Session 09

Introduction to Aerodynamics | Build Your Prototype
Activity 1: Build a Parachute

Session Overview:
Have you ever wondered what a parachute and an open rain jacket have in common? They both trap air and slow you down when you move fast! In this activity, you design a parachute for a miniature action figure. Tissue paper or a plastic bag and a few strings is all it takes to make your figure into an expert skydiver.

Session Objectives:
Students will be able to:

1. Adopt techniques for designing a parachute that falls slowly.
2. Determine which type of material works best by testing different options.
3. Understand how air resistance plays a role in flight.

Session Introduction:
What is the purpose of a parachute? What is the role of a parachute in skydiving?
Imagine you are jumping out of a plane 10,000 feet in the air. What type of material would you want your parachute to be made of and what size would you want it to be?
The design of a parachute is very important, especially in an extreme sport such as skydiving because someone's life is dependent on the parachute functioning correctly. Engineers thoroughly test the materials and designs of parachutes to ensure that they open as intended are reliable, and are strong enough to withstand the air resistance needed to slow skydivers to safe landing speeds.
A parachute is an umbrella-shaped device of light fabric used especially for making a safe jump from aircraft. Due to the resistance of air, a drag force acts on a falling body (parachute) to slow down its motion. Without air resistance, or drag, objects would continue to increase speed until they hit the ground. The larger is the object, the greater is its air resistance. Parachutes use a large canopy to increase air resistance. This gives a slow fall and a soft landing.

Word Bank:

- Air resistance - the force that air exerts on objects moving through it.
- Gravity - the force that attracts a body toward the center of the earth, or toward any other physical body having mass.
- Force: Interaction that changes the motion or direction of an object
- Acceleration: When a force causes an object to speed up or move faster.

Fun Facts:

- The oldest modern parachute was designed in the 1470s in Renaissance Italy to help people escape from burning buildings.
- Just a decade later, Leonardo da Vinci created an improved pyramidal design, which was successfully tested in 2000 and multiple times later on.
- The **modern parachute was invented in the late 18th century by Louis-**Sébastien Lenormand in France, who made the first recorded public jump in 1783. Lenormand also sketched his device beforehand.
- Any time a force pulls on another object, the object moves. When you jump out of a plane, the force of gravity immediately begins to pull you, speeding up your fall, which is known as acceleration. Without a parachute, you'd fall at about 125 mph. Ouch!
- A parachute slows your fall to about 12 mph – enough for a much safer landing.
- A parachute is bundled into a package called the container, which actually contains 3 parachutes – the main parachute, a back-up or reserve parachute, in case the main parachute doesn't open, and a pilot parachute. The small pilot parachute opens first and pulls the main parachute out.
- NASA used a parachute to safely land and stop the Space Shuttle.

Warm-up: HOOP GLIDER!

- By using paper hoops that act as wings, students discover how to make a straw glide through the air. They experiment with hoop size, placement, and other factors to see how far their glider can fly.
- Discuss how gliders are different from planes?

What you will need?

1. Plastic bag something round (to draw a circle)
2. Yarn
3. Plasticine /modelling clay
4. Scissors
5. Pen
6. Needle
7. Location to drop your parachute from, e.g. a 2nd floor window, balcony, open staircase.

Safety Note:

- Be cautious when using tools such as scissors, needle.

What are we going to build today?

Today you will design, build and test the parachute.

How do we build it?

Step 1:

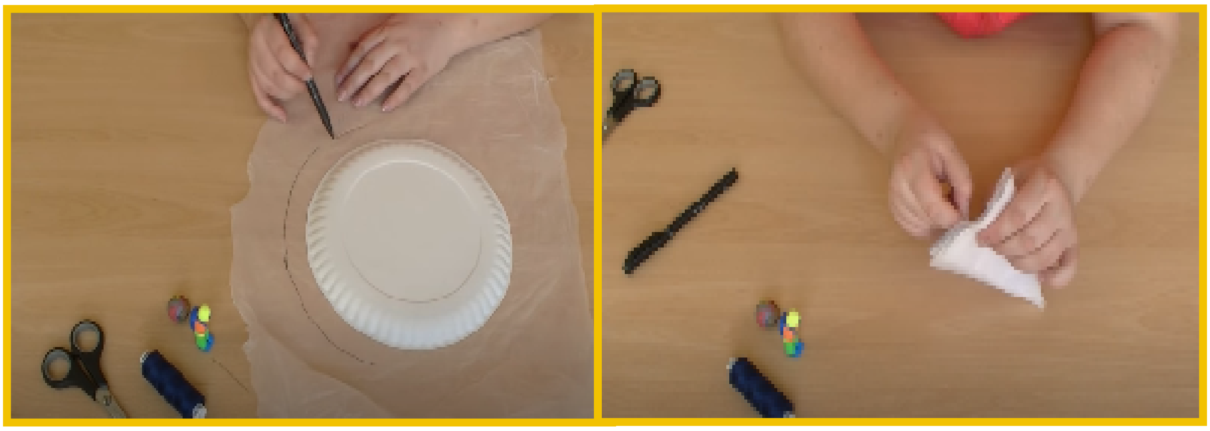
To make the canopy for the parachute, on the plastic bag draw a large circle (the largest we can) and cut it out.

Step 2:

The resulting circle fold 3 times in half - we should get 8 layers.

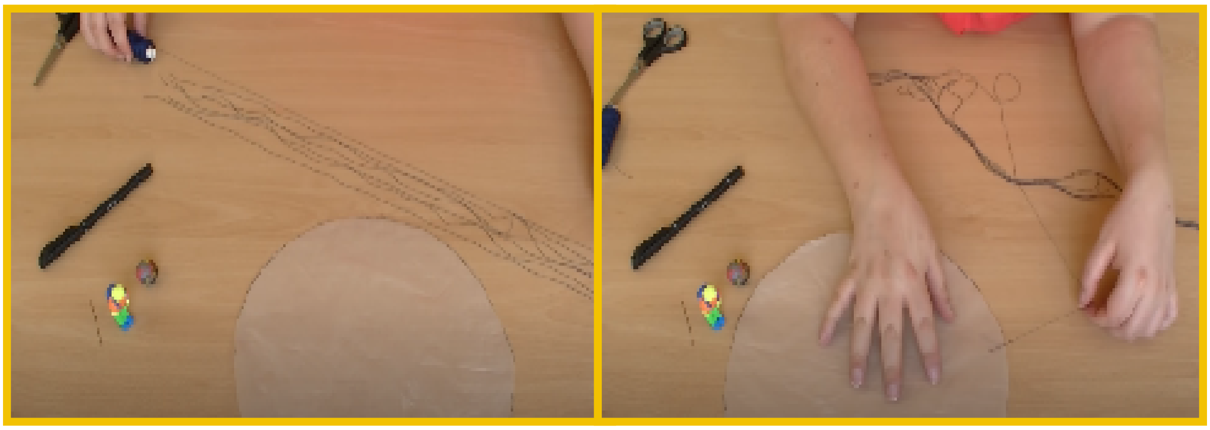
Step 3:

About 1 cm from the arc, in the middle make a hole (with a thick needle).



Step 4:

Unfold. Cut 8 threads about 40 cm long, thread them through the holes and tie a knot. It should be just behind the edge of the circle.



Step 5:

When all the threads are tied one hand grasp the parachute in the middle and with the other pull on the threads (not too tight) to even it out. The threads should be equally tight

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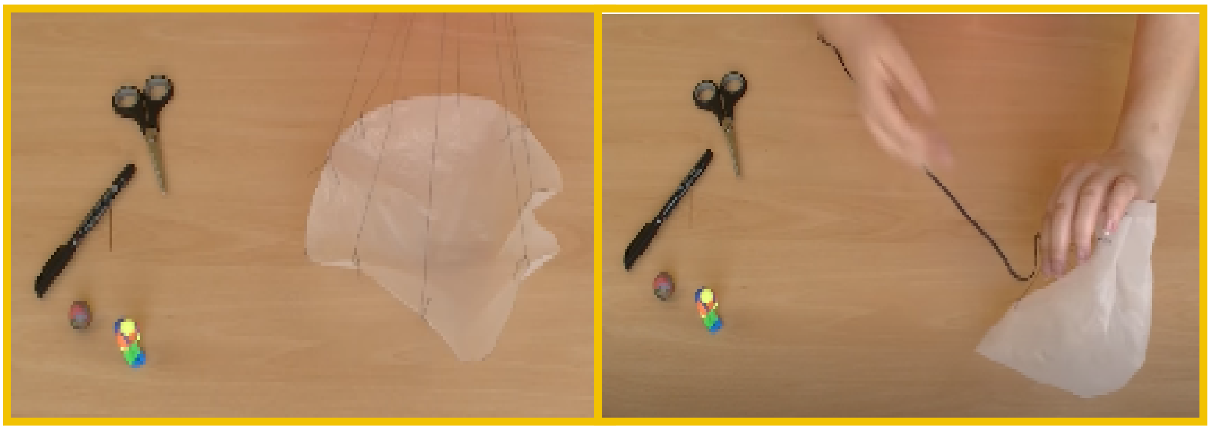
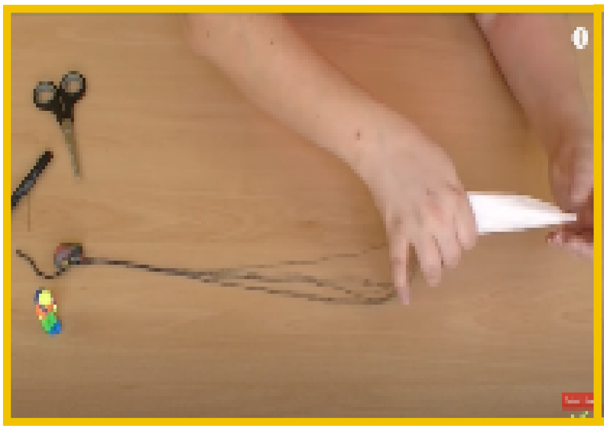
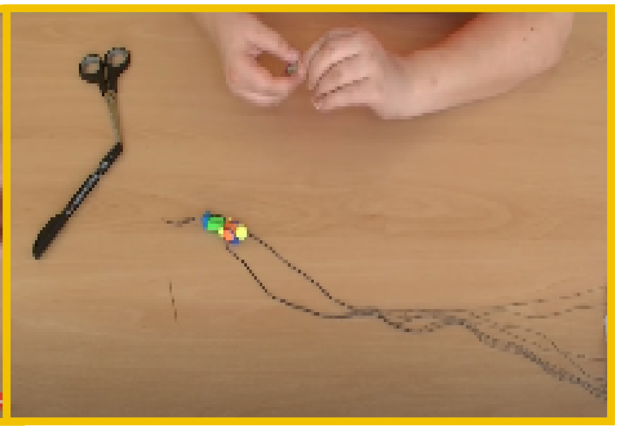


Step 6:

At the end of the threads attach a ball of Plasticine or people for example from modelling clay. It's better to start with a small amount and keep adding until you get the right mass. The man shouldn't be too big either - you can always weigh him down by adding Plasticine.





Step 7:

Drop your figure equipped with parachute several more times from the same location.

Step8: We grab the parachute in the middle, fold it in half, and then bend the thread so that the whole thing fits in our fist. We toss it into the air and watch the flight.

Troubleshooting Tips:

If the parachute lands faster, then try increasing or decreasing the weight of the figure.

In place of figure you can also use other material for weight. Eg: Clay, paper clip, etc.

Concept Explored:

Your figure probably fell straight down and had a hard landing at first. The figure equipped with a parachute probably had a softer landing, but it was probably also harder to predict where exactly it would land. The figure equipped with the parachute with the hole in the middle probably still had a pretty soft landing. All of this is expected.

Gravity pulls objects straight down towards the center of Earth. It is strong enough to make falling objects move quickly, creating hard landings! Luckily, we have a layer of of air around Earth which slows falls. Parachutes catch a lot of air creating a lot of drag, a push that opposes the movement of the parachute. It can drastically slow a fall, allowing a softer landing. However, this slow fall can be hard to control. A figure landing with a parachute might sway to the side during the fall.

Some parachutes trap air, just like a loose jacket can trap air on a bike ride. This trapped air wants to escape. Often, it can only escape at the edges which makes those edges (canopy edges or the sides of your jacket) flap. Some parachutes have a hole in the center to release air in a controlled way. It makes the chute more stable, with only a minimal change in drag.

Parachutes work because of something called air resistance. This has to do with the fact that air does actually have mass, even though we can't see it. The more of the air's mass that the parachute can "catch" the slower it will fall. This increases air resistance and makes the parachute fall more slowly. Without air resistance, a feather would fall as quickly as a bowling ball when dropped

S-T-E-A-M:

» Science: Explore the scientific principles behind parachutes, such as air resistance, gravity, and drag. Students can learn about the relationship between surface area, weight, and descent speed.

» Technology is all about using tools like string, polybag etc.

» Engineering: Designing parachute using step by step instructions.

» Arts: Promote creativity and artistic expression in parachute design. Encourage students to think about aesthetics, color combinations, and patterns when decorating their parachutes. They can also document their design process through sketches, diagrams, or photographs.

» Math: While designing students will be measuring, cutting and counting the string for the project. These seemingly simple tasks are a great way to practice math skills and teach kids how math is part of everyday life

Reflection:

1. » How did the parachute move? (Why do you think it floated down?) Why did it move slowly?
2. » How do you think the weight would drop without the parachute?
3. » Why might people use parachutes?

Extension Activity:

1. 1. Make parachutes using different materials, such as plastics, cotton and nylon.
2. 2. Use a timer to measure how long each fall takes. Can you calculate the average speed of your figure
3. during the fall? Which parachute creates the slowest fall?
4. 3. Make canopies of different materials, different sizes, and different shapes. Which ones work best?

Sources:
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https://www.teachengineering.org/activities/view/design_a_parachute
https://www.scienceworld.ca/resource/make-your-own-parachute/
https://ivyleaguekids.org/stem-at-home-hoop-gliders-craft/

Introduction to Aerodynamics
Activity 2: Build a Paper Rocket

Session Overview

Let's Blast off! Have you ever played with a model or toy rocket, or seen a real rocket launch on TV? In this project students will make simple rockets out of paper and launch them by blowing into a drinking straw. Can you make the rocket that flies the farthest? In this session, students learn about two more forces important for flight. They will construct a rocket using paper, pencil, and tape to investigate thrust and drag. They will investigate how a single variable on the rocket fin will change the performance of the model.

Session Objectives

Students will be able to:

» Build, test, and fly a model rocket made of paper.

» Observe and record their observations about the flight of a paper model rocket.

» Observe that a force must be applied to make a paper model rocket fly.

» Observe that drag increases when they bend the fins on a model rocket.

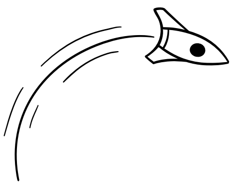
» Explain that thrust is the force that propels an object through air.

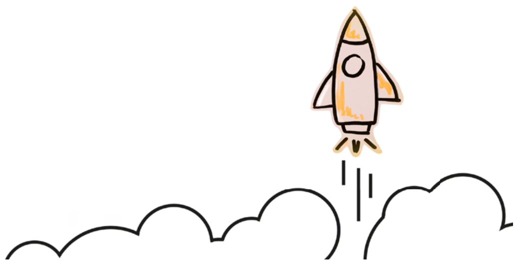
» Explain that drag is the force that slows the motion of an object moving through air.

Session Introduction

All flying objects, from rockets to airplanes to birds, have something in common—they need to remain stable when they fly. You are probably pretty familiar with what "stability" means for objects on the ground. Did you use training wheels when you learned how to ride a bike? Training wheels help keep the bike stable so you do not fall over. The same concept applies to things that fly. They need to stay pointed in the same direction when they fly forward, without spinning or tumbling, which could cause them to crash.

You may have noticed that rockets and missiles usually have triangular fins at their bases. The same applies to other long, skinny objects that fly through the air quickly, such as arrows. In this project you will find, how these fins can help a rocket fly straight. The fins make sure the rocket's center of pressure (the point where the equivalent force from air resistance acts) is behind its center of mass (the "middle" of the rocket, or equivalent point where all its mass is concentrated).





Word Bank

- Air resistance: a pushing force that slows things down
- Force: a push or pull on an object; in this case, how hard you blow or push air through the straw
- Gravity: a force that pulls things toward Earth
- Launch: to send or shoot something, such as a rocket, into the air, water or outer space
- Propel: to drive forward or onward by means of a force
- Rocket: a cylindrical projectile that can be propelled to a great height or distance by the combustion of its contents

Fun Facts

- Sound needs something to travel through. Because Space is a vacuum (i.e. nothing there at all, not even air) astronauts use radios to talk to each other. (Radio waves can travel through a vacuum).
- Some of the discoveries during Space research have various uses on the ground: e.g. solar cars, dental work, 'cot death' prevention, and potato crisp factories getting crisps into bags quickly without breaking them!
- In 1865 the science fiction writer Jules Verne suggested using a powerful gun to send people to the Moon!
- Rockets were invented in China over 800 years ago. The first ones were very simple - a cardboard tube packed with gunpowder and attached to a guide stick - a bit like the fireworks we use today.
- A space shuttle is a launch vehicle that blasts into space like a rocket, but it comes back to land on a runway, and can be used again and again.
- Satellites - which beam TV pictures and phone calls around the world, watch the weather, and do lots of other things - are launched into space by rockets or space shuttles.

Warm Up

SCRAMBLED!

How many of these jumbled words can you guess correctly?

- These help birds fly- IWNGS
- They fly airplanes – LTOPIS
- This is where you go to take a flight on an airplane – RPOTARI
- You need this document to fly internationally – PSOPATRS
- It was the first flight – THO IRA LOBALON

Divide the class in 4 groups. Teacher will read each question and the team answers first gets the point. Team with maximum points wins.

you've GOT THIS

Let's Begin!

What you will need?

1. A4 sheet of paper
2. Scissors
3. Pencil (of approximately the same diameter as the straw)
4. Drinking straws (wide diameter if possible),
5. Sellotape
6. Ruler
7. Clear space in which to launch your “rockets,” such as a large room, hallway or outdoor area with no wind
8. Measuring tape

Safety Note:

» Be cautious when using tools such as scissors.

» Do not point the rocket at other children when you are launching it - even though it is soft it might frighten them.

What are we going to build today?

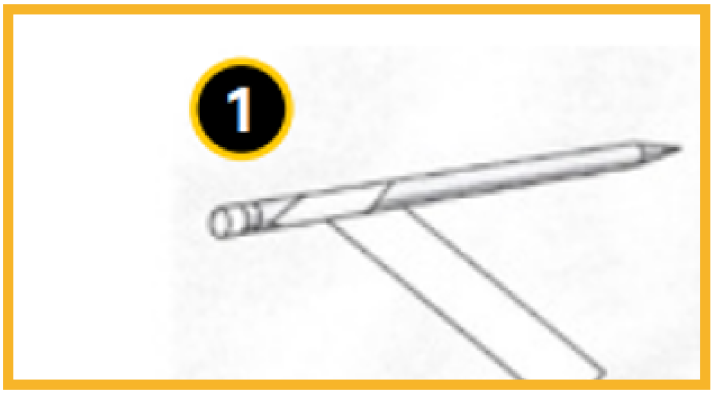
Today you will design, build and test the paper rockets.

How do we build it?

Cut a strip, 5 cm. wide, from the long side of an A4 sheet of paper.

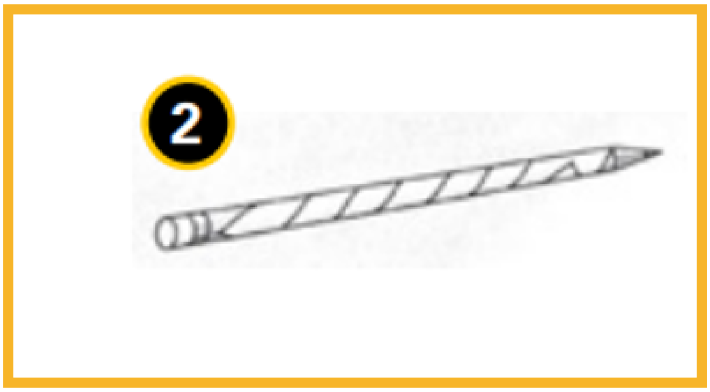
Step 1:

Starting at one end of the pencil, hold the paper at an angle of approximately 45˚ to the pencil.



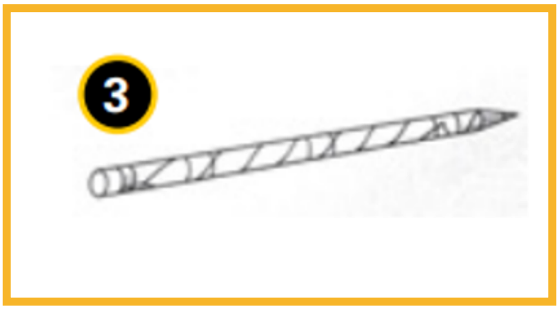
Step 2:

Roll the paper strip around the pencil fairly tightly until you get to the other end.



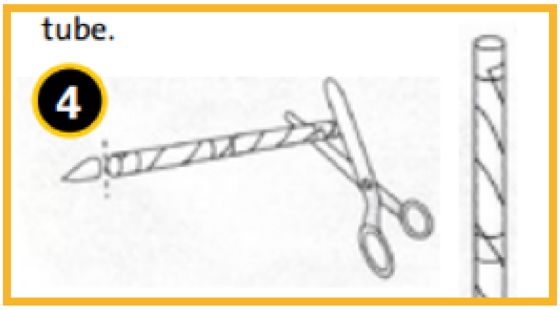
Step 3:

Tape the tube at each end and at the middle of the rocket.



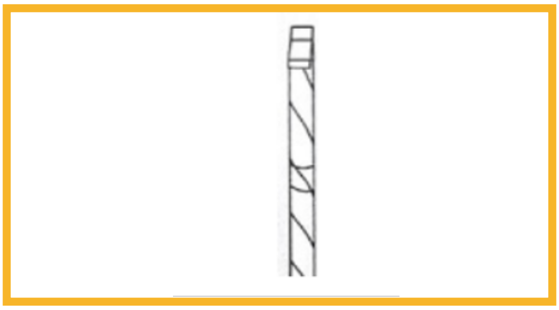
Step 4:

Cut off both ends of the tube.



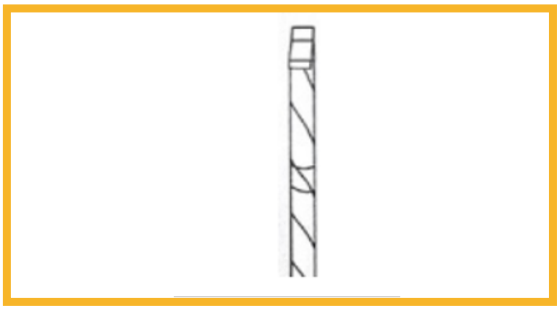
Step 5:

Fold the upper end firmly and tape it.

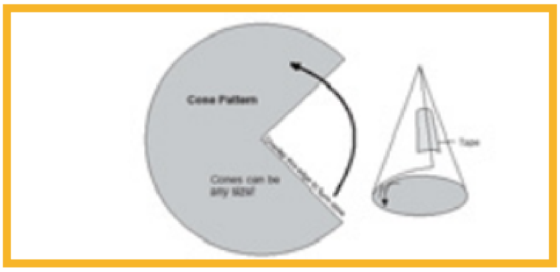


Step 6:

Design the rocket's nose* and fins.

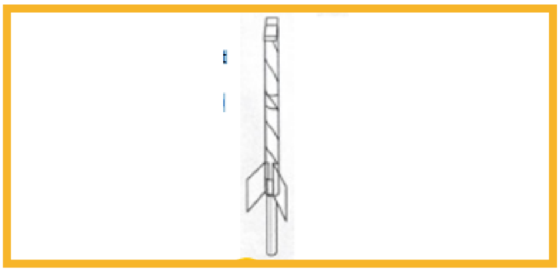


Note: One possible way of making a nose cone is as follows: draw and cut out a circle, then remove a segment from the circle. Overlap the straight edges and tape down.



Can they make a cone from a quarter of a circular disc?

Step 7:
Launch the rocket by inserting the straw in the open end and blow.



Step8:
Rocket launch!

Step 9:
Try different numbers of fins. For example, what happens if you only use two fins instead of four?

Troubleshooting Tips:

» If the rocket doesn't launch then check while inserting the rocket into the straw, if is it smooth enough or not.

Concept Explored:

The directions of thrust, lift, drag, and weight. Lift and drag are defined based on the direction of the rocket's movement relative to the air. Drag is opposite the direction of motion, and lift is perpendicular to the direction of motion. Normally, this does not cause any confusion because we think about objects that fly horizontally (like a paper airplane), so lift points up. However, if a rocket is launched vertically, then lift points sideways and not up.

The rockets have fins that, at first glance, might seem like they act like wings and generate lift if you launch the rocket horizontally. However, the fins are very small and their primary purpose is to keep the rocket stable and prevent it from tumbling—not to provide lift.

Real rockets provide continuous thrust by burning fuel, which is expelled out the back end of the rocket. According to Newton's third law of motion (for every action, there is an equal and opposite reaction), since the fuel is pushed out the back of the rocket, the rocket must be pushed forward. This concept also applies to certain toy rockets, like model rockets, water bottle rockets, and baking soda/vinegar rockets, all of which expel some sort of fuel. However, the paper rockets in this project do not carry any fuel. They are propelled forward by one initial puff of air from the straw, but after that, do not produce any thrust on their own.

S-T-E-A-M:

Science is observed while using physics terms of mass, air resistance, and force and trying the different angles and designs.

Technology is the use of tools like straw, pencil, tape etc.

Engineering is all about designing the paper rocket.

An art is introduced when you will make a drawing of the launch and landing of your rocket.

Math is applied when you use a stopwatch and measure how long the rocket is in the air from launch to landing. Try several different trials and put them on a line graph.

Reflection:

1. Why do you think the rocket falls back to the ground after being launched into the air?
2. What instrument will you choose to measure the actual distance?
3. Does the angle make a difference to the distance travelled?
4. Does it make a difference how far you push the straw into the rocket when you blow?
5. What do you think might happen if air leaks out of the nose of the rocket? Try and see! Why do you think this might happen?

Extension Activity:

1. Try out different lengths of rocket. Does a longer or shorter rocket make a difference to the distance it travels?
2. Experiment with different shapes of fins and noses. Is there any difference in controlling the direction of the rockets between those with fins and those without fins? Does the shape of the nose make any difference?
3. Can you think of any other ways of making a paper rocket which might go further?
4. Larger pencils could be tried with larger straws (available from Art and Craft catalogues) to see if these rockets would go further.

Sources:

https://www.scientificamerican.com/article/build-a-paper-rocket/

https://www.sciencebuddies.org/teacher-resources/lesson-plans/scientific-method-rockets#

https://www.sfi.ie/site-files/primary-science/media/pdfs/col/dpsm_paper_rocket.pdf

Capstone

Now, Work on your prototypes. Build them with the material you have collected.

Take Home Activity:

Improve the prototypes you have built and gather feedback from the community on the basic prototype version.

KEEP MOVING FORWARD