket

After your group has launched rockets, they may want to see if they can build better rockets. If they do, we suggest that you spend another session trying to improve rocket designs.

You might want to talk with your group about what changes might make a rocket fly better. Here are some things you might want to encourage them to think about.

To move through the air, a rocket has to push air aside. Things that travel fast—like sports cars and jets—are shaped to minimize the amount of air they have to push aside to move forward. The fins on the back of a rocket help it slide through the air easily with its nose forward. People might want to experiment with adding more or fewer fins or using different-sized fins.

Ask them to imagine that they are pushing a kid on a wagon. With the same push, they can make a little kid in a wagon roll farther than a big kid. The rocket launcher gives your rocket a push with a puff of air. If two rockets have exactly the same design and weight distribution, a lighter rocket will fly farther with the same push than a heavier one. Can they make their rockets lighter?

Ask them to think about what other changes they could make. Do long rockets fly higher than short ones? Do some people make better Launchers than others? Have people work together to see how high they can make a rocket fly.

Going Further—Another Experiment to Try

If your group wants to keep experimenting with rockets, here's another experiment to try. You'll need a big space (like a playground or a football field).

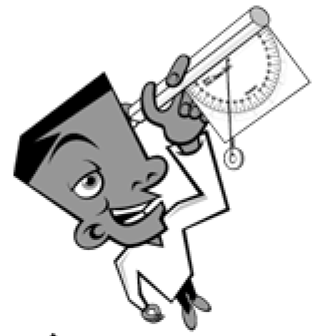
So far, people have been launching rockets straight up to see how high they will fly. Now ask them to try launching rockets to see how great a distance they can get a rocket to fly.

To get the greatest height, people held the launcher so it pointed straight up. To get the greatest distance, they'll need to change the angle at which they hold the rocket launcher. What angle gives them the greatest distance? Encourage them to experiment to find out.

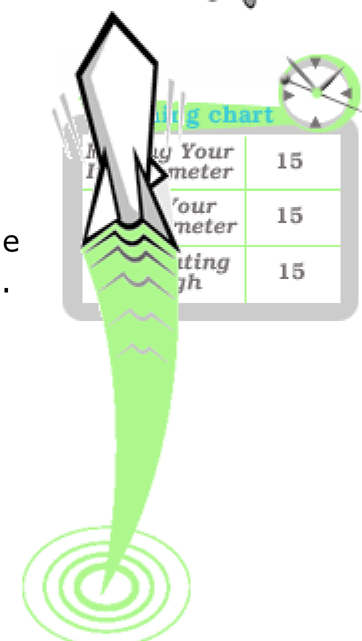
Height Site

Tips for Leaders

In this activity, members of your group will build **inclinometers**, devices that let them measure the height of a distant object. That object can be a flagpole, a building, a tree—or a rocket!



Making inclinometers and learning how to use them prepares your group for making rockets (Bottle Blast-Off!) and measuring how high they fly. It can be tough to get a group of young people excited about measurements, angles, and math. On the other hand, it's easy to get them interested in launching rockets and flying kites.



If you live in the Northern Hemisphere (that is, anywhere north of the equator), people can also use their inclinometers to figure out where on Earth they are by measuring the height of the North Star.

Preparation and Materials

To measure the height of something tall, people will need to measure the distance from where they are standing to the object they are measuring.

So you'll need another way to measure distance. You could use a measuring tape, or measure the distance with string, then measure the string with a meter stick.

For each member of your group to make an inclinometer, you will need:

- Copies of [Protractor for Inclinometer]
- Scissors (at least one pair for each group of three)
- Clear Tape
- A 3" x 5" card
- A hole punch
- 50 cm of string
- A washer or other small weight with a hole in it
- A sheet of 8 1/2 " x 11" paper (you can use paper from the recycling bin)
- A pen or pencil
- Paper
- Rulers (at least one for each group of three)

If you have time, we suggest that you make an inclinometer before introducing this activity to your group. Putting together the inclinometer will only take you a few minutes. It’s useful to have a completed inclinometer on hand to show your group.

Bottle Blast-Off!

Rocket Height Calculator

What Do I Do ?

Step 1

Collect measurements for your rocket's flight from three different people. Each person probably got a slightly different measurement.

Step 2

To improve the accuracy of measurement, sometimes scientists take many measurements and then average the results. To get an average, add up the three measurements for your rocket and divide by 3.

Measurement 1: _________ degrees
Measurement 2: _________ degrees
Measurement 3: _________ degrees
____
Total: _________ degrees/3 = _____average angle in degrees

Step 3

Take a look at the *Rocket Height Calculator Grid*.
Each division on the grid represents 100 cm in the real world. Imagine that your eye is right by the protractor in the lower left-hand corner of the grid. The line at the bottom of the grid is a line parallel to the ground, right at the level of your eyes.

Step 4

On the protractor in the corner of the grid, find the average angle that you calculated in Step 2. Mark this angle on the protractor.

Step 5

Place your ruler so you can draw a line through the mark on the protractor and through the corner of the grid. Extend this line all the way across the paper.

Step 6

The people measuring how high the rocket flew stood 10 meters (1,000 cm) away from where the rocket was launched. That's why the rocket launch site marked on the grid is ten squares away from the protractor. Starting at the rocket launch site, draw a straight line that's perpendicular Now you're ready to figure out how high your rocket flew.
to the eye-level line. Draw this line all the way up to the top of the grid.

Step 7

Now you have a triangle. At one corner of the triangle is your eye; at another corner is the rocket launch site; at the third corner is the rocket in flight.

The height of the triangle tells you how high your rocket flew above eye level.

The height above eye level is _____ cm.

Step 8

The eye level of the average American twelve-year-old is about 140 cm. So add 140 cm to the number you got in Step 7 to get the height of the rocket's flight.

The height of the rocket's flight is ______ cm.

Bottle Blast-Off!

Making Rockets

Make a paper rocket and see how high it flies.

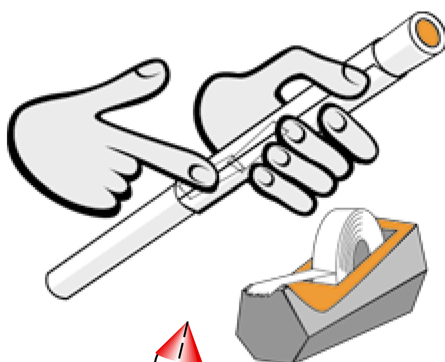
What Do I Need ?

- One sheet of 8 1/2" x 11" paper (can be printed on one side)
- 30 cm length of 1/2” PVC pipe or any tube with a 1/2" diameter
- Scissors
- Clear tape
- Playing Cards (or any stiff paper, such as used file folders or 3" x 5" cards)
- Markers

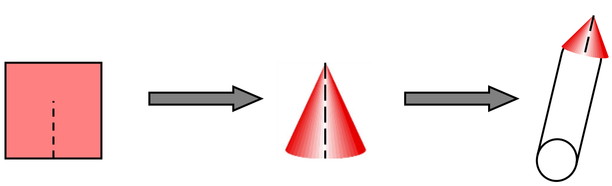
What Do I Do ?

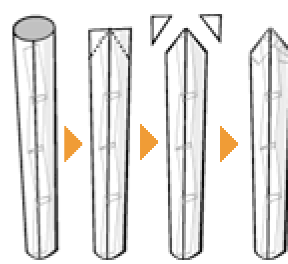
Step 1

Roll a sheet of 8 1/2" x 11" paper into a cylinder that will fit over the tube. The paper should not be tight around the PVC pipe, but should be able to slide off easily. Tape your paper tube so it stays rolled up, and slip it off the PVC pipe. Put the PVC pipe aside.



You can roll your sheet of paper the long way or the short way.





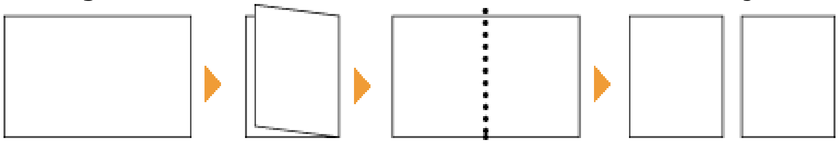
Step 2

There are two different ways you can create a nose cone for your rocket. First you could take a ½ sheet of paper and cut half way up with scissors and then twist into a cone. Next you would attach the cone to the body of the rocket. Another method is to clip the end of the tube to make it pointed. Use tape to seal the point so it’s airtight.

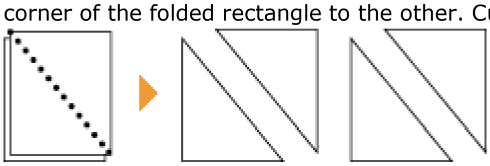
Step 3

Rocket fins will help your rocket fly straight. Fins are usually triangular shapes. Cut fins from the two playing cards by cutting them diagonally across. In your classroom, if you don’t have playing cards you may use some other stiff paper. Here’s one way to cut them from a 3" x 5" card.

If using a 3 X 5 Card: Fold the card in half to make a short rectangle. Unfold it and cut along the fold line.

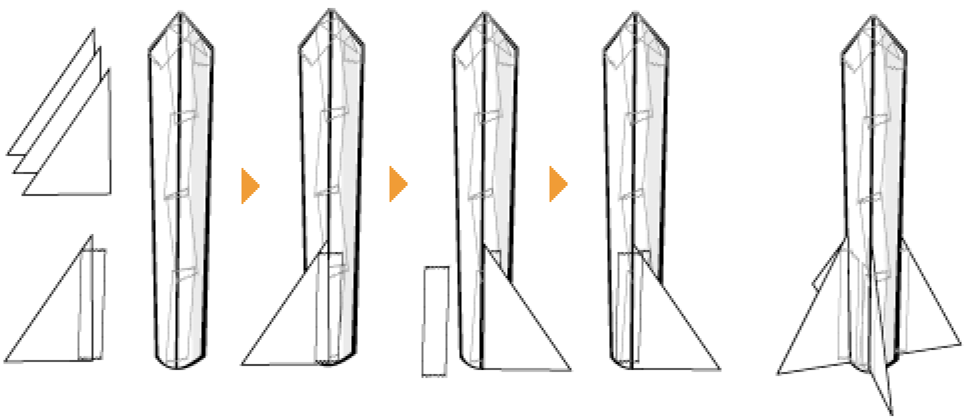


If using Playing Cards: Stack the two playing cards or two halves of the card created in the previous step. Draw a line from one corner of the folded rectangle to the other. Cut along the line you've drawn and you'll have four fins.



Step 4

Tape the fins to the sides of the rocket at the base. Be sure to tape both sides of the fin to the rocket.



Step 5

Use a marker to write your name on the side of your rocket.

You can build a rocket launcher from an old plastic soda bottle.

What Do I Need ?

- 2-liter plastic bottle (only one is required for each launcher, but we strongly recommend that you make two launchers and have a couple of extra soda bottles on hand in case one fails)

- 1 meter (about 3 feet) of clear flexible vinyl tubing with 1/2 inch inner diameter and 5/8 inch outer diameter (the type of tubing doesn't matter, as long as you can tape one end to the neck of the soda bottle and the other end to the PVC pipe). Another alternative is to use a Bicycle Inner-Tube.

- Duct tape or Hose Clamp
- 60 cm (about 2 feet) of PVC pipe with 1/2 inch inner diameter

What Do I Do ?

Step 1

Remove cap from bottle.

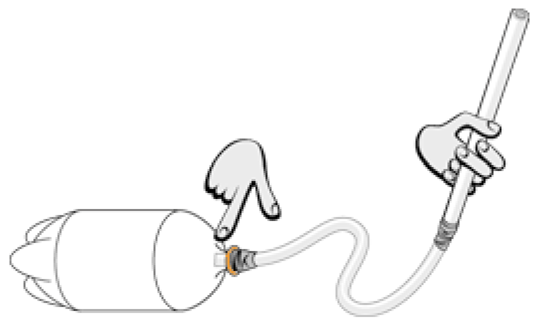
Step 2

Insert about an inch of flexible tubing into the bottle opening. Tape it in place with duct tape. Try to make the connection between the tubing and the bottle airtight.

Step 3

Push the PVC pipe against the other end of the flexible tubing. (Don't try to insert the tubing into the PVC pipe.) Tape the tubing and the PVC pipe together or secure with a hose clamp. Again, try to make the connection airtight.

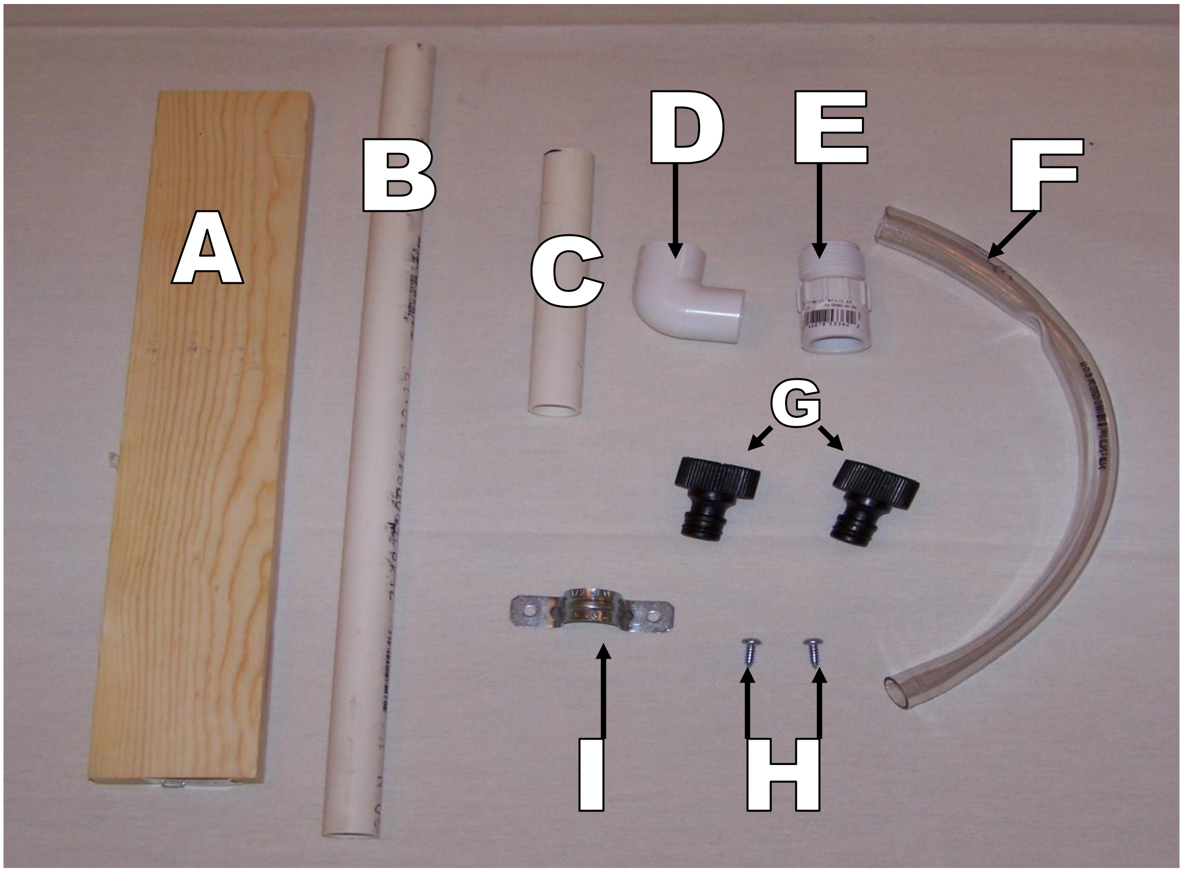
Your finished launcher should look something like this »»



Or… you could build the WAMC Super-Duty Launcher!

WAMC Super-Duty Launcher:

All of the parts necessary to build this launcher can be found at your local hardware store (Lowe's, Home Depot, etc.) and are farily inexpensive to build.

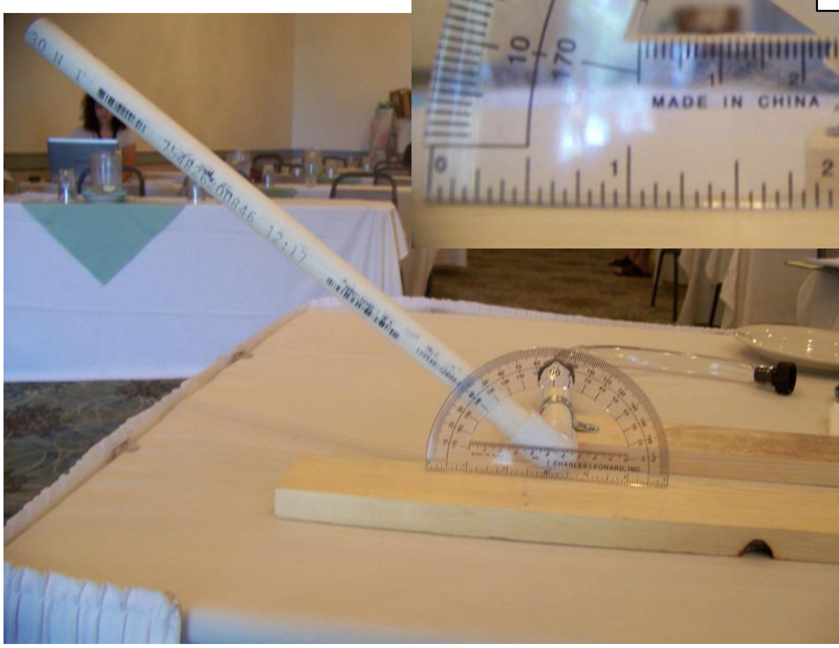


Parts List:

Part Letter	Part Name	Quantity
A	Plank (1-1/2 ft X 2-1/2" X ¾")	1
B	1-1/2 ft long ½" PVC	1
C	6" long ½" PVC	1
D	90° ½" PVC Elbow	1
E	¾" MHT to ½" Slip Hose to Pipe Fitting	1
F	1ft long Vinyl Tubing (3/4" OD X 5/8" ID)	1
G	Male Faucet Quick Connecter	2
H	½" Zinc Screw	2
I	½" Hose Clamp	1

WAMC Super-Duty Launcher:

The Assembled Launcher



Name: ___________________________

Period: _________________

Date: __________________

<u>Lab</u>: Stomp Rocket Lab

Bottle Blast-Off!

Making Rockets

Data Collection

Launch your rockets at the following inclines and measure how far the rocket travels. Once you've collected your information, graph the data and calculate a "line of best fit" in the *y=mx* + *b* format.

Angle (degrees)	**Distance Travelled (m)**
10°	
20°	
30°	
40°	

Questions:

1) How could you use this lab with your class?

2) In what ways could you add on to this activity to deepen your student's understanding?

3) What Units or State Standards could you align this to?

Mass:

1. Explain the procedure we used to determine how mass affects rocket flight? Be detailed in your explanation.

____

____

____

2. Look at the following data table, and answer the questions below.

Trial Number	Mass of clay (g)	Distance Rocket Traveled (m)
1	0	27
2	0	25.6
3	0	26.4
1	15	21.6
2	15	19.8

3	15	21
1	30	12
2	30	12.8
3	30	12.7

a. What is the average distance traveled by the rocket with 0 g of clay attached? Show **your work!**

b. What is the average distance traveled by the rocket with 15 g of clay attached? ___________

c. What is the average distance traveled by the rocket with 30 g of clay attached? ___________

3. What can you conclude about how mass affects rocket flight from this data?

____

____

4. Predict what the distance would be if you added 40 g of clay to a rocket. ________________________

Angle:

5. Explain the procedure we used to determine how angle affects rocket flight? Be detailed in your explanation.

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6. Look at the following data table, and answer the questions on the next page.

Trial Number	Launch Angle of Rocket	Distance Rocket Traveled (m)
1	10	19.1
2	10	20.3
3	10	19.7
1	40	27
2	40	25.6
3	40	26.4
1	80	12
2	80	12.8
3	80	12.7

a. What is the average distance traveled by the rocket launched at a 10 degree angle? Show **your work!**

b. What is the average distance traveled by the rocket launched at a 40 degree angle? ___________

c. What is the average distance traveled by the rocket launched at a 85 degree? _______________

7. What can you conclude about how launch angle affects rocket flight from this data?

____

____

8. In each of the three boxes below, draw the path the rocket flew for each angle tested.

10 degrees:

40 degrees:

85 degrees:

Remember, projectiles move in two directions; horizontally (x-axis) and vertically (y-axis). Use your drawings and this information to help you answer the following questions.

10. Which angle gave the rocket the most vertical movement? How do you know?

____

____

11. Which angle gave the rocket the least vertical movement? How do you know?

____

____

12. Which angle gave the rocket the most horizontal movement? How do you know?

____

____

13. Which angle, between 0 degrees and 90 degrees, allows a projectile to travel farthest? Explain why? (Hint: Be sure to talk about both the vertical and horizontal movement of projectiles.)

____

____

____

14. Once a projectile is released from its launcher, what is the ONLY force acting on it? _____________

Final Question:

15. Please explain why it is VITAL to only change ONE VARIABLE at a time when conducting an experiment?

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