TRAJECTORY

INTRODUCTION

Students need many opportunities to practice mathematical reasoning and experience the relationship between math and science. Practice is essential. This activity reviews conversion of units and basic principles of science and engineering practice.

Show students how to build the device described and illustrate how to use it. For accurate results they will need to try to blow with the same force each time and to launch from the same height. Try the activity yourself before students so that you can estimate how much is needed. With low ceilings or small rooms, you may need to take this to the hallway or playground. Encourage students to label their marshmallows with a marker for identification during testing (and to discourage unwanted marshmallow consumption). You may choose to provide models or pictures of Graphical Firing Tables after you do Slide Rules.

MATERIALS

+ Stiff paper
+ Tape
+ Protractors with an angle arm
+ Tape measure or meter sticks
+ Mini marshmallows

STANDARDS

Grades 3 – 5

3-5-ETS1-3
Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

3-5 PS2-A
The effect of unbalanced forces on an object results in a change of motion. Patterns of motion can be used to predict future motion.

3-5 PS2-A
The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center.

Grades 6 – 8

CCSS Math 6.EE.C.9
Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, and in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables; relate these to the equation.

6-8 PS2-A
The role of the mass of an object must be qualitatively accounted for in any change of motion due to the application of a force.

NGSS 5 PS2-2
Support an argument that the gravitational force exerted by Earth on objects is directed down.

NGSS MS PS2-2
Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

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This investigation gets right at the concept of trajectory, and the quantitative prediction of an object's motion. It helps students get from the third grade understanding that motion can be predicted, and adds in gravity and a quantitative aspect. It also introduces the making of a computational tool to make that prediction. It engages students in Developing and Using Models, Planning and Carrying Out Investigations, and Using Mathematics and Computational Thinking, among other Science and Engineering Practices. It uses the Crosscutting Concepts of Cause and Effect and Patterns.

NAME: DATE:

TRAJECTORY

Slide rules were commonly used for all sorts of calculations before electronic calculators became common. You are going to launch marshmallows in an investigation to make your own slide rule.

Use the card stock paper to roll a tube slightly larger than the size of the mini marshmallows. Tape the roll tight.

Next, tape the roll to the arm of a protractor. Use a marker to label the marshmallows with your initials.

Set the protractor upright on a table or chair so that you can hold it steady and at a constant height. Aim it in a direction with plenty of space. Be sure that when you launch the marshmallow you use the same amount of force each time.

Starting at 10º elevation, launch three marshmallows, and measure how far away they landed. Repeat three times for a total of four trials for each angle. Repeat up to 70º elevation.

ELEVATION	DISTANCE 1	DISTANCE 2	DISTANCE 3	DISTANCE 4
10º				
20º				
30º				
40º				
50º				
60º				
70º				

Briefly describe the relationship between elevation of your projectile's launch point and the distance it traveled:

Make a slide rule to quickly calculate the elevation required to shoot a small marshmallow a given distance. Enter elevation in the top of each column, and the distance you would expect a marshmallow to travel at the bottom of each column.

5º	10º	15º	20º	25º	30º	35º	40º	45º	50º	55º	60º	65º	70º	75º

In World War II, soldiers used Graphical Firing Tables to quickly calculate the elevation they needed to use to launch artillery at a target. These were based on slide rules, with two bands of data and a rule to help them move along it. Often they had multiple bands so that they could be used with different kinds of artillery.