BrainStorm
STEM EDUCATION

STEM KIT

EDUCATOR GUIDE

ROCKETRY

CREATED FOR BOTH HOME AND SCHOOL

PERFECT FOR THE CLASSROOM

DESIGNED BY TEACHERS FOR TEACHERS

TABLE OF CONTENTS

LESSON OVERVIEW
Class Information

In this lesson, students will learn about rocketry, including the history of rockets and the science behind their motion. The focus will be on the four forces of flight that rockets are subject to, as well as an overview of aerodynamics. Additionally, this lesson will cover the three main states of matter and how they apply to the different fuel types used in rockets.

CONCEPTS

- History of Rockets
- Forces of Flight
- Aerodynamics
- States of Matter
- Projectile Motion
- Rocket Rotations

LESSON OBJECTIVES

- Describe the forces of flight as applied to rockets.
- Explain how the angle of release will affect the projectiles motion.
- Describe how aerodynamics affects the flight of the rocket.
- Explain the most effective angle of release for launching the projectile the farthest distance.

EDUCATIONAL STANDARDS

NGSS - Next Generation Science Standards

Motion and Stability: Forces and Interaction

- K-PS2-1. Conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.
- K-PS2-2. Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.*
- 3-PS2-1.Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.
- 5-PS2-1. Support an argument that the gravitational force exerted by Earth on objects is directed down.

Engineering Design

- K–2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.
- K-2-ETS1-2 Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.
- K-2-ETS1-3 Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

Matter and its Interactions

- 2-PS1-1. Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.

Energy

- 4-PS3-1 Use evidence to construct an explanation relating the speed of an object to the energy of that object. [**Clarification Statement: Examples of evidence relating speed and energy could include change of shape on impact or other results of collisions.]
- 4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide
- 6-PS3–5. Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

CCSS MATH - Common Core State Standards Math

- CCSS.MATH.CONTENT.4.MD.C.5 Recognize angles as geometric shapes that are formed wherever two rays share a common endpoint, and understand concepts of angle measurement:
- CCSS.MATH.CONTENT.4.MD.C.6 Measure angles in whole-number degrees using a protractor. Sketch angles of specified measure.

INTRODUCTION

In this lesson we will be learning all about rocketry. Our lesson focuses on the forces of flight, projectile motion, aerodynamics, and how they apply to rockets. We will also focus on the history of rockets and how real rockets are able to breach the Earth's atmosphere. After the lesson we will be able to test out the projectile motion of the rocket using the air power launcher provided in the STEM kits.

VOCABULARY

Thrust - The force that is opposite of drag.

Lift - The push that lets something move up, the force that is opposite of weight.

Drag - The force that tries to slow something down.

Weight - The force that is a result of gravity pulling down on an object.

Projectile- An object propelled through the air, especially one thrown as a weapon.

Projectile Motion- The motion of an object thrown or projected into the air.

Trajectory - The path followed by a projectile flying or an object moving under the action of given forces.

Aerodynamics - the study of the properties of moving air and the interaction between the air and solid bodies moving through it.

WHAT IS A ROCKET?

Rockets are devices or engines used to produce a thrust force that moves an object. They are used to launch spacecraft into space, fire missiles, or even light fireworks.

HISTORY OF ROCKETS

The invention of rockets is most often attributed to the Chinese, dating back to the 1200s. Their design of rockets closely resembled early fireworks. These rockets were bamboo tubes filled with gunpowder. China used these fireworks both as weapons and during religious ceremonies. Around the 1700s, the design of rockets was improved by creating a metal exterior to encase the materials, replacing bamboo. This allowed rockets to be used more effectively as weapons, which eventually began to resemble modern missiles.

The very first liquid-fueled rocket was designed by an American engineer named Robert H. Goddard. This major advancement in rocket technology led to the successful launch of the Soviet Union's Sputnik 1 satellite into orbit in late 1957. This advancement opened the door to a whole new era of exploration, enabling us to send technology—and eventually humans—into the vast, uncharted expanse of space.

In April 1961, Soviet cosmonaut Yuri Gagarin became the first human to travel into space and orbit the planet. Just a few years later, in July 1969, Neil Armstrong became the first man to set foot on the moon. Each of these amazing technological advancements has propelled humanity’s exploration and ability to experience all that the universe has to offer.

HOW DO ROCKETS WORK?

Rockets have to burn an immense amount of fuel in order to reach outer space.

DID YOU KNOW?! *At liftoff, two Solid Rocket Boosters consume 11,000 pounds of fuel per second. That's two million times the rate at which fuel is burned by the average family car.*

In order for the fuel to be used, rockets typically ingnite a mixture of oxygen gas and fuel. When the fuel burns, it creates a hot gas that will shoot out of the back of the chamber. Since rocket fuel requires oxygen to burn, rockets have to carry their own supply of oxygen. This allows the fuel to still be used when the rocket reaches outer space where there is no oxygen. The hot gas that shoots out the back of the rocket, propelling the rocket forward, is a force called **jet propulsion.**

Rockets are not the only vehicles that use jet propulsion to propel themselves. Another example would be jet airplanes. The difference between these engines is that airplanes do not leave earth's atmosphere, so they are able to pull oxygen gas from the environment as they fly, creating the combustive propulsive force.

Engines on rockets can use either liquid or solid fuel in order to work. Each of the fuel types have their strengths and weaknesses. Solid fuels do not provide as much energy as liquid fuels and can be easier to handle as they do not release toxic fumes or require very specific cool temperatures to be stored in preparation for launch. Liquid fuels produce more toxic vapors and require very specific temperatures to remain stable, although they do provide more energy than solid fuel types. Another advantage of using a liquid fuel is the ability to shut off and restart the engines in order to control the explosive effect. Solid fuels do not have the capability of being stopped once they begin, making them harder to control during the flight.

In order for a rocket to reach outer space, the rocket would need to reach an escape velocity of 6.9 miles per second. In order to provide enough thrust to get off the ground, these rockets carry additional stages in self-contained rockets that will use their fuel and detach and fall off the rocket after its use.

NEWTONS LAWS OF MOTION

Sir Isaac Newton was a brilliant physicist and mathematician, recognized as one of the most influential scientists in history. Along with developing the theory of gravity in 1666, he was able to present his three laws of motion in his book titled, "Principia Mathematica Philosophiae Naturalis" in 1687. The laws of motion are the basis of modern physics, describing how an object reacts to the forces that act upon it.

FIRST LAW OF MOTION: LAW OF INERTIA

An object at rest will stay at rest, and an object in motion will stay in motion until acted upon by an outside force. When an object has a tendency to resist a change in its state of motion it is called inertia. If all the forces on an object are equal with no net force, the object will continue doing what it is doing. When an outside force changes the net force acting on the object the object will change its motion. In order for a rocket to launch, it would need an external force called thrust to cause it to move.

SECOND LAW OF MOTION: LAW OF FORCE / ACCELERATION

The acceleration of an object is dependant upon the mass of the object and the amount of force applied to the object. This law states that the speed of an object can be determined by the mass of an object and the amount of force that is applied to the object. If 2 objects, one heavy and one light, are given equal forces, the lighter object will experience more acceleration than the heavier one. In Rocketry, a bigger thrust will cause a rocket to accelerate more.

THIRD LAW OF MOTION: LAW OF REACTION

Every action has an equal and opposite reaction. If you have a ball that exerts force on a wall by hitting it, the wall exerts an equal and opposite force on the ball causing it to bounce back. In rockets the pressure that is built inside the rocket will push the gas or liquid inside downward sending the rocket upwards in an equal and opposite reaction.

TERMINOLOGY

AERODYNAMICS

Aerodynamics is the study of how air moves around an object. Any time an object goes into the air, it is subject to the 4 principles of aerodynamics; lift, weight, thrust, and drag. These forces control the rocket's flight and how they move through the air, depending upon how much of each force is being used at any given moment.

THRUST

Thrust is the force that pushes the rocket forward. This force is opposite of drag. In order for the rocket to keep moving forward, it would need to have more thrust than drag. Since rockets are extremely heavy, they require an immense amount of fuel to lift off the ground, so rockets are equipped with additional thrusters to allow for the extra thrust needed.

LIFT

Lift is the force that allows the rocket to stabilize its flight. This force is perpendicular to the direction of flight. In an airplane, this force allows for the plane to lift off the ground. In a rocket, this force helps to control the rocket's flight path. This force is controlled by the fins at the base of the rocket.

DRAG

Drag is the force that slows the rocket down. In order to reduce drag, we would want to make the rocket more aerodynamic. This can be achieved by shaping the rocket in a way that will allow the air to pass around the rocket more effectively. The drag is controlled by the nose cone of the rocket as well as the surface area of the fins.

WEIGHT

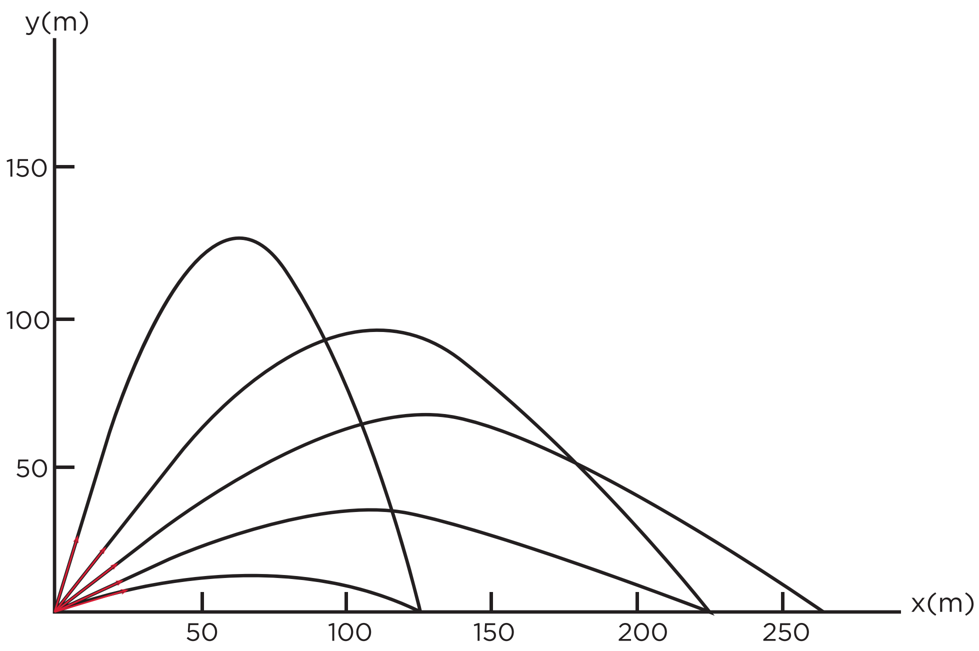
Weight comes from the earth's gravitational pull. Every object on the Earth has weight. In order for something to lift off the ground to fly, there needs to be a force opposite of gravity that is greater than the weight of the object. The less weight an object has, the less force is required to lift it off the ground.

PROJECTILE MOTION

Projectile motion is the motion that an object follows as it is thrown into the air. The motion of a projectile depends on a few factors including the air resistance, the angle of release and the power of the throw. When the projectile is released, the path that it is traveling in is a parabola.

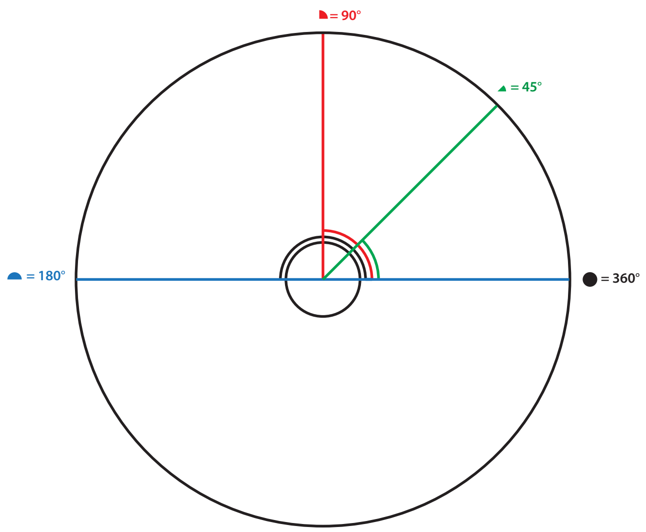
As the object is flying through the air, it is constantly being subjected to gravitational pull as well as air resistance. As the object flies forward, the air resistance pushes against the object causing its forward acceleration to slow down. As the forward acceleration of the object decreases, the gravitational pull has more effect on the object pulling it down towards the ground. This causes the flight of the object to make a parabolic path.

The height and length of the parabolic path can be determined by the launch angle. The optimal angle for the furthest distance is 45 degrees. If the projectile is launched at a higher angle, it will result in a much higher path, but it will not travel as far. If the projectile is launched at a lower angle, the parabolic path will travel along a much lower path, meaning it will hit the ground faster as gravity doesn't have as high of a path to pull down.



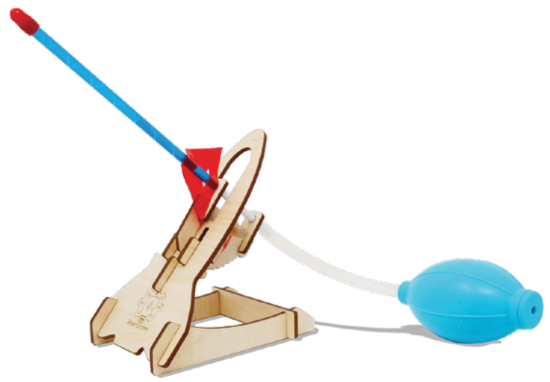
DETERMINING ANGLES

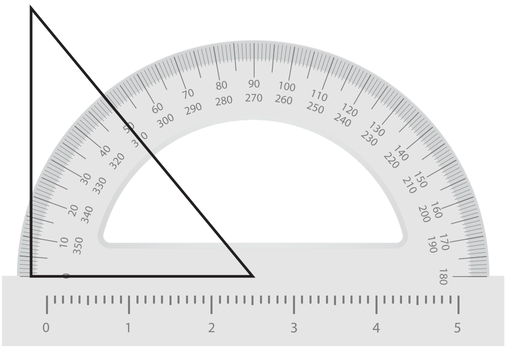
Angles are formed when 2 lines meet at a shared point. Angles are measured in degrees using the symbol ° When determining angles, it is helpful to visualize a circle.



Full circle = 360°
Half of a circle = 180°
Quarter of a circle = 90°
Eighth of a circle = 45°

We can figure out the launch angle of our rocket by visualizing the body of the rocket as the long side of a triangle. The launch angle is going to be the angle that body of the rocket makes with the ground. We can then figure out what the angle is by using a special measuring tool called a protractor. A protractor is a half circle that measures the angles from 0° to 180° We can line up our protractor with the rocket to determine the angle that it makes.





Launch Angle = 50°

To determine the launch angle, you will need to measure the angle using a protractor. To Identify the angle of the launch, you can place the protractor at the fulcrum with the base of the protractor being parallel to the surface the rocket launcher is sitting on. The end rocket body will line up with a number on the edge of the protractor. This will determine the launch angle of the rocket. The launch angle will correspond with the inner angle of the right triangle shape the body of the rocket makes.

PROJECT OVERVIEW

Engineer a rocket made from the body of a straw, and construct a stomp launcher all in the same project. Test the multiple ways to angle and launch the rockets to see which method gets the best results! Shoot for distance or accuracy in this activity.

SAFTEY WARNINGS:

Please read all saftey warnings before use:

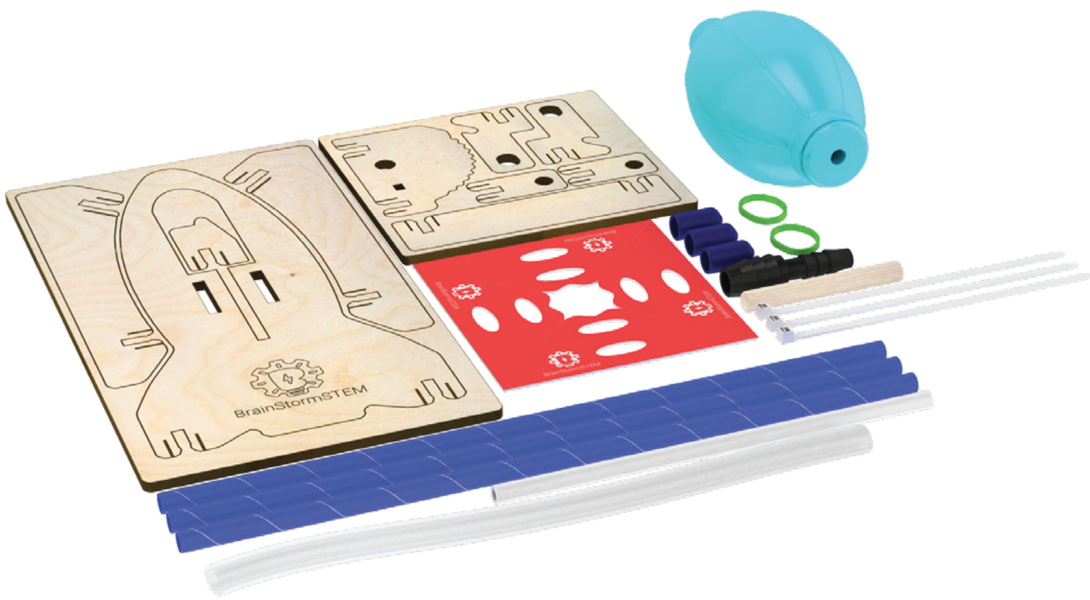
Choking Hazard: Small parts not for children under 6 years or any individual who have a tendency to place inedible objects in their mouths.

Eye protection should be worn at all times.

Adult supervision required.

MATERIALS

Durable wooden construction pieces
Rubber Bands
Adjustment Dowels
Rubber Nose Cone
Straws
Tubing
Tube Valve
Squeezy Bulb



1

Note: If you can not break out a piece(s) by hand, use a small tool or screwdriver to punch and press them out. If you have no experience with tools, get help from an adult or someone with experience. If there are any burrs, points or rough spots do to breaking or cutting, smooth them with a piece of sand paper.

2

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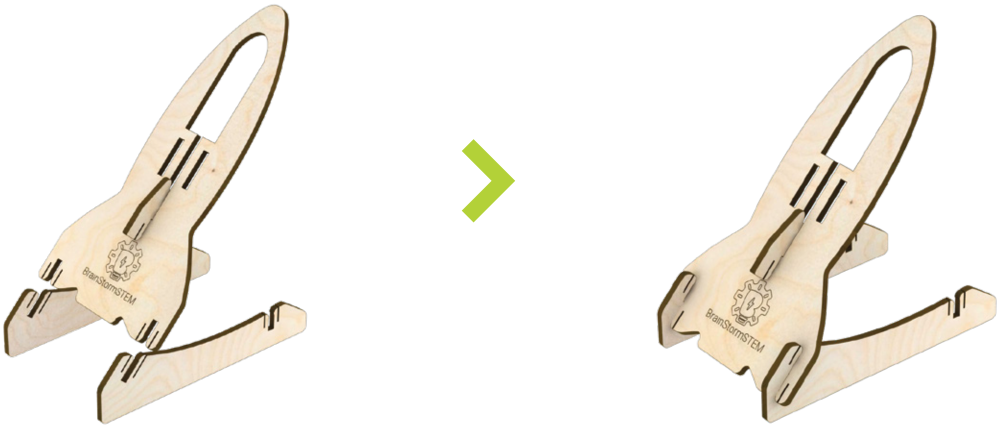

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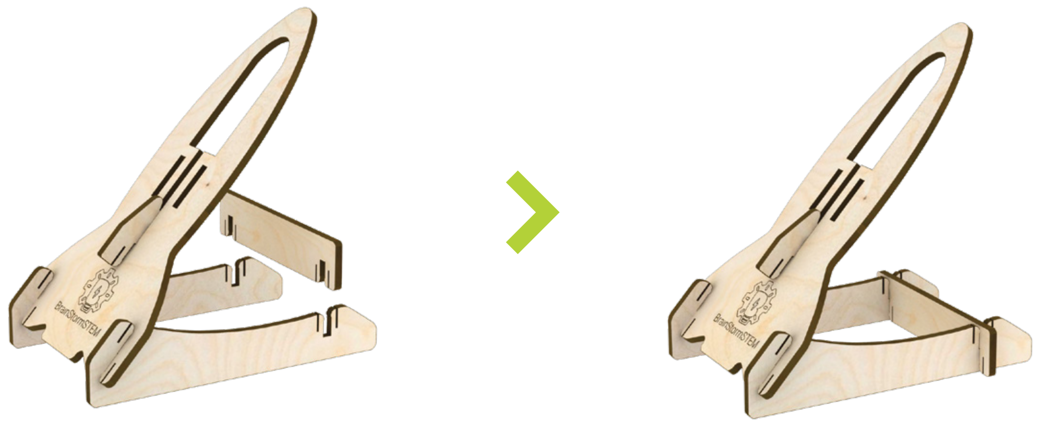

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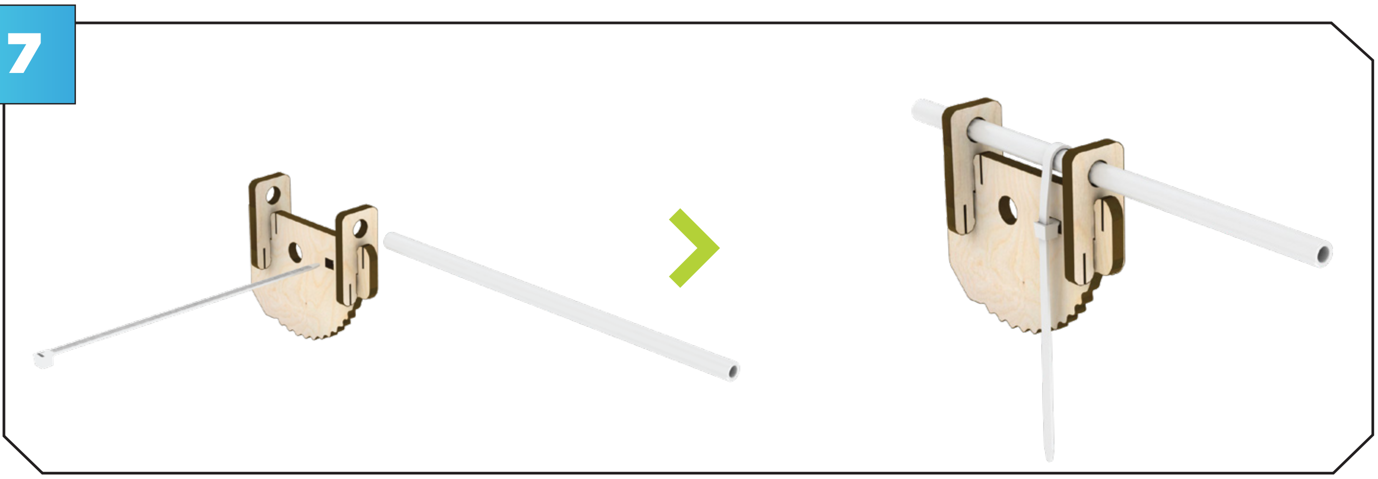

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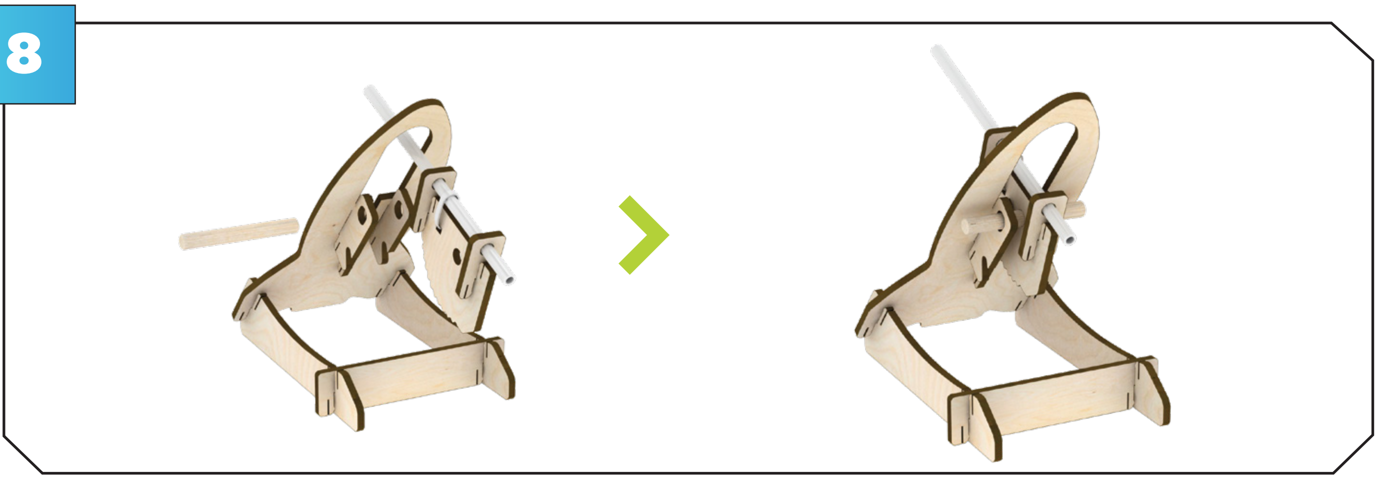

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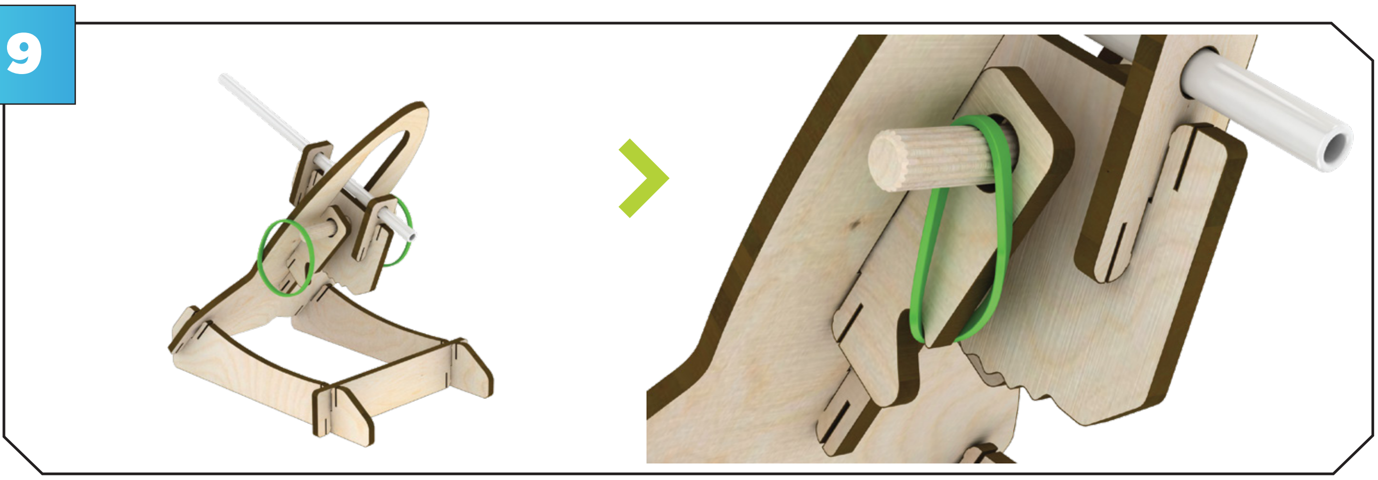
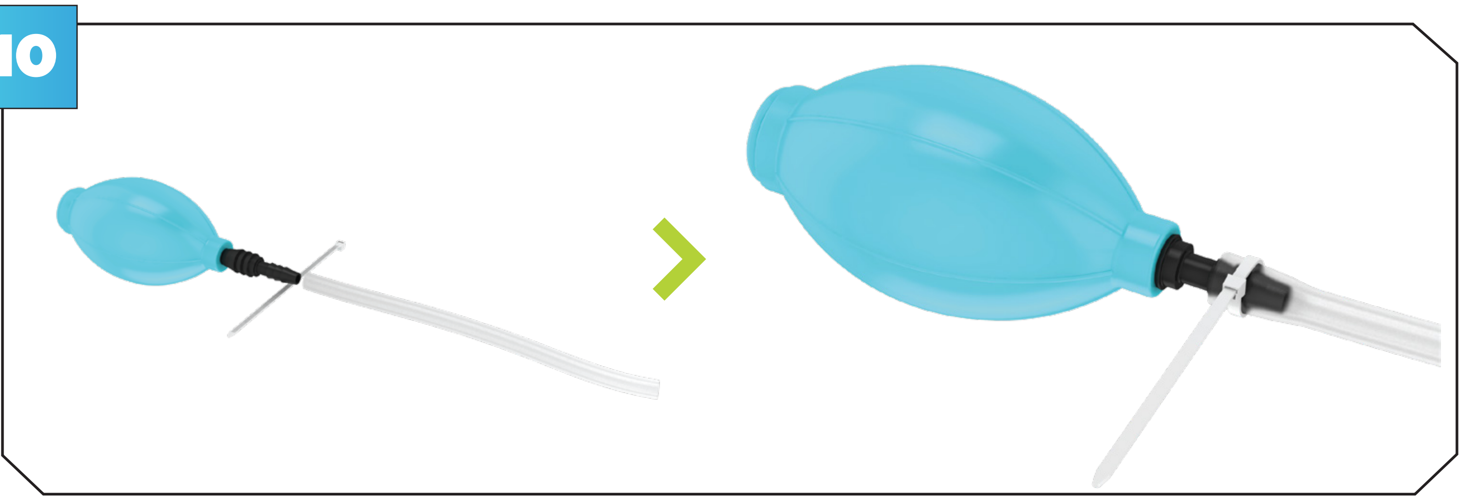


Repeat for both sides

10



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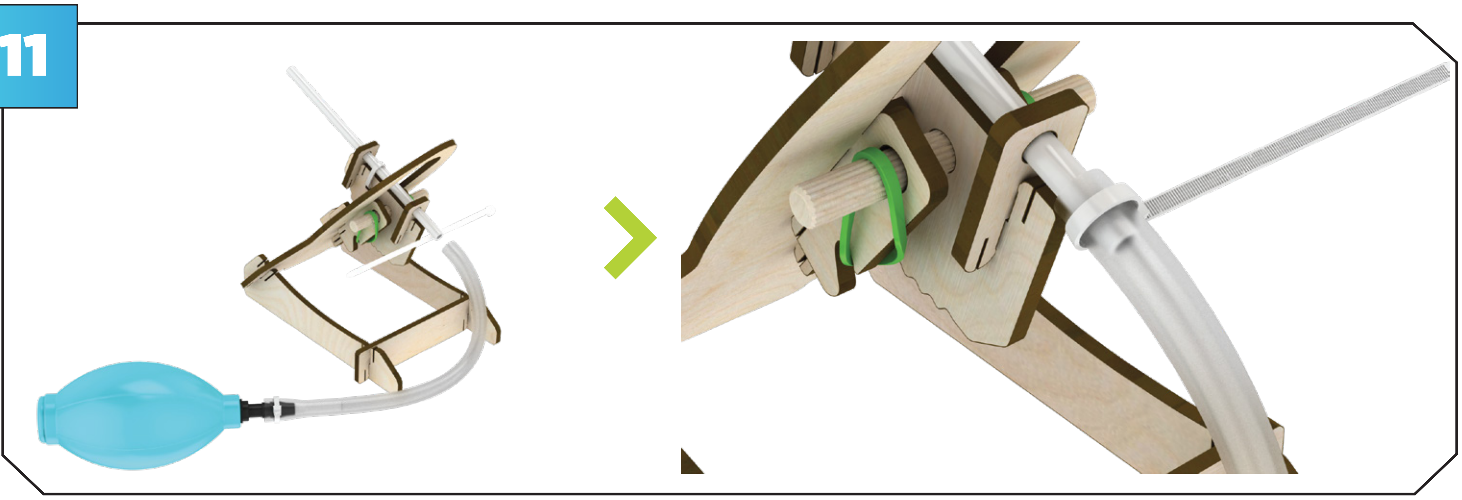

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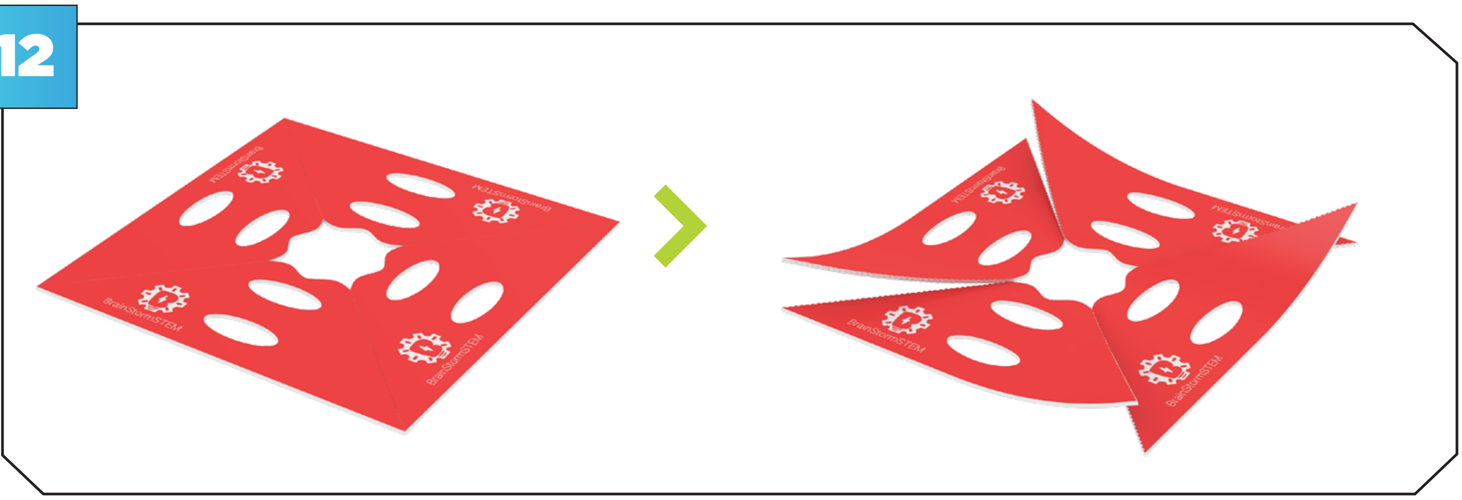

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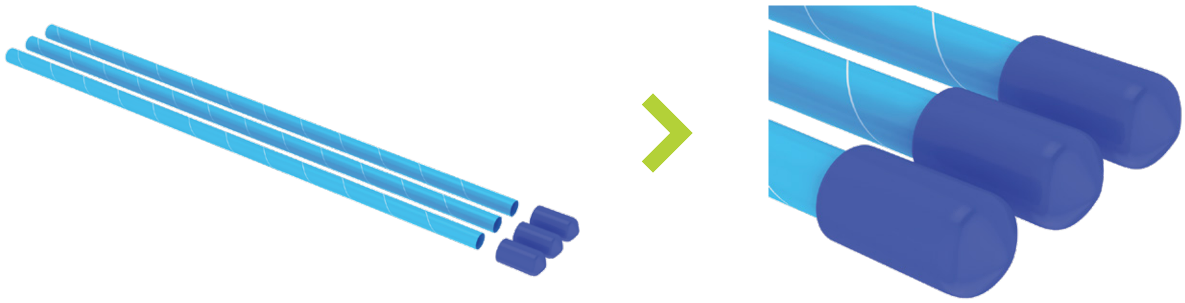

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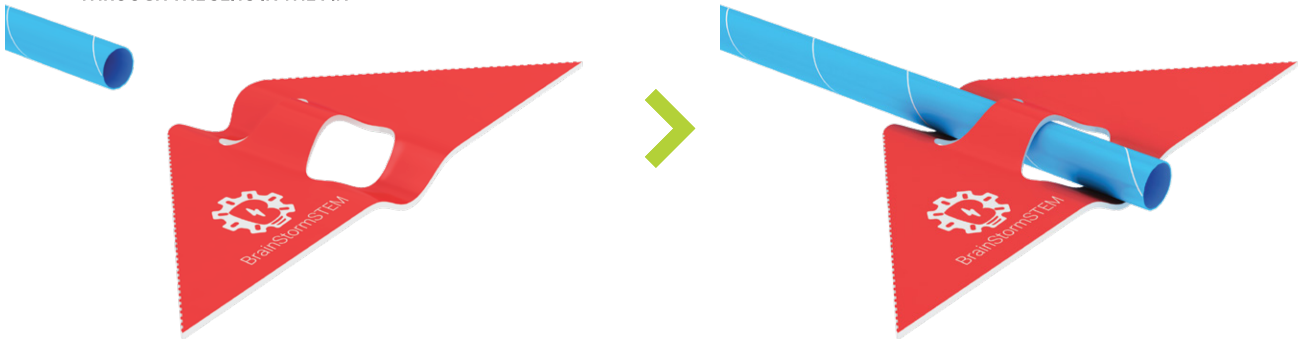
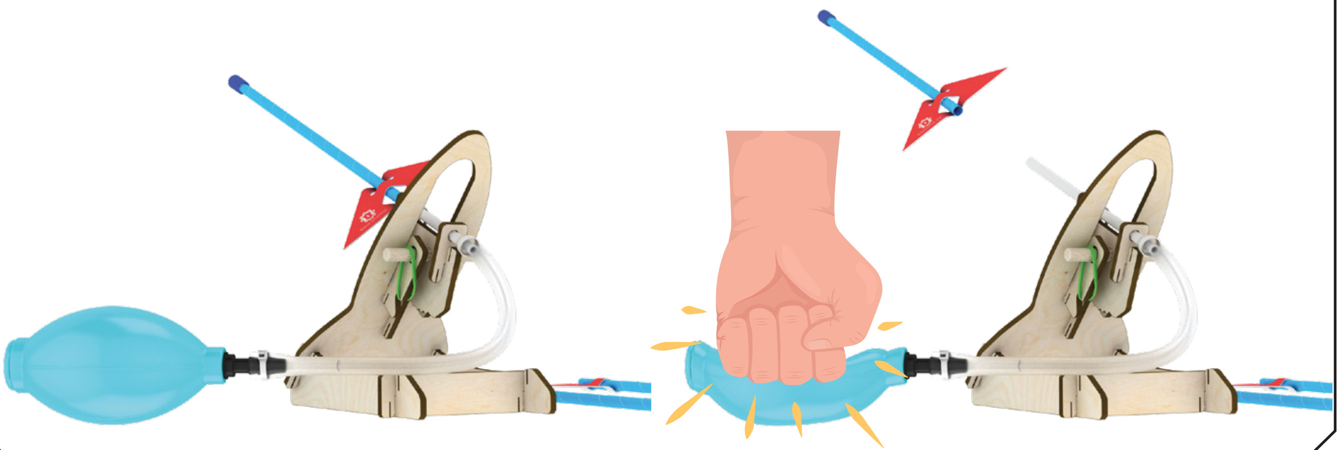
ADD FIN BY SLIDING THE STRAW

THROUGH THE SLITS IN THE FIN



HOW TO USE

1. Place straw rocket on launcher
2. Adjust launch angle
3. Press bulb to launch!



ACTIVITY FOR PROJECT

The Air Powered Rocket can be used just to build, launch and have fun. If a more engaging activity is desired, he rocket can be paired with the provided worksheets. There is a beginner worksheet and an advanced worksheet that are provided to adjust to the level of your student's understanding.

The rocket launch angle can be adjusted by moving the straw launcher up or down until the launcher stays in the next notch on the launcher.

Each of the worksheets is geared towards having the students figure out what angle is the best for the furthest launch distance. On the beginner worksheet, the students will experiment with different settings to see what will get them to the furthest target. On the advanced worksheet, the students will use a protractor to measure the specific angles at each setting to determine the most optimal angle to launch at.

The students will be able to see how adjusting the components will change the launch angle, and can verify that the launch angles closest to 45° will inevitably launch the furthest!

PLEASE NOTE: This activity requires students to launch their rockets which can launch up to 10 feet. You will need to do this activity in a room with lots of space or outside.

WORKSHEET (BEGINNER)

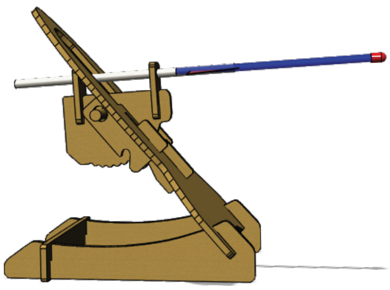
Name(s): ______________________________

Date: ______________________________

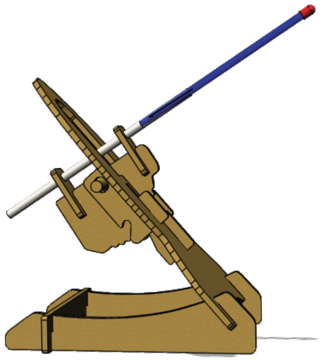
INSTRUCTIONS:

Instructions: Move the launcher up or down to match the settings in the pictures below.

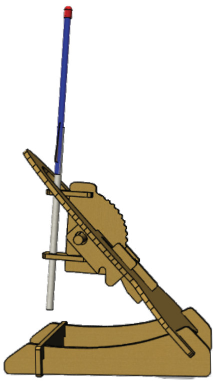
Circle the launch setting that makes the rocket launch the furthest.



20° Launch Angle



45° Launch Angle



90° Launch Angle

WORKSHEET (BEGINNER) ANSWER KEY

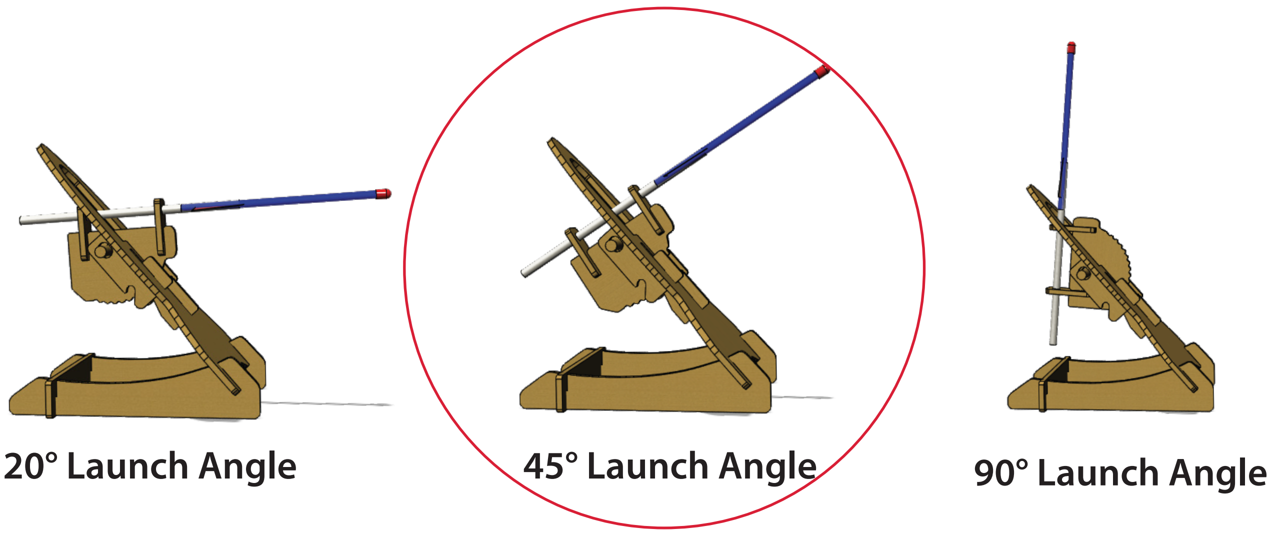
Name(s): ______________________________

Date: ______________________________

INSTRUCTIONS:

Instructions: Move the launcher up or down to match the settings in the pictures below.

Circle the launch setting that makes the rocket launch the furthest.



20° Launch Angle **45° Launch Angle** **90° Launch Angle**

When we set the stopping point right above the fulcrum, it makes a 45° angle.

45° is the best known angle to launch projectiles to reach the farthest distance.

WORKSHEET (ADVANCED)

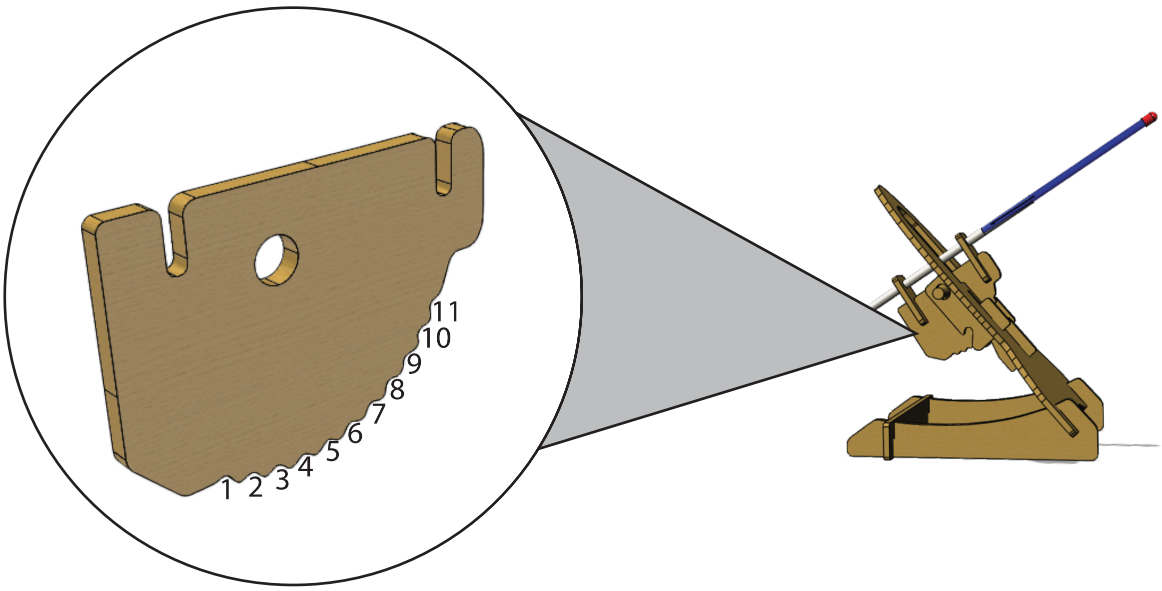
Name(s): ______________________________

Date: ______________________________

INSTRUCTIONS:

Measure the launch angle using your protractor and record that data in the table under the matching settings. Setting 1 is the smallest angle, setting 9 is the largest angle.

Next, launch the rocket, and measure how far from the launcher that the rocket landed and record that data in the table below!



	SETTINGS										
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
LAUNCH ANGLE(°)											
LAUNCH DISTANCE(in)											

Circle the greatest Launch Distances in your table.

What angle(s) produced the longest launch distances? ______________________

WORKSHEET (ADVANCED) ANSWER KEY

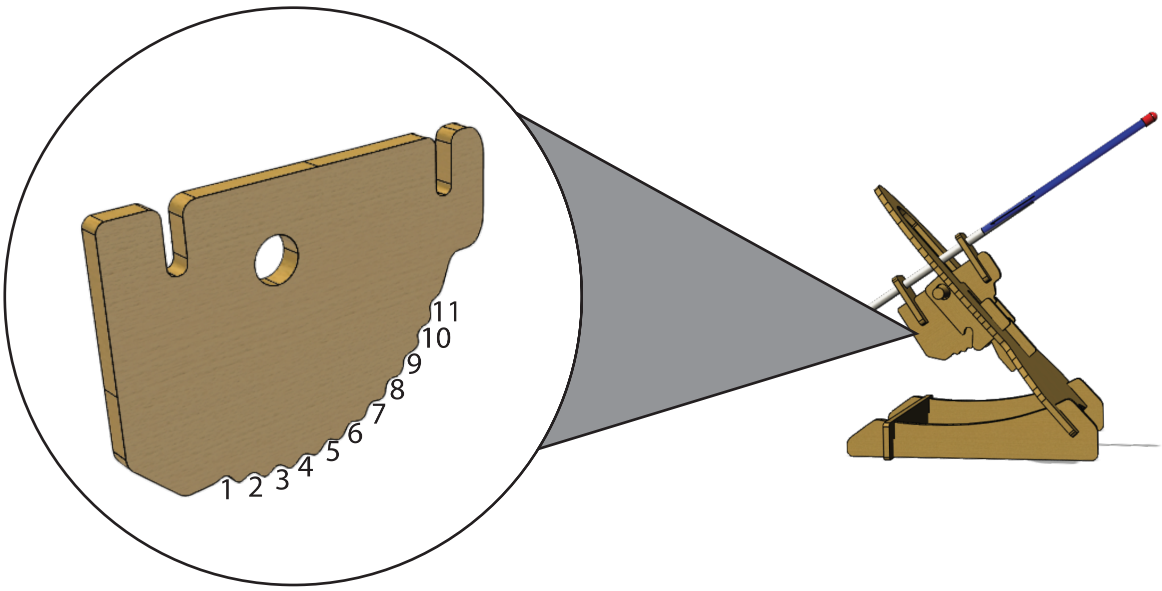
Name(s): ______________________________

Date: ______________________________

INSTRUCTIONS:

Measure the launch angle using your protractor and record that data in the table under the matching settings. Setting 1 is the smallest angle, setting 9 is the largest angle.

Next, launch the rocket, and measure how far from the launcher that the rocket landed and record that data in the table below!



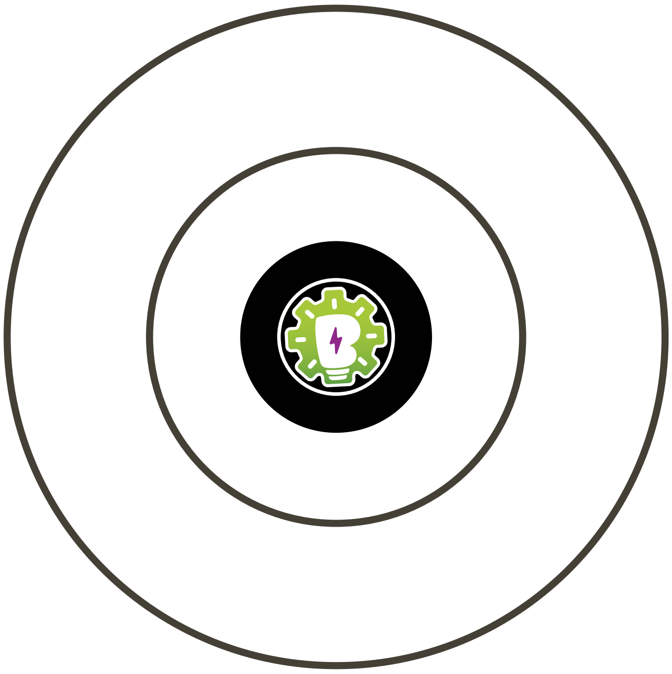
	SETTINGS										
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
LAUNCH ANGLE(°)	***20°***	***30°***	***40°***	***50°***	***60°***	***70°***	***80°***	***90°***	***100°***	***110°***	***120°***
LAUNCH DISTANCE(in)	***Distances are subjective to the amount of force used to launch***										

Circle the greatest Launch Distances in your table.

What angle(s) produced the longest launch distances? Approximately 40°-50° (45°)

PRINTABLES

PRINTABLES



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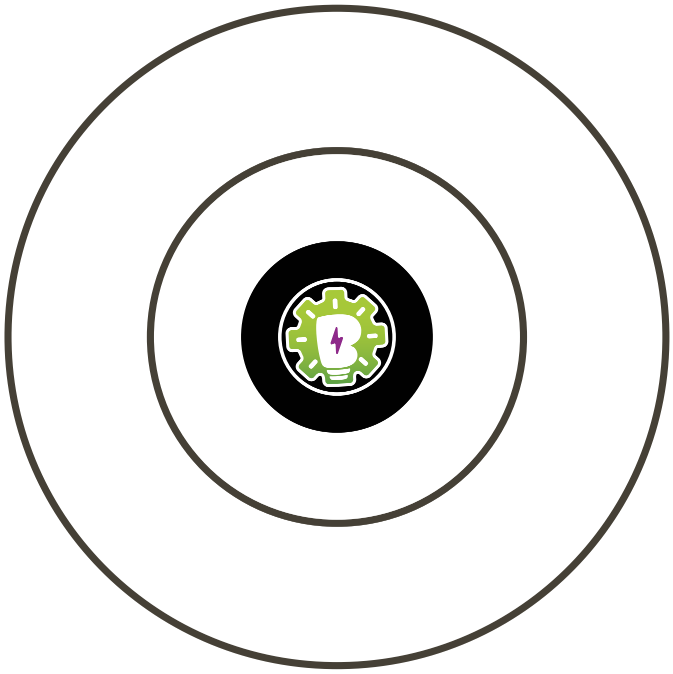

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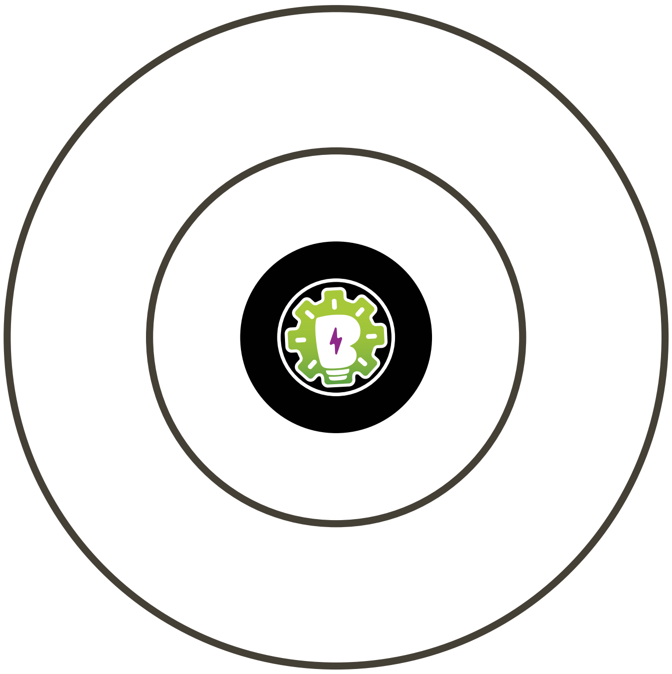

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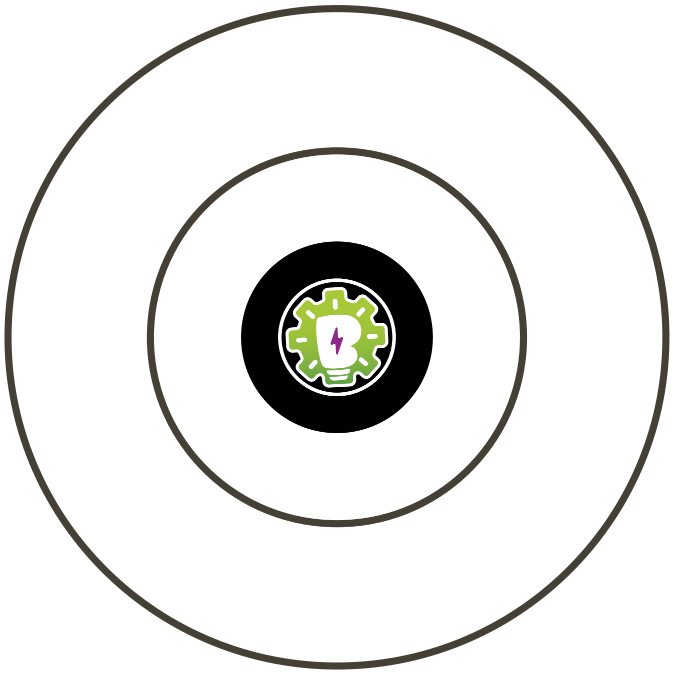

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