Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Period \_\_\_\_\_

BOCES Science Laboratory Investigation

THIS IS ROCKET SCIENCE

**Introduction**

When we hear the phrase “come on, this isn’t rocket science,” we are often referring to some menial task that should be easy to complete. The phrase also implies that rocket science is something that’s really difficult, and probably can’t be done by normal people walking around without pocket protectors and tape on their glasses. However, the science of launching and measuring the flight path of a rocket turns out to be fairly simple, provided you know a few things about how stuff moves around near the earth’s surface. To be fair to the good people at NASA, if you’re going to launch a rocket and have whatever it’s carrying make it safely and in one piece to someplace kind of far away – like Mars, for example – then you might need a bit more knowledge than your kind and caring teacher is able to provide.

Let’s consider a few things that could affect how a rocket flies. The first thing is the shape. Rockets are generally shaped like, well, rockets. They’re pointy at the business end and have fins to control how they move through the air. The shape of the fins, whether or not they are curved or straight and their size can determine how well the rocket flies. So when you design a rocket – as you’ll do in this lab – keep the basic principles of aerodynamics in mind.

The main thing that we need to worry about, however, is gravity. Gravity is, of course, the force that pulls things with mass toward each other. The earth has a very large mass (on the order of six septillion kilograms), while your rocket will be considerably lighter. But even though it might not even way one kilogram, because it has mass, the earth will pull on it. So, the less mass there is to pull on, the less gravitational force is experienced. In other words, making a lighter rocket will make it easier to go further.

Gravity on earth, as you know, always pulls with a constant acceleration of 9.81 m/s/s. While gravity can prevent your rocket from going as high as you might like it to, it can also help us figure out the height that your rocket achieved. Consider this: if your rocket leaves the launch pad at a certain velocity, gravity will start slowing it down as soon as it launches. How much will it be slowed down? 9.81 m/s for every second that it travels! That means that if it starts out going 20 m/s, then after 1 second it will be going 20 minus 9.81 m/s, which is 10.19 m/s. After 2 seconds, it’ll be going 10.19 minus 9.81 m/s, which is 0.38 m/s. And after three seconds? Well, your rocket has stopped, and gravity is starting to pull it back down. But how fast will it pick up speed? 9.81 m/s for every second that it travels! It’s always the same! So we know that, neglecting air resistance, the rocket will always be slowing down and speeding up at the same rate.

Using that information, we can get a pretty good estimation of the height that your rocket reaches, by using a very simple formula, given below:

**h = (t/2)2 x g/2**

Formula 1. Determinination of height from time of flight.

Where h is the height, t is the time and g is the acceleration due to gravity. If you think carefully, though, this formula doesn’t take into account the initial velocity of the rocket (which would be tough to measure), or air resistance. So this estimate is a little rough.

We can get a better answer by using a bit of trigonometry. Consider the figure below:

C:\Documents and Settings\dsyracuse\Local Settings\Temporary Internet Files\Content.IE5\7P26HDCB\MC900239635[1].wmf

C:\Documents and Settings\dsyracuse\Local Settings\Temporary Internet Files\Content.IE5\OGU44CTI\MC900383552[1].wmf

θ

X

Figure 1. Schematic diagram of rocket launch.

If we have an observer watch the rocket launch from a known distance away (X in this figure), and if that observer measures the angle between the ground and the rocket’s highest point, then all we need to do is to plug the data in the following formula:

**tan θ = h/x**

Formula 2. Trigonometric determination of height.

Where θ is the measured angle, h is the height and x is the distance between the observer and the rocket launch. This is the formula that we will use to officially record your rocket’s height.

**Purpose**

The purpose of this investigation is to design a rocket that can attain the greatest height. You’ll learn about aerodynamics, pressure relationships and how to design and build a rocket. You’ll also be able to figure out the height of a projectile based on its “hang time.”

**Materials**

PENCIL Two-liter pop bottle

Compressed air launcher Air compressor

Wind tunnel Fin and cone material

Glue Scissors

**Procedure**

PART I – DESIGN YOUR ROCKET

In this part of the lab, you’ll need to decide on the design of your rocket. Describe it in writing or by drawing in the space provided. Consider whether you’ll have straight or curved fins (to provide spin, for stability), what type of nose cone, any counterweights you’ll use, and the type and number of fins. As your test your design, you may find that you want to modify your rocket. That’s all part of science.

QUESTION 1: In the space below, sketch or otherwise describe your rocket. Include labels and any explanation necessary.

PART II – BUILD AND GROUND-TEST YOUR ROCKET

In this section, you’ll construct your rocket and test it in the wind tunnel. Remember, the purpose of the wind tunnel is to determine the stability of your rocket. If your rocket doesn’t fly straight, then it won’t achieve its maximum height. If the components that you use don’t stay firmly attached or are too flimsy and change shape during flight, this will, of course, affect the trajectory of your craft.

QUESTION 2: After testing your rocket in the wind tunnel, what are some things that you might change? Consider fins (number, shape, curve, size), counterweights, nose cone (size, shape) or decorations.

PART III – LAUNCH-TEST YOUR ROCKET

In this part, you’ll test your rocket on the launch pad. There are several things that you can change, including the amount of water that you add and the pressure. Record what you find in the table below. YOU MUST have at least THREE test launches with data. You are, of course, free to have more.

The maximum pressure that the launch device will permit is 60 psi, and the most water you can put in your rocket is 2 L.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Test Number** | **Pressure** | **Amount of Water** | **Height** | **Notes** |
| 1 |  |  |  |  |
| 2 |  |  |  |  |
| 3 |  |  |  |  |
| 4 |  |  |  |  |
| 5 |  |  |  |  |
| 6 |  |  |  |  |
| 7 |  |  |  |  |

Table 1. Test launch data

PART IV – LAUNCH YOUR ROCKET

You get only one final launch for the record books! There will be three students using inclinometers to track your rocket for the purposes of finding the height. We will average the angles from each student to get the official angle. Record the data you need here:

|  |  |
| --- | --- |
| **Student Number** | **Angle Measured** |
| 1 |  |
| 2 |  |
| 3 |  |

|  |  |
| --- | --- |
| **Average Angle** | **Maximum Height (from formula)** |
|  |  |

Table 2. Final results for rocket launch.

**Analysis**

QUESTION 3: List at least three things that you could do to make your rocket go higher.

QUESTION 4: We launched our rockets at a 90° angle. What would happen to the maximum height of the rocket if we launched them at a 45° angle?

QUESTION 5: We launched our rockets at a 90° angle. What would happen to the distance that the rocket traveled (that is, how far away from the launch pad it landed) if we launched them at a 45° angle?

QUESTION 6: What modifications to formula 1 (see the “background information” section) would you have to make if you were going to launch your rocket on the moon?

QUESTION 7: The laws of physics tell us that every time energy is converted from one form to another (e.g. from the potential energy stored in compressed air to the kinetic energy of a moving rocket), that it all must be conserved. That is, no energy can disappear; it all has to go somewhere. With that in mind, what are the benefits and the detriments of putting curved fins on your rocket to make it spin?

QUESTION 8: Imagine that your rocket has a mass of 0.5 kg and is initially accelerating at 60 m/s/s. If you were to stand over the rocket while it was being launched (a BAD idea), with what force would it hit you?

QUESTION 9: What are two things that you would change about this lab if you could?