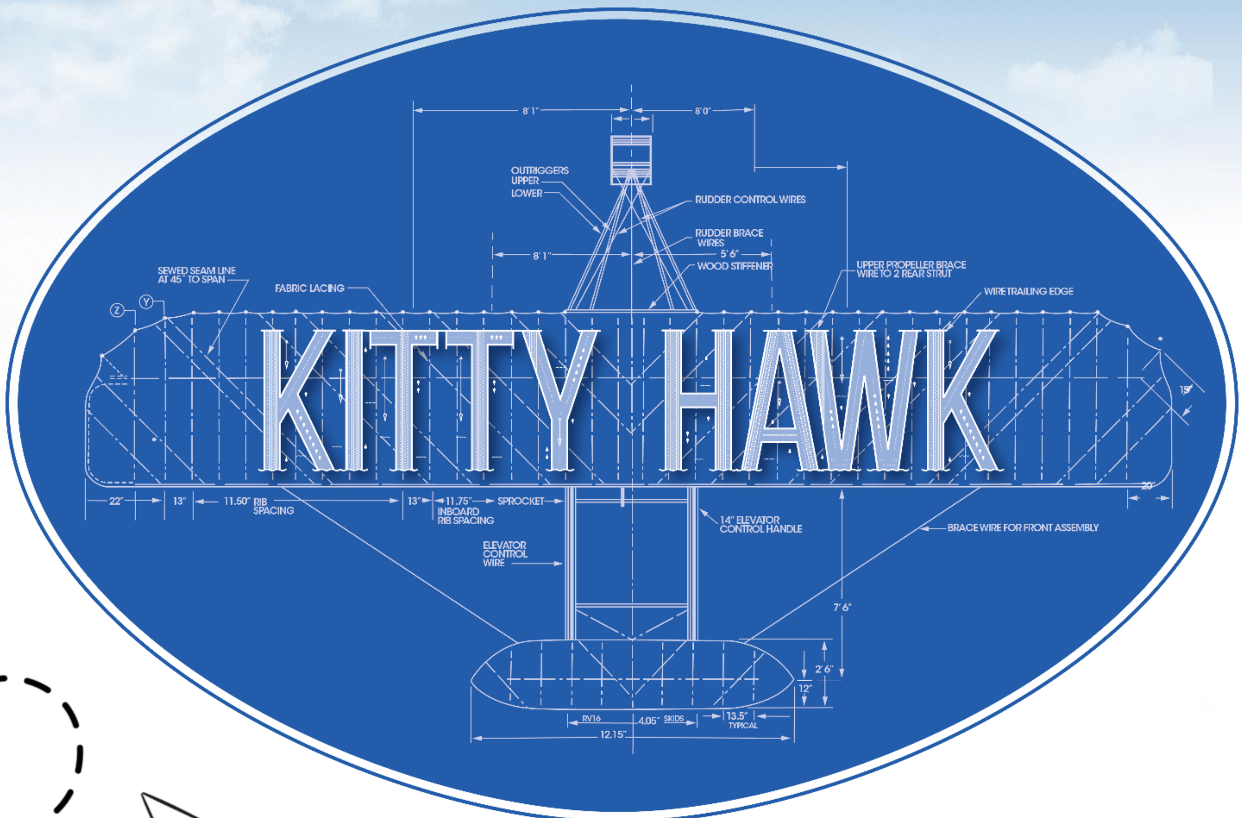
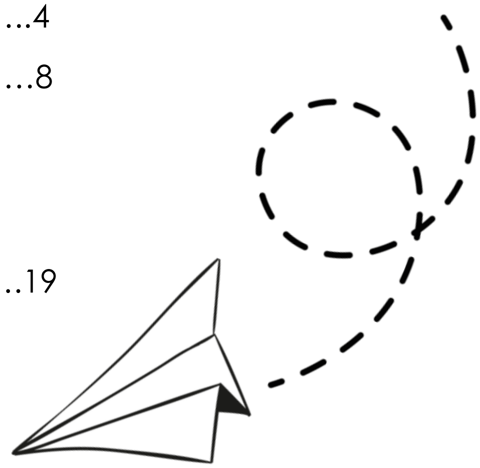


Resource Guide

Adrienne Arsht Center
FOR THE PERFORMING ARTS OF MIAMI-DADE COUNTY

Table of Contents



About

Wilbur and Orville Wright, a.k.a. the Wright Brothers, are known as the fathers of aviation. Thanks to their innovation and determination we are able to soar the friendly skies. They methodically did their experiments and investigations, and within a year they were flying gliders on the beaches near Kitty Hawk. Their gliding experiments ended with more doubts than success, leading Wilbur to say, "Nobody will fly for 50 years!" However, they did not give up and in 1903, the Wrights returned to Kitty Hawk with a powered "Flyer" and the determination to fly. On the morning of Dec. 17, Orville climbed aboard the Flyer and took off. The flight lasted a scant 12 seconds and covered only 120 feet, but later that day Wilbur flew 852 feet in 59 seconds, proving without a doubt the Flyer worked (adapted from Boeing Frontier).

Now, over a 100 years later, students will have the opportunity to experience history of flight come to life at the Adrienne Arsht Center in the "World Premiere Musical Adventure" - Kitty Hawk. These lessons will incorporate details from the play and historic details to engage students in this STEAM-powered adventure.

After School Workshop Sample

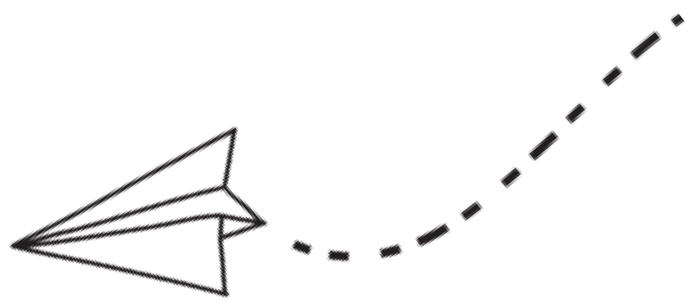
<table>
<tr><th>Week</th><th>E</th><th>Activity First hour</th><th>Second Hour</th></tr>
<tr><td rowspan="2">1</td><td>1</td><td>Curriculum Guide 1: Introduction to Flight
Activity 1: Paper Helicopter design challenge
Lab report format
Analysis/discussion video
Introduction to course/ paperwork to send home</td><td>Activity 2: Introduction to Flight
Kitty Hawk video and/or Wright Brothers Introduction

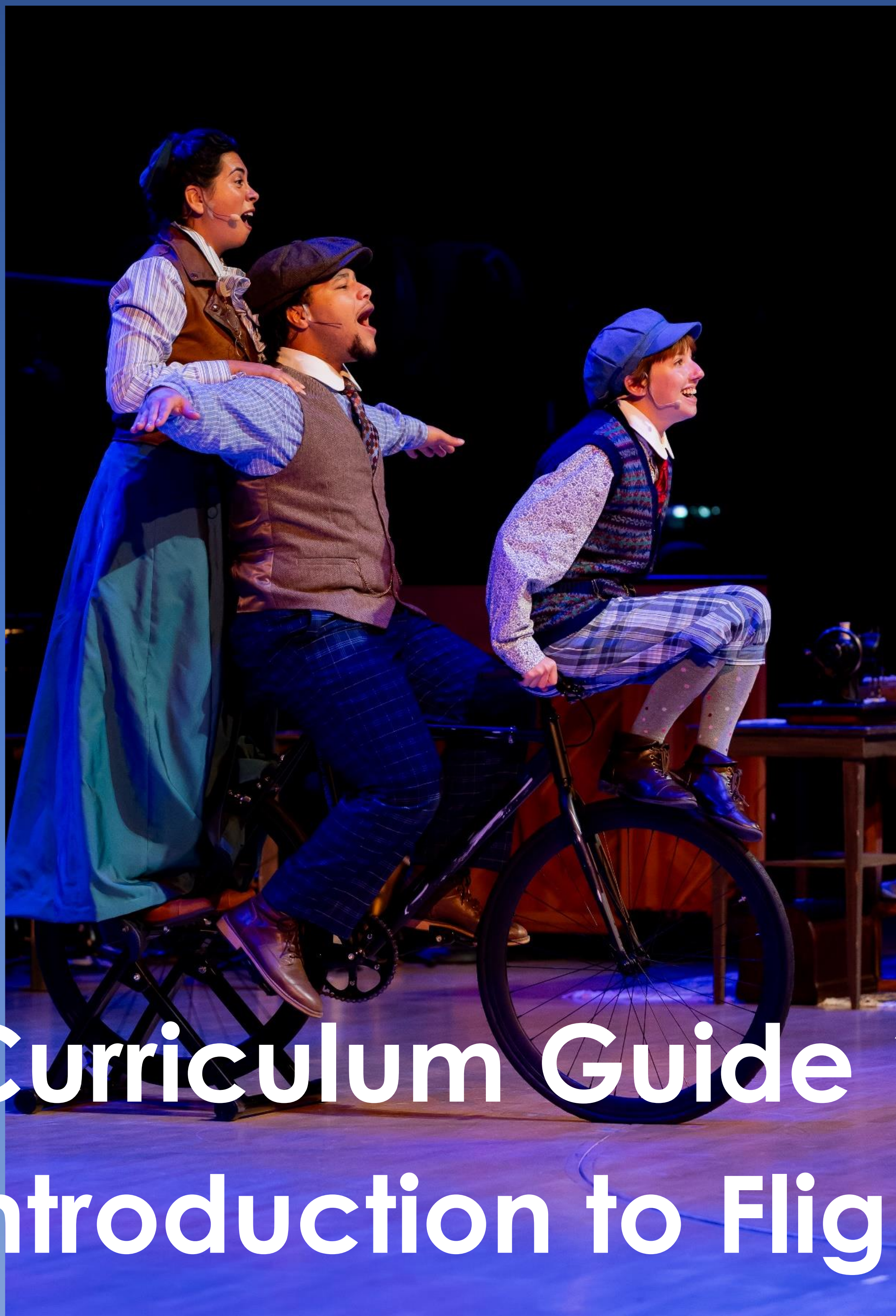
Introduction to “art” project</td></tr>
<tr><td>2</td><td>Curriculum Guide 2: Forces of Flight
Activity 1: Introduction to the Forces of Flight</td><td>Activity 2: Bernoulli’s Principle Activities (four forces)
video</td></tr>
<tr><td rowspan="2">2</td><td>3</td><td colspan="2">Curriculum Guide 3: Airfoil/Wing Design
Activity 1: Airfoil Design (paper airplane)
Everyone does the <u>same</u> design (templates in guide)
Build, Fly and test, measure flight distance
Data Collection/report</td></tr>
<tr><td>4</td><td>Science of cloud formation and identification of their cloud photos
Collect cloud photos</td><td>Guest Speaker</td></tr>
<tr><td rowspan="2">3</td><td>5</td><td colspan="2">Activity 1: Airfoil Design (paper airplane)
Everyone designs <u>their own</u>, hopefully at least 2 designs)
Build, Fly and test, measure flight distance
Data Collection/report</td></tr>
<tr><td>6</td><td colspan="2">Curriculum Guide 6: Expression of Flight
Activity 1: Art project - Introduction to watercolor painting and requirements
Need to have cloud photos</td></tr>
<tr><td>4</td><td>7</td><td>Work on art project
Rough draft figure</td><td>Activity 1: Analysis of paper airplane wing design
Discussion on what worked and why</td></tr>
</table>

			Introduction to wing ratio calculations, how wings work
	8	Work on art project Write story	Work on art project Rough draft figure
5	9	Work on art project Draw figure on painting	**Curriculum Guide 3: Airfoil/Wing Design** Activity 2: Power Up airplane Build, Fly and test, measure flight distance Data Collection/report
	10	Work on art project Paint figure	**Curriculum Guide 3: Airfoil/Wing Design** Activity 3: Balsa Glider Everyone does the same design (templates in guide) Build, Fly and test, measure flight distance Data Collection/report Balsa Planes
6	11	Work on art project Paint figure / ***Guest Speaker***	Activity 3: Balsa Glider Everyone designs their own Build, Fly and test, measure flight distance Data Collection/report Analysis of balsa airplane wing design Discussion on what worked and why
	12	Work on art project Paint figure	**Curriculum Guide 4:** Learn to code Activity 1: Introduction to Scratch Build a Scratch code (block) Practice using the drag and drop and building sequences Practice just flying the Tello drone****
7	13	Work on art project draft 'place'	**Curriculum Guide 4:** Learn to code Tello drone Activity 2: Introduction to Scratch/Tello

			Build a Scratch code (block) for the Tello Practice using the drag and drop and building sequences
	14	Work on art project Paint ‘place’	**Curriculum Guide 4:** Code 1 drone (working in pairs) Activity 2: Code the drone to go up & down – only 1 meter Code the drone to go side to side – only 2 meters Code front to back -only 1 meter Practice until they fly within the limits
8	15	Work on art project Paint ‘place’	Activity 2: Code 1 drone (working in pairs) Practice until they fly within the limits
	16	Work on art project Final painting	**Curriculum Guide 4:** Learn to code *CoDrone* Activity 3: Introduction to Robolink online platform Follow sequences to learn to code
9	17	Activity 3: Code 1 drone (working in pairs) Code the drone to go up & down – only 1 meter Code the drone to go side to side – only 2 meters Code front to back -only 1 meter Practice until they fly within the limits	
	18	**Curriculum Guide 4:** Code 2 drones (groups together) Since 2 drones require 2 computers and 4 people to cooperate – practice the code of movement and working together	
10	19	Code 3 drones (groups together) Since 3 drones require 3 computers and 6 people to cooperate – practice the code of movement and working together ***Guest Speaker***	
	20	**Curriculum Guide 5: Drone Dance/Ballet** Code 3 drones (groups together)	

		Since 3 drones require 3 computers and 6 people to cooperate – practice the code of movement and working together
11	21	Work on Drone ballet Work with some and movements
	22	Work on Drone ballet Practice movements to music
12	23	Work on Drone ballet finalize
	24	Final Drone Ballet presentation at Arsht Center





Curriculum Guide 1: Introduction to Flight

Activity 1.1: Falling Helicopter

OBJECTIVE: Students will conduct an experiment to determine if wing length will affect the descent of a paper helicopter

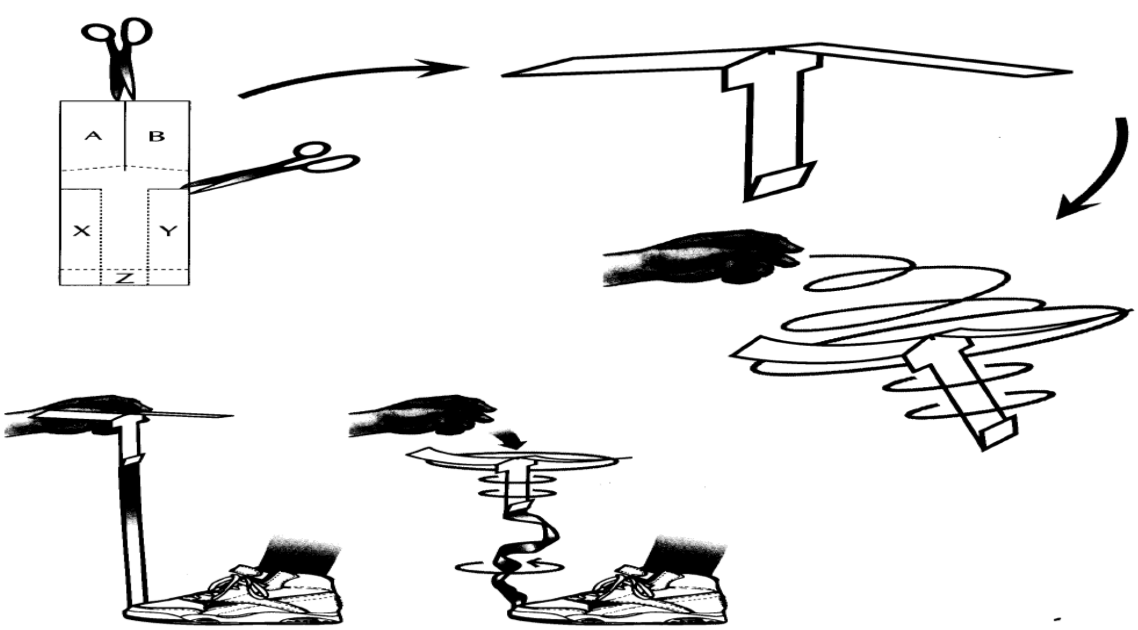
TIME: 50 minutes

MATERIALS:

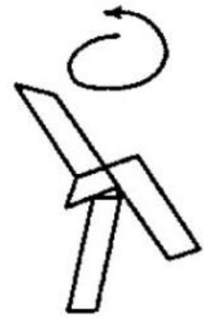
- Paper helicopter template
- Calculator
- (2) meter sticks
- Scissors
- Stopwatch
- Chair
- Paper clips

DIRECTIONS:

1. Read through the procedure. Hand out the "Falling Paper Helicopter Student Lab Report"
2. Students complete the problem, hypothesis, materials, and variables sections of the Student Lab Report.
3. Collect data
4. Calculate the average times of descent for each wing length.
5. Complete the Observations section of the Lab Report.
6. Graph your data.
7. Write a conclusion



Name(s): ____



Falling Paper Helicopter
Student Lab Report

PROBLEM/QUESTION: How does the __*Wing length*___(I.V.) **affect the** ___*rate of falling* (D.V.)?

HYPOTHESIS (Use numbers such as length of wing & time to fall)**:**

If the ____,

(I.V.)

then

____?

(D.V.)

MATERIALS (list the materials you will use to perform the experiment)**:**

VARIABLES:

a) Independent (what you will be changing): ________________________

b) Dependent (what will respond to the change): ________________________

c) Constants (what must remain the same): 1) ________________________

2) ________________________

3) ________________________

EXPERIMENTAL SETUP (drawing with labels):

PROCEDURE (step-by-step outline of experiment; include enough detail so that the experiment could be duplicated)**:**

1. Cut out the helicopter on the solid lines. Do not cut the lines with numbers. You will begin with the complete helicopter.
2. Fold on the dotted lines. Fold X & Y to meet on the middle. Fold Z up to the middle (see directions). Place a paper clip at the bottom. Wing A is fold opposite to wing B.
3. Measure 2 meters up. Stand on a chair **(SAFETY)** to drop the helicopter from a height of 2 meters.
4. When you drop the helicopter, start the stopwatch.
5. Stop the stopwatch when the helicopter hits the ground.
6. Record the number of seconds it takes for the helicopter to reach the floor in the data table (the time of descent).
7. Repeat at least 3 times.
8. Cut the ends of the wings at the 4. Repeat steps 2-7.
9. Repeat steps for each of the other wing lengths of 3, 2, and 1.

DATA:

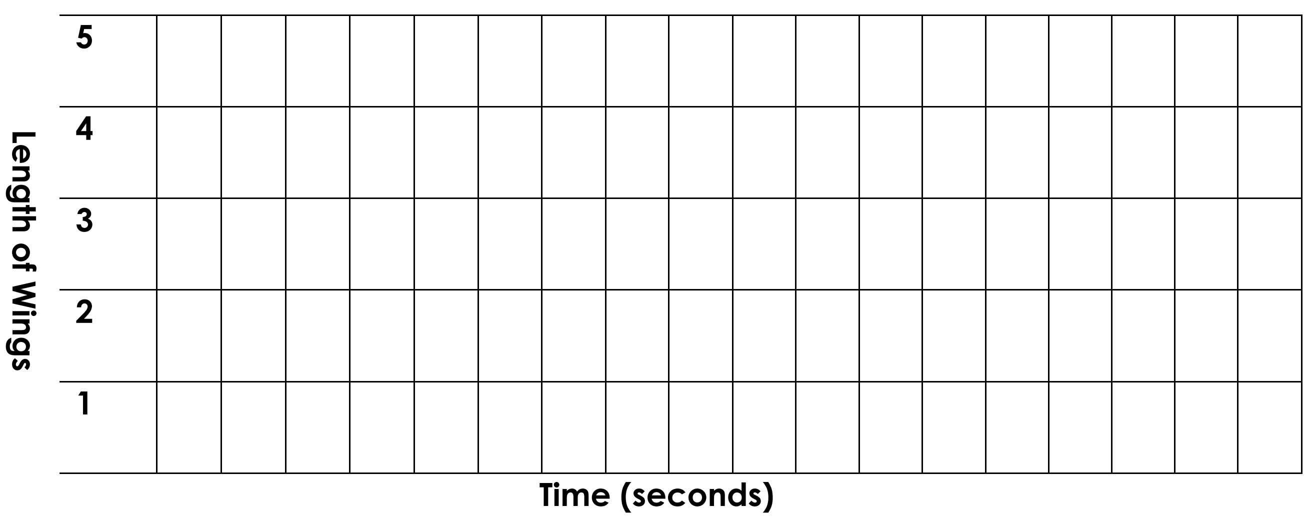
Number of Seconds for each Descent

Wing Length	Trial 1	Trial 2	Trial 3	Trial Average
5				
4				
3				
2				
1				

OBSERVATIONS:

DATA ANALYSIS:

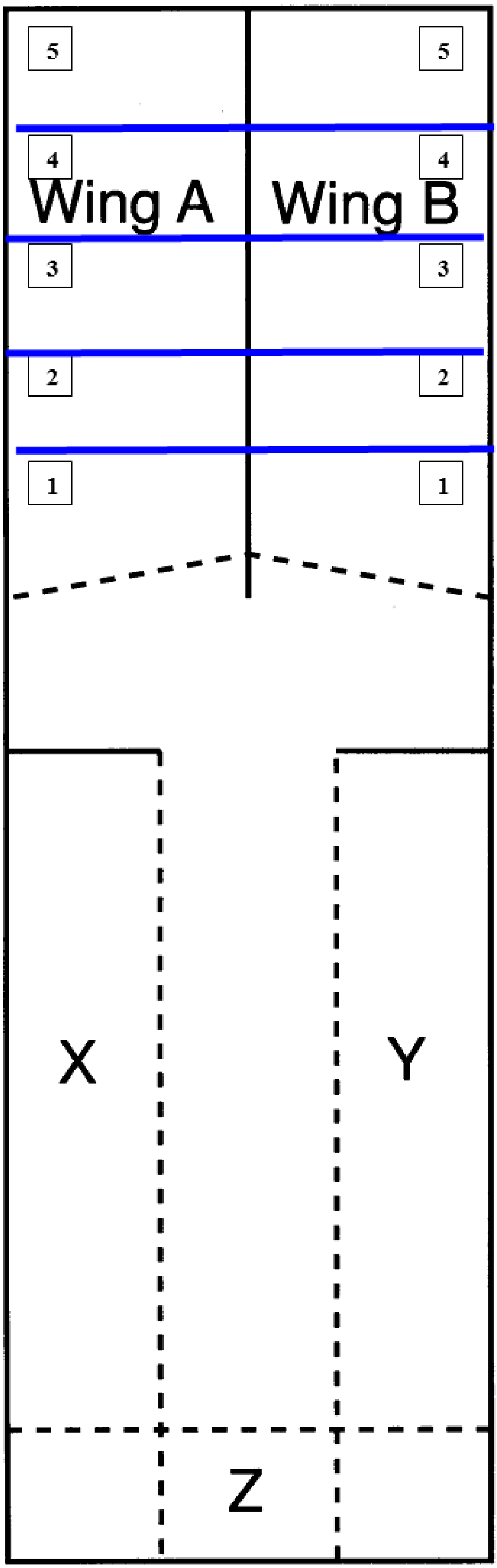
Graph your data. Be sure to label your axes, use a consistent interval, and title your graph. Graph the independent variable on the x-axis and the dependent variable on the y-axis.

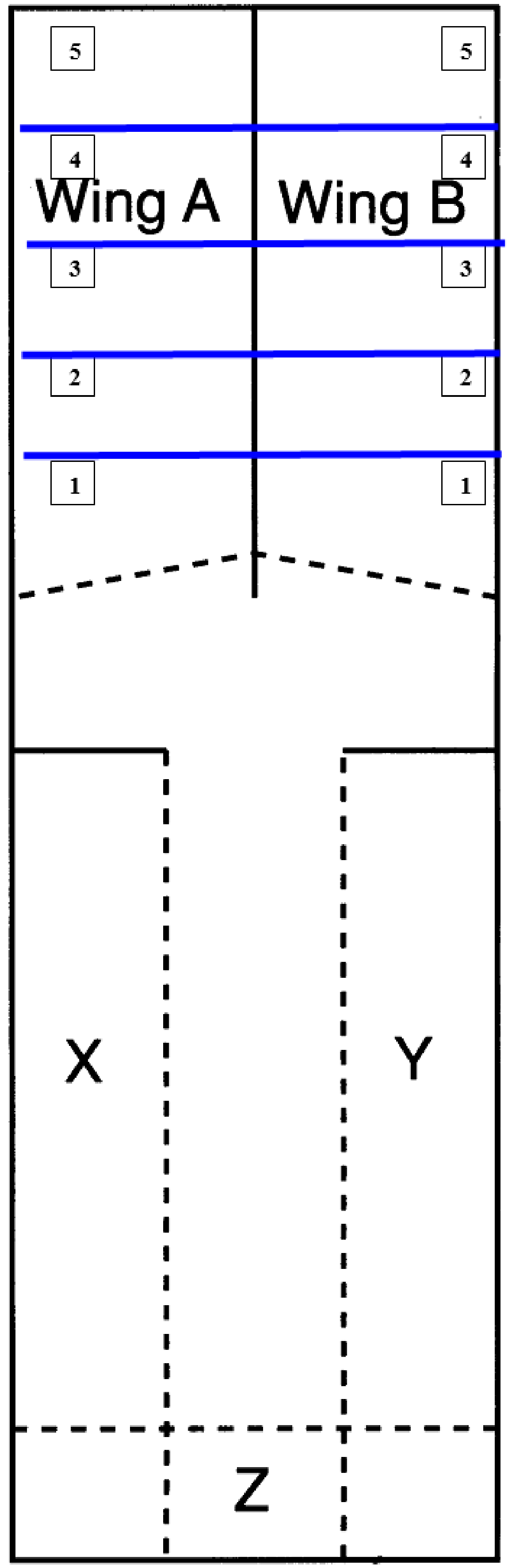


CONCLUSION:

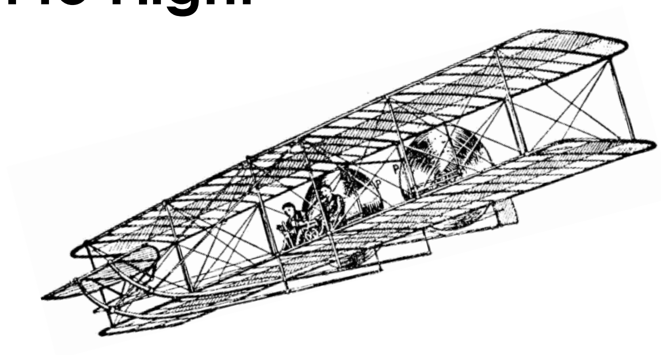
1. Restate the problem or question.
2. Summarize the data from your experiments.
3. Compare your data to your hypothesis: Do your results support your hypothesis? Why/why not?
4. Discuss what you learned. What is the relationship between the variables?
5. Problems/Improvements: What problems did you have with the lab? If you did this lab again, what would you do differently?
6. Further Study: Based on your data and what you have learned, what other questions would you like to investigate?

Templates





Activity 2.2: Introduction to Flight



OBJECTIVE: How are airplanes able to fly?

TIME: 50 minutes

MATERIALS:

- Internet
- Projection
- Audio/sound

INTRODUCTION:

Begin with a discussion on the topic of aerodynamics. It is known that people have always understood that flight was possible from observing birds, but it took thousands of years to actually achieve and there were many hurdles along the way. https://www.youtube.com/watch?v=AWUnvYwPODs&t=20s

BACKGROUND:

The Wright Brothers had spent a great deal of time observing birds in flight. They noticed that birds soared into the wind and that the air flowing over the curved surface of their wings created lift. Birds change the shape of their wings to turn and maneuver. The Wrights believed that they could use this technique to obtain roll control by warping, or changing the shape, of a portion of the wing. https://www.youtube.com/watch?v=vvRBNuOr6OI

These aircraft were all flown as kites to obtain aerodynamic performance. The Wright Brothers were kite enthusiasts, and they used the kite flights in the same way that modern engineers use wind tunnels and flight testing to try out their ideas concerning flight control. Kitty Hawk, North Carolina was chosen for their early flight experiments because its consistent high winds off the ocean are perfect for kite flying. The brothers correctly reasoned that a free flying object had to be controlled about all three primary axes; roll, pitch, and yaw. Their aircraft were built with movable surfaces on the wing, elevator, and rudder. Control of the surface shape was in the hands of the pilot. They extensively tested these ideas by glider flights of the aircraft. https://www.youtube.com/watch?v=JNf33QMHTm0&t=3s

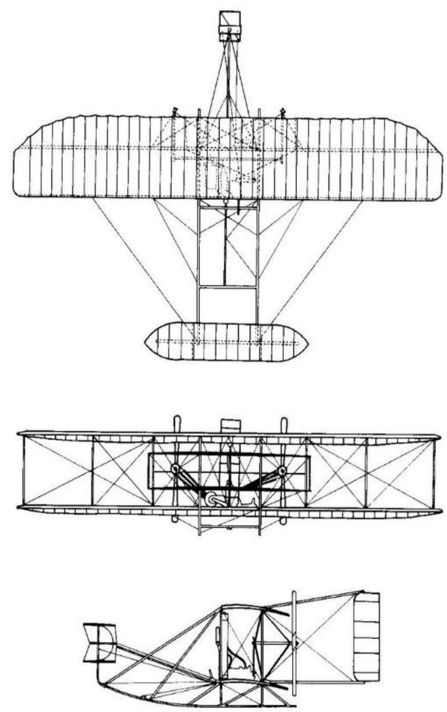
The early kite and glider experiments did not meet the performance goals which the brothers calculated before the flights. In late 1901, the brothers began to doubt the data which they were using to design their aircraft. They built a wind tunnel and developed model-testing techniques including a balance to more accurately determine the lift and drag of their aircraft.

They tested over two hundred different wings and airfoil models to improve the performance of their gliders. Their very successful 1902 aircraft was based on their new data. The Wright brothers used math and perseverance in their successful invention which earned them the name of the Fathers of Aviation.

They developed their piloting skills by making over 1000 flights on a series of gliders at Kitty Hawk between 1900 and 1902. At the time of their first powered flight, the brothers were the most experienced pilots in the world. From 1903 to 1905, they continued to perfect their piloting skills on a series of powered aircraft.

Information provided by NASA

DISCUSSION STARTERS:



Show the Animated History of Aviation on YouTube. (stop at 2:56) https://www.youtube.com/watch?v=GLAreFQ3G5k

- Take a moment to comment on the evolution of flight.
- Ask them what are some examples of things that fly? (Answers varies) Write the students answers on the board.

- Ask the students if they can group the responses into different types of flight (i.e., natural and man-made things).

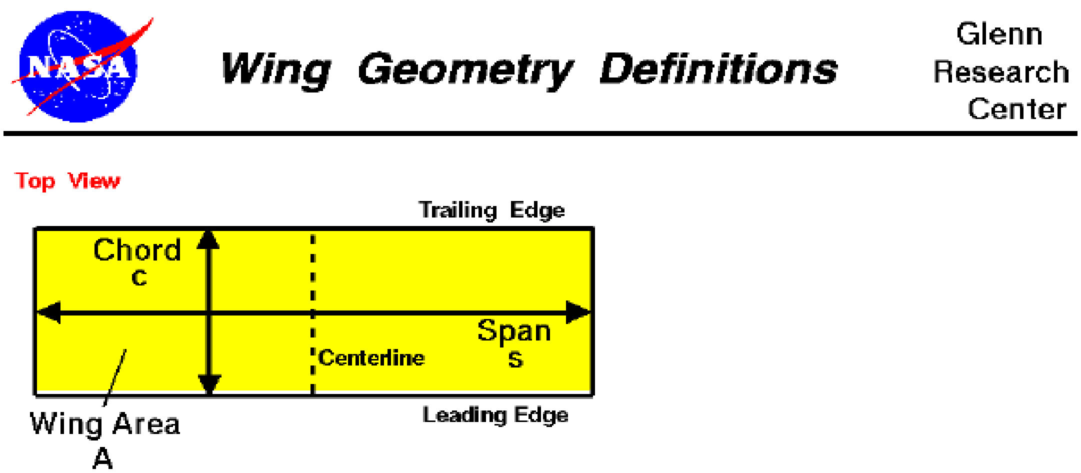
(Modified from Science for Kids http://www.sciencekids.co.nz/lessonplans/flight/flightintroduction.html)

- Discuss the Wright Brother's contribution to aviation. Orville Wright once said, "We were lucky enough to grow up in an environment where there was always much encouragement to children to pursue intellectual interests; to investigate whatever aroused curiosity."

- The Wright Brothers brought their ideas to reality. Show the Wright Brother's BrainPOP Video. https://www.brainpop.com/technology/scienceandindustry/wrightbrothers/ and have students take the corresponding quiz fun.

Explain that in order for the Wright Brothers to be successful, they had to have a method to conduct their trials and collect the data.

A variable in wing design is understanding the geometry of a wing. The wing design used by the Wright Brothers was a simple rectangle. If you look from the top of the wing - the front of the wing is the leading edge, and the back of the wing is the trailing edge. The distance from the leading to trailing edges is called the chord. The ends of the wing looking from above, is called a planform. For a rectangular wing, the chord length at every location along the span is the same. In modern aircraft, the chord length varies along the span, and the leading and trailing edges are swept. The wing area is NOT the total surface area of the wing.



We can calculate the performance of a wing using the **Aspect Ratio** formula. It is defined to be the square of the span **(S)** divided by the wing area **(A).** Aspect ratio is a measure of how long and slender a wing is from tip to tip. Or simply put: **Aspect ratio = wing length (m)/wing width (m).** A high aspect ratio indicates long, narrow wings. A low aspect ratio indicates short, wide wings. Typically, high aspect ratio wings have slightly more lift and enable sustained, endurance flight, while low aspect ratio wings are best for swift maneuverability. Another variable of a wing is its strength. The longer wing span will tend to bend downward, so to deal with this the wing must be stronger (more material – more weight). A heavier wing/ airplane means more drag and so you need more thrust to achieve lift.

When looking at the aspect ratios of birds' and bats' wings there is a lot of variability. Birds that fly long distances or spend long periods soaring such as albatrosses and eagles often have wings of high aspect ratio. Birds like falcon or hawk, require good maneuverability, so have wings of low aspect ratio.

In future lessons, as you design various types of wings for various types of airplanes, aspect ratio will become more evident and important.

REFLECT:

Have the students reflect on what they have learned, through writing, discussion, flip grid video topic to evaluate their understanding of some of the basic concepts of flight and who the Wright Brothers were and their contribution to society.

Curriculum Guide 2: Forces of Flight

Activity 2.1: Forces of Flight

OBJECTIVE: Explain the four forces of flight

TIME: 50 minutes

MATERIALS:
- Things that fly images
- Student Journal sheet for each student

For Activities:
- Index cards
- paper
- tape
- ping pong balls
- Large sheets of paper
- Student Journal for Activity 2
- Pencils
- Straw (for each student)
- String
- Funnel (or make a funnel out of paper and straw)
- Different size balls

INTRODUCTION:
Today we will begin our journey as Aerospace Engineers!

Let's look at some of the common characteristics of things that fly. There are four forces that act on an airplane as it flies, and they are: Thrust, lift, drag, and weight. Looking at bird wings and plane shapes the main characteristic is the airfoil shape. The wings of birds and planes have what is called an airfoil shape. This airfoil shape helps overcome weight which is the effect of gravity pulling down on the mass of the aircraft.

DISCUSSION QUESTIONS:
1. Who has watched something fly before?
2. Whether it was a plane or helicopter, a bird or a bug, we've all seen something fly. Has anyone ever imagined themselves flying?

BACKGROUND:

1. Have students take a look at pictures things that fly -Appendix A (either printed out before class, or on a projector.)
    - What things do they have in common?
    - How are they different?
    - How do they compare to flyers we find in nature?

2. Bernoulli's Principle is a physical science aspect dealing with fluid dynamics the flow of fluids – air and water) David Bernoulli was able to figure out from observations and investigations that pressure decreases as the flow of a fluid (like water) increases. Newton's 2nd Law also states that a fluid flow from an area of high pressure to an area of low pressure

3. Connections to Aviation: The Bernoulli Principle
   https://www.youtube.com/watch?v=xdg8_tF2K8Q

   Bernoulli's Principle - Easiest Way Explained
   https://www.youtube.com/watch?v=mgeIWXld9FU

4. The principles of flight are called aerodynamics. Aerodynamics deal with the motion of the air flowing around and airplane and the forces acting on the airplane's motion – all relative to the air. Thrust, drag, lift, and weight are the forces that act upon all aircraft that allow most anything to fly.

- Lift
  -lift is created as air passes around an airfoil (wing).
  -Air (or any fluid) flowing around an object exerts a force on it. Lift is the component of this force that is perpendicular to the oncoming flow direction. For flying these pushes upward.

- Gravity/Weight
  -Weight is simply the force of gravity on the airplane which acts vertically through the center of gravity of the airplane.
  -Weight has a definite relationship to lift (typically opposite).

- Thrust
  -Thrust is the forward acting force that opposes drag and propels the airplane forward

  -In powered aircraft, thrust is achieved through the powerplant, be it a propeller, rotor, or turbine. In a glider, thrust is created through the conversion of potential energy (altitude) to kinetic energy (airspeed)
- Drag
  -Drag is the rearward, resisting force caused by disruption of airflow
  -slows aircraft movement

5. In the student notebook/journal write the definitions: **Answers Key**

Lift: dynamic effect of the air acting on the airfoil, perpendicular to the flightpath through the center of lift

Flight occurs from a combination of many physical principles

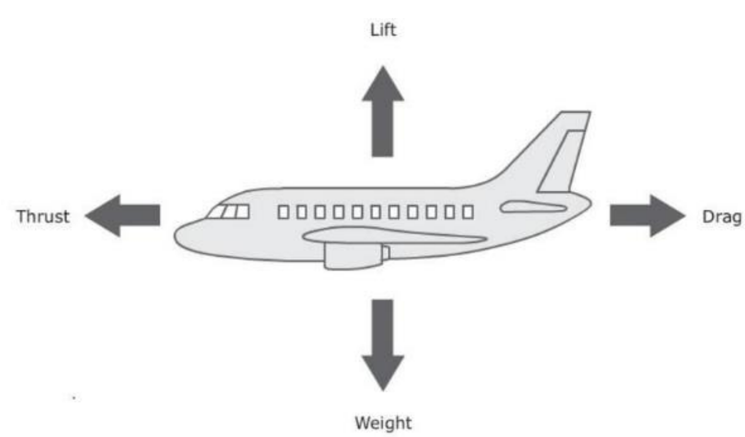
Daniel Bernoulli who is responsible for the explanation of fluid dynamics: increased speed creates decrease in pressure Faster air from above the airfoil moves downward. This action downward creates an opposite reaction upward.

Newton's third law: every action has an equal and opposite reaction

Weight: the combined load of the aircraft itself, the crew, the fuel, and the cargo or baggage—down through center of gravity. Weight is a function of gravity on a mass.

Thrust: forward force produced by the powerplant/propeller or rotor

Drag: rearward, retarding force caused by disruption of airflow by the wing, rotor, fuselage, and other protruding objects Wings, airfoils and the forces of flying:



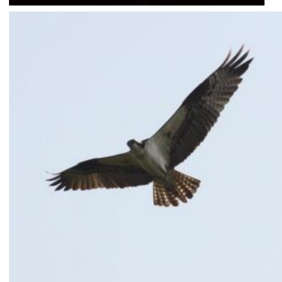
Appendix 2.A: Things that Fly

















Forces of Flight Student Journal

Today we will begin our journey as Aerospace Engineers! Everyone must first know and understand the terminology used in aviation.

Lift: ____

____

Flight occurs from a combination of many physical principles.

Daniel Bernoulli who is responsible for the explanation of fluid dynamics: ________

____

____

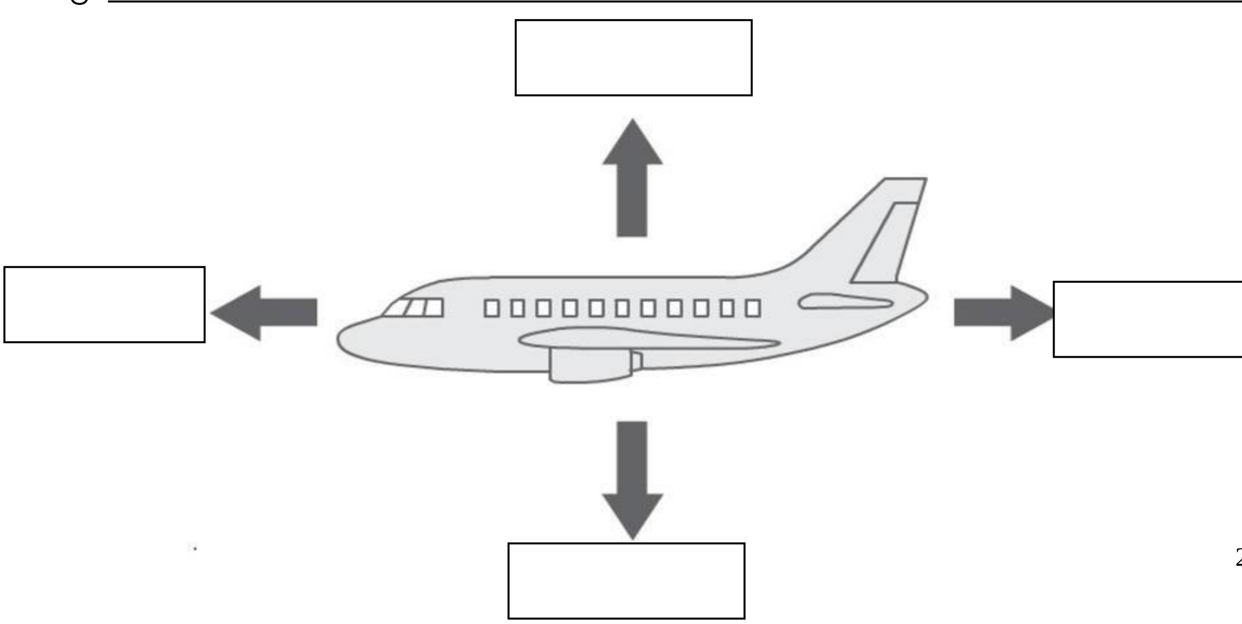
Newton's third law: ____

Weight: ____

____

Thrust: ____

Drag: ____



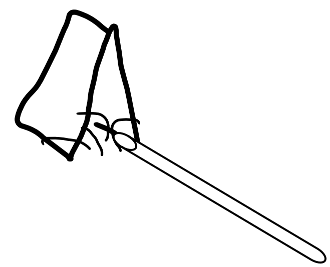
Activity 2.2: Forces of Flight Activities

Bernoulli's Principle: It seems almost impossible that something as large and heavy as an airplane can stay up in the air, or even get off the ground in the first place. The secret to this is LIFT. We're going to do a couple of little experiments to see how this works.

LIFT!

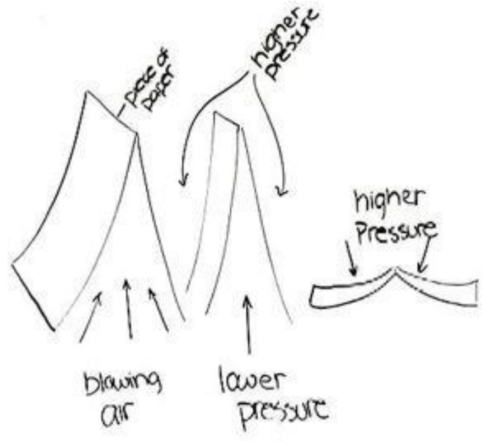
Part A: The Paper Tent

1. Have students fold a piece of 3 ½" x 4" paper (lengthwise) or index card in half and make a paper tent.
2. One straight straw for each student. Position the straw about 2 inches away from the paper tent so that you will be able to blow a steady stream of air across the surface of the table or desk and through the tent.



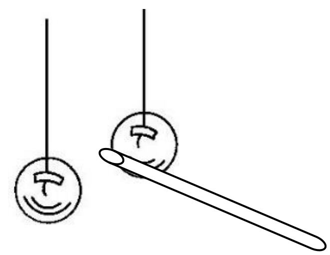
3. Observe what happens.
4. Now, blow harder and observe what happens.
5. Ask students to predict what will happen when they blow into the tent.
    a. Will it appear to get larger,
    b. will it remain unchanged,
    c. or will it bend down toward the table?
    d. (Alternately, have students turn their paper tents upside down and blow through the V-shaped paper.)
6. Make sure students notice that the tent flattens. This is because the air moving through the inverted V has less pressure, so the higher pressure on the outside of the paper tent flattens the paper.
7. Have students experiment with their paper tents, discuss their experience

Expected outcome and reason why: When the experiment is performed correctly, the sides of the card will pull towards one another. The reason for this outcome is that the faster moving air under the card creates relatively lower pressure compared to the air over the card, and as a result, the card will bend toward the table or desk because, according to the Bernoulli Principle, higher pressure air pushes toward lower pressure air.

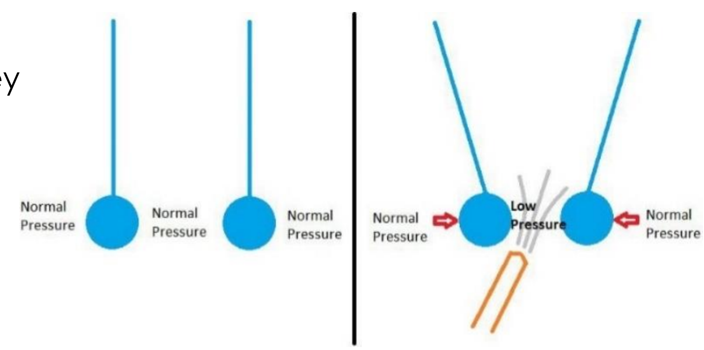


Part B: Moving Balls

1. Working in pairs. Take 2 ping pong balls and attach a string to each one with tape.
2. Have students hold the two ping pong balls together.
3. Ask them to predict what will happen when they blow between the two balls.



4. Have students hold the balls 1-2 cm apart and blow between them. If they hold the balls too close together, the balls simply move away from the student. The balls must be sufficiently far apart so that students can blow *between* the balls, not *at* the balls.



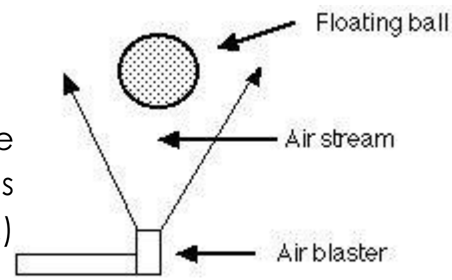
5. Expect students to see the balls come together
6. Have students discuss the results.

Expected outcomes: As they had predicted, rather than moving apart, because of Bernoulli's Principle, the spheres actually moved together! A fast-moving column of air creates a low-pressure area and draws other objects in.

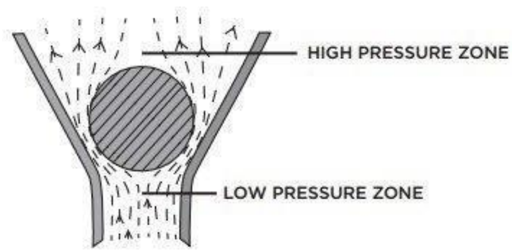
Part C: Funnel

1. Each student needs a flex straw, a funnel, and some clear tape.

2. Attach the narrow end of the funnel to the short end of the straw using the tape.
3. Funnel and straw did not need to fit snugly. The tape connected the two pieces kept any air from escaping.
4. Students then place their hand above the opening in the funnel, blow into the straw, record observations.
5. Asked the students to predict what would happen if they put a ping pong ball into the opening of their funnel and then blew into the straw.
6. Discuss prediction.
7. Have the student blow through the straw. Record observations (Ball does not move)
8. Now invert the funnel while blowing through the straw. (Make sure you take a very deep breath so as to sustain your blowing through this maneuver.) Record observations.
9. Now, with ball in the funnel as before, hold the funnel in front of you and blow forcefully across the top of the wider end of the funnel., record observations,



Expected Outcome: Bernoulli's Principle, states that an increase in the speed of moving air (or any flowing fluid) is accompanied by a decrease in the air or fluid's pressure.



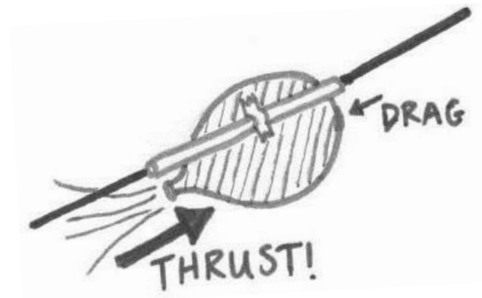
The airflow around a ball or other curved object placed in an airstream will increase its speed. When the air increases its speed its pressure decreases. The low air pressure created around the ball allows the high pressure from above the ball to push the ball back into the funnel.

Thrust!

Now, in order to get this lift, we need to have some relative air movement. This may come from wind, but most aircraft need THRUST to get the air moving around the wings. This next demonstration will show us how thrust moves an aircraft.

1. Give each group a drinking straw, a balloon, a long piece of string (at least 2-3 meters) and some tape.

2. One student should blow up the balloon, but don't tie it!
3. Have the student hold it closed (or use a paper clip to prevent air from escaping.)
4. Another student should tape the drinking straw to the balloon so that it is lined up from top to bottom with the balloon.



5. Then, have the students put the string through the straw.
6. Have two students each take an end of the string, and hold it tight, horizontally.
7. Now, slide the balloon to the end of the string and you're set for take-off!
8. Before they let go, have students make predictions.
   a. What will happen to our airplane (the balloon)?
   b. Why?
9. When groups have made their predictions, they can release their balloon and let it fly! If nothing is obstructing its path, the balloon should zoom down the length of the string to the other end.

Expected Outcome: We are seeing Newton's Third Law of Motion: For every action there is an equal and opposite reaction. As air is forced out the end of the balloon, it exerts an equal and opposite force, which pushes the balloon down the string. This activity most closely demonstrates jet propulsion, but there are other forms of propulsion that can be used. Can you think of any?

Drag!

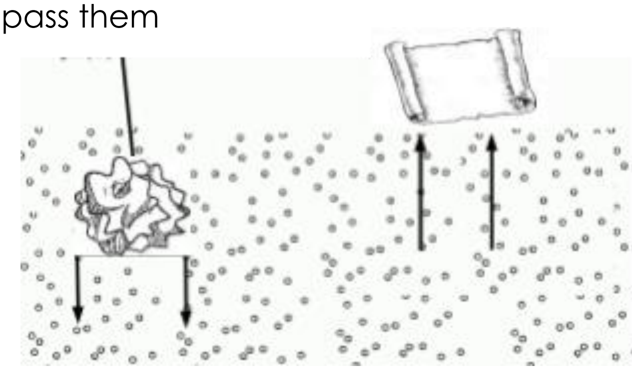
Drag is the force from the air in front of the balloon as it makes its way down the string. The air has mass and wants to stay at rest. As the balloon pushes on the air in front of it, the air pushes back, which creates drag and slows the balloon down

1. Assign two points on opposite sides of the room between which the students can
   safely run.
2. Have one student in the group run at a steady pace from one point to the other without the paper, while another student times the journey.
3. Now have the same student run again at the same pace as before, but

this time
holding the large sheet of paper behind them. Again, time the journey.
4. Have each student perform this activity noting the difference between the two times.

Weight!

1. Pass the two balls around the group. Ensure the students note that the two balls are of different weights by weighing them on the scale.
2. Have one student stand on the table or a chair for additional height.
3. Next, have the same student hold the two balls at arm's length and at equal height.
4. Ask the students which ball will hit the ground first, the lighter or the heavier.
5. Have the student holding the balls drop them simultaneously while the other students watch.
6. Repeat this with the other students taking turns dropping the balls until it is accepted that both balls hit the ground at approximately the same time.
7. Next, take two sheets of copy paper and pass them around the group to confirm they are identical.
8. Take one sheet of paper and scrunch it into a tight ball, leaving the other untouched.
9. Remind the students that both sheets of paper weigh the same.
10. Based on the previous demonstration, ask them to hypothesize as to which sheet of paper will hit the ground first.
11. As before, have the students take turns dropping the two pieces of paper, noting which one landed first.



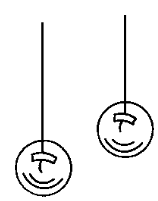
Expected outcome: Everything falls at the same rate because of the downward force of gravity. So even though there were 2 different size balls, then both hit the ground at the same time. A crumble sheet of paper and a flat piece of paper weigh the same, but the flat sheet has more air resistance so takes longer to hit the ground.

Forces of Flight Activities
Student Journal

1. Fold a piece of 3 ½" x 4" paper (lengthwise) or index card in half and make a paper tent.
2. Each student has a straw. Position the straw about 2 inches away from the paper tent so that you will be able to blow a steady stream of air across the surface of the table or desk and through the tent.
3. Observe what happens.
4. Now, blow harder and observe what happens.
5. Predict what will happen when they blow into the tent.
    1. Will it appear to get larger________________________________
    2. Will it remain unchanged ___________________________________
    3. Or will it bend down toward the table? ______________________
    4. (Alternately, have students turn their paper tents upside down and blow through the V-shaped paper.)
6. Experiment with the paper tents, discuss their experience Label the diagram to what is happening

Observations:____
____
____
____
____

Part B: Moving Balls

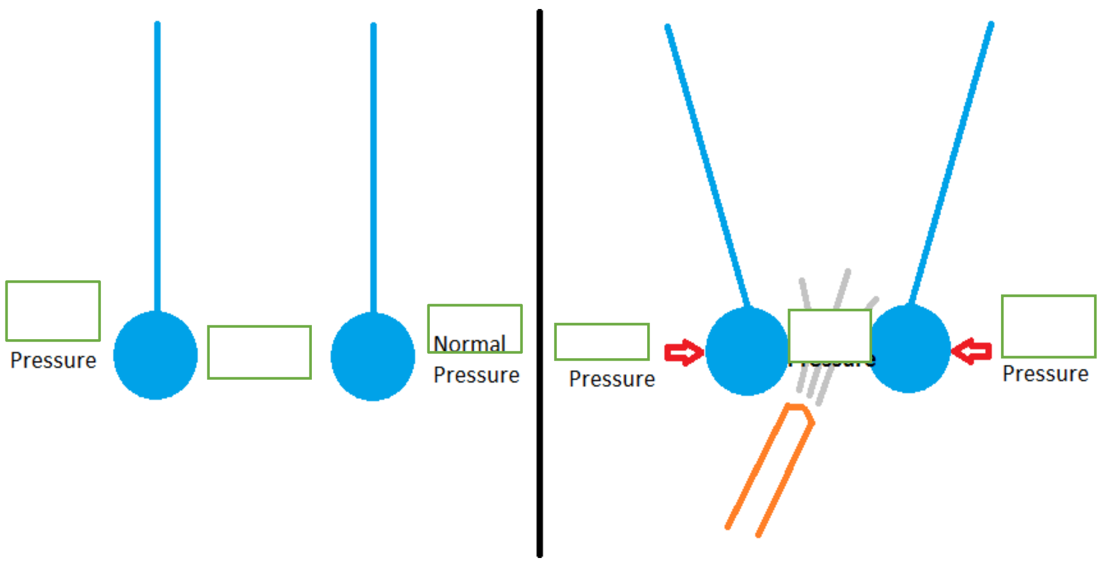


1. Working in pairs. Take 2 ping pong balls and attach a string to each one with tape.
2. Hold the two ping pong balls together but not touching.
3. Predict what will happen when they blow between the two balls.
    1. Prediction:______________________________________
4. Hold the balls 1-2 cm apart and blow between them. (If too

close together, the balls simply move away from the you. The balls must be sufficiently far apart so that you can blow *between* the balls, not *at* the balls.

5. Discuss the results.

Label the diagram to what is happening.



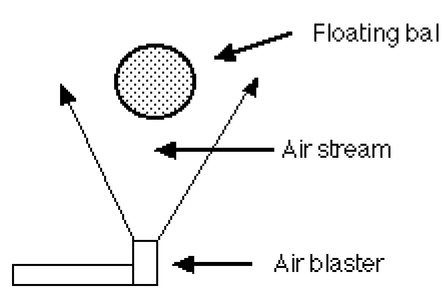
Observations:____

____

____

____

Part C:



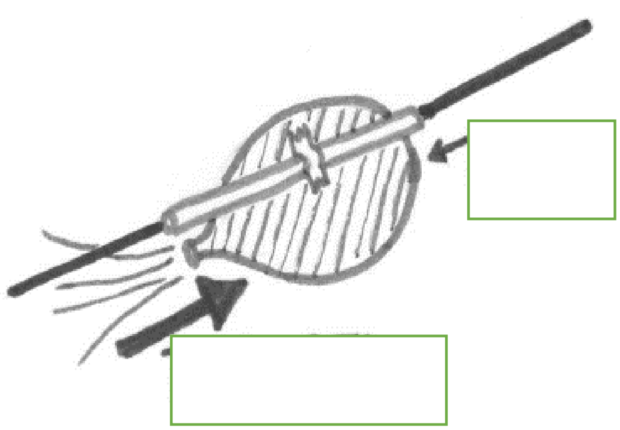
1. Everyone needs a flex straw, a funnel, and some clear tape.
2. Attach the narrow end of the funnel to the short end of the straw using the tape.
3. Funnel and straw did not need to fit snugly. The tape connected the two pieces kept any air from escaping.
4. Place your hand above the opening in the funnel, blow into the straw, record observations.
5. Predict what would happen if they put a ping pong ball into the opening of their funnel and then blew into the straw.

6. Prediction:____
7. Blow through the straw with the ping pong inside. Record observations
8. Now invert the funnel while blowing through the straw. (Make sure you take a very deep breath to sustain your blowing through this maneuver.) Record observations.
9. Now, with ball in the funnel as before, hold the funnel in front of you and blow forcefully across the top of the wider end of the funnel., record observations,

Thrust!

1. Each group a drinking straw, a balloon, a long piece of string (at least 2-3 meters) and some tape.
2. The sting needs to be attached to wall so as to create a clothesline, the straw should be through the string before it is attached. Or have two students each take an end of the string, and hold it tight, horizontally.
3. One student should blow up the balloon, but don't tie it!
4. Hold it closed (or use a paper clip to prevent air from escaping.)
5. Another student should tape the balloon to the straw so that it is lined up from top to bottom with the balloon.
6. Now, slide the balloon to the end of the string and you're set for take-off!
7. Before they let go, Make predictions.
   a. What will happen to our airplane (the balloon)? _________________________
   b. Why? ____
8. When groups have made their predictions, they can release their balloon and let it fly! If nothing is obstructing its path, the balloon should zoom down the length of the string to the other end.

Label the diagram to what is happening



Observations:____

____

____

____

Drag!

1. Assign two points on opposite sides of the room between which the students can
   safely run.
2. Have one student in the group run at a steady pace from one point to the other without the paper, while another student times the journey.
3. Now have the same student run again at the same pace as before, but this time
   holding the large sheet of paper behind them. Again, time the journey
4. Have each student perform this activity noting the difference between the two times.

	Run without paper	Run with paper
Trial #1		
Trial #2		
Trial #3		
Average		

Observations:____

____

____

____

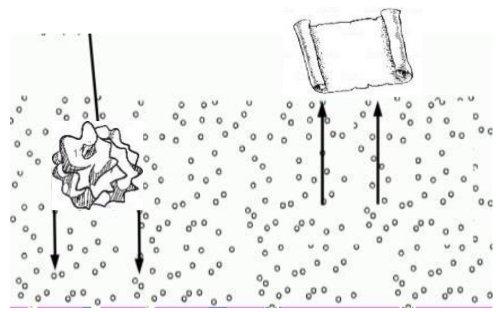
Weight!

1. Pass the two balls around the group. Note that the two balls are of different weights by weighing them on the scale.
2. Have one student stand on the table or a chair for additional height.
3. Next, have the same student hold the two balls at arm's length and at equal height.
4. Which ball will hit the ground first, the lighter or the heavier?

   ____
5. The student holding the balls drop them simultaneously while the other

students watch.

6. Repeat this with the other students taking turns dropping the balls until it is accepted that both balls hit the ground at approximately the same time.
7. Take two sheets of copy paper and pass them around the group to confirm they are identical.
8. Take one sheet of paper and scrunch it into a tight ball, leaving the other untouched.
9. Remember that both sheets of paper weigh the same.
10. Predict which sheet of paper will hit the ground first.



____

____

11. Take turns dropping the two pieces of paper, noting which one landed first.

Observations:____

____

____

____

Curriculum Guide 3: Airfoil Design

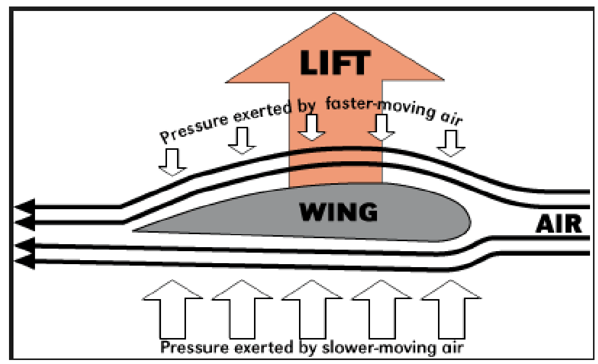
Activity 3.1: Wing Design/Airfoil Design - Paper Airplanes

OBJECTIVE: Demonstrate knowledge of the basic principles of aerostatics and aerodynamics.

TIME: 100 minutes x 2 days (50 minutes each day)

MATERIALS:

- 12" Ruler
- 30' Tape Measure
- Calibrated Weight Scale
- paper airplane templates
- paper clips
- Wing Design/Airfoil Design Paper Airplanes Student Activity Lesson data sheets



INTRODUCTION:

In aviation today, many companies are looking to design planes that can travel far distances in minimal time. Before we continue let us explore Bernoulli's Principle and the various components that impact a wing's efficiency.

Video Segment Title: How Wings Actually Creates Lift!
https://www.youtube.com/watch?v=YDeQXPNpLeY&t=126s

Great you tube video on the best paper airplane "How to Make a World Record Paper Airplane"

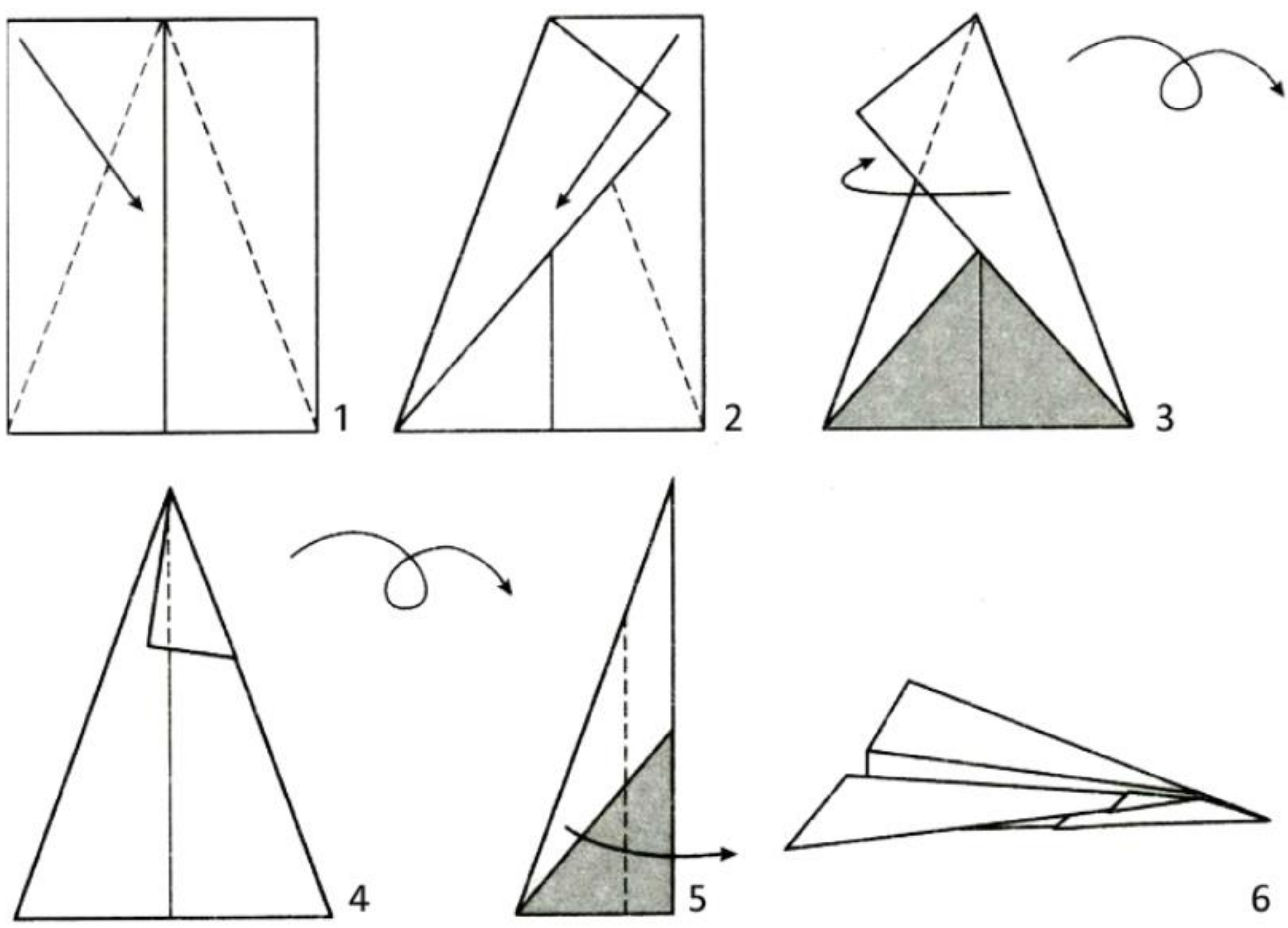
https://www.youtube.com/watch?CMPID=ene083018&v=SfquWcLHrKc

DIRECTIONS:

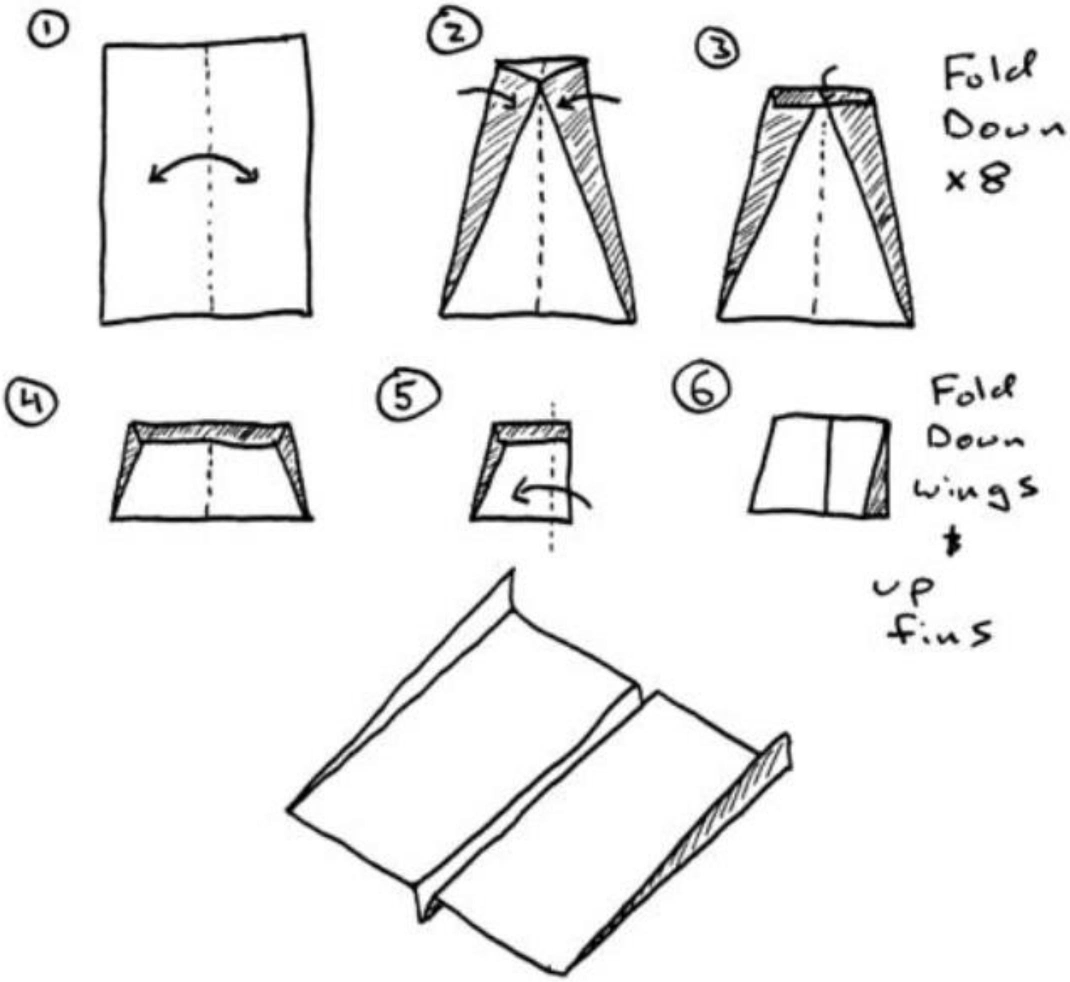
Day 1 In groups, today you will explore the art of making paper airplanes to find the best design for distance and speed.

1. Before beginning, remember the lesson and activities of Bernoulli's Principle and forces of flight.
2. This lesson will deal with how surface area, Shape (cross section of wing), Angle of attack (relative to oncoming air), and wing proportions impact the LIFT of an airplane wing.
3. Duplicate the paper airplane models; Model A and Model B
4. Following the instructions below each group builds the models. For this part each group will need to have the same paper airplane (no changes now). Sometimes adding a paper clip to the nose helps in flight.
5. Then one team member will draw the design in the Data Collection Sheet. Complete the data sheet with the dimensions of plane, and weight of plane
6. After each flight measure distance, record.

Paper Airplane Model A



Paper Airplane Model B



Day 2 In the same groups from Day 1, you will design two original paper airplanes.

1. Before beginning look over the data you collected on day 1.
2. Allow the data to influence your original design. Are you up for the challenge to design a faster paper airplane that can travel a longer distance?
3. Follow the same procedures as before. Begin with your original design.
4. Don't forget to draw your design in the large design area.
5. Consider wing span and the proportion of wing length to width.
6. Build your two new paper airplanes, label first plane as **plane C** and the second plane as **plane D**. This is important, so you can distinguish all the

models from both Day 1 and Day 2.

7. Once planes are built measure the length of your plane as well as the length and width of the wing of the plane.
8. In addition, also measure the weight of the plane.
9. Collect the data in the Data Collection Section for Day 2.
10. Once data is collected it is time to test your planes in flight.
11. After students have completed this experiment, share with them these renderings of an airplane wing.

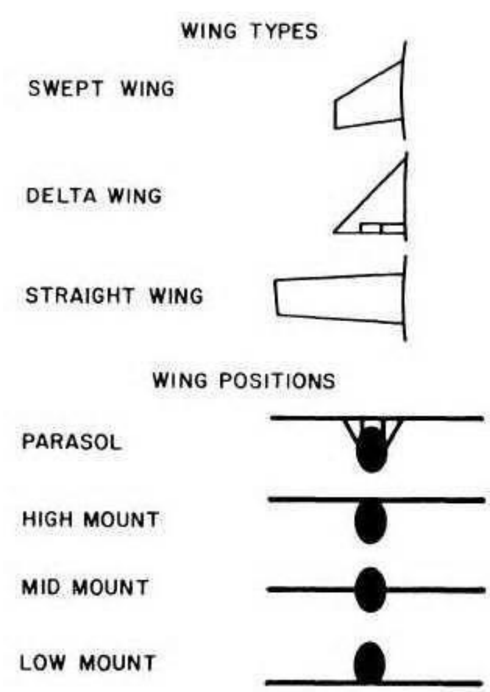
Help them understand the design of the wing as well as the different positions being used for specific tasks while plane is in flight as well as landing throughout the lesson.

After experiment share with students the following wing types and wing positions, so they can learn that there are various wing designs used for specific flight purpose.

(Optional) Other videos that you can explore to get ideas for teaching Bernoulli Principle or to make demonstrations in class.

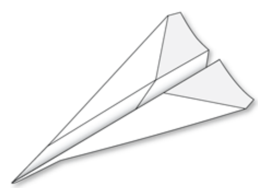
How Does a Wing Actually Work?
https://www.youtube.com/watch?v=aFO4PBolwFg

(Optional) Appendix A: Other paper airplane models



EXAMPLE OF DATA COLLECTION

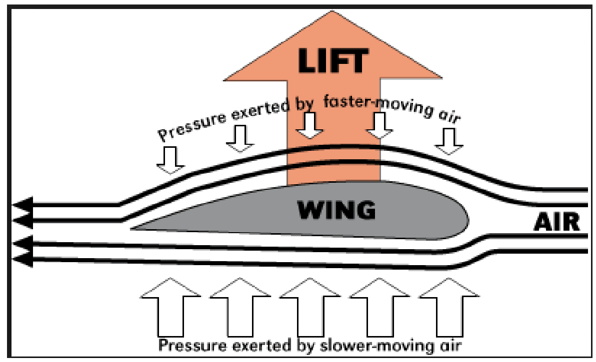
- Please look at the Data Collection sample chart to help you understand how to record your data. Also note that students will need to draw each airplane design in the large drawing section.
- If you do not have long tape measure, then have them measure their stride. (a regular step), then they can count their stride and calculate the distance.

<table>
<tr><td>Sample Design Type</td><td>Airplane Name</td><td>Drawing</td></tr>
<tr><td>Total Plane length</td><td>11 in</td><td rowspan="11">
SAMPLE</td></tr>
<tr><td>Total Plane weight</td><td>60 g or 60 grams</td></tr>
<tr><td>Wing length</td><td>8 in</td></tr>
<tr><td>Wing width</td><td>4 in</td></tr>
<tr><td>Ratio calculation</td><td></td></tr>
<tr><td rowspan="3">Other Information</td><td></td></tr>
<tr><td></td></tr>
<tr><td></td></tr>
<tr><td>Team Member Role</td><td></td></tr>
<tr><td>Name of Student throwing plane</td><td>Thrust</td></tr>
<tr><td>Name of Student recording Measurements</td><td>Measure</td></tr>
<tr><td>Name of Student recording DATA Collection</td><td>Recorder</td><td></td></tr>
</table>

Activity 3.2: Wing Design/Airfoil Design Power Up Paper Airplanes

OBJECTIVE: Demonstrate knowledge of the basic principles of aerostatics and aerodynamics.

TIME: 100 minutes x 1 day



MATERIALS:
- Power Up 2.0 Kits
- paper
- Wing Design/Airfoil Design Power Up Paper Airplanes Student Activity Lesson data sheets

INTRODUCTION:

Power Up How to Video:

https://www.youtube.com/watch?v=TYWp4mH12XA

Power Up Teacher Guide:
https://cdn.shopify.com/s/files/1/0165/4322/files/teacher_guide_14.10.pdf?1781

Power Up (DAY 2) videos
https://www.poweruptoys.com/pages/free-downloads

You now have been flying paper airplane gliders. Now we add a motor to the paper airplanes. Remember the principles learned earlier will not change.

DISCUSSION STARTER:
How will a motor affect our airplane?

Now the running motor provides a constant thrust. The thrust provides a major part for a successful first flight if the airplane is trimmed properly. The motor will add some weight to the paper airplane and this extra weight will mean the airplane will need more lift. A higher speed will create the additional lift. So the students will have to launch the airplane a bit stronger

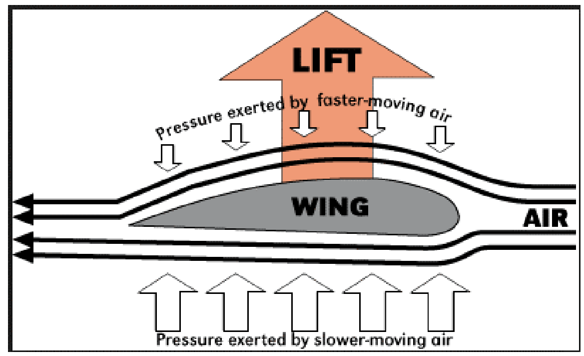
DIRECTIONS:

In groups, today you will explore how a motor (increased thrust) affects the distance and speed.

1. Refresh the lesson and activities of Bernoulli's Principle and forces of flight.
2. Take their paper airplane model they made and follow the directions in the teacher guide to attach the motor and propeller. Have different groups use different designs
3. SAEFTY
4. Then one team member will draw the design in the Data Collection Sheet. Complete the data sheet with the dimensions of plane, and weight of plane
5. After each flight measure distance, record
6. Additionally, the students can remove the system to make changes

Activity 3.3: Wing Design/Airfoil Design Balsa Gliders

OBJECTIVE: Demonstrate knowledge of the basic principles of aerostatics and aerodynamics.



TIME: 100 minutes x 2 days (50 minutes each day)

MATERIALS:
- Balsa glider kit
- Thin balsa sheets
- Xacto knife (scissors can be used)
- Ruler & pencil
- Hot glue can be used to secure new wings on body
- New wing designs can be drawn ad cut on a Cricut machine with Balsa wood sheets
- Pennies or paper clips
- Wing Design/Airfoil Design Balsa Glider Student Activity Lesson data sheets

INTRODUCTION:

A glider is an aircraft that has no engine such as paper airplanes and balsa gliders. They need to be given an initial velocity by throwing the airplane. The choice of Balsa wood as the material of choice for the construction of these gliders it is light and strong. The characteristics of the balsa material with the design of the glider has an effect on the stability, flight distance, and flight duration of the gliders.

BACKGROUND:

Balsa wood has physical characteristics that make it ideal for aerodynamic use. The wood is light, but strong making it one of the preferred choices for making gliders. Balsa as a construction material for gliders in the US dates back to the 1920's. Even though it is not found here, the Balsa tree is widely distributed in

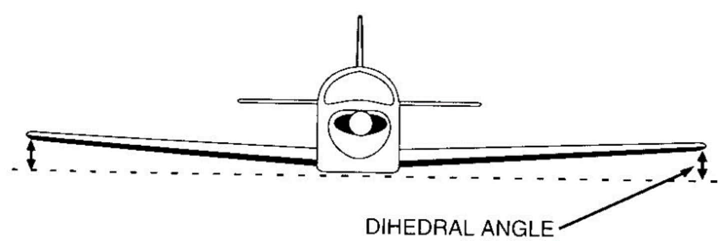
Central and South America and considered a weed. It is a fast-growing plant that takes six to 10 years to mature.

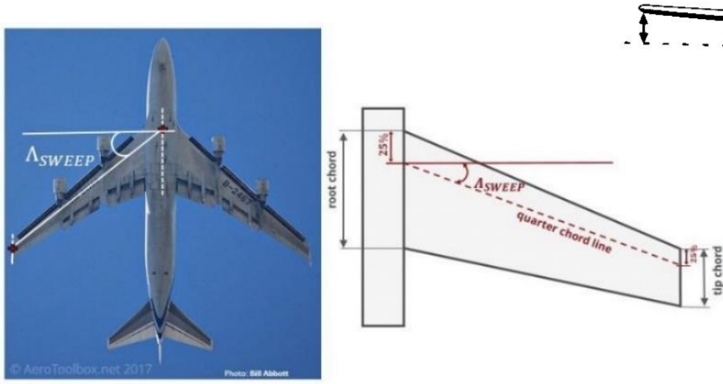
The parts of a Balsa Glider are the fuselage, wing, and tail. So, each part plays a major function in helping the entire airplane have a successful flight. They must be properly constructed to ensure successful long-range flight. When constructing a Balsa Glider, the body, wing, and tail have to be in such a manner as to ensure they maximize natural flight requirements, remember to also minimizing drag and air resistance. The range of a Balsa glider depends on the stability of the craft. A properly constructed glider will fly further and longer. For a glider to be aerodynamically functional, all the components must be in the right location. The fuselage provides the necessary counterbalance by holding the wing and tail in the proper symmetry for flight. It holds the majority of the weight for the glide. This can also determine its speed.

Heavier, the glider flies at a fast speed. Lower, it flies at a slower speed.

For manually launching gliders to fly, you must attain lift. Lift is provided by the wing. The wing forces a mass of air downward and in the process, it creates an equivalent and reverse upward reaction upon itself-Lift. Aspects of wing design can determine the effectiveness of the wing in providing the necessary lift. As well as lift, the wing provides stability during flight.

The last part of a glider is the tail section. It is made up of the vertical and horizontal part of the tail end. The location of these parts of the glider affects its directional turning and dipping. Stability during flight is affected by two aspects of the wing. These are dihedral (the upward angle of an airplane's wings) and wing sweep (is the angle at which the wing is translated backwards).





DIRECTIONS:

Day 1 In groups, today you will explore the art of making balsa glider to find the best design for distance and speed.

1. Before beginning, remember the lesson and activities of Bernoulli's Principle and forces of flight.
2. This lesson will deal with how surface area, Shape (cross section of wing), Angle of attack (relative to oncoming air), and wing proportions impact the LIFT of an airplane wing.
3. Each student should receive a package with the parts and directions to put together the Balsa glider.
4. Build as instructed. Everyone will build the same design (or only 2 pre-made design kits)
5. A weight might need to be added to the nose of the plane (such as paper clips or pennies on each side.
6. One team member will draw the design in the Data Collection Sheet. Complete the data sheet with the dimensions of plane, and weight of plane.
7. After each flight measure distance, record.

Day 2 In the same groups from Day 1 you will design the wings of a Balsa Glider.

1. Before beginning look over the data you collected on day 1.
2. Allow the data to influence your original design. Are you up for the challenge to design a Balsa Glider that can travel a longer distance?
3. Follow the same procedures as before. Begin with your original design. Only change the wing design, keep the original body and tail.
4. Don't forget to draw your design in the large design area.
5. Consider wing span and the proportion of wing length to width.

6. Once glider is built measure the length of your plane as well as the length and width of the wing of the plane.
7. In addition, also measure the weight of the plane.
8. Collect the data in the Data Collection Section for Day 2.
9. Once data is collected it is time to test your planes in flight.
10. After students have completed this experiment, share with them these renderings of an airplane wing.

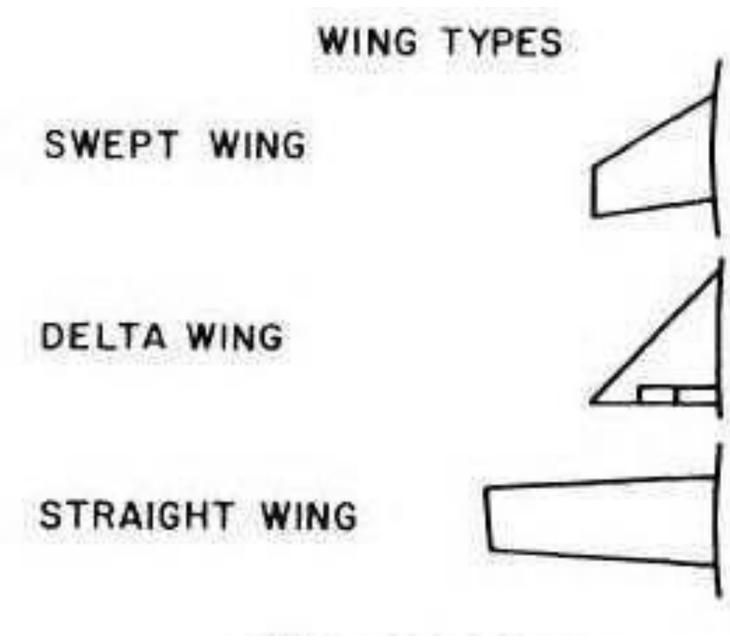
Help them understand the design of the wing as well as the different positions being used for specific tasks while plane is in flight as well as landing.

After experiment share with students the following wing types, positions on fuselage and purpose for each wing type, so they can learn that there are various wing designs used for specific flight purpose.

(Optional) If time permits, then change the tail design.

Swept back wings reduce drag when an aircraft is flying at transonic speeds.

The main advantage of a **delta wing** is that it is efficient in all regimes (supersonic, subsonic, and transonic). Moreover, this type of wing offers a large area for the shape thereby improving maneuverability and reducing wind loading.



The **rectangular wing** is the simplest to manufacture. It is a non-tapered, straight wing that is mostly used in small aircrafts. One major disadvantage of a rectangular wing is that it isn't aerodynamically efficient.

Extra Activity: Wing Design/Airfoil Design Model Rockets

OBJECTIVE: Demonstrate knowledge of the basic principles of aerostatics and aerodynamics.

TIME: 50 minutes x 2 days (not including building)

MATERIALS:
- Model Rocket kits
- Glue or hot glue
- Rocket Engines (SAFETY)
- Rocket launcher
- Wing Design/Airfoil Design Model Rocket Student Activity Lesson data sheets

INTRODUCTION:

Model rockets can help students learn the basics of the math and physics that govern the design and flight of rockets. Also, the flight of the rocket involves the interaction of the forces of flight in different way.

BACKGROUND:

One of the first devices to successfully employ the forces of flight that are essential to rocket flight was a wooden bird. Aulus Gellius wrote about a Greek named Archytas about the year 400 B.C. Archytas mystified and amused the citizens of Tarentum by flying a pigeon made of wood. Escaping steam propelled the bird suspended on wires. The pigeon used the action-reaction principle, which was not stated as a scientific law until the 17th century.

No one really knows when the first true rockets appeared. Reports of early rocket like devices appear sporadically through the historical records. Sometime in the first century A.D., the Chinese reportedly had a simple form of gunpowder made from saltpeter, sulfur, and charcoal dust. They used this to create explosions during religious festivals, in which they filled bamboo tubes with this mixture and tossed them into fires. At some point, the Chinese attached bamboo tubes to arrows and launched them with bows. Soon they discovered that these gunpowder tubes could launch themselves just by the power produced from the escaping gas. The true rocket was born. Nearly all uses of rockets were for warfare or fireworks.

During the latter part of the 17th century, Sir Isaac Newton organized his understanding of physical motion into three scientific laws. The laws explain how rockets work and why they can work in the vacuum of outer space. Newton's laws soon began to have a practical impact on the design of rockets. Rocket scientists in Germany and Russia began working with rockets with a mass of more than 45 kilograms. Some of these rockets were so powerful that their escaping exhaust flames bored deep holes in the ground.

In the 18th Century, rockets were used in war. The success of rocket barrages against the British in 1792 and again in 1799 caught the interest of an artillery expert, Colonel William Congreve. Congreve who designed war rockets. He was highly successful. In the Star- Spangled Banner the words "the rockets' red glare," that Francis Scott Key wrote was inspired by these war rockets. In 1898, Konstantin Tsiolkovsky, a Russian schoolteacher, developed the idea of space exploration by rocket. In a report he published in 1903, he suggested the use of liquid propellants for rockets to achieve greater range. He stated that the speed and range of a rocket were limited only by the exhaust velocity of escaping gases. For his ideas, careful research, and great vision, Tsiolkovsky has been called the father of modern astronautics. Early in 20th century, an American, Robert H. Goddard conducted experiments in rocketry. He had become interested in a way of achieving higher altitudes with solid propellant then moved onto liquid fuel. He achieved the first successful flight with a liquid-propellant rocket on March 16, 1926. The rocket was fueled by liquid oxygen and gasoline, it flew for only two and a half seconds, climbed 12.5 meters, and landed 56 meters away in a cabbage patch. The flight was unimpressive, by today's views, but like the first powered airplane flight by the Wright brothers in 1903, Goddard's gasoline rocket was the forerunner of a whole new era in rocket flight.

Hermann Oberth published a book in 1923 about rocket travel into outer space. His writings were important. Because of the book, many small rocket societies sprang up around the world. In Germany, the formation of one such society, the Verein fur Raumschiffahrt (Society for Space Travel), led to the development of the V-2 rocket, which was used against London during World War II. In 1937. With the fall of Germany, many unused V-2 rockets and components were captured by the Allies. Many German rocket scientists came to the United States. Others went to the Soviet Union. The German scientists, including Wernher von Braun, were amazed at the progress Goddard had made.

Fortunately for London and the Allied forces, the V-2 came too late in the war to change its outcome. Nevertheless, by war's end, German rocket scientists and engineers had already laid plans for advanced missiles capable of spanning the Atlantic Ocean and landing in the United States. These missiles would have had winged upper stages but very small payload capacities.

With the fall of Germany, many unused V-2 rockets and components were captured by the Allies. Many German rocket scientists came to the United States. Others went to the Soviet Union. The German scientists, including Wernher von Braun, were amazed at the progress Goddard had made.

Both the United States and the Soviet Union soon realized the potential of rocketry as a military weapon and began a variety of experimental programs. They began with the high-altitude atmospheric sounding rockets, one of Goddard's early ideas. Later, a variety of medium- and long-range intercontinental ballistic missiles were developed. These became the starting point of the U.S. space program. Missiles such as the Redstone, Atlas, and Titan would eventually launch astronauts into space.

On October 4, 1957, world shattering news of an Earth-orbiting artificial satellite that was launched by the Soviet Union, called Sputnik I. A month later, the Soviets followed with the launch of a satellite carrying a dog named Laika on board. Laika survived in space for seven days before being put to sleep before the oxygen supply ran out.

The United States followed with a satellite of its own. Explorer I was launched by the U.S. Army on January 31, 1958. Later that year, the space program was born creating the National Aeronautics and Space Administration (NASA).

DIRECTIONS:

Day 1 In groups, today you will explore the art of making Model rocket to find the best design for distance upward.

1. Before beginning, remember the lesson and activities of Bernoulli's Principle and forces of flight.

2. This lesson will deal with how surface area, Shape (cross section of wing), Angle of attack (relative to oncoming air), and wing proportions impact the LIFT of a model rocket
3. Each student should receive a package with the parts and directions to put together the model rocket.
4. Build as instructed. Everyone will build the same design (or only 2 pre-made design kits)
5. It takes several days to build due to glue drying on the wings. Mybe have the students build at home. Ring in finished rocket to fly at school.
6. One team member will draw the design in the Data Collection Sheet. Complete the data sheet with the dimensions of plane, and weight of plane
7. After each flight measure distance, Record

Day 2 In the same groups from Day 1 you will design the wings of a Model Rocket.

1. Before beginning look over the data you collected on day 1.
2. Allow the data to influence your original design. Are you up for the challenge to design a Model Rocket that can travel a longer distance upward?
3. Follow the same procedures as before. Begin with your original design. Only change the wing design, keep the original body and tail.
4. Don’t forget to draw your design in the large design area.
5. Consider wing span and the proportion of wing length to width.
6. Once glider is built measure the length of your plane as well as the length and width of the wing of the plane.
7. Collect the data in the Data Collection Section for Day 2.
8. Once data is collected it is time to test your rockets in flight.
9. After students have completed this experiment, share with them their renderings of a rocket wing.

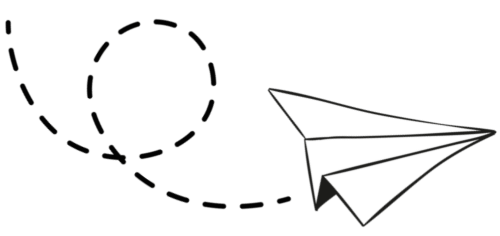
Wing Design/Airfoil Design Paper Airplanes Student Data Collection Sheet

Day 1 Template Paper Airplane

Team Members: ___________________, _______________________,

____

Design Type A		Drawing
Total Plane length		
Total Plane weight		
Wing length		
Wing width		
Ratio calculation		
Other Information		
Team Member Role		
	Thrust	
	Measure	
	Recorder	



Design Type B		Drawing
Total Plane length		
Total Plane weight		
Wing length		
Wing width		
Ratio calculation		
Other Information		
Team Member Role		
	Thrust	
	Measure	
	Recorder	

DAY 2 Own Design Paper Airplane

Design Type C (Own)		Drawing
Total Plane length		
Total Plane weight		
Wing length		
Wing width		
Ratio calculation		
Other Information		
Team Member Role		
	Thrust	
	Measure	
	Recorder	

Design Type D (Own)		Drawing
Total Plane length		
Total Plane weight		
Wing length		
Wing width		
Ratio calculation		
Other Information		
Team Member Role		
	Thrust	
	Measure	
	Recorder	

	Day 1	Day 1	Day 2	Day 2
DISTANCE OF FLIGHT	Type A	Type B	Own Design Type C	Own Design Type D
Trial #1				
Trial #2				
Trial #3				
Average				

Analysis/Reflection Paper Airplane

Go back and review your recorded data found in the Data Collection Sections and the Distance of Flight Table. Then answer the following questions using your data. Once all questions are answered be ready as a team to share your data with the rest of your class (oral presentation). Be ready to answer questions from your classmates.

1. What wing design flew the farthest?

2. What evidence does your team have for flight distance? Explain.

3. Why did it fly that far? (reasons)

4. What other factors might/could have affected the outcome?

5. Why did the other designs not perform as well?

6. How would you redesign the plane and wing to get a better outcome?

Student Data Collection Sheet
Wing Design/Airfoil Design
Power Up Paper Airplanes

Power Up Paper Airplane

Team Members: ___________________, _______________________,

____

Design Type		Drawing
Total Plane length		
Total Plane weight		
Wing length		
Wing width		
Ratio calculation		
Other Information		
Team Member Role		
	Thrust	
	Measure	
	Recorder	

DISTANCE OF FLIGHT	**Without Power**	**With Power**
Trial #1		
Trial #2		
Trial #3		
Average		

Analysis/Reflection Power Up Paper Airplane

Go back and review your recorded data found in the Data Collection Sections and the Distance of Flight Table. Then answer the following questions using your data. Once all questions are answered be ready as a team to share your data with the rest of your class (oral presentation). Be ready to answer questions from your classmates.

1. How did thrust(power) affect the distance traveled?

2. Did the wing design you chose have any effect?

3. How would you redesign the plane and wing to get a better outcome?

Student Data Collection Sheet
Wing Design/Airfoil Design
Balsa Gliders

Day 1 Template Balsa Glider

Team Members: ___________________, ______________________,

____

Design Type		Drawing
Total Plane length		
Total Plane weight		
Wing length		
Wing width		
Ratio calculation		
Other Information		
Team Member Role		
	Thrust	
	Measure	
	Recorder	

DAY 2 Own Design Paper Airplane

OWN Design Type		Drawing
Total Plane length		
Total Plane weight		
Wing length		
Wing width		
Ratio calculation		
Other Information		
Team Member Role		
	Thrust	
	Measure	
	Recorder	

	Day 1	Day 2
DISTANCE OF FLIGHT	Type A	Own Design
Trial #1		
Trial #2		
Trial #3		
Average		

Analysis/Reflection Balsa Glider

Go back and review your recorded data found in the Data Collection Sections and the Distance of Flight Table. Then answer the following questions using your data. Once all questions are answered be ready as a team to share your data with the rest of your class (oral presentation). Be ready to answer questions from your classmates.

1. What wing design flew the farthest?

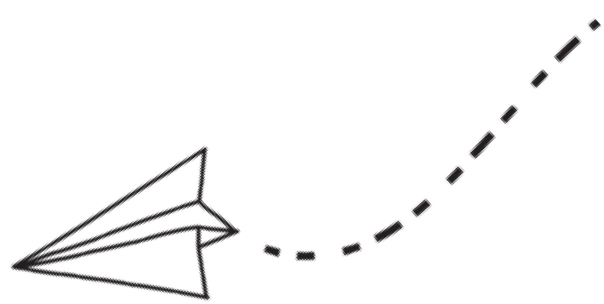
2. What evidence does your team have for flight distance? Explain.

3. Why did it fly that far? (reasons)

4. What other factors might/could have affected the outcome?

5. Why did the other designs not perform as well?

6. How would you redesign the plane and wing to get a better outcome?



Wing Design/Airfoil Design
Model Rockets
Student Data Collection Sheet

Day 1 Template Model Rockets

Team Members: ______________________, __________________________,
____

Design Type		Drawing
Total Rocket length		
Total Rocket weight		
Wing length		
Wing width		
Ratio calculation		
Other Information		
Team Member Role		
	Thrust	
	Measure	
	Recorder	

DAY 2 Own Design Model Rocket

OWN Design Type		Drawing
Total Rocket length		
Total Rocket weight		
Wing length		
Wing width		
Ratio calculation		
Other Information		
Team Member Role		
	Thrust	
	Measure	
	Recorder	

	Day 1	Day 2
DISTANCE OF FLIGHT	Kit Design	Own Design
Trial #1		
Trial #2		
Trial #3		
Average		

Model Rocket Analysis/Reflection

Go back and review your recorded data found in the Data Collection Sections and the Distance of Flight Table. Then answer the following questions using your data. Once all questions are answered be ready as a team to share your data with the rest of your class (oral presentation). Be ready to answer questions from your classmates.

1. What wing design flew the highest?

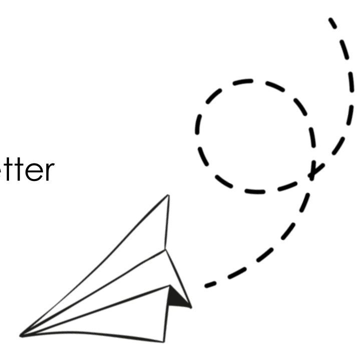
2. What evidence does your team have for flight distance? Explain.

3. Why did it fly that high? (reasons)

4. What other factors might/could have affected the outcome?

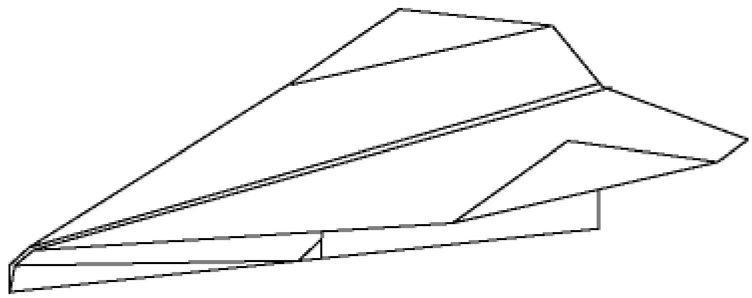
5. Why did the other designs not perform as well?

6. How would you redesign the rocket and/or wing to get a better outcome?

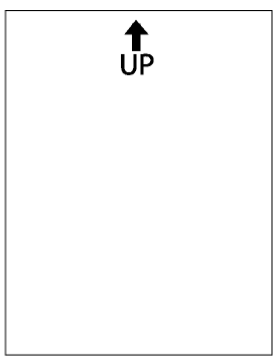


Appendix 3.A:

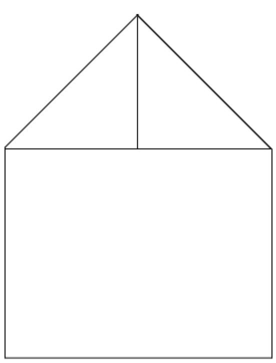
Classic Dart



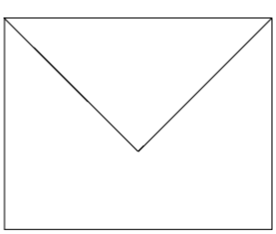
This plane is the classic schoolyard dart. It has short, compact wings and will fly straight as an arrow. It generally needs some up elevator along the back wing edges to fly properly.



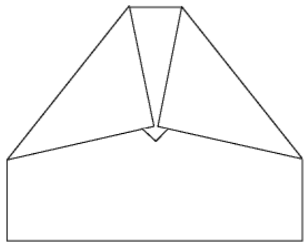
Orient the template with the "UP" arrow at the top of the page. Then, flip the paper over onto its backside, so that you cannot see any of the fold lines.



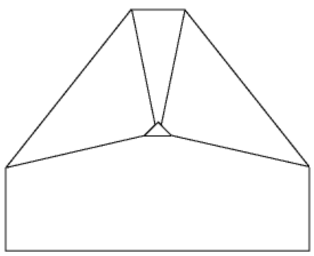
Pull the top right corner down toward you until fold line 1 is visible and crease along the dotted line. Repeat with the top left corner.



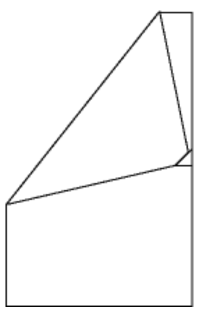
Fold the top point down toward you until fold line 2 is visible and crease along the dotted line.



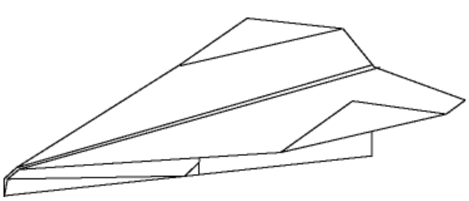
Fold the top left and top right corners down and toward you and crease along fold lines 3.



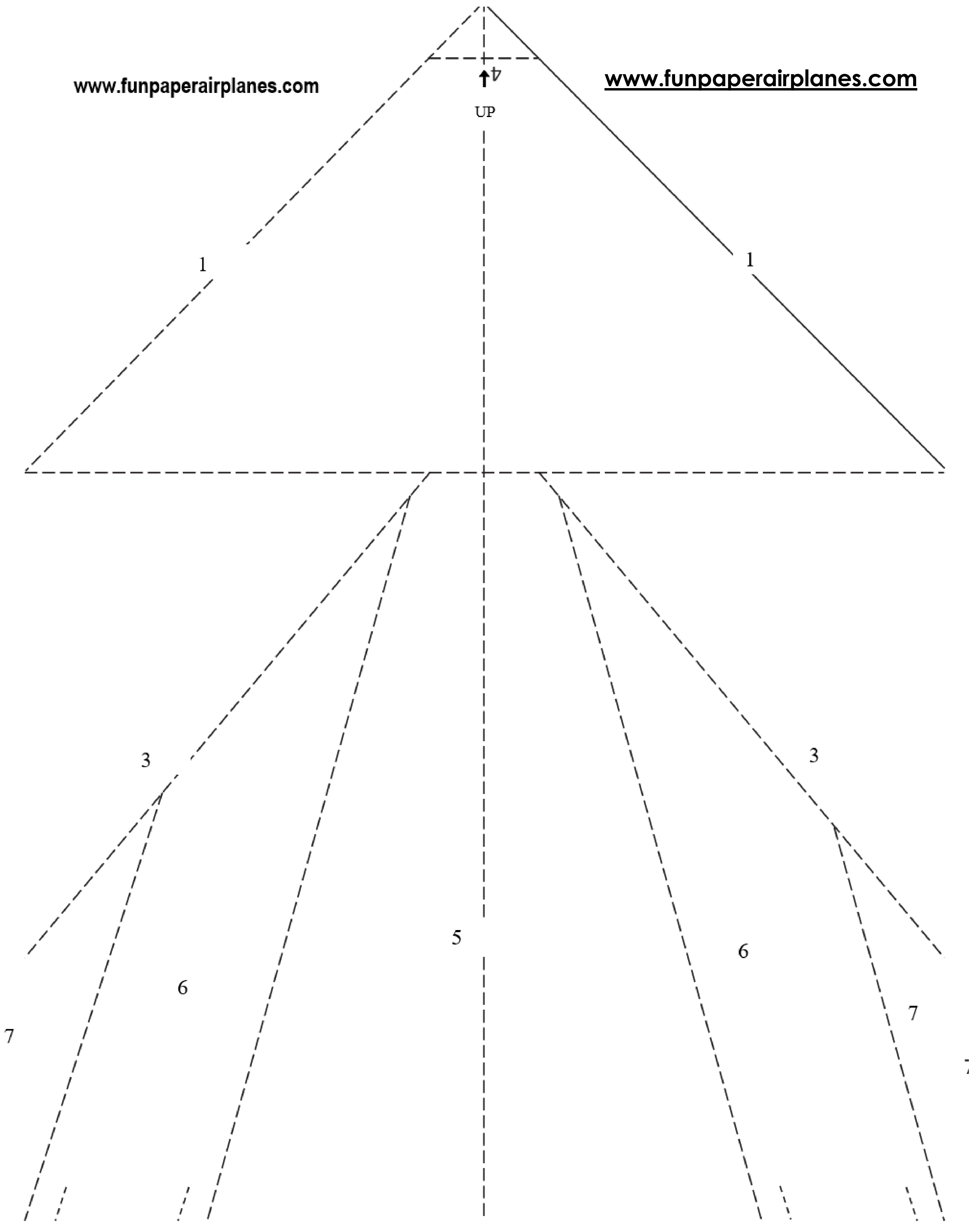
Fold the tip up and over the two diagonal folds along fold line 4 to secure them in place.



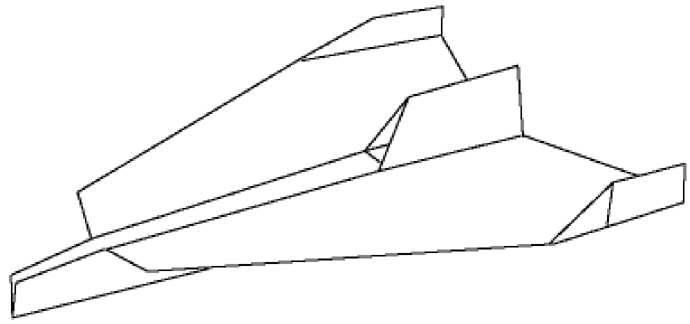
Flip the plane over and fold the right side over onto the left side as shown along fold line 5 so that the outside edges of the wings line up. Also make sure the diagonal folds do not become untucked from the tip you folded up in the previous step.



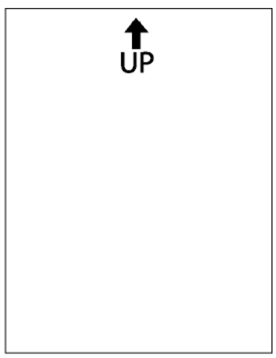
Fold the wings down along fold lines 6 and the winglets up along fold lines 7. Add wing dihedral by tilting the wings up slightly away from the fuselage. The wings will have a slight "V" shape when viewed from the front. Cut two slits, one inch apart, along the back edge of each wing to make elevator adjustments. Start out by trying some up-elevator. **You are ready to fly!**


www.funpaperairplanes.com
4
UP
www.funpaperairplanes.com
1
1
3
3
5
6
6
7
7

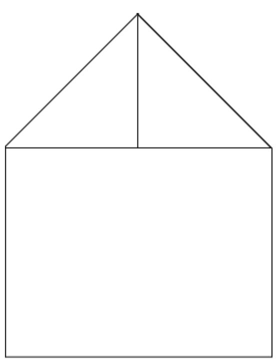
Interceptor



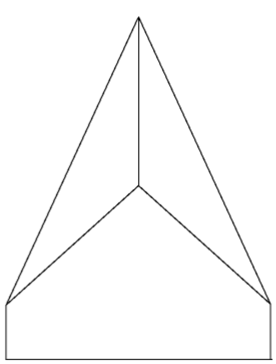
This plane has a central vertical stabilizer on the fuselage that helps produce excellent straight flights. Make sure to complete the final step of the instructions for good performance.



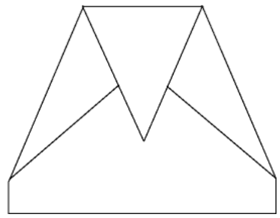
Orient the template with the "UP" arrow at the top of the page. Then, flip the paper over onto its backside, so that you cannot see any of the fold lines.



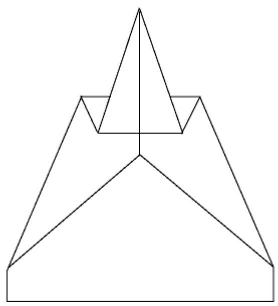
Pull the top right corner down toward you until fold line 1 is visible and crease along the dotted line. Repeat with the top left corner.



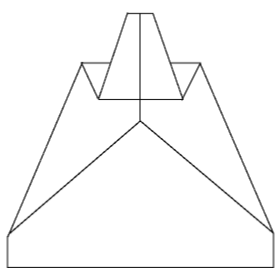
Fold the right side over again and crease along fold line 2. Repeat with the left side.



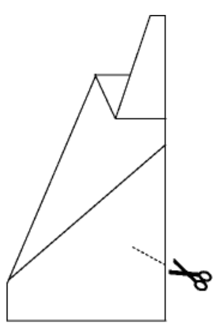
Fold the nose down toward you along fold line 3.



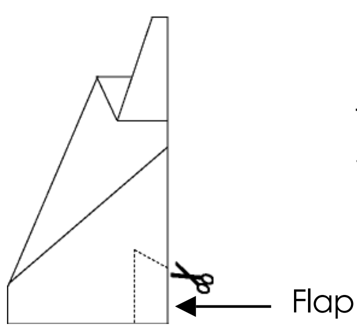
Fold the nose back up and crease along fold line 4.



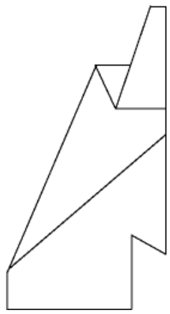
Fold the tip of the nose back away from you and crease along fold line 5.



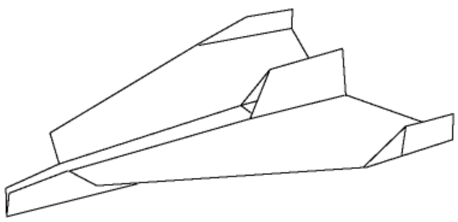
Flip the plane over. Fold the right half of the plane over onto the left half along fold line 6. Cut along the dotted line 7 for the vertical stabilizer.



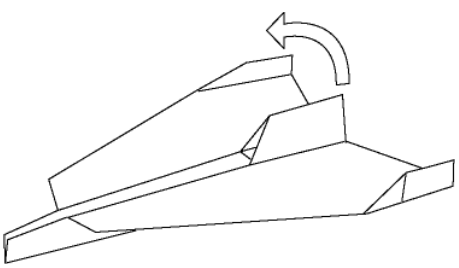
Tuck the flap that was formed by your cut between the two halves of the plane and crease it along fold lines 8.



When you have completed the step above, your plane will look like this.

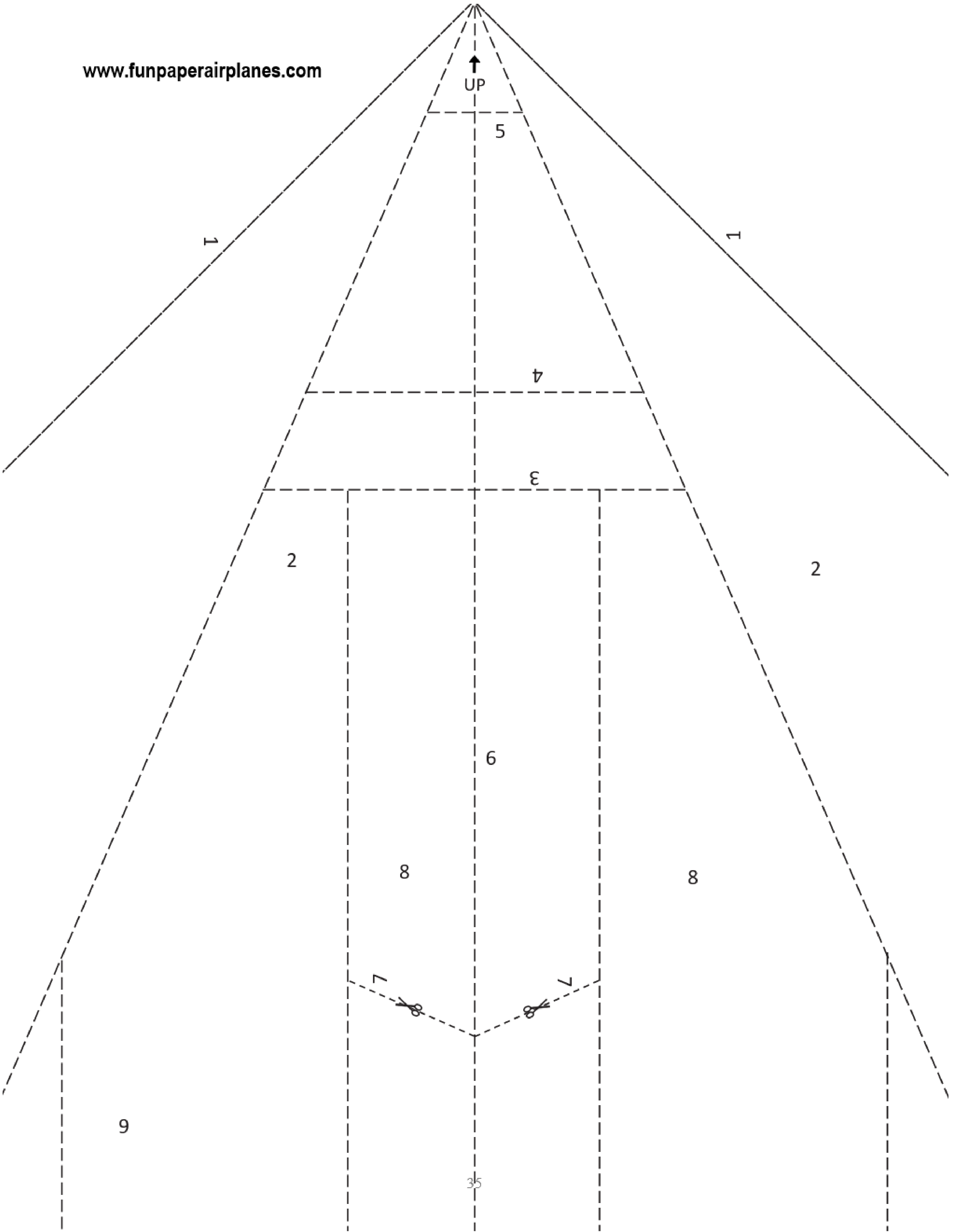


Fold the wings down along fold lines 8 and the winglets up along fold lines 9. Add wing dihedral by tilting the wings up slightly away from the fuselage. The wings will have a slight “V” shape when viewed from the front.



VERY IMPORTANT: Pull the back tip of the vertical stabilizer up and toward the front of the plane to put a slight upward curve to the trailing edge of the wings. This is to prevent the back edge of the wings from sagging downward. If you do not do this, your plane will nose-dive straight to the ground. After completing this step, **you are ready to fly!**

www.funpaperairplanes.com



Curriculum Guide 4: Learn to Code

Activity 4.1: Learn to Code Scratch

OBJECTIVE: To understand and use block-based coding as a programming language where the instructions are represented in blocks.

TIME: 50 minutes

MATERIALS:
Computer with internet access to Scratch Online version
https://scratch.mit.edu/

Computer downloaded Scratch3 https://scratch.mit.edu/download/ offline (no need for internet)

Note: This offline version will be needed to code the Tello drones
Scratch 2 https://scratch.mit.edu/download/scratch2 needs adobe air
https://airsdk.harman.com/runtime you will need an older version of Node Js
https://nodejs.org/download/release/v13.0.0/ choose appropriate download

INTRODUCTION:

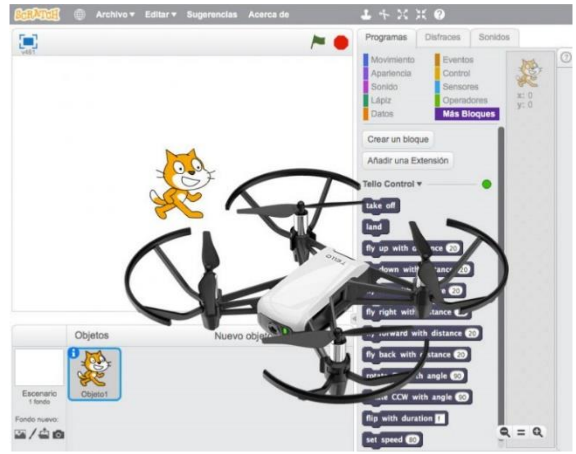
Easy/ Beginner

Scratch was invented by MIT, Scratch is an open-source system that enables individuals to program interactive stories, games and animations. Scratch is an ideal tool for teaching kids how to code. All the material is free and there are many resources to help teachers integrate coding with their curriculum. Scratch enables students to program interactive stories, games and animations. Instead of typing code, Scratch uses visual blocks like puzzle pieces to create a program. Scratch is very similar to Lego because the number of ways to arrange the blocks is endless. While Scratch is largely used to introduce kids to coding, it can also create sophisticated programs.

DIRECTIONS:

1. Scratch has many tutorials that should be viewed by the teacher if unfamiliar with it. The tutorials can also be used by the students.

2. Introduce to the students how to drag and drop the "blocks" how to connect them into s sequence. Make sure they have a stating 'event'
3. Demonstrate the various types of "blocks" like events, motion, sound. Limit what they explore initially
4. Allow the students to explore and create various sequences called 'sprites'
5. Since it is also online, they can continue to explore their own pace.



Activity 4.2: Learn to Code Scratch & Tello Drone

OBJECTIVE: Learn how to program their own drones to move, make noise, light up, and follow other instructions as directed

TIME: 50-minute x 2 or 3 days

MATERIALS:

Scratch 3 Version

- Scratch 3 https://github.com/kebhr/scratch3-tello/releases

Scratch 2 Version

- Scratch 2 https://scratch.mit.edu/download/scratch2
- needs adobe air https://airsdk.harman.com/runtime
- you will need an older version of Node Js https://nodejs.org/download/release/v13.0.0/ choose appropriate download
- Document (Appendix A) on how to set up Scratch for Tello

INTRODUCTION:

Now that the students have practiced using Scratch, it is time to code their drone.

NOTE:

1. Use Scratch offline, so it must be downloaded. Ensure prior to the class that the computers have the program downloaded.
2. Using mice might make it easier for some students to drag and drop.
3. Even though the internet is not required the computers must have the ability to connect to the Tello drones through Wi-Fi inside the computer.
4. Each time Scratch is logged off, the software must be set up.

DIRECTIONS:

The outcome for coding the drones is multiple drones will be moving together in a coordinated motion. Students must learn to code within a define space. Recommended is 2 meters (6 feet) up, 2 meters (6 feet) back, 2 meters (6 feet) side to side. The students need to be able to do movements and land at the point where they started.

NOTE:

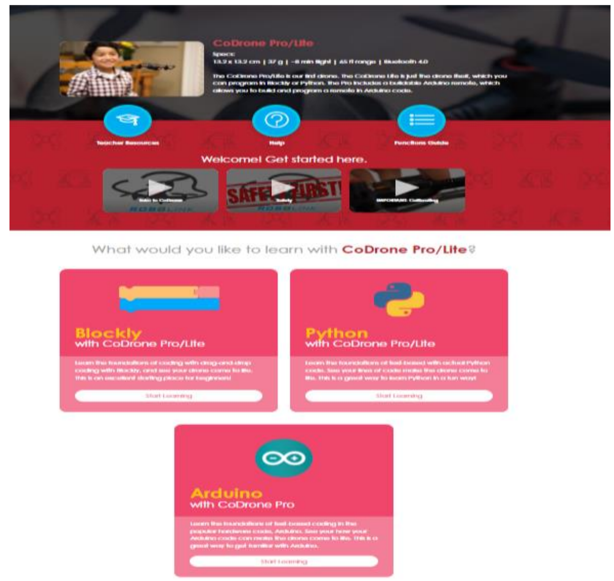
- Battery life is very short. When not flying, turn the drone off (pull battery). This means that they will need to connect their drone each time. It is recommended that each drone have at least 3 charged batteries.
- Ensure there is enough room between drones since the computers can pick up another drone. They should know the code for their drone.

In pairs:

- ✓ Task 1: Code the drone to go up 2 meters (6 feet) pause 5 seconds then land.
- ✓ Task 2: Code the drone to go up 1 meter (3 feet) pause 5 then to go left 2 meters (6 feet) pause 5 seconds then return to center, pause 5 seconds then land.
- ✓ Task 3: Code the drone to go up 1 meter (3 feet) pause 5 then to go right 2 meters (6 feet) pause 5 seconds then return to center, pause 5 seconds then land.
- ✓ Task 4: Code the drone to go up 1 meter (3 feet) pause 5 then to go backwards 2 meters (6 feet) pause 5 seconds then return to center, pause 5 seconds then land.
- ✓ Task 5: Code the drone to go up 1 meter (3 feet) pause 5 then to go forwards 2 meters (6 feet) pause 5 seconds then return to center, pause 5 seconds then land. MAKE sure there is enough room from the starting position.
- ✓ Task 6: Code the drone to go up 1 meter (3 feet) pause 5 turn counter clockwise pause 5 seconds then land.
- ✓ Task 7: Code the drone to go up 1 meter (3 feet) pause 5 turn clockwise pause 5 seconds then land.
- ✓ Task 8: Code the drone to go up 1 meter (3 feet) pause 5 flip the drone pause 5 seconds then land.
- ✓ Task 9: Begin to combine various movements.

Activity 4.3: Learn to Code - CoDrone

OBJECTIVE: Learn how to program their own drones to move, make noise, light up, and follow other instructions as directed using advanced coding.



TIME: 50-minute x 2 or 3 days

MATERIALS:
Robolink/ Codrone Online learning platform: https://learn.robolink.com/product/codrone-pro-lite/
There are teacher resources as well, but the students can follow each step.

INTRODUCTION:

Advanced: The CoDrone is a programmable drone, with block-based coding, Arduino, and Python. It comes with a buildable Arduino-based controller, which can be coded using the Arduino environment. It's modular and can be fully disassembled. The CoDrone allows students to get into advanced coding while also getting hands on with building hardware. It provides open access to code and sensor data for talking about STEM topics, and enough durability and repairability to withstand the rigors of classroom use. There are plenty of advanced sensors packed into a small package. All of these sensors can be accessed from code and used to detect information about the environment. Code the lights and sound to indicate when you've detected an obstacle or flown above a certain height, or code them just for fun. Use up to 15 drones in a classroom without worrying about signal interference.

DIRECTIONS:
The outcome for coding the drones is multiple drones will be

moving together in a coordinated motion. Students must learn to code within a define space. <u>Recommended is 2 meters (6 feet) up, 2 meters (6 feet) back, 2 meters (6 feet) side to side.</u> The students need to be able to do movements and land at the point where they started.

NOTE:

- Battery life is very short. When not flying, turn the drone off (pull battery). This means that they will need to connect their drone each time. It is recommended that each drone have at least 3 charged batteries.
- Ensure there is enough room between drones since the computers can pick up another drone. They should know the code for their drone.

Before coding the Codrones, the students must go through the tutorials on how to pair the drone with the computer and how to upload the code.

In pairs:

- ✓ Task 1: Code the drone to go up 2 meters (6 feet) pause 5 seconds then land.
- ✓ Task 2: Code the drone to go up 1 meter (3 feet) pause 5 then to go left 2 meters (6 feet) pause 5 seconds then return to center, pause 5 seconds then land.
- ✓ Task 3: Code the drone to go up 1 meter (3 feet) pause 5 then to go right 2 meters (6 feet) pause 5 seconds then return to center, pause 5 seconds then land.
- ✓ Task 4: Code the drone to go up 1 meter (3 feet) pause 5 then to go backwards 2 meters (6 feet) pause 5 seconds then return to center, pause 5 seconds then land.
- ✓ Task 5: Code the drone to go up 1 meter (3 feet) pause 5 then to go forwards 2 meters (6 feet) pause 5 seconds then return to center, pause 5 seconds then land. MAKE sure there is enough room from the starting position.
- ✓ Task 6: Code the drone to go up 1 meter (3 feet) pause 5 turn counter clockwise pause 5 seconds then land.
- ✓ Task 7: Code the drone to go up 1 meter (3 feet) pause 5

turn clockwise pause 5 seconds then land.

- ✓ Task 8: Code the drone to go up 1 meter (3 feet) pause 5 flip the drone pause 5 seconds then land.
- ✓ Task 9: Begin to combine various movements.

APPENDIX 4.A:

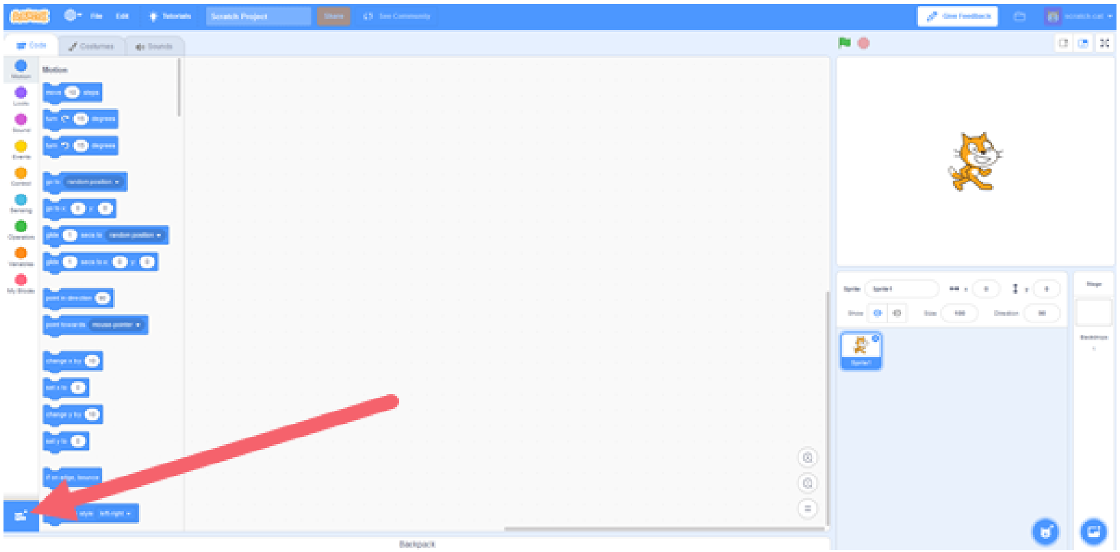
How to connect to Tello drone to Scratch 2

1. THIS MUST BE DONE EVERYTIME SCRATCH IS CLOSED
2. Open Scratch 2
3. Look for 'FILE' on Scratch
4. Press "FILE" and "SHIFT" at the same time
5. Click 'IMPORT EXPERIMENT HTTP EXTENSION'
6. Select *tello.s2e* and 'OPEN'
7. Go to "MORE BLOCKS' on Scratch
8. Now Go to the bottom left of the computer screen look for Type *cmd.exe* in the box next to it should open terminal (black screen box))
9. Go to the desktop files.
10. Look for the Scratch folder on desktop and open
11. Highlight all 3 files shown (Tello, Tello.s2e, TelloChs.s2e)
12. Then Click on top bar and highlight + copy the address
13. Go back to open terminal
14. Type *cd* press 'SPACE BAR' and paste copied files
    OR drag and drop Scratch folder files in terminal
15. Press 'ENTER"
16. Type *node* press 'SPACE BAR' type *tello.js* and press 'ENTER'
    (minimized (must be kept opened) terminal window)
17. Go back to Scratch
    If this is done correctly – in Scratch the dot (found in the middle) turns green
18. Turn on Tello drone and connect to Tello drones WIFI (may take a while)
19. Go back to Scratch and go to 'MORE BLOCKS'
20. Code your drone and have fun
21. SAVE your sequence.

How to connect to Tello drone to Scratch 3

1. Connect the Tello drone to Wi-Fi
2. Download the Scratch3-Tello app (choose operating system)
3. Extract files (might need to allow permissions)
4. Open Scratch3-Tello file this will open Scratch 3

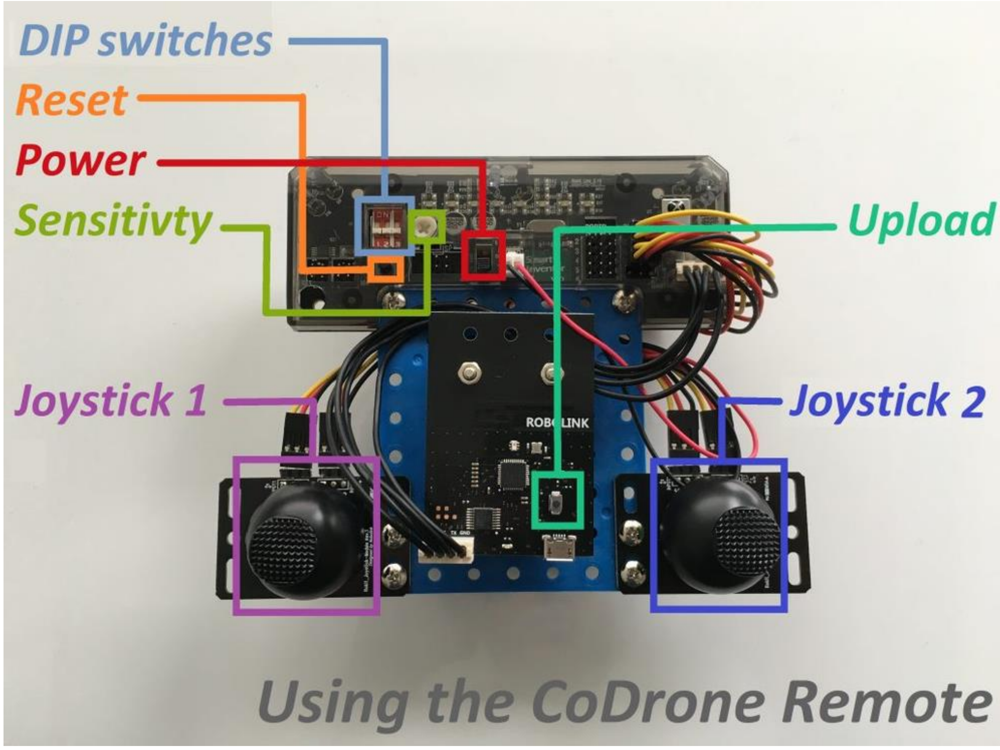
5. Click on the 'add extension; icon at the bottom left of the program



6. This will open all the available extensions for Scratch.
7. Click on the [TELLO] extension box
8. This activates all the available blocks to use.
9. Create sequence and "Fly"
10. SAVE your sequence.

Connections for CoDrone

Remote parts



DIP switches

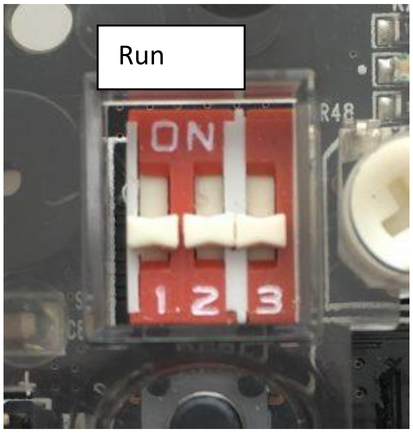
The three small switches on the lefthand side of your Smart Inventor board are called DIP switches.

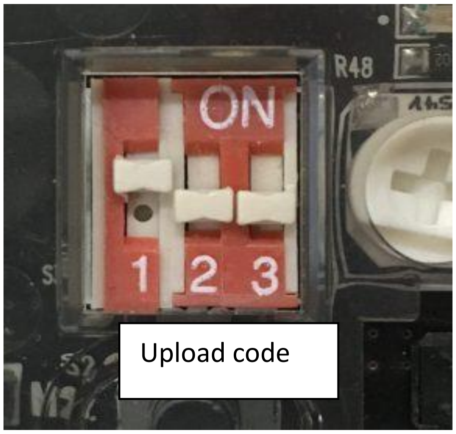
• OFF is at the bottom of the red panel, and ON is at the top of panel. Hint: it says on!

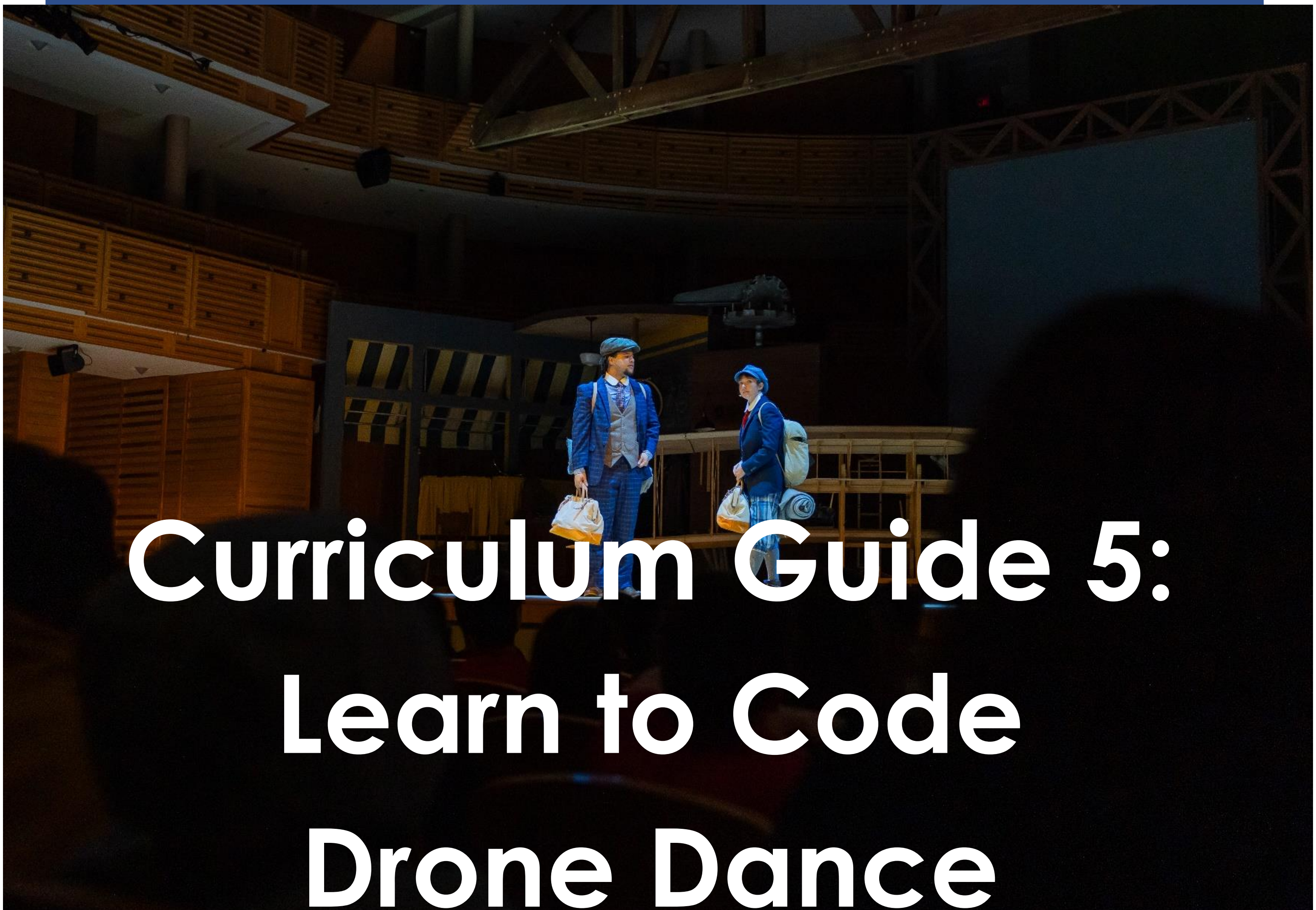
• If you want to run your code, all three DIP switches should be off. This is called run mode.

• If you want to upload your code, put switch 1 in the on position and switches 2 and 3 in the off position. This is called upload mode.

To upload code, you must make sure that both the Smart Inventor board and the Bluetooth module are in 'Upload Mode'.







Curriculum Guide 5: Learn to Code Drone Dance

Imagine a swarm of drones. coding drones, together with real time movements as well as storytelling, and a music score, to create a dance of the drones -an aerial ballet. Using a collection of small drones called SWARMS that autonomously coordinate with each other, students can code the flight of the drone to move automatically instead of manually. Using the Engineering Design Process allows a flexible process that takes students from identifying a design challenge to creating and/or developing a solution. Students develop & create a prototype, then test, evaluate, and redesign. The focus is on taking different approaches, making mistakes, accepting and learning from them, and trying again and then developing solutions. Students work is hands-on and in collaborative groups, and decisions about solutions are student-generated. They control their own ideas and design their own investigations. They learn by doing, trying, experimenting, failing and trying again. Adding in light-emitting diodes (LEDs) for display purposes these dance Swarms of drones can now be ‘firelight" shows instead of fireworks.

Step-by-step guide in implementing

Options:

Introduce the concepts of coding through any coding program. This can be done as an assignment or as home learning.

Give an introduction to Arduino coding. Arduino.cc needs to be downloaded but has some tutorials

Introduce the students to Scratch initially,

Use the tutorials in the CoDrone (ariel) to have the students learn the basics of Arduino coding and the movements for programing a drone flight.

The Tello drone uses Scratch which is block based coding. Introduce the students to Scratch initially, then with the drone. *Appendix has the instruction to use with the drone

Activity 5.1: Code a Drone Dance/Ballet

OBJECTIVE:

Coding drones (robots), together with real time movements as well as storytelling, and a musical score, to create a dance of the drones -- an aerial ballet.

- Solve real-life issues in science and engineering (i.e., generalize a solution to open-ended problems) using computational thinking skills.
- Apply math, reading, science, and critical thinking skills as they relate to industry.
- Use critical-thinking skills for various contexts to develop, refine, and reflect on an artistic theme.
- Demonstrate visual-thinking skills to process the challenges and execution of a creative endeavor.
- Use non-traditional thinking and various techniques to create two-, three-, and/or four-dimensional artworks.
- Students interacted on the electronic network.
- Students accessed information from various data systems.
- Students located, interpreted, and applied information found to perform tasks.
- Students gathered information to answer questions and make conclusions from existing information.
- Working in a group, the students assimilated their information and discussed implications of their findings.

TIME: 110-minute x 2 or 3 days

MATERIALS:

- Tello drones and computer
- CoDrone Pro and computer
- Coding program

INTRODUCTION:

Now that the students have learn to work together to code 1 drone, begins the dance

1. 2 drones (2 pairs of students, 2 drones, 2 computers)

***Repeat the tasks of 1 drone but learning to be **synchronized**

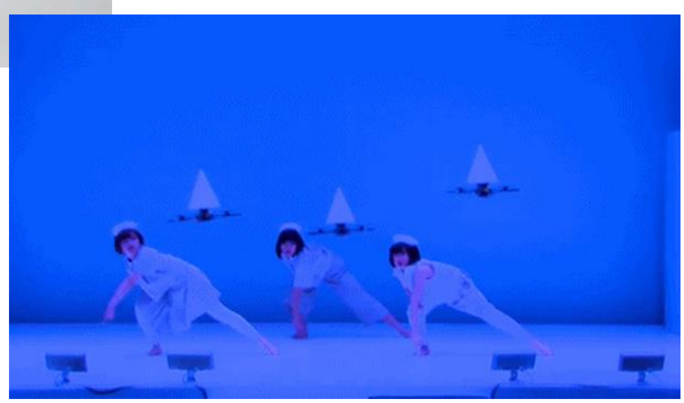
- ✓ Task 1: Code the drone to go up 2 meters (6 feet) pause 5 seconds then land.
- ✓ Task 2: Code the drone to go up 1 meter (3 feet) pause 5 then to go left 2 meters (6 feet) pause 5 seconds then return to center, pause 5 seconds then land.
- ✓ Task 3: Code the drone to go up 1 meter (3 feet) pause 5 then to go right 2 meters (6 feet) pause 5 seconds then return to center, pause 5 seconds then land.
- ✓ Task 4: Code the drone to go up 1 meter (3 feet) pause 5 then to go backwards 2 meters (6 feet) pause 5 seconds then return to center, pause 5 seconds then land.
- ✓ Task 5: Code the drone to go up 1 meter (3 feet) pause 5 then to go forwards 2 meters (6 feet) pause 5 seconds then return to center, pause 5 seconds then land. MAKE sure there is enough room from the starting position.
- ✓ Task 6: Code the drone to go up 1 meter (3 feet) pause 5 turn counter clockwise pause 5 seconds then land.
- ✓ Task 7: Code the drone to go up 1 meter (3 feet) pause 5 turn clockwise pause 5 seconds then land.
- ✓ Task 8: Code the drone to go up 1 meter (3 feet) pause 5 flip the drone pause 5 seconds then land.
- ✓ Task 9: Begin to combine various movements

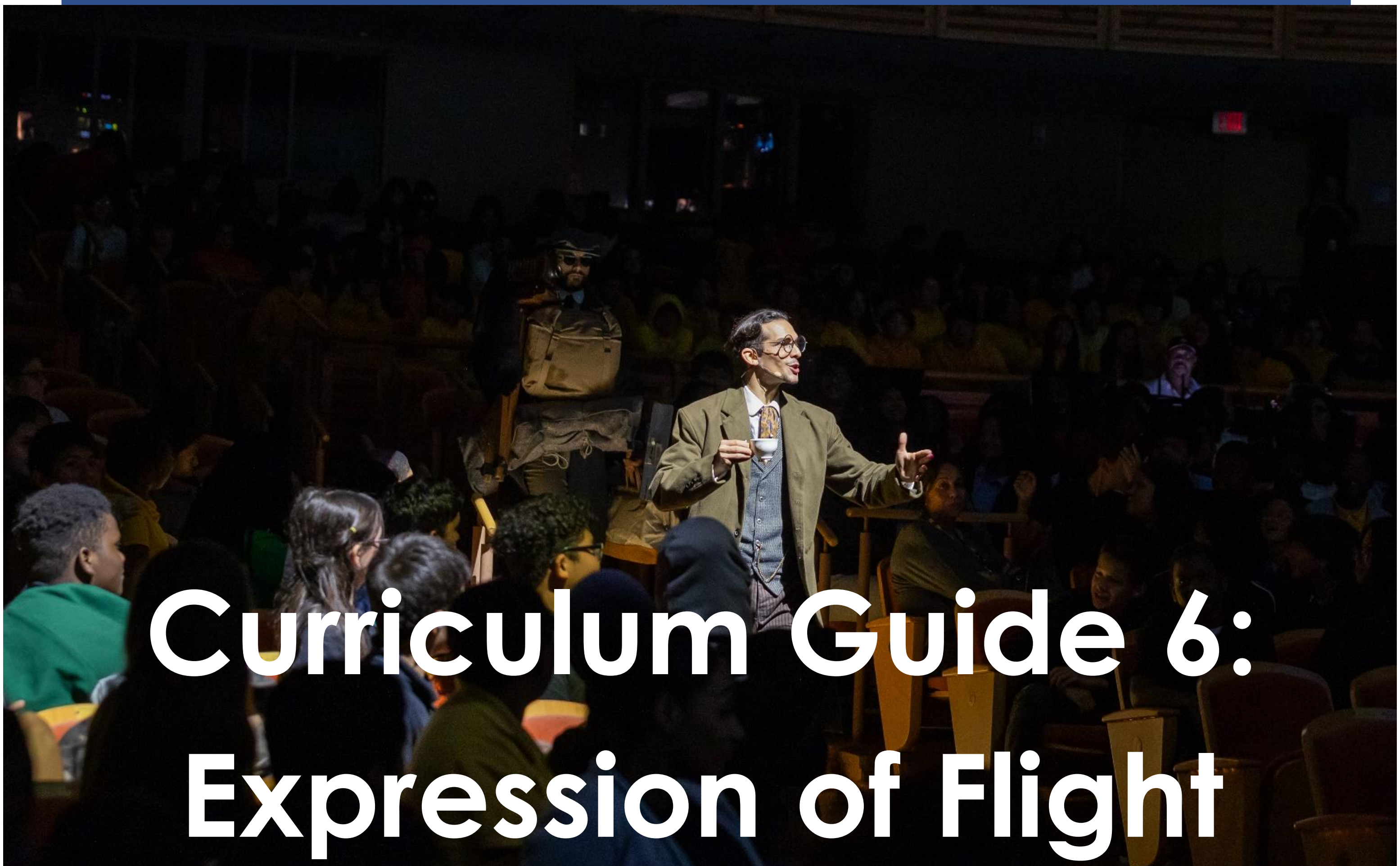
2. When the students have learned to be **synchronized** with 2 drones, they can add a 3rd drone (pair)
3. Students need to begin to decide on their musical score and the movements to match the beat. Choose only a part of a musical score that include at least 5-10 movements (some can be repeated)

IDEAS:

- ❖ Typically, always begin with the drone rising up about 1 meter

- ❖ Move to the left or right all together, then back to middle or to the back
- ❖ Add a flip somewhere
- ❖ Add turning the drone around
- ❖ Create a square or triangle pattern
- ❖ Create an up and down pattern
- ❖ Have a person 'dance' with the drones





Curriculum Guide 6: Expression of Flight

The Wright Brothers demonstrated STEAM in action. They were not just engineers and inventors they approached problem solving through the creative process. It does make a difference. By adding the arts to STEM education, can makes science, technology, engineering, and math experience more entertaining and approachable for children. Doing hands-on activities that involve the arts solidifies a child's understanding of concepts. STEAM connects a student's interests to the real world. We know that to connect with experiences is when we can touch, see, or understand how to use it in everyday life. The arts can demonstrate to students how to be creative problem solvers but value the mistakes. With the arts there isn't always a right answer and so it provides students a safe way to make interesting mistakes and challenge themselves. The Wright Brothers did not start out to be a scientist or engineer, but embracing the STEAM, look at how they changed the world. When students embrace the STEAM disciplines, they too can become better citizen of the world. The more well-informed we are at a young age the more well-informed adults they can be. This program focuses on innovation but add design thinking and creativity elements that are crucial for this innovation.

The Adrienne Arsht Center for the Arts provides ARTS in action through visiting artists and mentors. These people will support the students on their journey using their creative mind.

Activity 6.1: Expressions of Flight

Art/ Watercolor

OBJECTIVE: To use watercolors to express themselves in flight

TIME: 1- 100-minute class, 10- 50 minutes classes

MATERIALS (for each student)**:**

- 17" x 24" light weight drawing paper
- 17" x 24" watercolor paper
- Small wooden posable human mannequins
- Several sizes of brushes
- Watercolor palettes
- Pencils
- Fine black permanent marker

Students need to look at clouds (possible take pictures prior to beginning this project) Appendix A: Color chart

INTRODUCTION:

NOTE: Typically, the introduction to Expressions of Flight is done by a visiting artist and/or mentor. They will introduce the project, the basics in techniques and expectations. Working on the project is done over several class periods.

Art is a way of expressing feelings and concepts. Through art, a student can express their own special view about events, conceptions, philosophies. Using watercolors, the students will be able to express themselves in flight (such as themselves with wings, super hero, space person, rocket man) flying over a landscape of their choice. There are countless reasons to justify the importance of artistic expression as part of the integral development of children. Time and resources that aim at art expression in children is an important investment that will boosts their development.

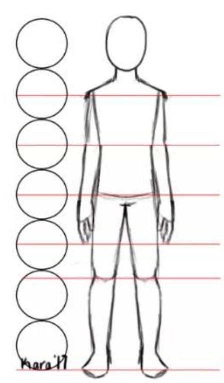
The process of developing a creative attitude will follow certain rules. There has to be a guided and systematic approach so that the children familiarize with the different elements of art

DIRECTIONS:

<u>Visiting Artist:</u>

A. Using a strip of water color paper, the students will create a color reference strip
    1. Experiment with separate primary colors—red, blue and yellow. Let them see the dynamic and expression of color, how it looks on paper, how it changes when adding water. Every color has its unique traits, and the best way children can learn about it is by playing with them. Then let them create a different kind of shapes, guide them on how to gradually add water and see how color tones can be graded.
    2. Mix colors to create secondary colors like orange, green and purple. Let them focus especially on the translucent property of the paint so they can appreciate the nature of watercolor.
B. Teach them about perspective
C. Posable Mannequins
    1. Each student poses their mannequins in the position of their flight
    2. On drawing paper, they learn the rules of eight (8)





On their Own In class (Visiting Artist/Mentor may come by other classes)

3. It might take the students a couple of sessions to draw themselves in flight

50 minutes class period

4. Once they are satisfied with their drawing, they will need to transfer it to the watercolor paper
5. On the back of the drawing, using the side of a pencil, the students shade the area directly behind their drawing. This will provide material to transfer their design.
6. Once the area is shaded, turn it over and place their drawing of their flying selves where they would like it to be.
7. Using a pencil trace their design. Pressing hard enough will transfer the shaded marks upon the watercolor paper.
8. Now their drawing is transferred onto the watercolor paper, they need to fill it in with a pencil.
9. When they are satisfied with it, then trace over the pencil with a fine black permanent marker. This will not be harmed by the watercolor.

50 minutes class period

10. Using their cloud images, draw in pencil first their sky.
11. Now draw in the landscape in pencil
12. When satisfied with them, then draw in black marker

50 minutes class periods each

ONLY do one color at a time and DO NOT TOUCH a wet area. Area must be dry before the adjoining space is painted or colors will bleed.

13. Choice an area and one color to start painting. Remember what was introduced at the beginning
14. Some areas could be more translucent than others.

Activity 6.2: Expressions of Flight

Dance/Movement

OBJECTIVE: To learn how their body moves and translate to the movement of a drone

TIME: 50 minutes

MATERIALS:

- A place where students can practice movements/dance safely

INTRODUCTION:

NOTE: Typically, the introduction to Expressions of Flight is done by a visiting artist and/or mentor. They will introduce the project, the basics in techniques and expectations. Working on the project is done over several class periods.

Through dance, children learn to coordinate and control their bodies. Movement also assists in the development of spatial awareness. Dancing, singing, and playing music are part of a child's process of growing up and learning what their bodies can do. Dance teaches children how to interact with other people, objects and the world around them. Dance is a powerful way to promote creativity and critical thinking with students. Students also learn discipline, because they have to memorize and execute specific steps and body movements that require practice and perseverance. The movement of dance provides experiences for students to experiment with travelling motions such as walking, sliding and jumping, as well as other movements like twisting, bobbing and bending. These are the same movements a drone does. Drones move up, down, backwards, forwards, turn and twist and flip.

Students will also learn teamwork by having to work with other students toward a common goal, which will translate to so many different areas in life.

DIRECTIONS:

<u>Visiting Artist/ Dance Specialist</u>

1. Discussion of the physical origin of presented movement, how a dancer considers their body in space, quality of movement, visual imagery, and intent.
2. Demonstrating a figure in motion through a variety of dance inspired short poses.
3. Students practice these short poses
4. Then expressive dance sequences accompanying to a musical beat
5. Students practice
6. Students learning to have their movement ‘flow’ with the music

<u>On their own In class (Visiting Artist/Mentor may come by other classes)</u>

1. As students code their drone movements, they will also ‘move with these movements

2. The drone dance/ballet is a series of drone movements sometimes with a person.
3. Students doing the actual dance movements can improve their drone dance movements.

Activity 6.3: Expressions of Flight
Music/ To the Beat

OBJECTIVE: To gain an understanding of musical beats and to relate them to their drone dance movements.

TIME: 50 minutes

MATERIALS:

INTRODUCTION:

NOTE: Typically, the introduction to Expressions of Flight is done by a visiting artist and/or mentor. They will introduce the project, the basics in techniques and expectations. Working on the project is done over several class periods.

Music can set a mood, drop the beat, and create the motivation needed to start moving. It has the ability to make us feel a certain way, which is why it plays such an immense role in dance. Different styles of music create various types of beats, which all correspond to movements in dance. Music is energy. Music is movement. Sound and its vibration are the 'movement of music'. It does not matter how we move; we are 'moved' by the rhythm and eventually the count of each phrase. Each phrase has an opening and ending place within the pulse and then repeats itself. Drones move according to a set measure in space and time. These movements can be set to the beat of music. Not just the movement of music but for the performance of the dance it must be timed. Team dancing (a coded swarm of drones) timing is even more important as the drones won't be able to perform the individual movements if they are out of time from the other drone dancers.

DIRECTIONS:

<u>Visiting Artist/ Musician</u>

1. Discussion of the musicality which is "sensitivity to, knowledge of, or talent for music". Music may describe a performance on the page to life; of expressing more than the mere faithful reproduction of pitches, rhythms, and composer dynamic markings.

2. Discussion and experiences with the aspects of music including pitch, rhythm, and harmony.
3. Listening to various types of music.
4. Understand that each piece of music has a beat or pulse. The steady repetitive pattern which gives us the timing of the music.
5. Playing with various simple instruments (drums, rattles, tambourine, sticks, etc.) to investigate the aspects of music.

<u>On their own In class (Visiting Artist/Mentor may come by other classes)</u>

1. As students code their drone movements, they will begin to develop what type of music fits the "beat" of their drone dance.

Kitty Hawk: Can Humans Fly?

RECAP

- Add bones, muscles, wings, and fashion to your figure
- Design a location for a flyover
- Transfer work to good watercolor paper
- Outline with fine point sharpie
- Practice watercolor technique … color mixing, value scale, painting technique
- Paint sky in first using phone or photo as reference
- Paint figure and landscape using techniques that you learned
- Allow drying time in between layers
- Write an artist reflection explaining your work and inspiration
- Exhibit your work in school and at the Bakehouse, JCC, and Wynwood Dacra Gallery and at Kitty Hawk virtual exhibition.

Extra Activity: Expressions of Flight

Wright Brothers 1903 Flyer Model Instructions

DESIGNED BY Roger Storm, NASA Glenn Research Center

https://www.grc.nasa.gov/WWW//Wright/ROGER/1903model.htm#:~:text=WRIGHT%20BROTHERS%201903%20FLYER%20MODEL%20INSTRUCTIONS%201%20Clean,Cardboard%20or%20board%20to%20cut%20on%20More%20items

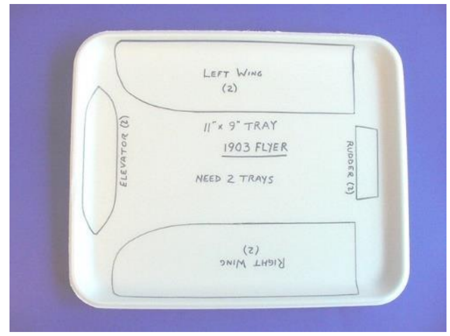
MATERIALS

- Clean foam meat trays, at least 9 inches by 11 inches and preferably white
- 40 to 50 toothpicks
- 30-inch piece of 1/8 x 1/8 piece of balsa wood
- 2 craft sticks or Popsicle sticks
- Low temperature glue gun
- Scissors
- Hobby knife, razor utility knife, or single-edge razor blade (adult help here)
- Cardboard or board to cut on
- Fine tip permanent black marker
- Ruler
- Emery board
- Manila folder
- Clear plastic sheet, such as used on an overhead transparency
- Plastic toy army soldiers (optional)

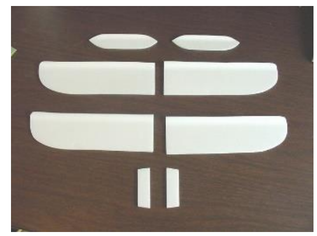
GENERAL INSTRUCTIONS:

1. Download and print a copy file "1903 template".
2. Use scissors to cut out all templates on the heavy lines.
3. Do all hobby knife or razor blade cutting on the board or cardboard to protect your working surface.
4. The finished model is for display only; it is not meant to fly.

PROCEDURE:



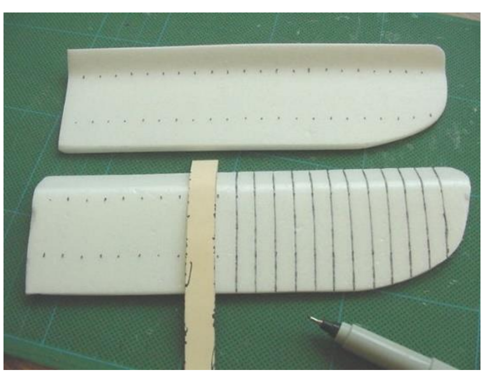
1. Carefully trace the wing and elevator shapes on the inside of two meat trays as shown. Be sure the front edges of the wings go about 2/3 of the way up the curved sides of the tray. Check the bottom of the tray and avoid any logo found there. Cut out the wings and elevator with the hobby knife or scissors. Use the emery board to smooth the cut edges and sand off the pen lines.



2. When finished you should have the parts as shown.

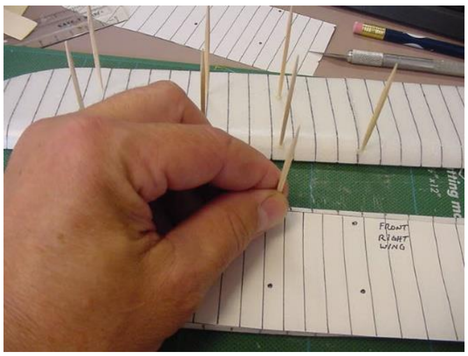
3. Use the emery board to smooth the edges. Make sure that the two halves of the upper and lower wings are flat where they will be joined, as shown at the lower right. Using an emery board to make joint line on wing half straight before gluing.

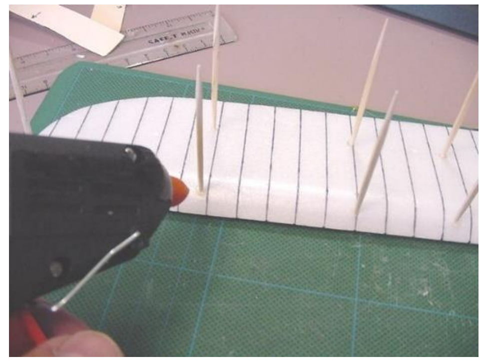
4. Using the template as a guide, take a black marker and mark the locations of the rib lines on the tops and bottoms of each wing and elevator section. Make two sets of marks, one on each edge. Connect the marks to make the rib lines. Use a permanent ultra fine black marker and a straight edge made from a manila folder (since it can be bent to conform to the rounded shape of the foam). Black lines, about one centimeter apart, are drawn across all wing surfaces.



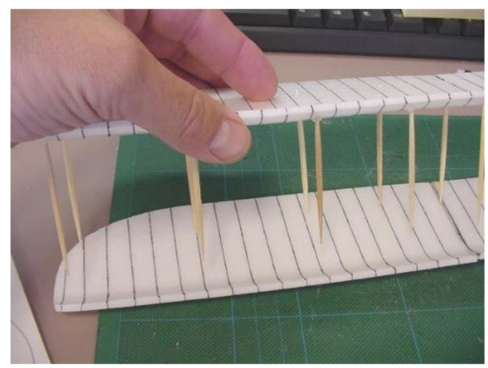
5. Place glue on the flat edge of the upper and lower wing halves and join each wing.

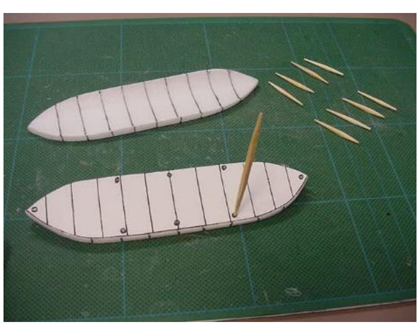
6. Use the wing template and a sharp toothpick to mark the holes for the spars on the top surface of the lower wing. Note that the front edges of the wings curve down. Dip toothpicks into glue and set them upright in the lower wing. Try not to push them all the way through the wing. Be sure they are straight and <u>let them dry.</u> Spars are glued into the lower wing.





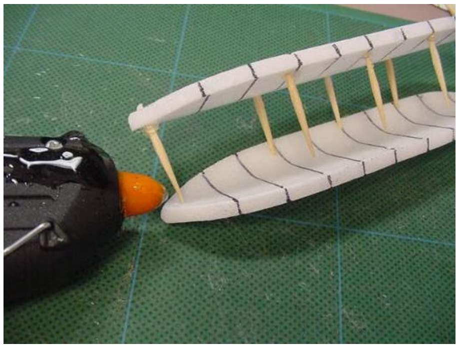
7. Now turn the lower wing upside down and insert the spars into the underside of the upper wing, doing the back row (away from the curved edge) first. Be sure each is vertical and add a little glue to hold each in place. Now tip the wing forward and insert the front row of spars, working from one end to the other. Again, try not to push them all the way through the wing. It takes some effort to get each in the right place and vertical. Add a dab of glue at the top of each spar to help secure them to the upper wing.





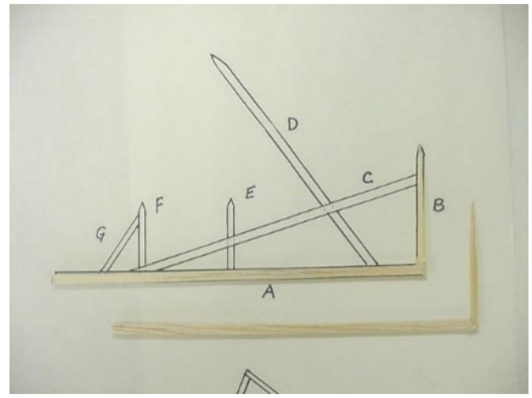
8. Cut eight toothpick sections, each 2.5 cm. in length, and sharpen the cut ends. Mark the locations for these spars on the upper surface of the lower elevator using the template just as you did previously with the wings.

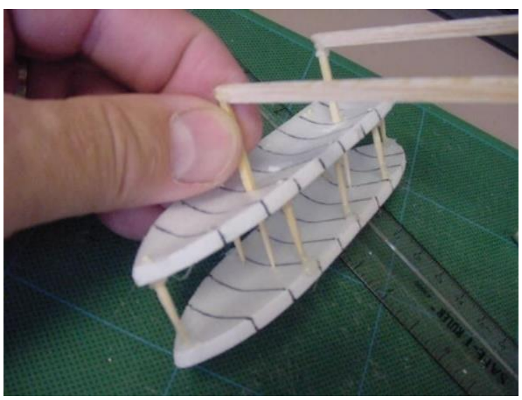
9. Set the eight short spars into the top surface of the lower elevator and add a bit of glue to each at the base as shown.



10. Turn this over and insert the spars into the underside of the upper elevator, doing the back row first and then the front, trying not to go all the way through the foam. Anchor with glue.

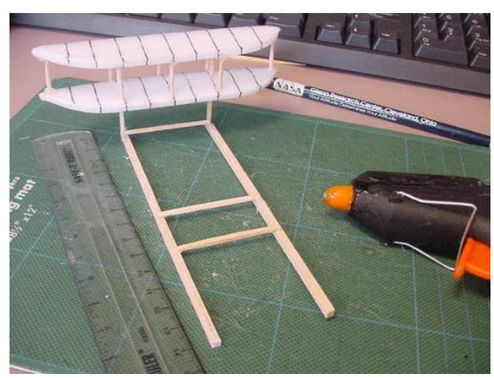
11. Print the file "1903 skid template". Cut a 14 cm. piece of balsa wood "A" and lay it on the template. Cut the right end at a 45-degree angle. Cut a toothpick "B" to a length of 4.5 cm., with the cut end also being at a 45-degree angle. Glue the toothpick to the balsa to form a 90-degree angle as shown. Repeat this step to make a second skid.

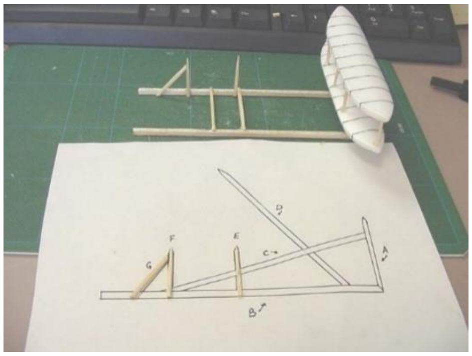




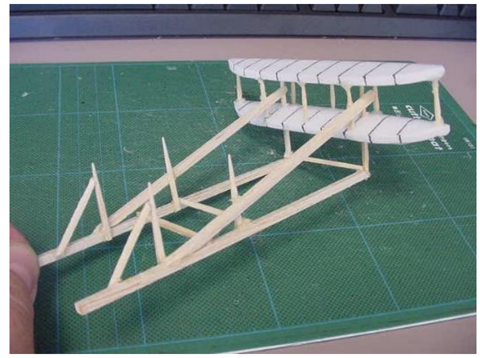
12. Turn the elevator assembly over and poke a hole through the lower elevator midway between the front and rear spars of the pairs next to the center pair of spars. Push the top of the skid assembly "A" through the hole just made, add a bit of glue, and then stick the skid into the upper elevator. Repeat with the second skid as shown.

13. Cut the pointed ends off three toothpicks so that they are 4.5 cm. in length and place them as cross-braces across the skids as shown, one at the right angle, one at 7 cm. from the right angle, and one at 9 cm.

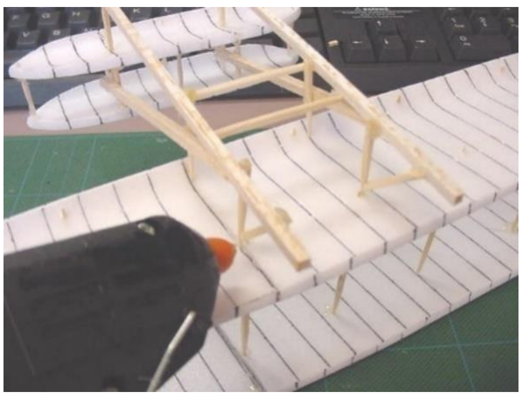




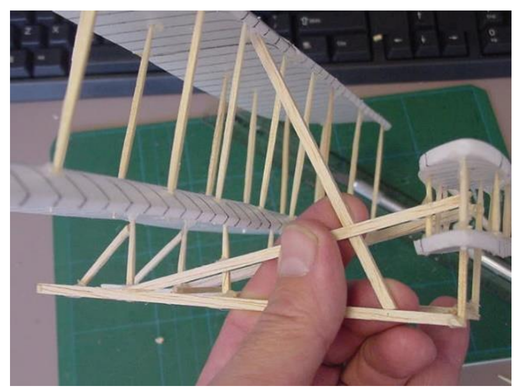
14. Cut 2 toothpicks to a 3 cm. length. Glue them to the skid as shown on the template at "E" and "F", pointed ends up. Now measure and cut another toothpick as the rear brace "G" and glue it in place. Repeat Step 14 for the second skid.



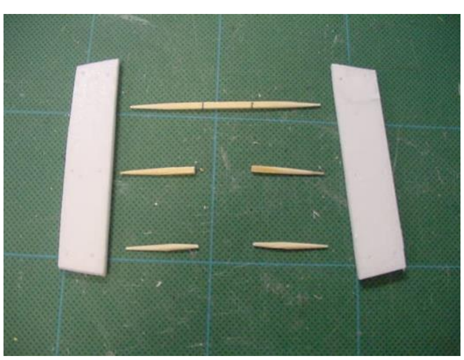
15. Now cut 2 balsa braces "C" to go from rear skid support up to elevator support. Glue them in place as shown.



16. Turn the wing assembly over and press the skid assembly into the center of the lower wing as shown. Be sure the elevator projects out from the curved edge of the wing. Try to keep the toothpicks from going through the foam. Add some glue to each support.

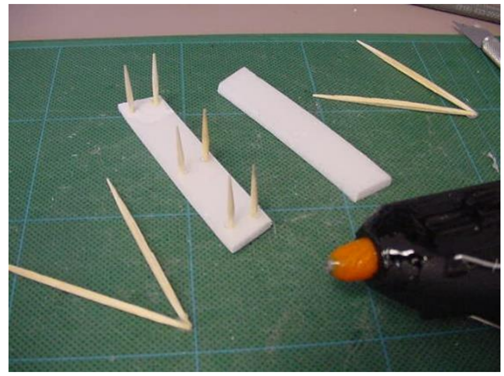


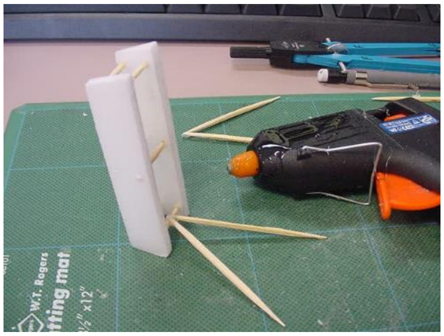
17. Cut two 10 cm. pieces of balsa "D" (see template) and sharpen one end. Glue one end under the leading edge of the upper wing between the center and next-to-center spar and then glue the other end to the bottom skid. Repeat on the other side of the skid.



18. Six 2 cm. rudder braces are needed. Cut them from three toothpicks as shown and sharpen the cut ends.

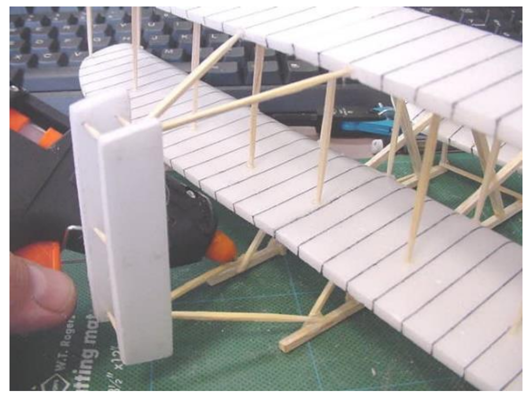
19. Dip the braces in glue, insert them into the rudder as shown here, and then turn the assembly over and insert it into the other rudder. Add more glue for support. To attach the rudder to the flyer, make two sets of V-shaped braces by gluing together two toothpicks as shown.



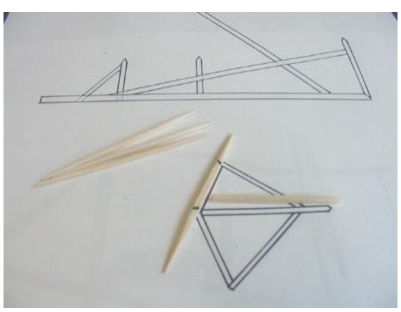


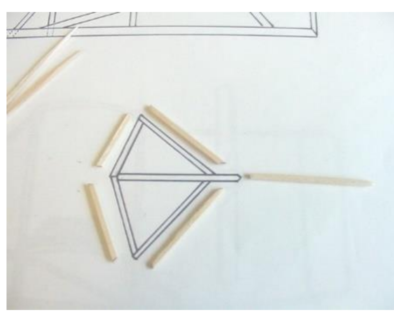
20. Glue the V-shaped braces to the rudders as shown. Once the glue is set, turn this over and glue on the other brace.

21. Stick the upper brace ends into the rear edge of the upper wing as shown and add a spot of glue. (If the wing is thin, glue the brace under the wing.) Now glue the ends of the lower brace to the rear of the skid so that the rudder is vertical.

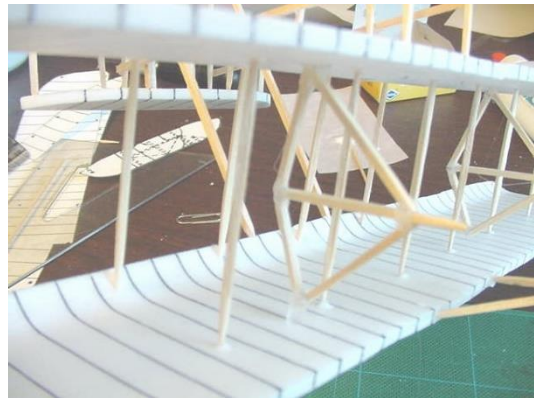


22. To make the propeller supports, use the template and mark and cut 5 toothpicks for each. Try to keep the assembly flat as it is glued. Measuring pieces of toothpick on template to make propeller support.



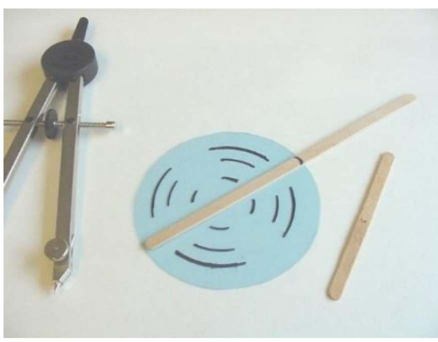


23. When dry, glue each propeller support to the lower wing 5.5 cm. from the center, in line with the back struts. Turn the Flyer over and glue to the top wing so that the support is vertical. Extra hot melt glue may be added to fill in any gap.



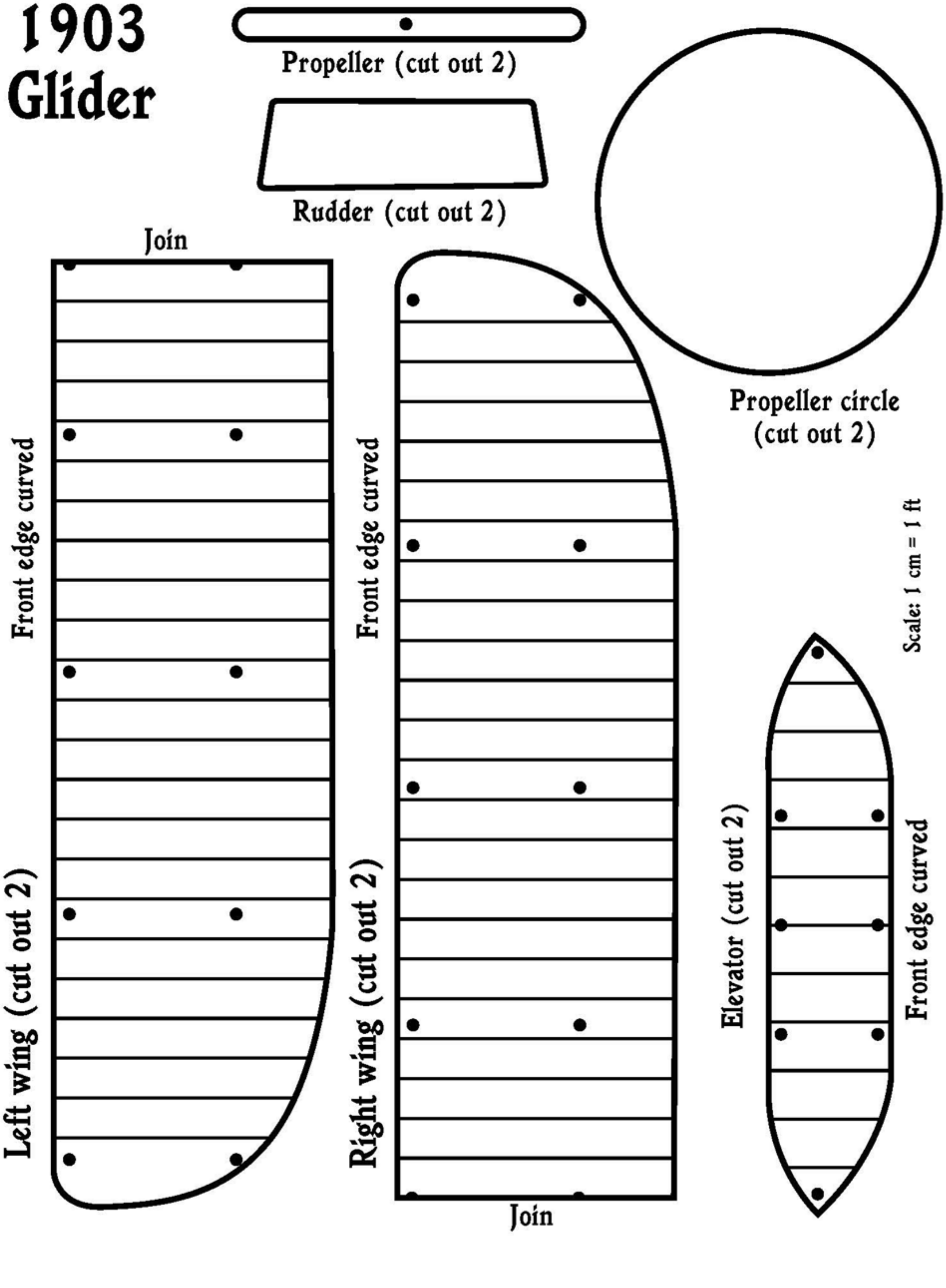
24. Simulate the small engine by gluing two 2 cum. x 3 cm. pieces of foam together and then adding a 1 cm. x 3 cm. piece on top. Trace and cut a circle with a penny or dime, cut out, and then glue on the end of the engine. Glue the engine onto the lower wing just to the right of center.

25. To simulate a turning propeller trace and cut two 7.2 cm. circles out of clear plastic, such as a piece of a blank overhead transparency. Use a black marker to draw pieces of smaller circles. Enlarge the small hole in the center of each circle with a toothpick.



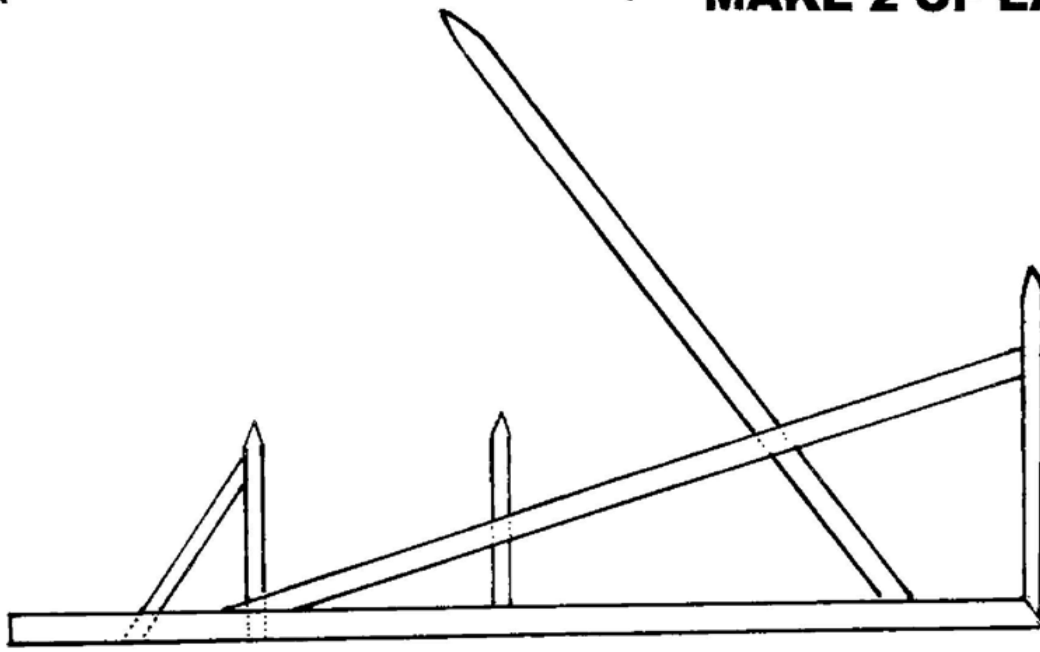
From a thin craft stick or Popsicle stick cut a piece the diameter of the plastic circle, round the cut edge, and poke a hole in the center. Make two of these. Mount the plastic circle and then the propeller on the end of the propeller support and add glue. Repeat on the other side.

1903 Glider


Propeller (cut out 2)
Rudder (cut out 2)
Propeller circle (cut out 2)
Join
Front edge curved
Left wing (cut out 2)
Front edge curved
Right wing (cut out 2)
Join
Scale: 1 cm = 1 ft
Elevator (cut out 2)
Front edge curved

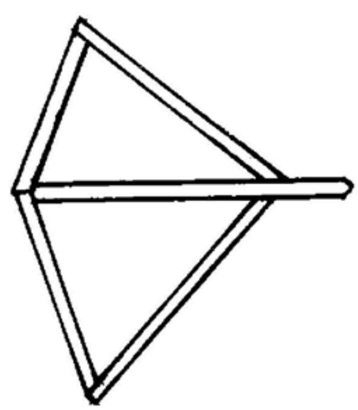
1903 SKIDS TEMPLATE

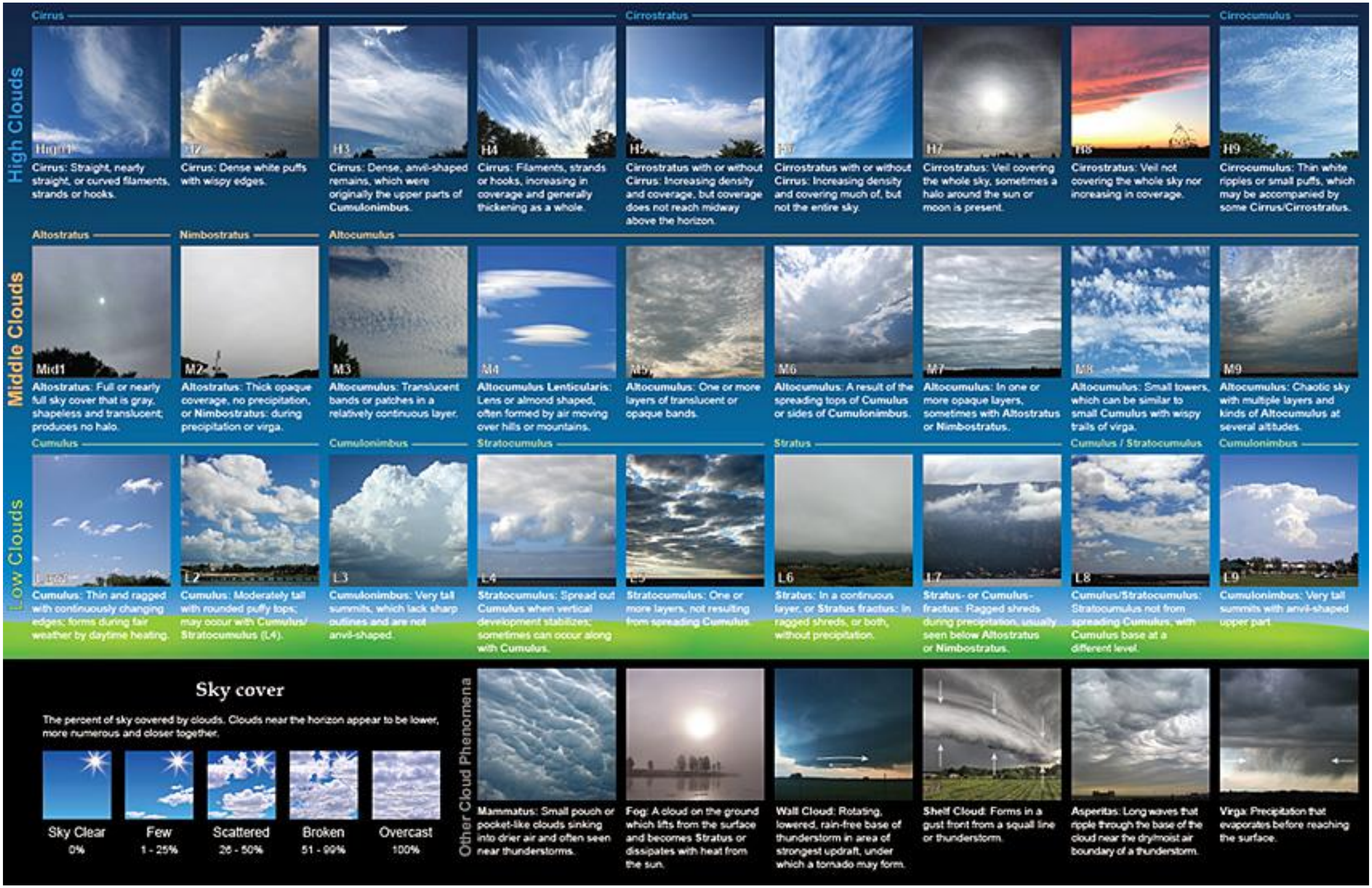
(3 LONG PIECES ARE BALSA) **MAKE 2 OF EACH**



1903 PROPELLER MOUNT TEMPLATE

MAKE 2 OF EACH




High Clouds
Middle Clouds
Low Clouds
Cirrus
Cirrostratus
Cirrocumulus
Cirrus: Straight, nearly straight, or curved filaments, strands or hooks.
Cirrus: Dense white puffs with wispy edges.
Cirrus: Dense, anvil-shaped remains, which were originally the upper parts of Cumulonimbus.
Cirrus: Filaments, strands or hooks, increasing in coverage and generally thickening as a whole.
Cirrostratus with or without Cirrus: Increasing density and coverage, but coverage does not reach midway above the horizon.
Cirrostratus with or without Cirrus: Increasing density and covering much of, but not the entire sky.
Cirrostratus: Veil covering the whole sky, sometimes a halo around the sun or moon is present.
Cirrostratus: Veil not covering the whole sky nor increasing in coverage.
Cirrocumulus: Thin white ripples or small puffs, which may be accompanied by some Cirrus/Cirrostratus.
Altostratus
Nimbostratus
Altocumulus
Altostratus: Full or nearly full sky cover that is gray, shapeless and translucent; produces no halo.
Altostratus: Thick opaque coverage, no precipitation, or Nimbostratus: during precipitation or virga.
Altocumulus: Translucent bands or patches in a relatively continuous layer.
Altocumulus Lenticularis: Lens or almond shaped, often formed by air moving over hills or mountains.
Altocumulus: One or more layers of translucent or opaque bands.
Altocumulus: A result of the spreading tops of Cumulus or sides of Cumulonimbus.
Altocumulus: In one or more opaque layers, sometimes with Altostratus or Nimbostratus.
Altocumulus: Small towers, which can be similar to small Cumulus with wispy trails of virga.
Altocumulus: Chaotic sky with multiple layers and kinds of Altocumulus at several altitudes.
Cumulus
Cumulonimbus
Stratocumulus
Stratus
Cumulus / Stratocumulus
Cumulonimbus
Cumulus: Thin and ragged with continuously changing edges; forms during fair weather by daytime heating.
Cumulus: Moderately tall with rounded puffy tops; may occur with Cumulus/Stratocumulus (L4).
Cumulonimbus: Very tall summits, which lack sharp outlines and are not anvil-shaped.
Stratocumulus: Spread out Cumulus when vertical development stabilizes; sometimes can occur along with Cumulus.
Stratocumulus: One or more layers, not resulting from spreading Cumulus.
Stratus: In a continuous layer, or Stratus fractus: In ragged shreds, or both, without precipitation.
Stratus- or Cumulus-fractus: Ragged shreds during precipitation, usually seen below Altostratus or Nimbostratus.
Cumulus/Stratocumulus: Stratocumulus not from spreading Cumulus, with Cumulus base at a different level.
Cumulonimbus: Very tall summits with anvil-shaped upper part.
Sky cover
The percent of sky covered by clouds. Clouds near the horizon appear to be lower, more numerous and closer together.
Sky Clear 0%
Few 1 - 25%
Scattered 26 - 50%
Broken 51 - 99%
Overcast 100%
Other Cloud Phenomena
Mammatus: Small pouch or pocket-like clouds sinking into drier air and often seen near thunderstorms.
Fog: A cloud on the ground which lifts from the surface and becomes Stratus or dissipates with heat from the sun.
Wall Cloud: Rotating, lowered, rain-free base of thunderstorm in area of strongest updraft, under which a tornado may form.
Shelf Cloud: Forms in a gust front from a squall line or thunderstorm.
Asperitas: Long waves that ripple through the base of the cloud near the dry/moist air boundary of a thunderstorm.
Virga: Precipitation that evaporates before reaching the surface.

Standards

Curriculum Guide 1: Introduction to Flight

Benchmarks:

SC.6. P.13.1 Investigate and describe types of forces including contact forces and forces acting at a distance, such as electrical, magnetic, and gravitational.

SC.6. P.13.3 Investigate and describe that an unbalanced force acting on an object changes its speed, or direction of motion, or both.

SC.7. P.11.2 Investigate and describe the transformation of energy from one form to another. **(AA) SC.7. P.11.3** Cite evidence to explain that energy cannot be created nor destroyed, only changed from one form to another.

MAFS.6.NS.1.1: Interpret and compute, quotients of fractions, and solve word problems involving division of fractions by fractions.

MAFS.6.RP.1.2: Compute unit rates associated with ratios of fractions in like or different units.

Curriculum Guide 2: Forces of Flight

Benchmarks:

SC.6. P.13.1 Investigate and describe types of forces including contact forces and forces acting at a distance, such as electrical, magnetic, and gravitational.

SC.6. P.13.3 Investigate and describe that an unbalanced force acting on an object changes its speed, or direction of motion, or both.

SC.7. P.11.2 Investigate and describe the transformation of energy from one form to another. **(AA) SC.7. P.11.3** Cite evidence to explain that energy cannot be created nor destroyed, only changed from one form to another.

MAFS.6.NS.1.1 Interpret and compute, quotients of fractions, and solve word problems involving division of fractions by fractions.

MAFS.6.RP.1.2 Compute unit rates associated with ratios of fractions in like or different units.

Curriculum Guide 3: Airfoil Design

Benchmarks:

SC.6. P.13.1 Investigate and describe types of forces including contact forces and forces acting at a distance, such as electrical, magnetic, and gravitational.

SC.6. P.13.3 Investigate and describe that an unbalanced force acting on an object changes its speed, or direction of motion, or both.

SC.7. P.11.2 Investigate and describe the transformation of energy from one form to another. **(AA) SC.7. P.11.3** Cite evidence to explain that energy cannot be created nor destroyed, only changed from one form to another.

MAFS.6.NS.1.1 Interpret and compute, quotients of fractions, and solve word problems involving division of fractions by fractions.

MAFS.6.RP.1.2 Compute unit rates associated with ratios of fractions in like or different units.

Curriculum Guide 4: Learn to code

Benchmarks:

SC.68.CS-CP.2.3 Develop problem solutions using a block programming language, including all of the following: looping behavior, conditional statements, expressions, variables, and functions.

SC.68.CS-CS.5.1 Describe how information, both text and non-text, is translated and communicated between digital computers over a computer network.

SC.68.CS-CS.6.4 Describe ways in which computers use models of intelligent behavior (e.g., robot motion, speech and language understanding, and computer vision)

SP.PK12.US.20.6 Work cooperatively in small groups to achieve common outcomes.

Curriculum Guide 5: Drone Dance/Ballet

Benchmarks

SP.PK12.US.1.4a Develop mathematical skills and/or computational fluency for everyday living, such as money skills, estimation skills, time and measurement skills, and comprehension of graphs, tables, schedules, and charts

SC.68.CS-CS.2.2 Solve real-life issues in science and engineering (i.e., generalize a solution to open-ended problems) using computational thinking skills

CTE-GEN.68.GENRL.17.14 Apply math, reading, science, and critical thinking skills as they relate to industry.

VA.912. C.1.2 Use critical-thinking skills for various contexts to develop, refine, and reflect on an artistic theme.

VA.912. S.2.3 Demonstrate visual-thinking skills to process the challenges and execution of a creative endeavor.

VA.68. F.1.1 Use non-traditional thinking and various techniques to create two-, three-, and/or four-dimensional artworks.

Curriculum Guide 6: Expression of Flight

Benchmarks:

VA.912. C.1.2 Use critical-thinking skills for various contexts to develop, refine, and reflect on an artistic theme.

VA.912. S.2.3 Demonstrate visual-thinking skills to process the challenges and execution of a creative endeavor.

VA.68. F.1.1 Use non-traditional thinking and various techniques to create two-, three-, and/or four-dimensional artworks.