Mass vs Range Pitsco Straw Rockets

Adapted from: NASA Rockets Educator Guide

Objectives

Students will:

- Learn about a brief history of rocketry
- Learn common terms associated with rocketry
- Explore the relationship between rocket mass and flight range
- Practice with beta-tests and modifications to improve results
- Utilize scientific method and inquiry

Suggested Grade Levels

3rd – 12th

Subject Areas

Physical Science, Math, Engineering Design

Timeline

60 minutes

Standards

- **3-PS2-2** Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion
- **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
- **MS-PS2-5** Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact
- **MS-ETS1-3** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success
- **HS-PS2-1** Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

21st Century Essential Skills

- Critical thinking and problem solving
- Collaboration and teamwork
- Carrying out investigations
- Creativity and innovation
- Initiative
- Leadership
- Flexibility

Background
What is a rocket scientist? When people think about jobs at NASA, certain careers come to mind first. Astronaut is almost always near the top of the list, often followed by the fabled "rocket scientist." The job title is almost mythical -- the gold standard for a challenging occupation. To put a task in perspective, a common expression is "Well, it's not rocket science." But, at NASA, it is. Rockets have always been a big part of what NASA does, and someone has to make them fly. But what is a rocket scientist? The truth is, a lot of them are actually engineers -- men and women who take the raw science of Newtonian physics and apply it to design vehicles to launch things into space. As NASA research engineer Tom Benson put it, "Call them what you want, scientist or engineer. People who work on rockets have to eventually build an efficiently working piece of machinery that has many complex physical and chemical phenomena present that must be fully understood. The success of the rocket depends on the knowledge and experience of the builder." Do you have what it takes to earn the title of rocket scientist? (Dunbar, 2012)

For more background info visit NASA's Rocketry Website:
https://www.nasa.gov/pdf/265386main_Adventures_In_Rocket_Science.pdf

Vocabulary
Control, hypothesis, nose cone, variable, weight, mass, rocket body, fins, fuel, payload, descent, ascent, altitude, friction, hypothesis, independent and dependent variables, data, analysis, test, modify, force, angle, trajectory

Materials
- Pitsco® Straw Rocket Launcher (https://www.pitsco.com/Shop/Aerospace/Rockets/Straw-Rockets)
- Precision Straws (https://www.pitsco.com/Shop/Aerospace/Rockets/Straw-Rockets)
- Index cards
- Modeling clay
- Ruler or measuring tape
- Scissors
- Transparent tape
- Balance or scales
- Pencil
- Mass vs. range data sheet

Lesson
1. (optional) Begin by discussing a brief history of rockets. Information could include anything from launching the first satellite (Sputnik), to launching humans to the moon, to the latest launches to the International Space Station.
2. Discuss Newton's laws of physics, and how each affect something like a rocket launch. Discuss how these laws might affect their design challenge in this lesson.
3. Locate the "mass vs. range data sheet" and write a hypothesis stating how you think variations in the rocket mass will affect the rocket's range.

4. Construct one 15 cm long straw rocket with minimum of two fins and a maximum of five fins.
5. Add a one-gram clay nose cone to the rocket.
6. Perform three launches at a 45-degree launch angle and a calibration mark of 5. Record the ranges on the data sheet.
7. Remove the one-gram nose cone and replace it with a two-gram nose cone. Perform three launches with the same launch angle calibration mark. Record the results.
8. Repeat the process with a three-gram, four-gram, and five-gram nose cones, keeping the angle and calibration mark the same. Record all results.
9. Analyze the data generated from your tests and write a conclusion explaining how the difference in mass affects the rocket's range. Make a recommendation concerning mass and rocket range. Support your recommendation for future rocket scientists with a graph of your experimental data.

Extensions

- Have students choose another variable to test, varied launch angle, rocket body length, fin shape, etc.
- Utilize an online launch simulation to allow students to further explore mathematics, physics, and rocket science. Recommended: https://phet.colorado.edu/en/simulation/projectile-motion
- To level-down the lesson, remove the data sheets, and focus only on the initial design, launch, and redesign.

Resources

Dunbar, B. (2012, July 30). Rockets Educator Guide. Retrieved from https://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Rockets.html

Name______________________

Mass vs. Range Data Sheet

Hypothesis

How do you think mass will affect the straw rocket? Record your hypothesis, describing how you think mass will affect the range achieved by the rocket.

Design Description

Describe the controls of your design including all numerical values and dimensions.

Experiment Description

Describe the controls of your experiment including all numerical values and dimensions.

Data

Record your data in the appropriate area of the table below.

	Nose Cone Mass	Range Launch 1	Range Launch 2	Range Launch 3
Rocket 1				
Rocket 2				
Rocket 3				
Rocket 4				
Rocket 5				

Conclusion

What conclusion can you make about the relationship between the rocket's mass and the range achieved? How does this conclusion compare to your original hypothesis?

Graph
Use data on the previous page to create a graph showing the relationship between mass and distance.

Recommendations
What recommendations would you make to future rocket scientist concerning mass and range?
Refer to the graph above in your recommendation.