National Aeronautics and
Space Administration

NASA Out-of-School Learning Network

Aeronautics

module

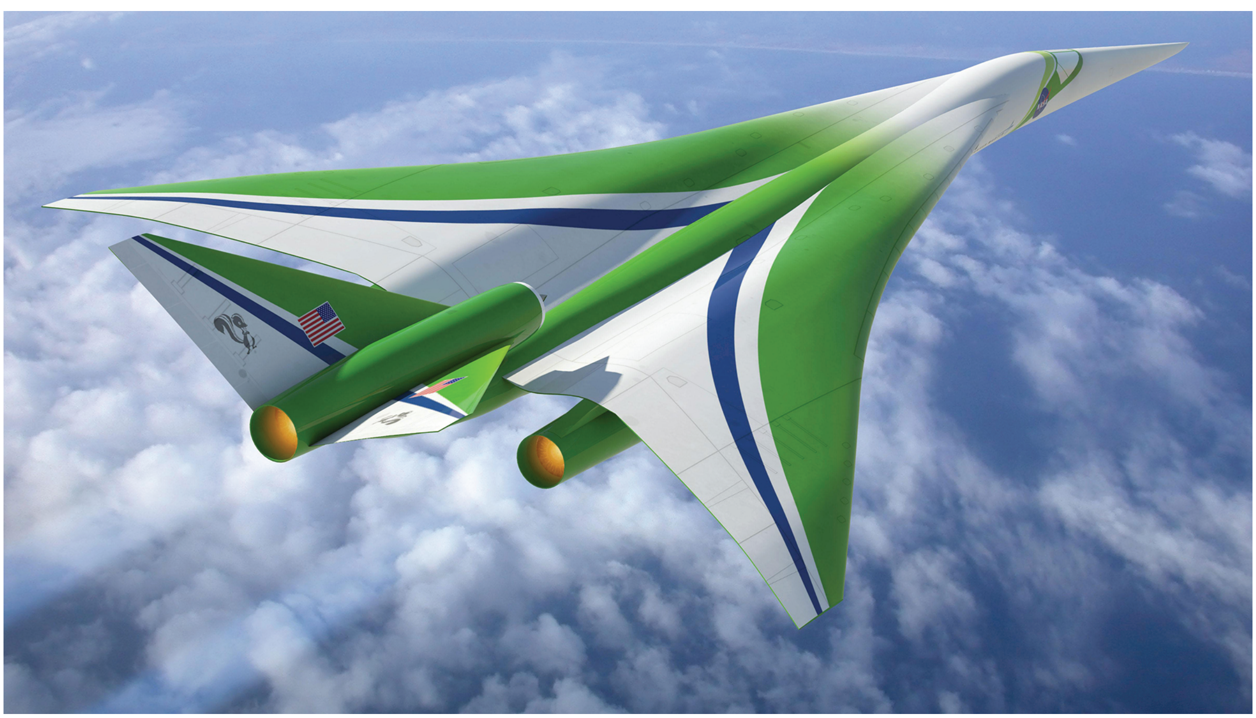


Table of Contents

Introduction

Activities

NASA Out-of-School Learning Network

The NASA Out-of-School Learning (NOSL) Network is designed to offer inquiry-based science, technology, engineering, and mathematics (STEM) learning experiences that connect students with NASA scientists, engineers, and mission-content-related activities. The NASA engineering design challenge: *Let It Glide* has been paired with the Aeronautics Module and is located on the NOSL Web site. The engineering design challenge allows students the opportunity to work through the engineering design process used by NASA scientists.

The complete module is designed to provide the student with an understanding of

- Newton's Third Law of Motion
- The engineering design process
- Interactions between the atmosphere and geosphere

Scope and Sequence

The Aeronautics Module covers the following Next Generation Science Standards for Earth Systems, Engineering Design, and Physical Science.

Next Generation Science Standards

Middle School Physical Science (MS–PS)

- MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.
- MS-PS2-1. Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.

Middle School Engineering Design (MS–ET)

- MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

Middle School Earth Systems (5–ESS)

- 5-ESS2-1. Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.

Disciplinary Core Ideas

- Defining engineering problems
- Developing possible solutions
- Optimizing the design solution
- Forces and motion
- Analyzing and interpreting data
- Constructing explanations and designing solutions

Science and Engineering Practices

- Asking questions and defining problems
- Developing and using models
- Analyzing and interpreting data
- Engaging in argument from evidence
- Planning and carrying out investigations
- Constructing explanations and designing solutions

Crosscutting Concepts

- Cause and effect
- Stability and change
- Systems and system models
- Influence of science, engineering, and technology on society and the natural world

Connections to the Nature of Science

- Scientific knowledge is based on empirical evidence

Connections to Engineering, Technology, and the Applications of Science

- Interdependence of science, engineering, and technology

BACKGROUND INFORMATION FOR FACILITATORS

Aeronautics—How Planes Fly

We see aircraft flying in the sky all the time. All kinds of propeller planes, jet planes, and helicopters soar, zoom, and roar through the air. Even though most of us think nothing about flying, knowing the science behind it helps us understand the marvels of air travel. The way airplanes fly may seem magical because we know planes weigh way too much to float; therefore, how can something so big and so heavy fly?

Four forces act on airplanes in order to achieve flight. A force is a push or a pull on something. A plane in the air is in the middle of a tug of war. The four forces of flight—lift, gravity, thrust, and drag—are pushing and pulling on it. Lift opposes gravity and thrust opposes drag. If you have ever flown a Frisbee, you have observed the four forces of flight. As a Frisbee flies through the air, lift holds it up. You give it thrust with your arm to move it forward. Drag soon overcomes the Frisbee's forward motion and slows it down, and gravity brings it back to Earth again. Wings keep an airplane up in the air, but it takes all four forces to make a plane fly. The four forces push planes up, down, and forward, or cause them to slow down. Let's take a look at each of the four forces to further understand their meaning.

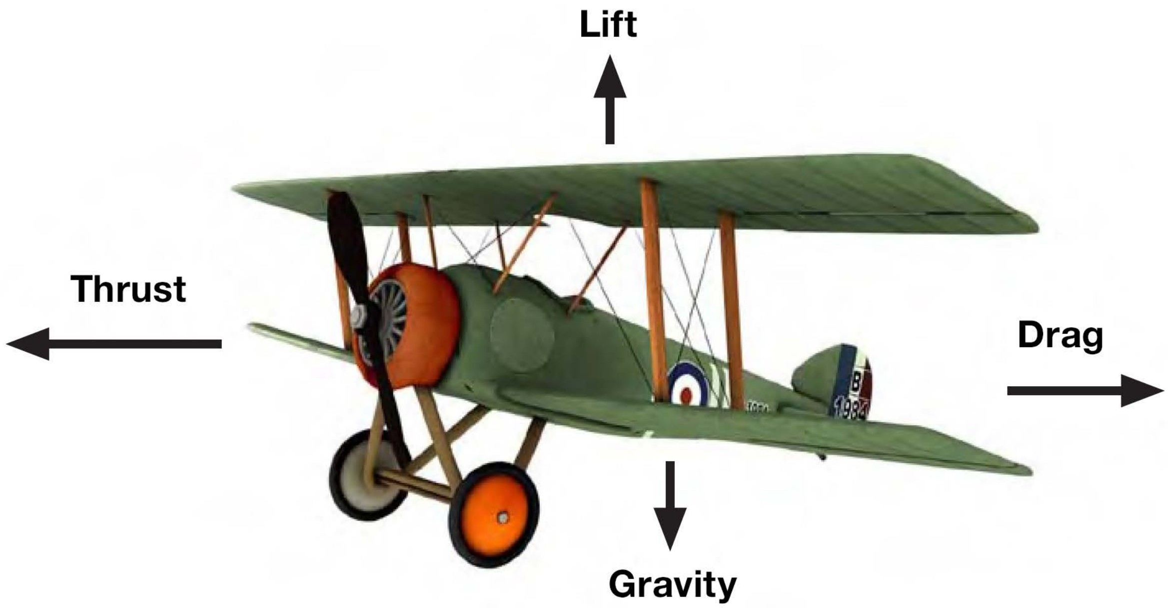
- Lift is the force that holds airplanes up in the air. Airplane wings create most of the lift.

- Earth's gravity is the force that pulls down on objects and gives them weight. All matter has weight. Weight means how heavy or how light an object is.

- Thrust is the force that moves aircraft forward. Propeller or jet engines usually provide thrust for airplanes, and your hand provides thrust when launching a paper airplane.

- Drag is caused by friction and differences in air pressure. You can experience drag by putting your hand out of a car window and feeling it pull back. Drag slows an airplane down so it can land.

The way each of the four forces act on airplanes makes planes do different things. As stated earlier, each force has an opposite force that works against it. When the forces are balanced, a plane flies in a horizontal direction. The plane goes up if the forces of lift and thrust are more than weight and drag. The plane goes down if weight and drag are greater than lift and thrust.



History of Aeronautics

In the mid-17th century, the Montgolfier brothers (who were French paper makers) began experimenting with paper bags after they noticed how smoke from a fire lifted pieces of charred paper into the air. They held the bags, open end downward, over a fire for a while and then released them. The smoke-filled bags moved quickly upward. Smoke, the brothers deduced, created a lifting force. Scientists would later explain that when air is heated, it becomes less dense, thus creating a buoyant or lifting force in the surrounding cool air.

On September 19, 1783, they put a sheep, a rooster, and a duck in a basket beneath a suspended cloth and paper balloon. Their balloon was 17 meters high and 12 meters in diameter. A fire was lit, and minutes later the balloon was filled with hot air. The brothers' balloon rose majestically to a height of more than 500 meters. The farm animals survived the ordeal and became the first living creatures carried upwards in a manmade device. The dream of flight became the reality of flight. Two months later on November 21, 1793, two volunteers stepped into the basket and flew for 8 kilometers over Paris, thus becoming the world's first aeronauts. Flying became practical in lighter-than-air devices, and balloon mania set in.

Throughout the 19th century, aeronauts experimented with hydrogen-gas-filled balloons and struggled to devise a method to control them. After another century of experimenting, the balloons became elongated and fitted with propulsion and steering gear. To escape the limitations of a floating craft, early researchers began the search for another, more exciting form of lift.

A small handful of dedicated pioneers were convinced that the future of human flight depended more on wings and less on smoke and hot air. One of these early pioneers had an intense interest in the flight of birds and became obsessed with ways those principles might be adapted to allow humans to experience flight. As early as 1796, Sir George Cayley, an Englishman, conducted basic research on aerodynamics by attaching bird feathers to a rotating shaft, thus building and flying a model helicopter. In 1804, he built and operated the world's first fixed-wing flyable model glider. This pioneering model used a paper kite wing mounted on a slender wooden pole. The tail was supported at the rear of the pole, which provided horizontal and vertical control. It was the first true airplane-like device in history.

In 1849, after years of extensive and persistent research, Cayley constructed his "boy glider." This full-sized heavier-than-air vehicle lifted a 10-year-old boy a few meters off the ground during two test runs. Four years later, Cayley persuaded his faithful coachman to get into another glider and become the first person in the world to fly a fixed-wing glider.

A German, Otto Lilienthal, believed that arched or curved wings held the secret to the art of flight. In his Berlin workshop, Lilienthal built test equipment to measure the amount of lift that various shapes of wings produced. His work clearly demonstrated the superiority of the curved wing. By 1894, Lilienthal's unpowered flying machines achieved spectacular glides of over 300 meters in distance. Lilienthal built a 1/2 horsepower carbonic acid gas engine that weighed 90 pounds. He was ready to begin powered glider experiments but unfortunately, Lilienthal was killed in an 1896 glider mishap. His extensive research and experiments in aviation brought the world closer to realizing the age-old dream of human flight.

In 1899, Wilbur and Orville Wright, brothers, began conducting research and studying methods on aeronautics that other experimenters had tried. They conducted hundreds of wind tunnel experiments, engine and propeller tests, and glider flights to gain the knowledge and skills needed to fly. On December 17, 1903, four years after beginning their research, the Wright Brothers changed the world forever. A fragile wooden airplane rose into the air from a windswept beach at Kitty Hawk, North Carolina, and flew a distance of 36 meters for 12 seconds. The brothers provided the world with a powered flying machine controlled by the person in the machine. Ingenuity, persistence, and inventiveness finally paid a big dividend—the Wright Flyer was successful. This historic event marked the beginning of real progress in the development of human-carrying, power-driven airplanes. By 1905, an improved Wright Flyer could fly more than 32 kilometers and stay up for almost 40 minutes.

Five years later, the first international air meet was held in Los Angeles, California. Glenn Curtiss set a new world's speed record of 88 kilometers per hour and Frenchman Louis Paulhan set an altitude record of 1,250 meters. By the beginning of World War I, airplanes could fly at speeds of over 200 kilometers per hour and reach altitudes of 7,500 meters. The Congress of the United States recognized that a new era in transportation was beginning and the changes would have significant impact on human interaction, commerce, foreign relations, and military strategy.

Flight research in the United States got a significant boost in 1915 when the National Advisory Committee for Aeronautics (NACA) was formed by Congress "to supervise and direct the scientific study of the problems of flight, with a view to their practical solutions." By the 1930s, NACA wind tunnels and flight test investigations led to improvements in aircraft safety and performance. Research produced new airfoils (wing shapes) and propeller designs that increased the safety and efficiency of airplanes. New engine cowlings and streamlined aerodynamics reduced drag and increased aircraft speed.

Today NACA's successor, the National Aeronautics and Space Administration (NASA), has a much broader mission. As its name implies, NASA continues research to keep aviation on the cutting edge of technology for airfoils, materials, construction techniques, engines, propellers, air traffic control, electronics, efficiency, and safety. NASA is striving to make airplanes more environmentally friendly by lowering the sonic boom for aircraft traveling at supersonic speeds and developing propulsion systems that use pollutant-free fuel.

Four Forces
of Flight

Grades 6 to 8

INQUIRY-BASED ACTIVITY

activity

FOUR FORCES OF FLIGHT

Grades: 6 to 8   Prep Time: 1 hour   Activity Time: 2 hours

About This Activity

In this activity, which was taken from the NASA Courage to Soar educator guide, students will do simple experiments to become familiar with the four forces of flight.

Next Generation Science Standards

MS-PS2-1. Apply Newton's Third Law of Motion to design a solution to a problem involving the motion of two colliding objects.

MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

Learning Objective

Learners will

- Conduct a series of activities to gain an understanding of the four forces of flight

Materials

- Student handouts (1 set per group)

Paper Shape activity

- Notebook paper
- 1 golf ball

Chin Ups activity

- 1 piece of 15.2- by 5-cm (6- by 2-in.) paper or 1/4 sheet of notebook paper

Paper Pull activity

- 2 strips of 5- by 30.5-cm (2- by 12-in.) paper

Flow Away activity

- Strong plastic cup (10 to 12 ounce size)
- 3 pieces of 25.4-cm (10-in.) long string
- Container of water
- Dishpan
- Hole punch
- Scissors
- Masking tape

It's a Drag activity

Note: this activity should be performed close to a sink to make cleanup easier between groups.

- One tall clear container with a wide mouth
- Tongs or other device to retrieve clay shapes from corn syrup
- Enough clear corn syrup to fill 3/4 of the container
- Modeling clay
- Balance scale (optional)
- Stopwatch
- Pencil and paper

Procedure

Preparation Steps

Step 1

Find a location where you can set up five different activities with materials needed for each. Label the stations by their names but do not put which force of flight is being demonstrated.

Step 2

Distribute copies of the student handouts, give students time to read them, and discuss the reading with students.

Step 3

Explain to students that they will be conducting activities on gravity, thrust, lift, and drag. Assign them to groups of four and designate a leader, recorder, reader, and scientist. Explain the job descriptions as follows and let students know they will be switching jobs at each station:

- The leader makes sure that all directions are followed correctly.
- The recorder records all group information including filling out the student handouts.
- The reader reads the text of the activity.
- The scientist conducts the activity.

Step 4

Explain that each group will start at one station and rotate around to all the other stations. Have the recorders write down the names of the reader, the leader, and the scientist for each station on the student handout.

- Time is limited to about 15 minutes per station, therefore they need to work quickly.
- After the reader reads the problem, have the group discuss and predict what will happen. Remember that the prediction is a good guess. The recorder will write down the prediction on the student handout. The reader will read the procedure as the scientist performs each step.
- After all steps are completed, the group should discuss the results and the conclusion. The leader should help the group come to a final answer and the recorder will add the data to the student handout.
- Explain the procedure for moving to the stations. Students may move freely as they finish a station or students need to wait for a signal from the instructor before moving to the next station.

Step 5

Assign a beginning station to each group. Keep track of time and monitor each station, assisting as needed. Allow longer periods of time at each station if needed.

Step 6

When all groups are finished, discuss the results and conclusions of each activity, and make sure that they understand the principles of the four forces.

Preparation for Stations

Paper Shape activity (gravity)

Step 1

Label station.

Step 2

Have 1 sheet of paper for each group and 1 golf ball.

Chin Ups activity (lift)

Step 1

Label station.

Step 2

Have 1 sheet of 15.2- by 5-cm (6- by 2-in.) paper or 1/4 sheet of notebook paper for each group.

Paper Pull activity (lift)

Step 1

Label station.

Step 2

Have 2 strips of 5- by 30.5-cm (2- by 12-in.) paper for each group.

Flow Away activity (thrust)

Step 1

Label station.

Step 2

Punch three equally spaced holes around the top of the cup.

Step 3

Thread and knot each piece of string through a hole so that the cup can be suspended and balanced. Then tie the three strings together to use the knot as the handle.

Step 4

Use the scissors to punch a hole where the side of the cup intersects the bottom. Seal the hole with masking tape.

Step 5

Have a container of water at the station to refill the cup after use.

It's a Drag activity (drag)

Step 1

Label station.

Step 2

Fill the tall glass or clear container 3/4 full with corn syrup and mark the outside of the container to show the fill line.

Step 3

Divide the modeling clay into equal size pieces. Each group will need 4 pieces of clay. Use the balance scale to make sure all the pieces weigh the same.

Step 4

Place a pair of tongs and extra corn syrup at the station for students to use.

Illustrations by Media Fusion

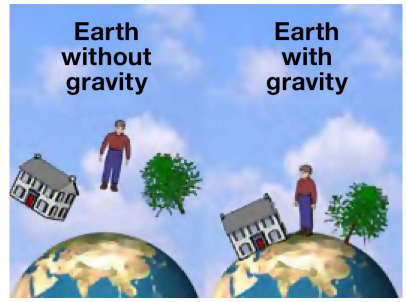
Suggestions for Differentiation

Below are additional strategies to differentiate instruction depending on student readiness.

Support:
Conduct the activities as demonstrations and have students fill out student handout.

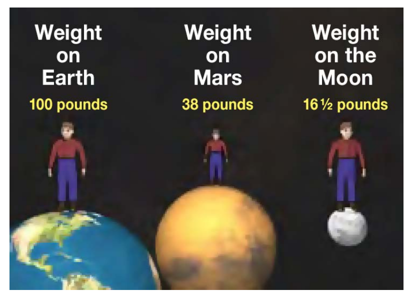
Complexity:
Have students develop their own activities that demonstrate the four forces of flight.

The Pull of Gravity



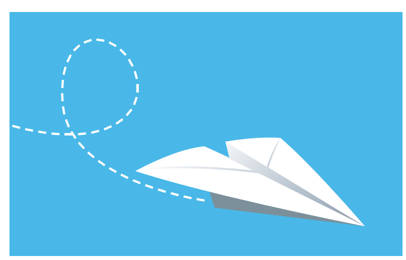
A force is a push or a pull. Gravity is the natural force that pulls objects toward Earth. If the Earth did not have gravity, we would float into space. Some people compare Earth's gravity to a huge magnet. Unlike a magnet that attracts only iron, Earth's gravity attracts all objects to the ground. Gravity is also the force that gives objects weight. If the Earth had no gravity, we would have no weight.

All matter has gravity—even you, but you do not have enough mass to produce enough pull. Huge masses like the Earth have a strong pull. In fact, the more mass an object has, the stronger the pull. Earth's pull of gravity is so strong that it can hold the Moon in orbit. The Sun's pull of gravity is even stronger and holds all planets in orbit.



Gravity gives everything weight. An object's weight is a measure of the force of Earth's gravity on it. The greater the force of gravity on an object, the more it weighs. Sometimes this is hard to understand. No matter where we are in the universe, we still have the same mass, but we will not have the same weight. Remember, the more mass an object has, the stronger the pull. Earth has 6 times the mass of the Moon. So, its gravity is 6 times greater than the Moon. If you weigh 100 pounds (45.3 kilograms) on the Earth, you will weigh about 16.5 pounds (7.5 kilograms) on the Moon.

Thrust



Wings give an airplane lift, but wings cannot make a plane go forward. Thrust is the force that moves an airplane forward. Thrust affects how fast and how far you go. When you throw a paper airplane forward, you are providing the thrust. Birds flap their wings to create thrust.

In airplanes thrust is usually provided with propellers or a jet engine. When planes use propellers, engines (usually piston engines) turn the propellers at very high speeds. A propeller plane has a set of two or more small rotating wings. Like a fan, the propellers pull air in and push it out in the opposite direction. Jet airplanes use jet engines to pull air in and mix it with fuel. Then the burning gas goes out the back and pushes the plane forward. Newton's Third Law of Motion states, "For every action there is an equal and opposite reaction." In both kinds of engines, air is pulled in and then pushed out in the opposite direction. When the air pushes backward, the plane is pushed forward.

Drag

Look at the opposing forces at work on a plane again. Gravity works against lift and drag works against thrust. Drag is the resistance of the airplane to forward motion. It wants to hold a plane back. You can feel a force pushing on you when you ride in a car and put your arm and hand out the window. As the car drives down the road, the force of the air pushes your arm backward. Your arm is creating drag.

Drag is caused by air pushing against the airplane and is called air resistance. As an airplane moves through the air, it collides with air molecules that must go around the plane. The air "rubbing" against the metal of the plane is one way drag slows the airplane down. The shape of the plane can create more or less drag. A streamlined plane has less drag and moves through the air more easily because its shape allows the air to flow easily over it. A bulky shaped plane has more drag because air cannot flow easily over it.

Lift

Lift is the force that holds the airplane in the air and directly opposes the weight of an airplane. Lift is generated by every part of the airplane, but most of the lift is generated by the wings. Lift is a mechanical aerodynamic force produced by the motion of the airplane through the air. Because lift is a force, it is a vector quantity, having both a magnitude and a direction associated with it. The magnitude of the lift depends on several factors including the shape, size, and velocity of the aircraft. Lift acts through the center of pressure of the object and is directed perpendicular to the flow direction.

Record the name of the person who performs each task for all five activities.

Station Number	Reader	Scientist	Leader	Recorder
1				
2				
3				
4				
5				

Answer the questions related to each station before you move to another station. Read the information about the four forces of flight with your team and determine the force being demonstrated in each activity.

Paper Shape activity

Problem

What will happen when you drop a sheet of paper and a golf ball from the same height at the same time? What will happen if you crumple the sheet of paper and repeat the drop?

Prediction

How will the sheet of paper fall in comparison to the golf ball? ______________________________

How will the crumpled paper fall in comparison to the golf ball? ____________________________

Procedure

1. Drop the sheet of paper horizontally and the golf ball from the same height at the same time. Record your observation below.
2. Crumple the sheet of paper into a tight ball.
3. Drop the golf ball and the crumpled paper from the same height at the same time. Record your observation below.

Observation

Compared to the golf ball, the sheet of paper fell ____

Compared to the golf ball, the crumpled paper fell ______________________________________

Conclusion

This happened because ____

Which force of flight was demonstrated? _________________________________

Chin Ups activity

Problem

What will happen when you blow across the top of a piece of paper held against your chin?

Prediction

The paper will ______________________________

Procedure

1. Hold the piece of paper under your lip against your chin with one finger. Make sure that most of the paper is hanging over your finger.
2. Blow across the top surface of the paper.

Observation

The paper ______________________________

Conclusion

This happened because ______________________________

Which force of flight was demonstrated? ____________________

Paper Pull activity

Problem

What will happen to two long strips of paper when you blow air between them?

Prediction

The strips of paper will ______________________________

Procedure

1. Hold a strip of paper in each hand about 5 cm (2 in.) apart between thumb and forefinger.
2. Blow between the pieces of paper and observe what happens.

Observation

The strips of paper ______________________________

Conclusion

This happened because ______________________________

Which force of flight was demonstrated? ____________________

Flow Away activity

Problem

What will happen to a cup filled with water that is suspended from a string when you open a hole in the side of the cup?

Prediction

The cup will ____

Procedure

1. Fill the cup with water and hold it over the dishpan so no water will get on the floor.
2. Carefully remove the tape.

Observation

The cup ____

Conclusion

This happened because ____

Which force of flight was demonstrated? ______________________________

It's a Drag activity

Problem

What will happen to pieces of modeling clay of the same mass but different shapes when they are dropped into a bottle of corn syrup?

Prediction

The ____________________________ shape will drop the quickest.

Procedure

1. Form various shapes with the four pieces of clay ranging from very streamlined like a pencil to more bulky shapes like a teardrop, a cube, a sphere, or a rectangular prism. Draw a sketch of your shape in the table on the back.
2. Drop the shapes, one at a time, into the bottle of corn syrup and time how long it takes each shape to fall to the bottom of the container. Record each time on the table on the back.
3. Retrieve the shapes with the tongs and discard as directed by your instructor. Make sure the container is still filled to the line. If not, add more corn syrup.

Observation

The ______________________________ shape dropped the quickest.

Conclusion

This happened because ____

Which force of flight was demonstrated? _________________________________

Shape	Time, sec

Wind in Your Socks

Grades 6 to 8

INQUIRY-BASED ACTIVITY

activity

WIND IN YOUR SOCKS

Grades: 6 to 8 Prep Time: 0.5 hour Activity Time: 1 hour

About This Activity

In this activity, which was taken from NASA Aeronautics: An Educator's Guide, students will make and use a wind sock to measure wind direction and relative speed.

Background

A wind sock is a type of kite that is used to detect wind direction. It is a tapered tube made from flexible material or cloth that is held open at one end by a stiff ring. Wind blows into the larger open end and through the tube, and causes the narrow end to point in the same direction. Brightly colored wind socks are used at airports to help pilots determine the wind direction along the ground, and meteorologists use wind direction to help predict the weather.

Next Generation Science Standards

5-ESS2-1. Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.

Learning Objective

Learners will

- Make a wind sock and measure wind direction and relative speed
- Demonstrate how wind is affected by geospherical elements by using different shaped objects representing land masses

Materials

- 8.5- by 11-in. copy paper
- 28- by 28-cm tissue paper
- Glue
- Transparent tape
- Scissors
- Hole punch
- Paper clip
- Metric ruler
- 1.2-m kite string
- Compass
- Wooden dowel 5 cm (1/8 in.) round by 1 m long
- Large boxes or other shapes to represent land masses
- Hole reinforcements (optional)
- Student handouts

Procedure

Step 1

Cut the tissue paper into 28- by 28-cm squares before beginning the activity for each student making a wind sock.

Step 2

Explain to students that they will be making a wind sock that will demonstrate wind direction and relative speed. Explain that winds are named for the directions from which they blow (south, north, east, and west). For example, a north wind blows from a northerly direction.

Step 3

Fold an 8.5- by 11-in. piece of paper so the long edges meet in the middle. The paper will be used to make the border strip for the wind sock.

Step 4

Form the strip of paper into a loop and tape the ends together. Mark the letter A on the outside (Fig. 1).

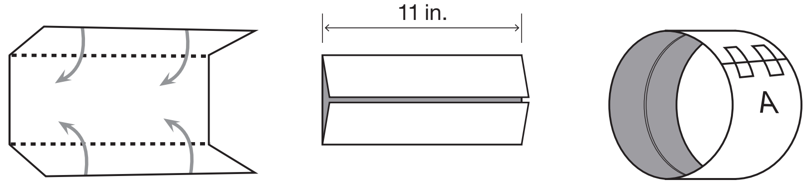


Figure 1

Step 5

Draw a 4-cm line from one edge across the tissue paper. Mark the 4- by 28-cm area with the letter B (Fig. 2).

Step 6

Beginning along one end of the line drawn in Step 5 above, measure and mark a point 3 cm from the edge. Continue marking points along the edge every 3 cm as shown in Figure 2.

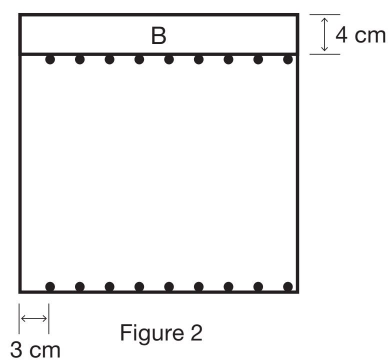


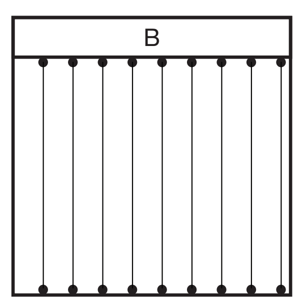
Figure 2

Step 7

Repeat Step 6 to mark points along the opposite end of the tissue paper.

Step 8

Using the points, draw a series of lines on the tissue paper. With scissors, cut along these lines to make strips (Fig. 3).



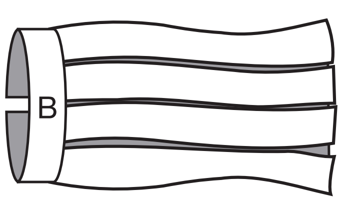


Figure 3

Step 9

Glue edge B of tissue paper to edge A of the loop strip made in step 4 (Fig. 4). Allow time for the glue to dry.

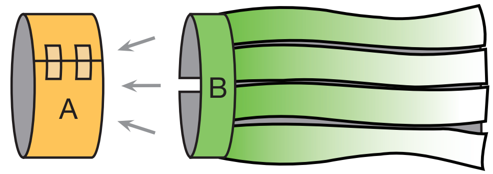


Figure 4

Step 10

Punch three equally spaced holes around the paper ring as shown in Figure 5.
Note: hole reinforcements can be used.

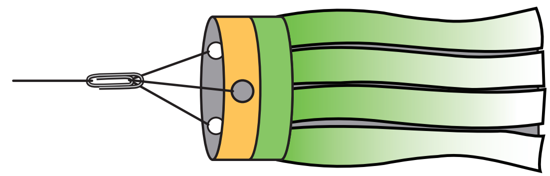


Figure 5

Step 11

Cut three pieces of 30-cm-long string. Tie one end of each string to the holes in the wind sock.

Step 12

Tie the 3 loose ends of the string to a single paper clip. Add another 30-cm piece of string to the paper clip.

Step 13

Test the wind sock by holding the single string in front of a fan. The fan simulates the wind, and the wind sock should point in the direction the wind flows.

Step 14

Explain to students that wind is affected by geographical elements. When wind interacts with mountain regions it travels up the side of the mountain on the windward side and over the top and down on the leeward side. Changes in wind direction are very important to pilots because different land masses have different effects on wind speeds and direction.

Step 15

Have students place various sized objects between their fan and wind socks to demonstrate how land masses can affect winds and record their observations.

Step 16

Tape the wind sock to a wooden dowel as shown in Figure 6 and take it outside. This wind sock speed gauge is a way to measure general speeds (not actual speeds). Use the compass to mark north, south, east, and west below the wind sock to help determine wind direction.

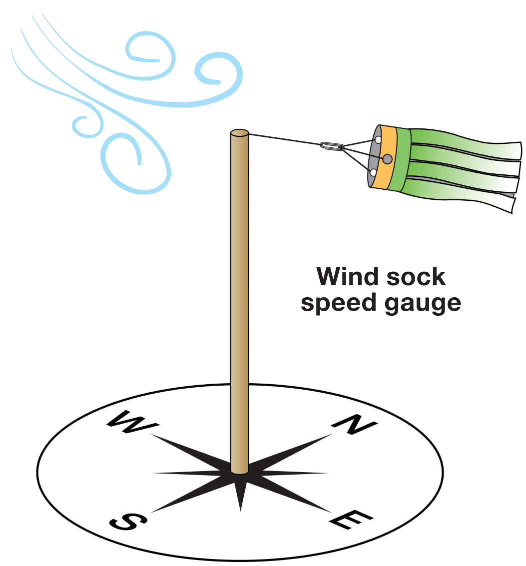


Figure 6

Suggestions for Differentiation

Below are additional strategies to differentiate instruction depending on student readiness.

Support:
Make one wind sock for the class and use it to record data on the student handout.

Complexity:
Have students make a more weather-resistant wind sock from nylon fabric or a plastic garbage bag.

Name: ____________________________

Using your wind sock, record the following information. Color the charts to show the correct wind strength and directions.

Day:

____

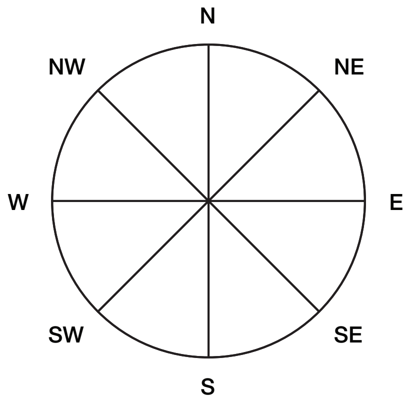
Time:

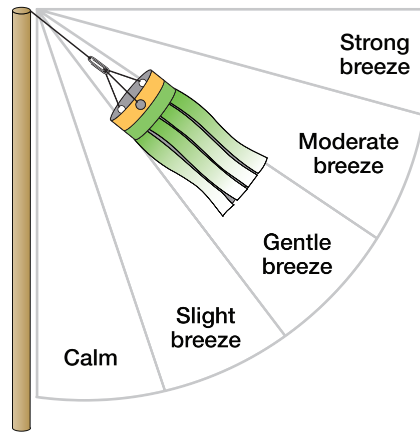
____

Weather conditions:

____

____





1. How does the weather affect the wind strength and wind direction?

____

____

2. What does the wind sock do in the wind?

____

____

3. What are some ways wind socks can be used?

____

____

4. What did you observe when you placed the smaller objects between the fan and the wind sock?

____

____

5. What did you observe when you placed the larger objects between the fan and the wind sock?

____

____

6. How did the various land mass shapes affect the wind strength and direction?

____

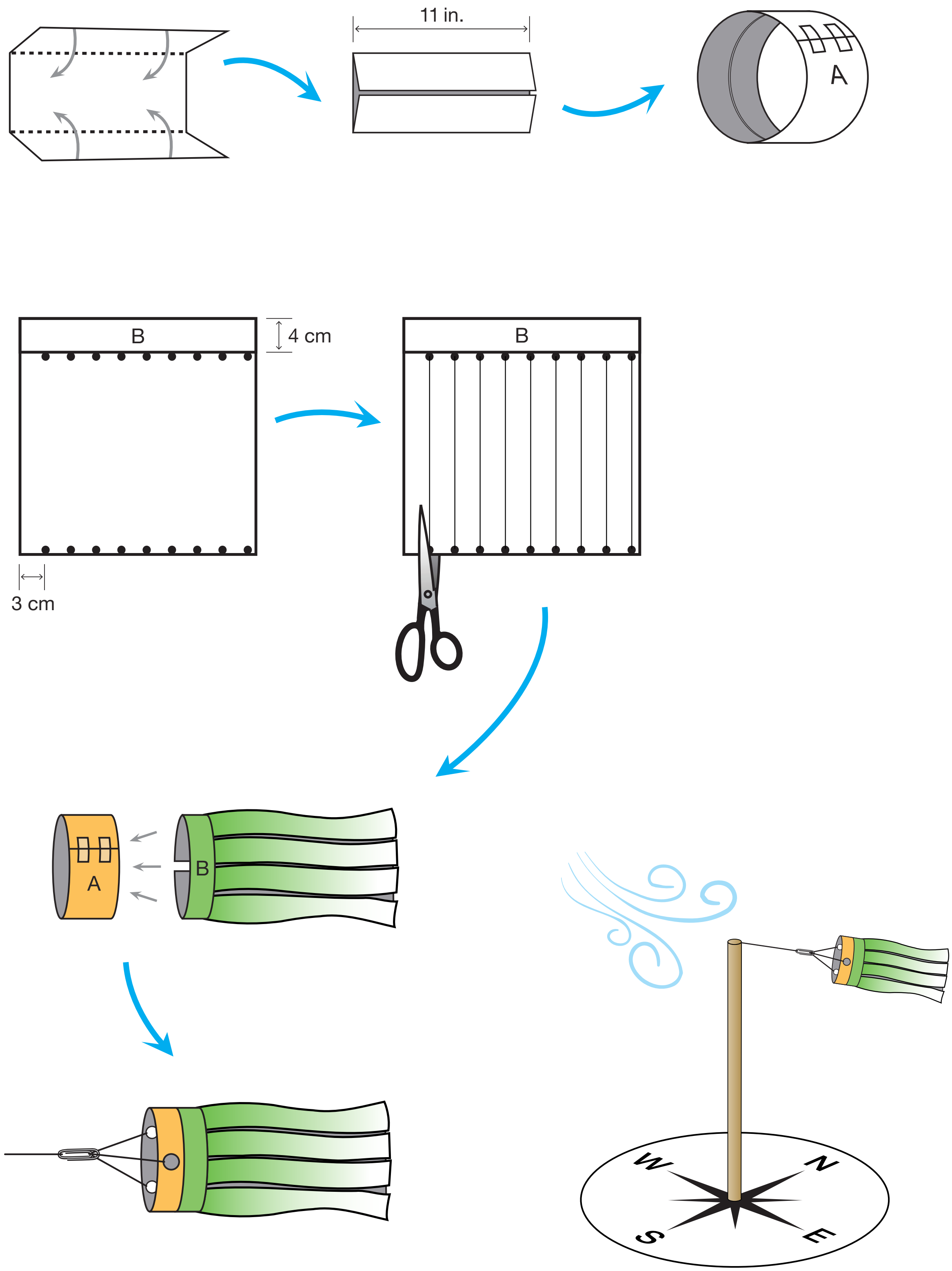
____

7. Why do pilots need to know about geographical features when they fly a plane?

____

____

How to Build a Wind Sock



Overcoming Gravity

Grades 6 to 8

INQUIRY-BASED ACTIVITY

activity

OVERCOMING GRAVITY

Grades: 6 to 8   Prep Time: 0.5 hour   Activity Time: 1 hour

About This Activity

In this activity, which was taken from the NASA "Why?" Files: The Case of the Challenging Flight, students will perform an activity to test the effect of weight on thrust.

Next Generation Science Standards

MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

Learning Objective

Learners will

- Construct a model and test the effects of weight on thrust

Materials

- Round balloon (7- or 9-in. when blown up)
- Balloon pump
- Masking tape
- Clothespin
- Straw
- Small paper cup (3-ounce size)
- String, long enough to reach from the floor to the ceiling
- Scissors
- Paper clips
- Hole punch
- Student handouts
- Pencil
- Safety goggles
- Tape measure or meter stick

Background

The four forces of flight—gravity, lift, drag, and thrust—are properties that affect how objects move through the air. The forces cause objects to move up or down and faster or slower. The balance of these forces changes how objects move through the air.

Every object on Earth has weight. Weight is the result of gravity pulling on the mass of an object. On Earth, the force of gravity is equal to 9.8 m per second squared (9.8 m/s^2). For an aircraft to fly a force needs to push it in the opposite direction of gravity. The weight of an object controls how much force is needed. A kite needs a lot less of a push than an aircraft.

Lift is the force that is the opposite of weight and the push that lets something move up. Everything that flies must have lift. For an aircraft to move upward, it must have more lift than weight.

Drag is the force that slows something down and makes it hard for objects to move.

Thrust is the force that is opposite of drag. Thrust opposes gravity and creates lift to push an aircraft upward and forward when it takes off from the runway. For an aircraft to keep moving forward, it must have more thrust than drag. A small airplane could get its thrust from a propeller while a larger airplane gets its thrust from jet engines. Because gliders do not have thrust, they can only fly until drag causes them to slow down and gravity pulls them toward land.

Procedure

Step 1

Before the students are ready to test, introduce the lesson by reviewing the background material. Note: a doorframe can be used instead of the ceiling to test their devices.

Step 2

Divide the students into groups of three or four.

Step 3

Measure the distance from the ceiling to the floor. Note you will be measuring the distance from the floor to how high your balloon rises. Try to do this step close to a wall or door so you can secure a tape measure near the string.

Step 4

Add 15 cm to the measurement from the ceiling to the floor and cut a piece of string for that amount. Tape or tie the string to a spot on the ceiling.

Step 5

Thread the string through the straw. Stretch the string tight and tape it to the floor.

Step 6

Use the hole punch to make three holes around the top of the cup. Space the holes evenly as shown in Figure 1.

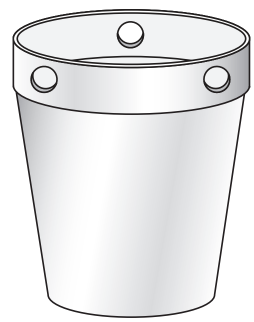


Figure 1

Step 7

Cut three pieces of 30-cm-long string. Tie one string to each hole in the cup.

Step 8

Use the balloon pump to blow the balloon up and count the number of pumps it takes. Use a clothespin to keep the air from escaping until you are ready to release it.

Step 9

Tape the other end of the strings to the balloon so that it looks like a hot air balloon with a basket under it.

Step 10

Tape the balloon to the straw as shown in Figure 2.

Step 11

Lower the balloon to the floor, count down, and let go of the clothespin.

Step 12

Mark how high the top of the balloon rose on the string. Measure and record data on your student handout.

Step 13

Blow up the balloon about the same size as before and add five paper clips in the basket. Launch the balloon and record the height.

Step 14

Repeat Steps 7 to 11 and add five more paper clips each time until the balloon will no longer launch.

Step 15

Analyze data and graph your results in the student handout.

Suggestions for Differentiation

Below are additional strategies to differentiate instruction depending on student readiness.

Support:
Assemble one test apparatus and have all student teams take turns using it.

Complexity:
Repeat the experiment using a different size balloon to determine if modifying part of the design can increase thrust or reduce drag.

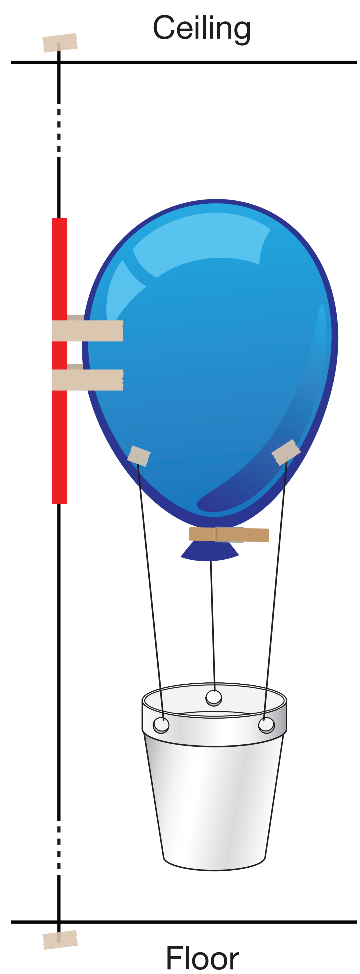


Figure 2

Names: ______________________________

Directions

Step 1

Use the hole punch to make three holes around the top of the cup. Space the holes evenly as shown in Figure 1.

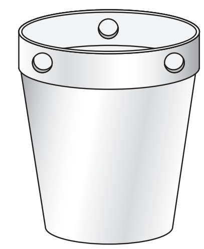


Figure 1

Step 2

Cut three pieces of 30-cm-long string. Tie one string to each hole in the cup.

Step 3

Use the balloon pump to blow up the balloon and count the number of pumps it takes. Use a clothespin to keep the air from escaping until you are ready to release it.

Step 4

Tape the other end of the strings to the balloon so that it looks like a hot air balloon with a basket under it.

Step 5

Take your device to the designated test area that your instructor has provided and tape the balloon to the straw as shown in Figure 2.

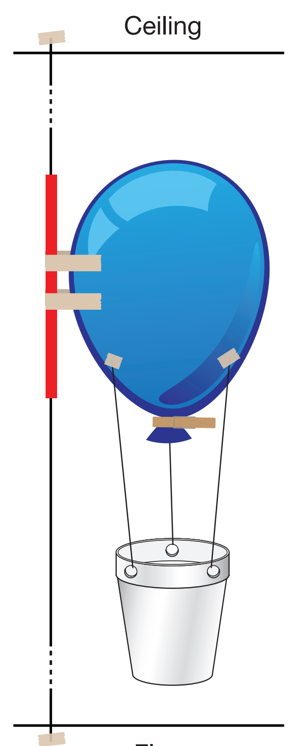


Figure 2

Step 6

Lower the balloon to the floor, count down, and let go of the clothespin.

Step 7

Mark how high the top of the balloon rose on the string. Measure and record data in the table.

Step 8

Blow up the balloon about the same size as before, and add five paper clips in the basket. Launch the balloon and record the height the balloon reaches.

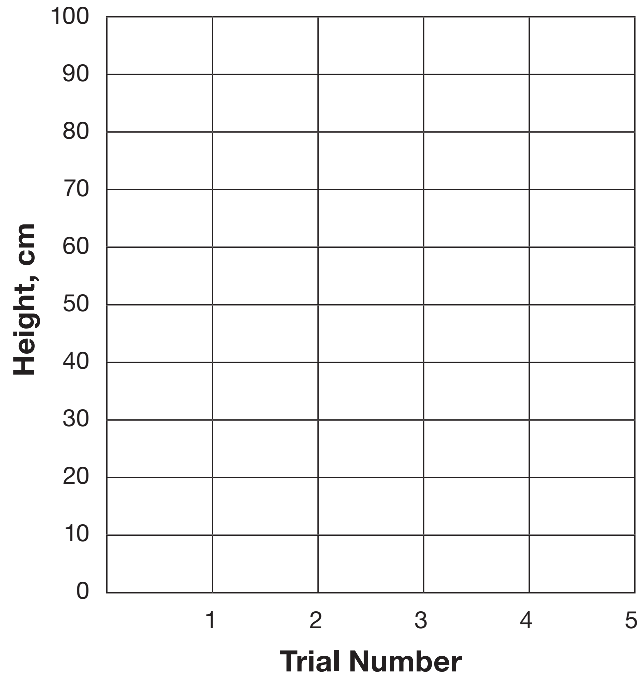
Step 9

Repeat Step 11, adding five more paper clips each time until the balloon will no longer launch.

Step 10

Analyze data and graph your results.

Trial	Number of paper clips	Launch height from the floor, cm
1	0	
2	5	
3	10	
4	15	
5	20	



Questions

1. What happened during the trials?

2. Did everything happen the way you thought it would?

3. What happened to the elevation of the balloon as you added weight? Explain why this occurred.

4. What could you do to redesign this activity to allow 20 paper clips to rise to the same height that the balloon reached initially? Illustrate your idea.

What a Drag

Grades 6 to 8

INQUIRY-BASED ACTIVITY

activity

WHAT A DRAG

Grades: 6 to 8   Prep Time: 0.5 hour   Activity Time: 1 hour

About This Activity

In this activity, which was taken from the NASA Why?: Files, The Case of the Challenging Flight, students will determine which shapes are the least and most susceptible to the force of drag.

Background

Drag is a force that slows something down and makes it hard for an object to move. It is harder to walk or run through water than through air because water causes more drag than air. The shape of an object also changes the amount of drag. Most round surfaces have less drag than flat ones. Narrow surfaces usually have less drag than wide ones. The more air that hits a surface, the more drag it causes.

Next Generation Science Standards

MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

Learning Objective

Learners will

- Construct a test stand, test arm, and four three-dimensional shapes to test drag
- Predict and test the shapes in moving air to determine which shape creates the most and least drag
- Record and analyze data

Materials

- Box fan or hair dryer
- Foam block
- Wooden skewer
- Wooden ruler
- Duct tape
- Flexible drinking straws
- Patterns for shapes
- Student handouts
- Safety goggles

Procedure

Preparation Steps

Step 1

To make the drag stand, measure and mark 15 cm from the flat top of the skewer, and insert into the foam block.

Step 2

Measure and cut a 10- by 1-cm piece of duct tape. Wrap the tape around the straw 2 cm from one end. Make sure the tape is evenly wrapped and forms a level surface.

Step 3

Slide the straw over the wooden skewer until it makes contact with the foam block as shown in Figure 1. Loop a piece of duct tape to make a piece of double-sided tape. Attach the double-sided duct tape to the bottom of the foam block.

Step 4

Place the drag stand 1 m from the front center of the box fan as shown in Figure 2. Make sure the drag stand is secured to the floor.

Step 5

To assemble the drag arm, insert a flexible straw into the outer holes of the ruler an equal distance from the center hole (pivot point). Secure straws to the ruler by wrapping two small pieces of duct tape around the top of the straw (Fig. 3).

Step 6

Cut out the shapes from the patterns provided and fold on the dotted lines. Tape the edges together to form a cone, cube, tetrahedron, and pyramid.

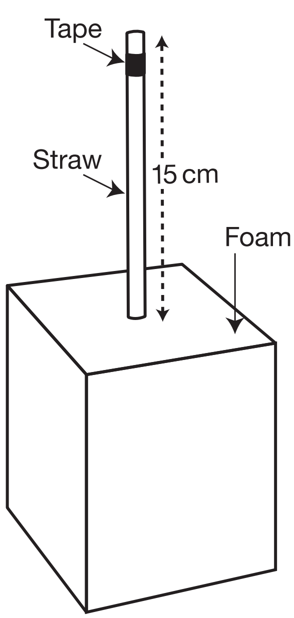


Figure 1

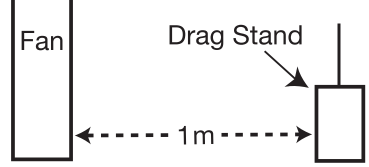


Figure 2

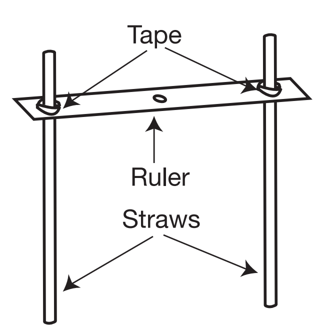


Figure 3

Steps With Students

Step 1

Introduce the activity and background by asking the students

- What is drag?
- How would shape affect drag?
- How does drag affect an airplane's ability to fly?

Step 2

Explain to the students that they will be observing what will happen to three-dimensional paper shapes as moving air blows toward them. Students will need to write down their predictions and record what actually happened in their student handouts.

Remind students that they must not touch the fan blades while the fan is running.

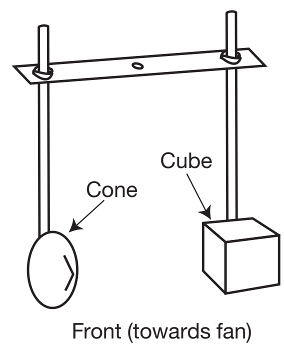


Figure 4

Step 3

Attach the cone and cube shapes to the bottom of each straw using transparent tape as shown in Figure 4.

Step 4

Place the ruler over the straw on the drag stand as shown in Figure 5.

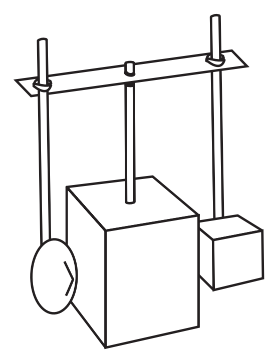


Figure 5

Step 5

Have students predict which shape will have the most drag and record their predictions in their student handouts.

Step 6

Turn the fan on low speed, observe what happens, and note which shape moves closer to the fan.

Step 7

Have students record the shape that had the least amount of drag on their student handouts.

Step 8

Repeat Steps 1 to 7 with the following combination of shapes:

- Cone and pyramid
- Cone and tetrahedron
- Cube and pyramid
- Cube and tetrahedron
- Pyramid and tetrahedron

Step 9

Allow students time to complete their student handouts and have all the students discuss their predictions and results.

Suggestions for Differentiation

Below are additional strategies to differentiate instruction based on student readiness.

Support:
Ask the class for predictions and write them on a blackboard. After the tests are completed, write down the results.

Complexity:
Have students cut out 10-, 20-, 40-, and 60-cm sized squares of cardboard and stand in front of the box fan and hold each square one at a time. Ask students if they can feel how the size of an object affects drag. The larger squares should push on the students more than the smaller squares.

Name: ______________________________________

Data and Observations

Prediction (for each set of shapes, indicate how the shapes will move)

Shapes	Moves closer to fan (less drag)	Moves away from fan (more drag)
Cone and pyramid		
Cone and tetrahedron		
Cube and pyramid		
Cube and tetrahedron		
Pyramid and tetrahedron		

What shape did you write most often in your predictions?

____

Test Results (do not touch the fan blades while the fan is running)

Shapes	Moves closer to fan (less drag)	Moves away from fan (more drag)
Cone and pyramid		
Cone and tetrahedron		
Cube and pyramid		
Cube and tetrahedron		
Pyramid and tetrahedron		

1. How does shape affect drag?

____

2. Did your predictions match the test results?

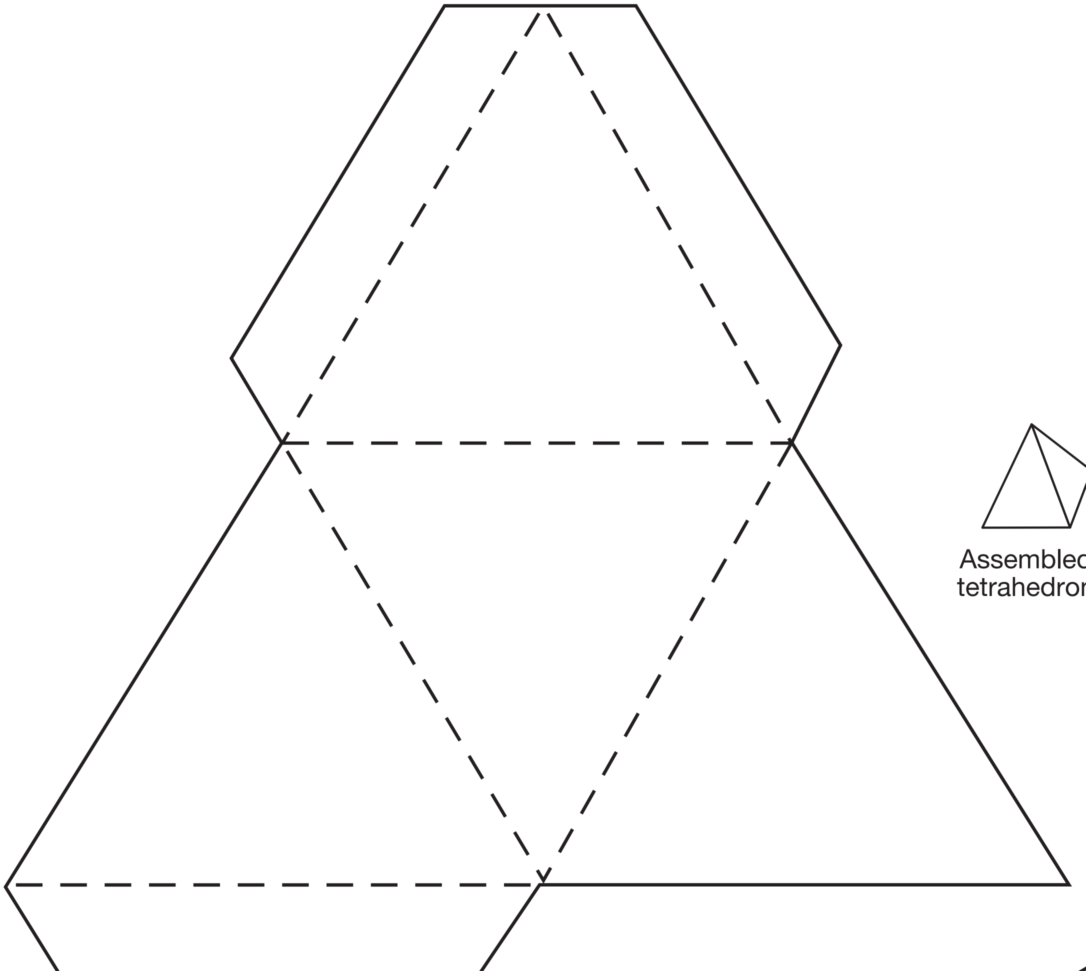
____

3. Which shape has the least amount of drag based on the data?

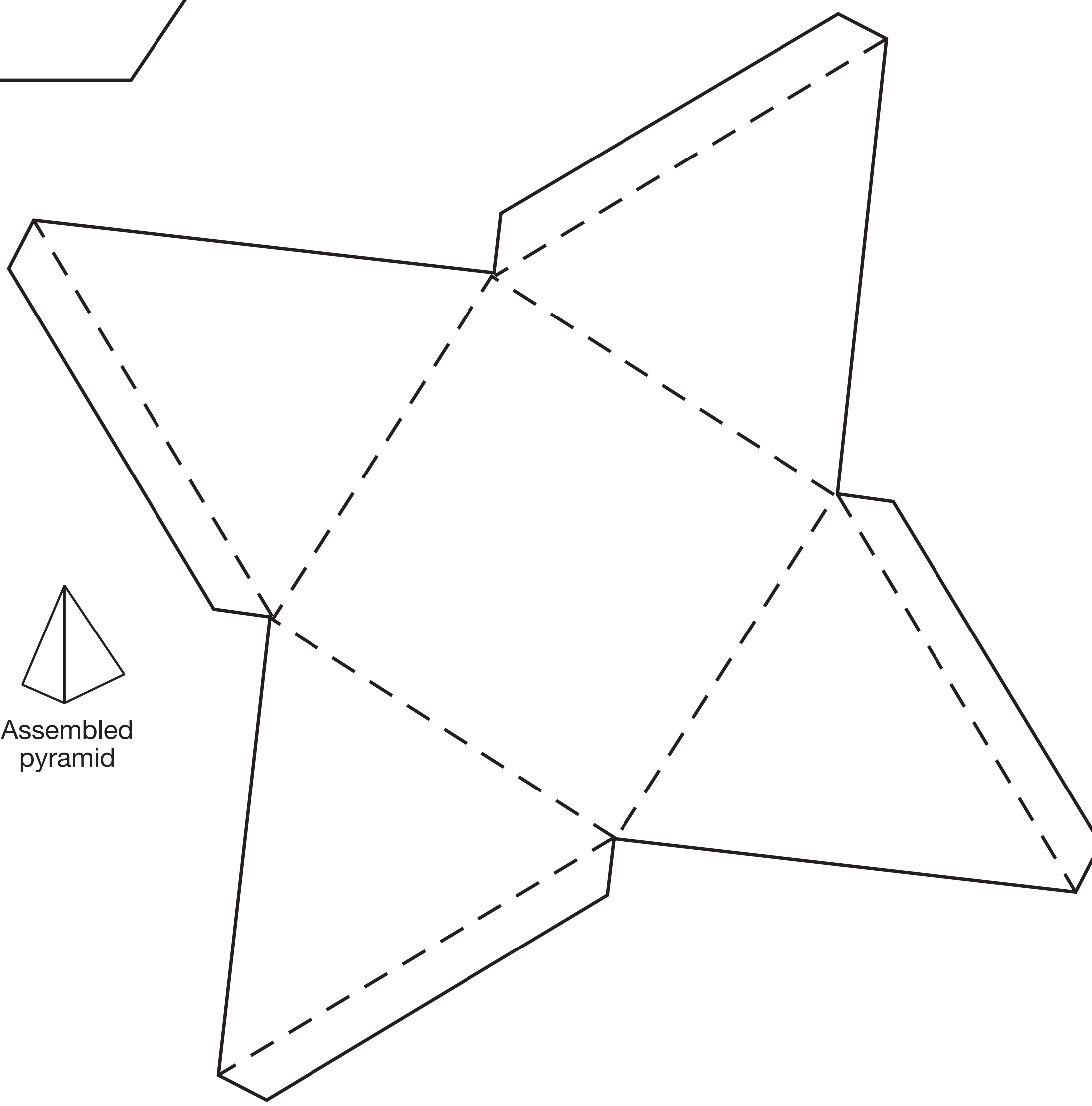
____

4. How does changing the size of the shape affect the outcome of this experiment?

____

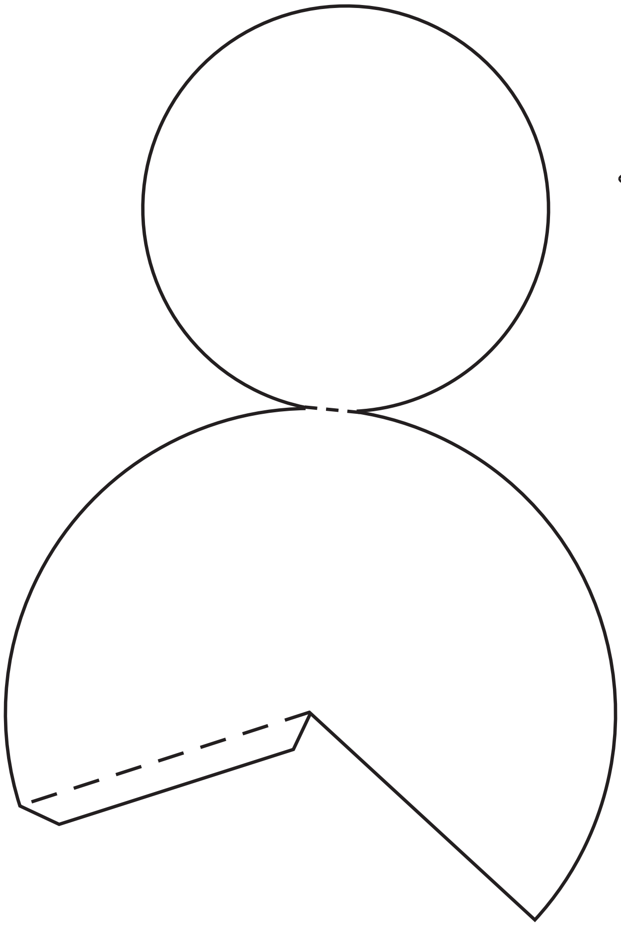


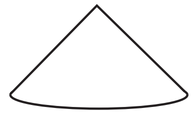
Assembled
tetrahedron



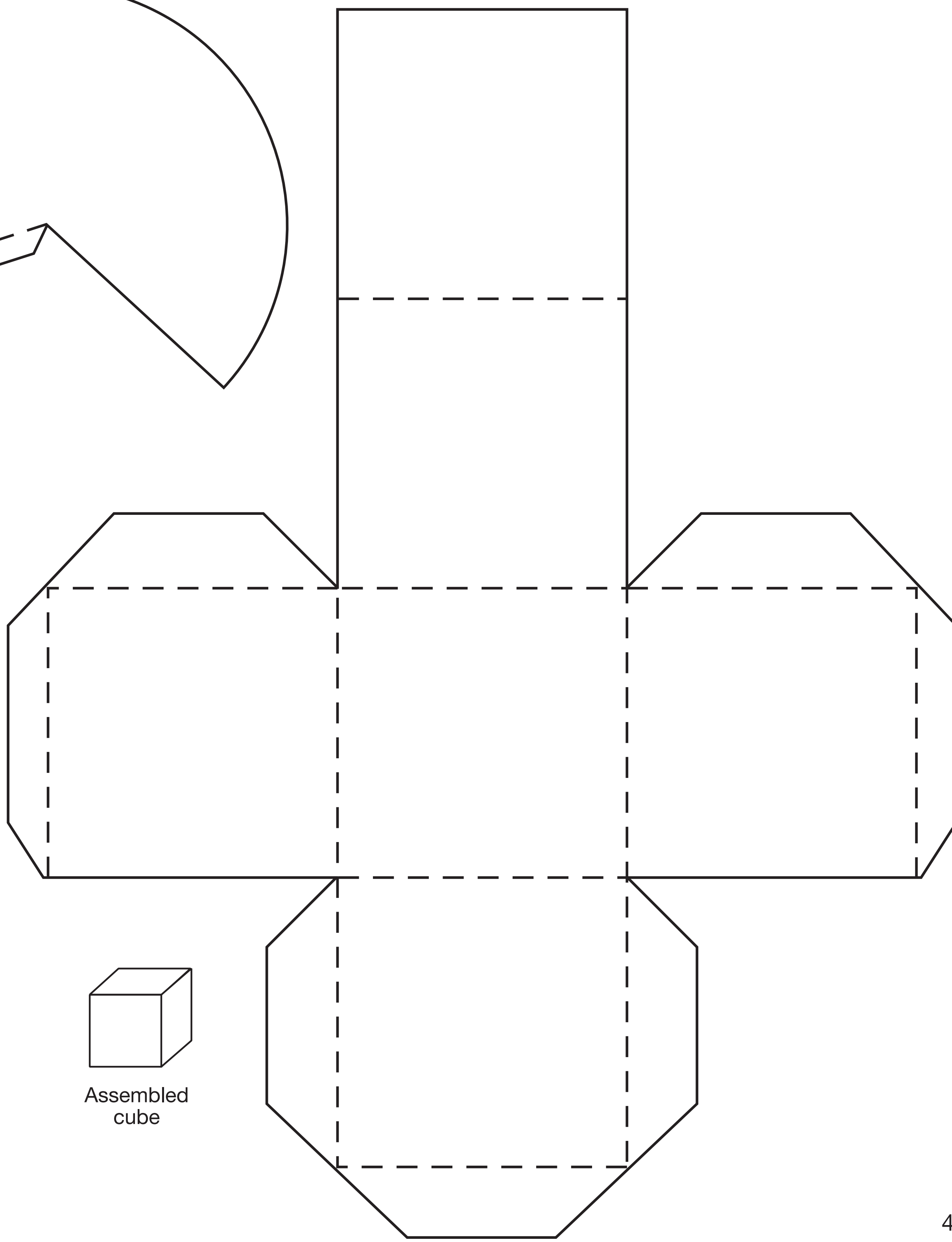
Assembled
pyramid

WHAT A DRAG





Assembled
cone



Assembled
cube

Ring Wing

Grades 6 to 8

INQUIRY-BASED ACTIVITY

activity

RING WING

Grades: 6 to 8   Prep Time: 0.5 hour   Activity Time: 1 hour

About This Activity

In this activity, which was taken from the NASA Ring Wing Glider, students will construct an innovative wing design and improve on the design.

Background

NASA's Aeronautics Research Mission Directorate is developing technologies that will make future aircraft more economical and efficient than today's aircraft. Aeronautics research takes on many forms, including various wing shapes and configurations.

One revolutionary wing configuration, called the blended wing body, or BWB, has a thick airfoil-shaped fuselage, or main body section that combines the engines, wings, and body into a single lifting surface. The BWB can carry as many as 800 passengers over 7,000 miles at an approximate cruise speed of 560 mph. Compared with today's airliners, the BWB would reduce fuel consumption, harmful emissions, operating costs, and noise levels.

Another research concept used for personal aircraft utilizes ring wing technology, which allows aircraft to take off and land in a variety of locations. Airplanes of the future may look very different from those of today.

Materials

- Template (optional)
- 8.5- by 11-in. sheets of paper
- Tape
- Ruler or tape measure
- Additional types or sizes of paper for experimentation
- Safety goggles
- Student handouts

Next Generation Science Standards

MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

Learning Objective

Learners will

- Determine what criteria will be used to make the best glider design
- Build the innovative wing design and make improvements to make the wing fly the best according to the criteria determined

Procedure

Step 1

Discuss with students that NASA engineers are developing new and interesting wing designs, including one called the ring wing. Let students know that they will build a ring wing glider and redesign the glider to make the best design possible. As a group, they will decide what design factors will be used to determine the best design.

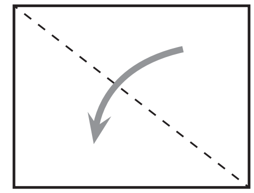
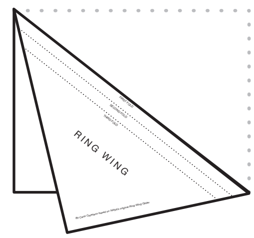


Figure 1



Step 2

Fold a piece of 8.5- by 11-in. paper diagonally as shown in Figure 1.

Step 3

Make a 1/2-in. fold along the previously folded edge and another 1/2-in. fold as shown in Figure 2.

Step 4

Curl the ends of the paper to make a ring and tuck one end into the fold of the other. Use tape to hold the ring shape together (Fig. 3).

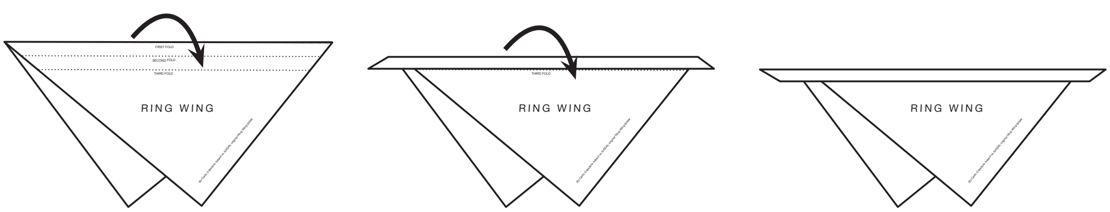


Figure 2

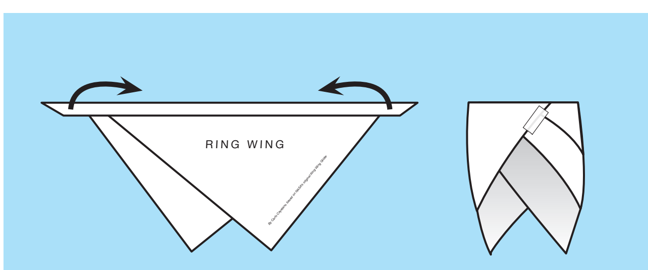
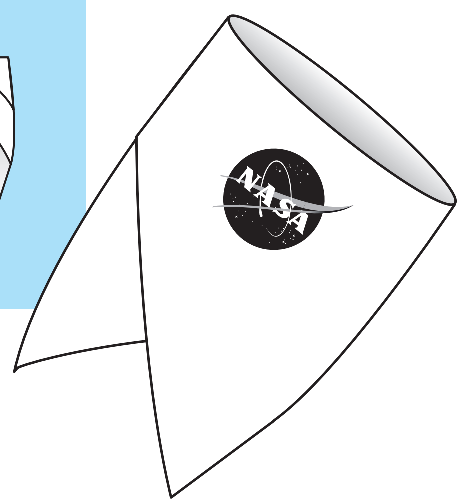


Figure 3



Step 5

To fly the ring wing glider, gently grasp the V shape between the two points with your thumb and index finger.

Step 6

Raise your arm back over your head and toss the glider forward lightly. Note the folds in the paper make the front end heavy and the back end light. Curling the ends to make a ring changes the shape of the wing and improves the glider's flight performance. Students should record the data in their student handout.

Step 7

Bring the students together and discuss what determines the best flight. Is it distance? Hang time? Loops? Once criteria is determined, have students embark on creating the best/better ring wing glider.

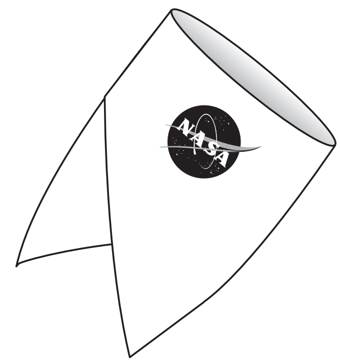
Suggestions for Differentiation

Below are additional strategies to differentiate instruction based on student readiness.

Support:
Assist students with making the last fold and taping it together.

Complexity:
Have students keep a log of engineering changes and measurements as they investigate other variables. Students should change only one variable at a time like paper sizes and weights or varying the folds.

Name: ______________________________



Directions

Step 1

Make the ring wing as your instructor demonstrated.

Step 2

To fly: Gently grasp the V between the two points with your thumb and index finger. Reach back over your head and toss the glider lightly forward.

Step 3

Fly your ring wing three more times and answer the questions below.

Questions

1. What did you notice about the flight of your aircraft?

____

____

2. Does it repeat the pattern each time you tested it?

____

3. According to your group, what constitutes the best flight?

____

____

4. Create the best ring wing glider you can. What changes did you make to the original design to create the best flying craft?

____

____

TEST PILOT: ____________________

FIRST FOLD

SECOND FOLD

THIRD FOLD

RING WING

By Carlo Cayetano based on NASA's original Ring Wing Glider

Sled Kite

Grades 6 to 8

INQUIRY-BASED ACTIVITY

activity

SLED KITE

Grades: 6 to 8 Prep Time: 0.5 hour Activity Time: 1–1.5 hours

About This Activity

In this activity, which was taken from the NASA Aeronautics: An Educator's Guide, students will construct a type of airfoil called a parawing.

Next Generation Science Standards

MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process so that the optimal design can be achieved.

Learning Objective

Learners will

- Construct and fly a simple parawing airfoil or sled kite
- Demonstrate how adding tails to the kite affects how the kite flies

Materials

- Template
- Drinking straws
- Transparent tape
- Scissors
- String
- Metric ruler
- Single-hole paper punch
- Paper clip
- Selection of paper (crepe, tissue, or newspaper)
- Safety goggles
- Student handouts

Background

The sled kite in this activity is based on a type of airfoil called a parawing. Like any wing shape, movement of air over the parawing generates a lifting force. (Parasails, parafoils, and paragliders are similar devices.)

NASA's Paraglider Research Vehicle (Paresev) was the first flight vehicle to use the parawing design by Francis Regallo. NASA built, flew, and evaluated the glider during the early 1960s to evaluate the concept and to determine its suitability to replace the parachute landing system on the Gemini spacecraft. Although the parawing was never used on a spacecraft, it revolutionized the sport of hang gliding, which uses parawings to glide from cliffs or mountain tops.

Kites are made from many different shapes, sizes, and colors. The sled kite in this activity is made from a piece of cloth or paper and two drinking straws. The straws are attached on opposite sides of the cloth or paper and are parallel to each other. This arrangement shapes the kite like a sled when it catches the air. The straws are attached toward one end of the kite, which causes the opposite end to hang downward, and stabilizes the kite during flight.

Procedure

Step 1

Discuss the background information with students.

Step 2

Provide students with a copy of the template and student handouts. You may wish to demonstrate the steps to construct the sled kite or allow students to read the directions to construct.

Suggestions for Differentiation

Below are additional strategies to differentiate instruction based on student readiness.

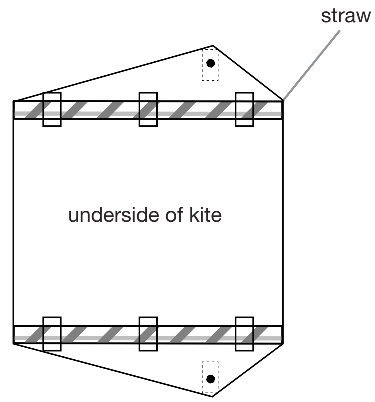
Support:
Assemble kites for students and have students fly kites and answer questions on student handout.

Complexity:
Have students design their own sled kites.

Name: ______________________________

Weather: ____________________

Directions

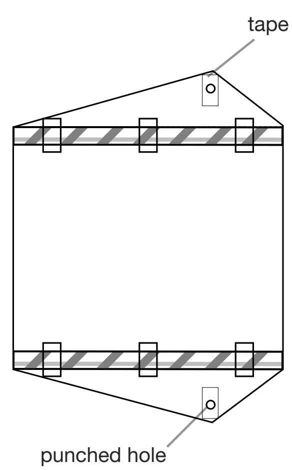


Step 1

Trim the two drinking straws so they will fit in the template area marked for them and tape them in place.

Step 2

Place two or three pieces of tape over the circles as shown, and use the hole punch to punch the holes in the circles.



Step 3

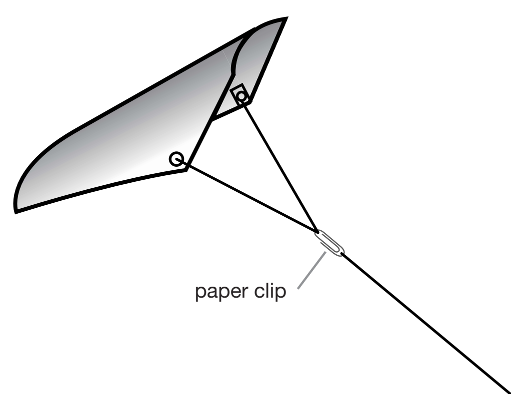
Cut two pieces of 45-cm string. Tie a string through each hole in the template but not tight enough to tear the paper.

Step 4

Tie the opposite ends of both strings to a paper clip.

Step 5

Tie one end of a 1-m-long piece of string to the other end of the paper clip. The sled kite is ready to fly!



Step 6

Go outside to a clear area, hold the 1-m length of string, and run with the kite to make it fly.

Step 7

Run slow and fast, observe how the kite flies at different speeds, and answer the questions on the back.

Questions

1. What did your sled kite do when you walked with it?

2. What did your sled kite do when you ran with it?

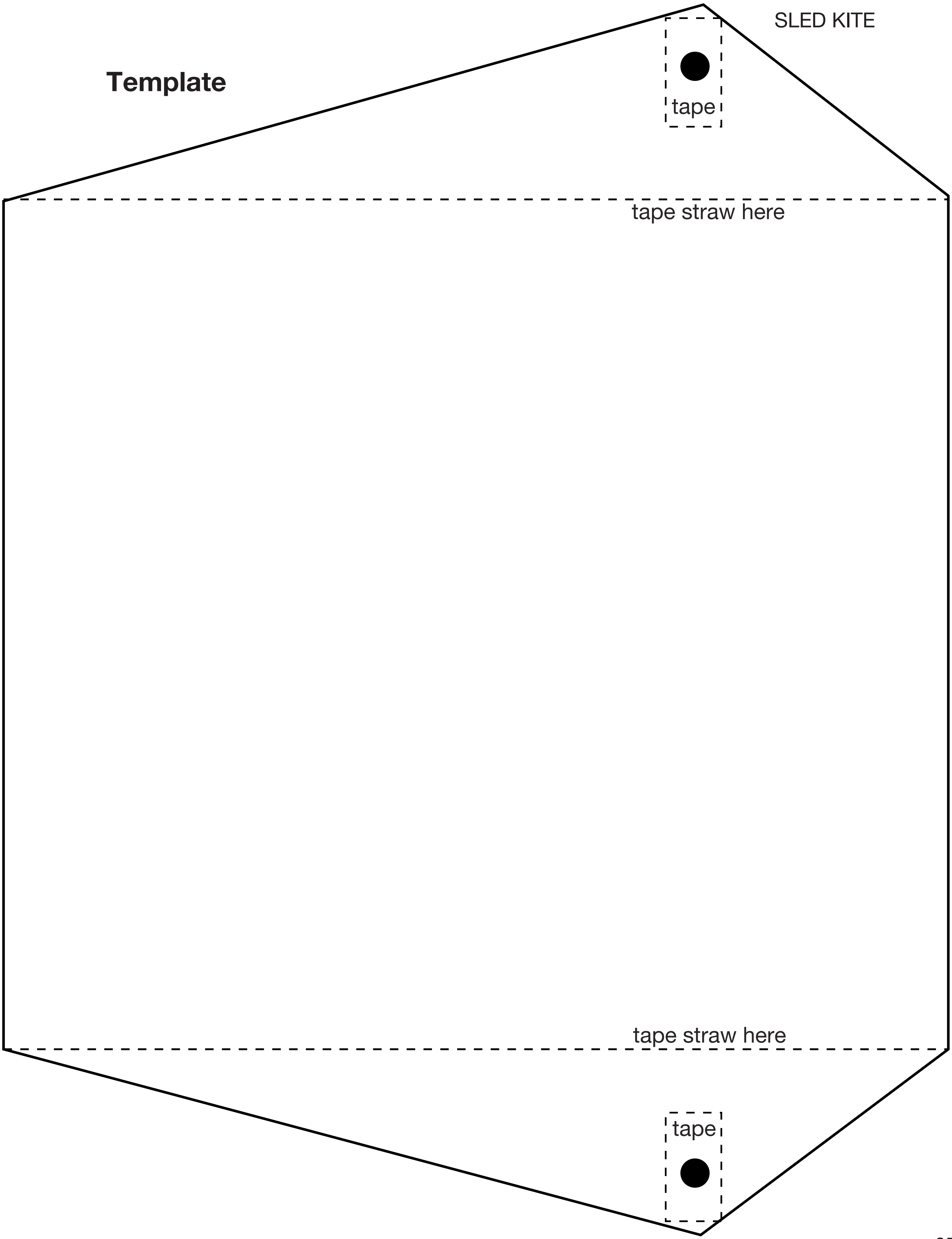
3. Add a tail to your kite. Predict what will happen when you walk or run with it.

4. Describe how adding a tail to your sled kite affected the way it flew.

5. Shorten the tail. Predict what will happen when you walk or run with it.

6. Describe how the shorter tail affected the flight.

Template



Right Flight

Grades 6 to 8

INQUIRY-BASED ACTIVITY

activity

RIGHT FLIGHT

Grades: 6 to 8   Prep Time: 0.5 hour   Activity Time: 1 hour

About This Activity

In this activity, which was taken from NASA Aeronautics: An Educator's Guide, students will construct and fly a model Styrofoam glider.

Next Generation Science Standards

MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

Learning Objective

Learners will

- Construct a model glider
- Make improvements on a basic design that increases flight distance

Materials

- Styrofoam food tray
- Template
- Plastic knife
- Toothpicks
- Sandpaper or emery boards
- Binder clips
- Paper clip
- Markers
- Safety goggles
- Student handouts

Background

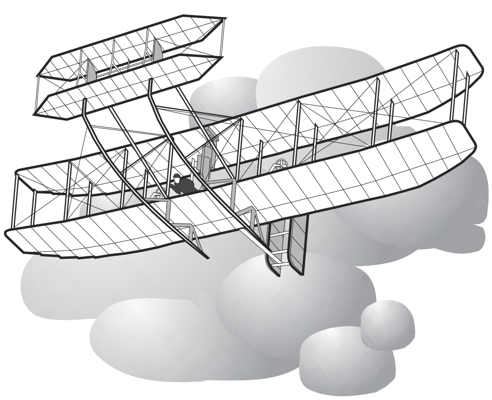
On December 17, 1903, two brothers named Wilbur and Orville Wright became the first people to fly a controllable, powered airplane. The Wright brothers unraveled the mysteries of flight by building and experimenting with lots of model gliders. Gliders are airplanes without motors or a power source.

Building and flying model gliders helped the Wright brothers learn and understand the importance of weight and balance in airplanes. If the weight in the airplane is not positioned properly, the airplane will not fly. For example, too much weight in the front (nose) will cause the airplane to dive toward the ground. The precise balance of a model glider can be determined by varying the location of small weights.

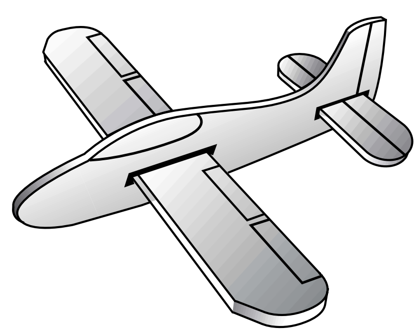
Wilbur and Orville also learned that the design of an airplane was very important. Their experiments with different designs showed that airplanes fly best when the wings, fuselage, and tail were designed and balanced to interact with each other. The Wright Flyer was the first airplane to complete a controlled takeoff and landing.

To manage flight direction, airplanes use control surfaces. Elevators on airplanes, like tail wings or stabilizers, are flight control surfaces that make the nose of the airplane pitch up and down. Rudders move the nose left and right. The Wright Flyer used a technique called wing warping to begin a turn. On modern airplanes, ailerons are used to roll the airplane into a turn.

NASA uses model airplanes to develop new concepts, create new designs, and test ideas in aviation. Some models fly in the air using remote control while others are tested in wind tunnels. Information learned from models is an important part of NASA's aeronautical research programs. NASA’s aeronautical research goals are to make airplanes fly safer, perform better, and more efficiently.



Wright Flyer



Right Flight Glider

Procedure

Step 1

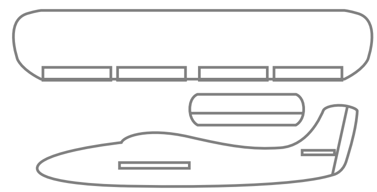
Discuss the background information with students. Ask students to name some materials that could be used to build a model glider. Some ideas are: balsa wood, paper, cardboard, plastic, and Styrofoam.

Step 2

Gently toss a Styrofoam tray into the air and ask the students to describe how the tray flew. The tray did not fly because it is not designed to fly; it dropped instead.

Step 3

Explain that Styrofoam is lightweight and strong, which makes it an ideal material for constructing model gliders.

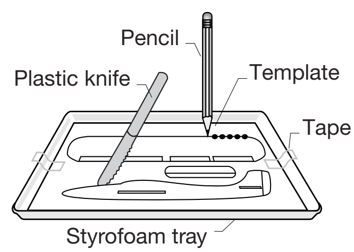


Step 4

Explain that students will cut the wings, fuselage, and elevator from the Styrofoam tray.

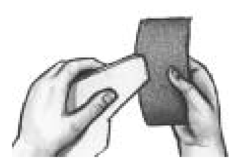
For younger students, the facilitator or older students can cut out the parts beforehand and give to students to assemble.

For older students, the facilitator can demonstrate cutting out the parts with a serrated plastic knife or by punching a series of holes approximately 2 mm apart around the outside edge of each piece and then pushing the pieces out with a sharp pencil or round toothpick.



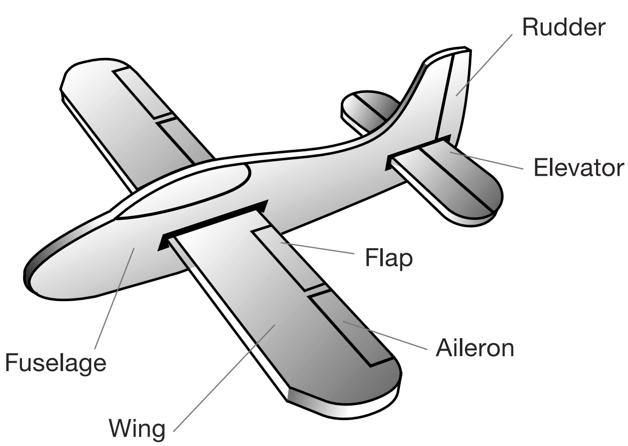
Step 5

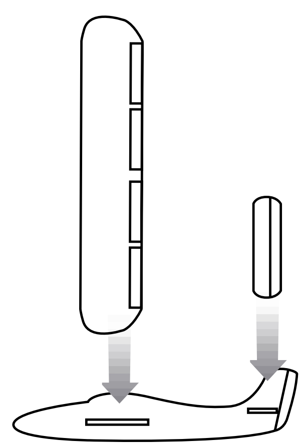
Use sandpaper or an emery board to sand the edges smooth.



Step 6

Have students assemble their gliders by inserting the wings and elevators into the fuselage slots.





Step 7

The weights on each model glider must be balanced or distributed evenly before it can fly. Demonstrate this by asking a student to launch their glider before adding weight and balance. Have students describe the flight characteristics.

Step 8

Add weight with paper clips, binder clips, or a penny. Attach the paper clip or penny to the nose of the glider. If a binder clip is used, attach it to the bottom of the fuselage. Ask the students to test their gliders and observe the flight characteristics.

Step 9

Move the weights (clips) forward or backward on the fuselage to determine the best weight and balance for the glider. The best weight and balance combination is the one that allows the glider to fly the greatest distance.

Step 10

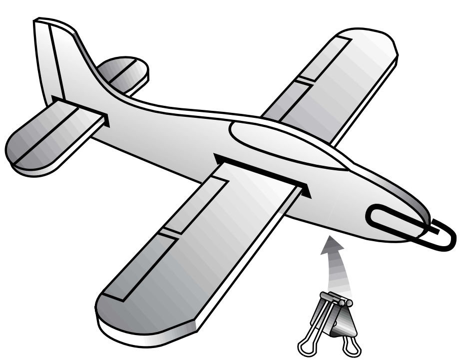
Have students test their gliders and redesign the wings to improve their glider performance and flight distance.

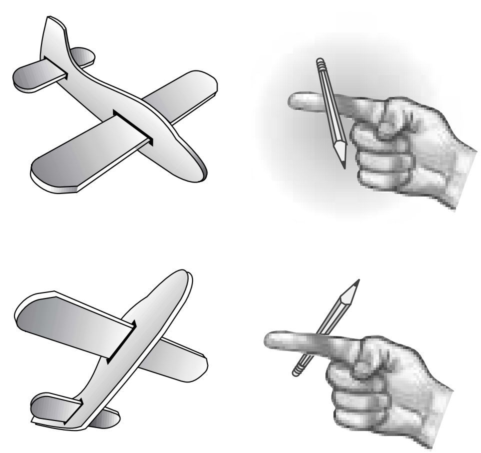
Suggestions for Differentiation

Below are additional strategies to differentiate instruction based on student readiness.

Support:
Cut out the parts for the glider beforehand and allow students to assemble.

Complexity:
Have students design their own plane parts and cut out of Styrofoam or balsa wood.



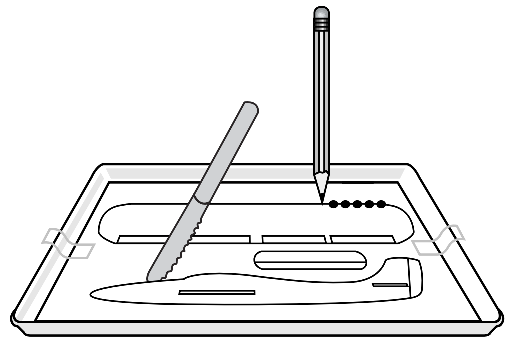


Aircraft weight is balanced like
a pencil is balanced on your finger.

Directions

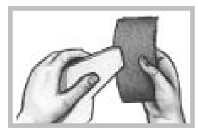
Step 1

Cut out the paper shapes for the wings, fuselage, and elevator and trace around them on a Styrofoam tray. Cut out the parts using a serrated plastic knife or by punching a series of holes about 2 mm apart around the outside edge of each piece and then push the piece out. A sharp pencil or round toothpick can be used to punch the holes too.



Step 2

Use sandpaper or an emery board to sand the edges smooth.



Step 3

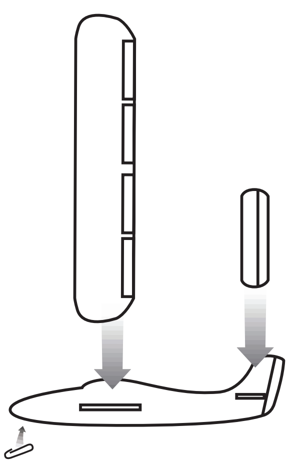
Assemble the glider by inserting the wings and elevator into the fuselage slots.

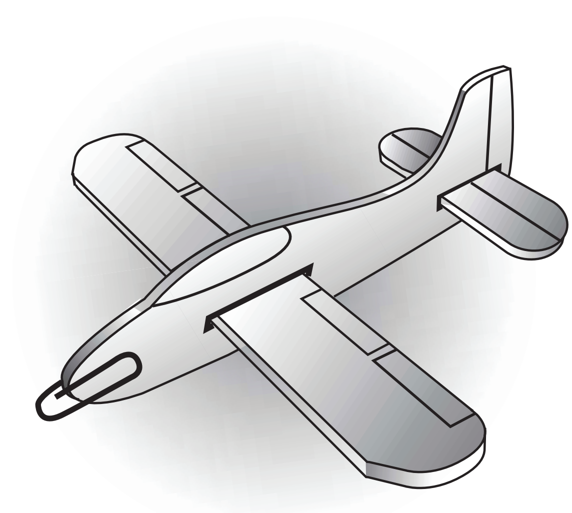
Step 4

Because your glider must be balanced to fly correctly, add weight to the model using paper clips, binder clips, or a penny. Attach the paper clip or penny to the nose of the glider. If a binder clip is used, attach it to the bottom of the fuselage. Test fly the glider and observe the flight characteristics.

Step 5

Move the weight (clips) forward or backward on the fuselage to determine the best weight and balance for the glider. The best weight and balance combination is one that allows the glider to fly the greatest distance.





Name: ______________________________

Directions

1. Why does the model glider fall erratically during test flights before its proper weight and balance is determined?

____

____

2. How did you determine the weight and balance for your glider?

____

____

3. What adjustments did you make to achieve balance on your glider?

____

____

4. Test your glider and fill out the information in Table 1.

Test	Distance flown, cm
1	
2	
3	
4	

Table 1

5. Redesign wings for your glider that will improve the performance and distance it will fly.

6. Test your redesigned glider and fill out the information in Table 2.

Test	Distance flown, cm
1	
2	
3	
4	

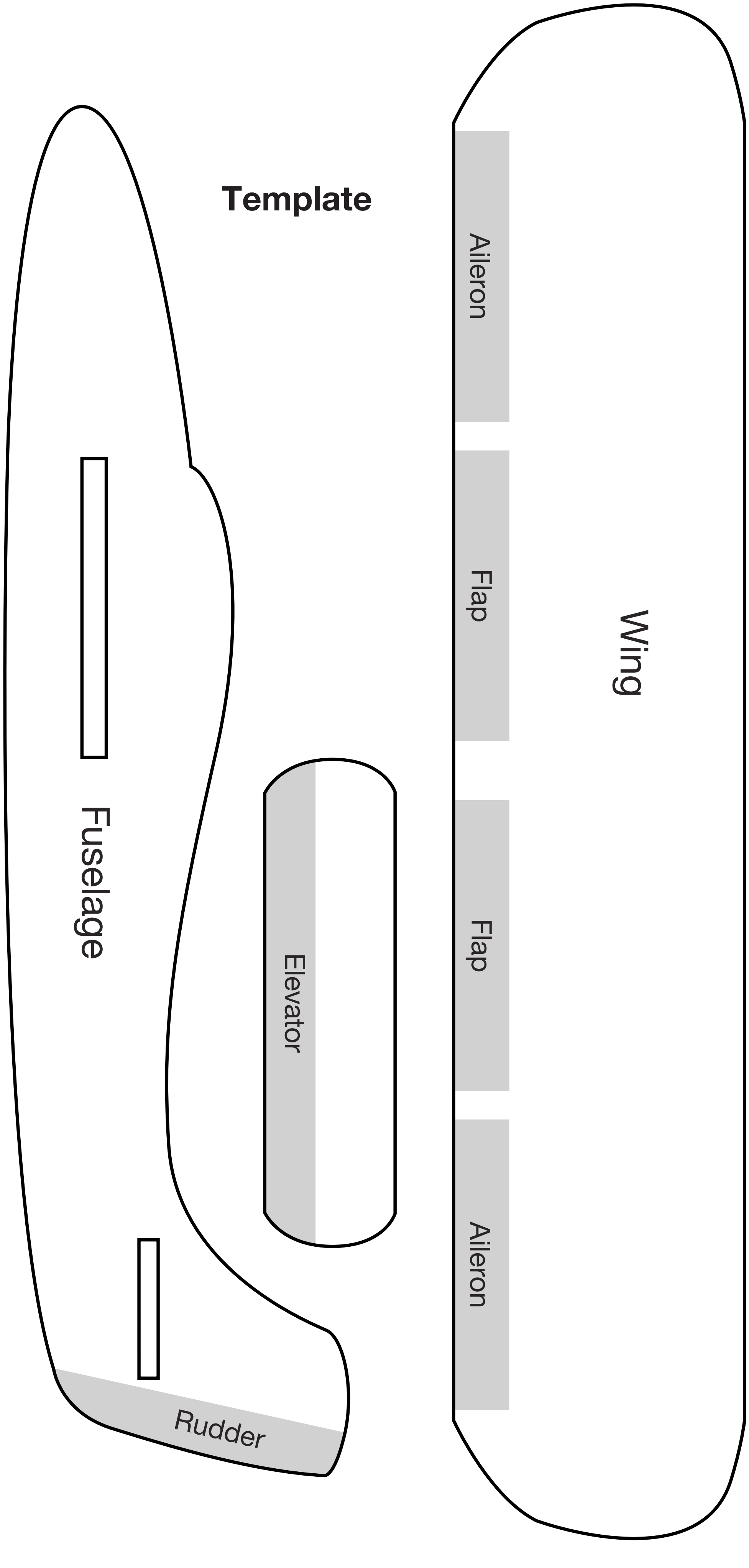
Table 2

7. Did your design improve your glider's performance? Why or why not?

____

____

Template



Rotor Motor

Grades 6 to 8

INQUIRY-BASED ACTIVITY

activity

ROTOR MOTOR

Grades: 6 to 8   Prep Time: 0.25 hour   Activity Time: 1 hour

About This Activity

In this activity, which was taken from NASA Aeronautics: An Educator's Guide, students will use paper to make a rotary wing model.

Next Generation Science Standards

MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Learning Objective

Learners will

- Construct a rotor motor from a template and redesign the rotor motor to make it descend slower

Materials

- Template printed on plain white paper
- Student handout
- Scissors
- Measuring tape
- Pencil or marker
- Ladder or stable platform, at least 4 feet high
- Stopwatch

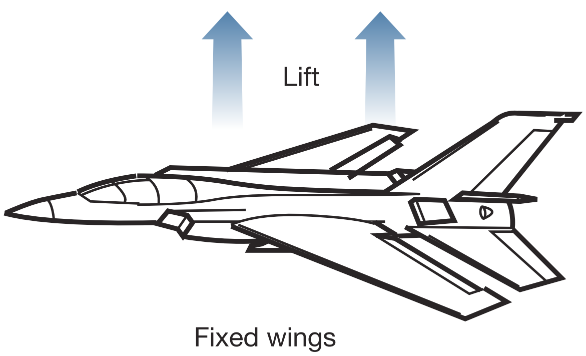
Background

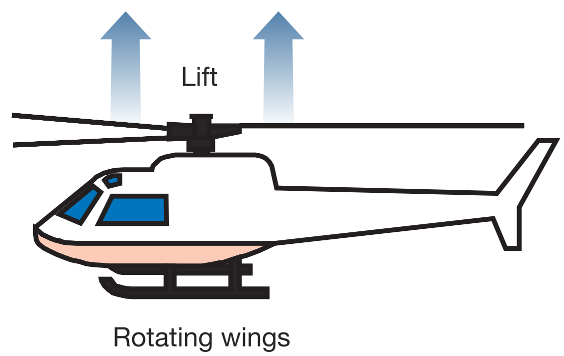
Air moves faster over the top of an airplane wing than it does under the wing. Because the faster moving air produces less pressure, there is relatively less pressure over the wing than under it. This is how lift is produced. To fly, birds and insects use a flapping motion to move the air over and around their wing surfaces. Airplane wings are attached to the fuselage in a fixed position. Lift is generated by the entire wing moving through the air.

Because helicopters are rotary wing aircraft, lift is generated when their blades rotate through the air. Lift is produced by the pressure differences caused by the shape of rotating blades; this is the same way lift is produced by aircraft wings. The rapidly moving air over the top of the blade creates low pressure while the slower moving air beneath the blade creates higher pressure. Higher pressure under the rotor blades creates lift making the aircraft rise up.

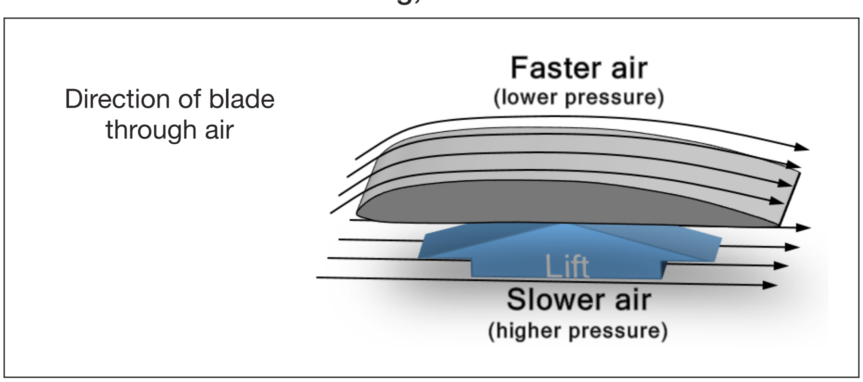
Because paper models do not have motors, they only have one source of lift. As paper models fall, they spin like the rotor blades of a helicopter. Because there is no engine to produce upward movement, the paper model will not fly upward, but the spin will reduce the rate of fall by producing lift, resisting the force of gravity.

NASA builds and tests experimental helicopters and tiltrotor airplanes to achieve lower noise levels and greater fuel efficiency. NASA tests their models in wind tunnels at Langley, Glenn, and Ames Research Centers.





Cross section of aircraft wing, or a rotor blade



Procedure

Step 1

Discuss background information and give each student a template.

Step 2

Cut the template along the solid lines.

Step 3

Fold the template along the dotted lines. Fold the propeller blades A and B in opposite directions. Fold the body supports X and Y toward the center, and fold Z up, which will make the body more rigid, and lower the center of gravity.

Step 4

Drop the rotor motor from a standing position.

Step 5

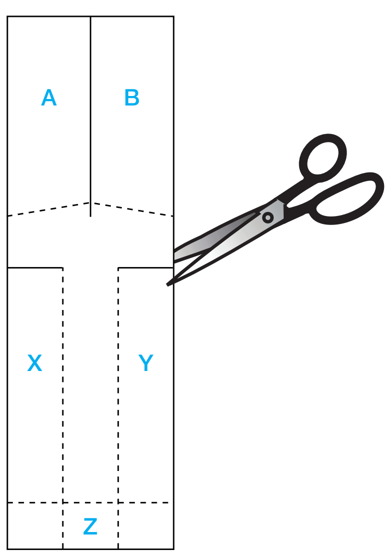
Have students drop their rotor motors three times from the ladder or platform. Students should time each descent and record their results in their student handout.

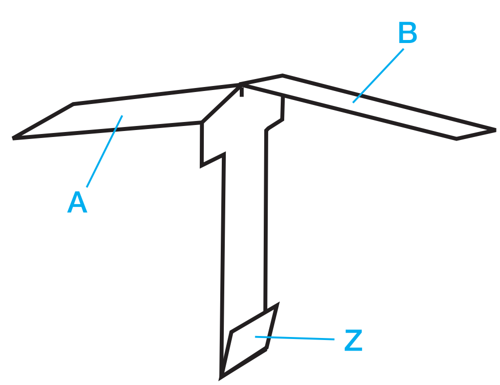
Step 6

Explain that they need to make changes to their rotor motors in order to slow down the descent and make the descent time longer.

Step 7

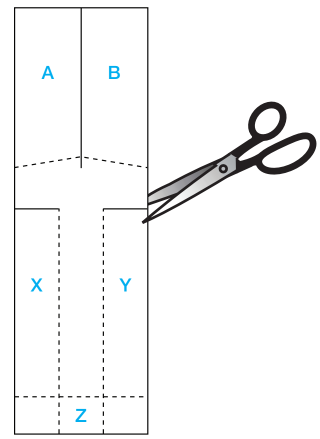
After all students have completed their student handout sheets, discuss which design changes they made to their rotor motors to get the longest descent times and why the changes worked.





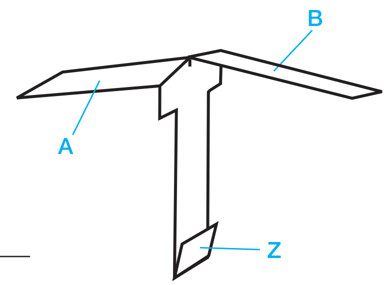
Name: ____

Directions



1. Cut along the solid lines of the template.
2. Fold along the dotted lines. The propeller blades should be folded in opposite directions. X and Y fold toward the center, and Z is folded up to give the body rigidity, and lower the center of gravity.
3. Go to the designated drop location your facilitator has prepared and drop the rotor motor. Have a partner time your rotor motor descent time and record your observations in the table below.

Trial	Descent time, seconds
1	
2	
3	



4. What modifications would make the rotor motor descend slower?

____

____

5. Select one modification and make the change.
6. Test and time your new design. Record the information in the table below.

Trial	Descent time, seconds
1	
2	
3	

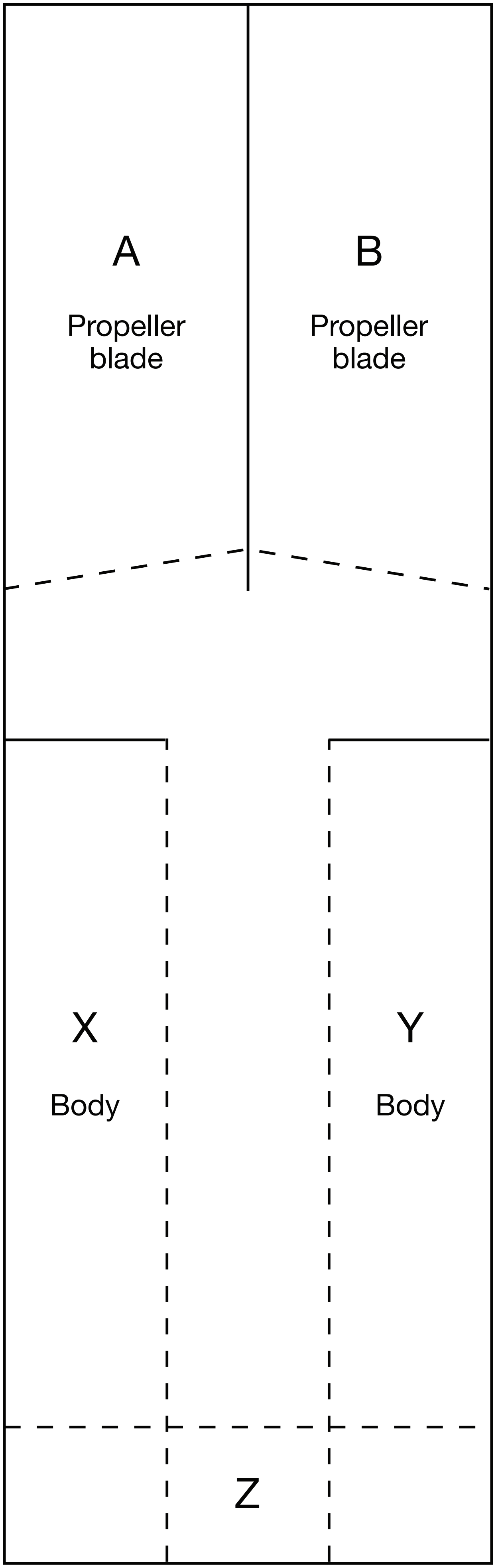
7. Were your changes successful? How do you know?

____

____

8. If time permits, modify your design again and record your results in the table below.

Trial	Descent time, seconds
1	
2	
3	


A
Propeller
blade
B
Propeller
blade
X
Body
Y
Body
Z

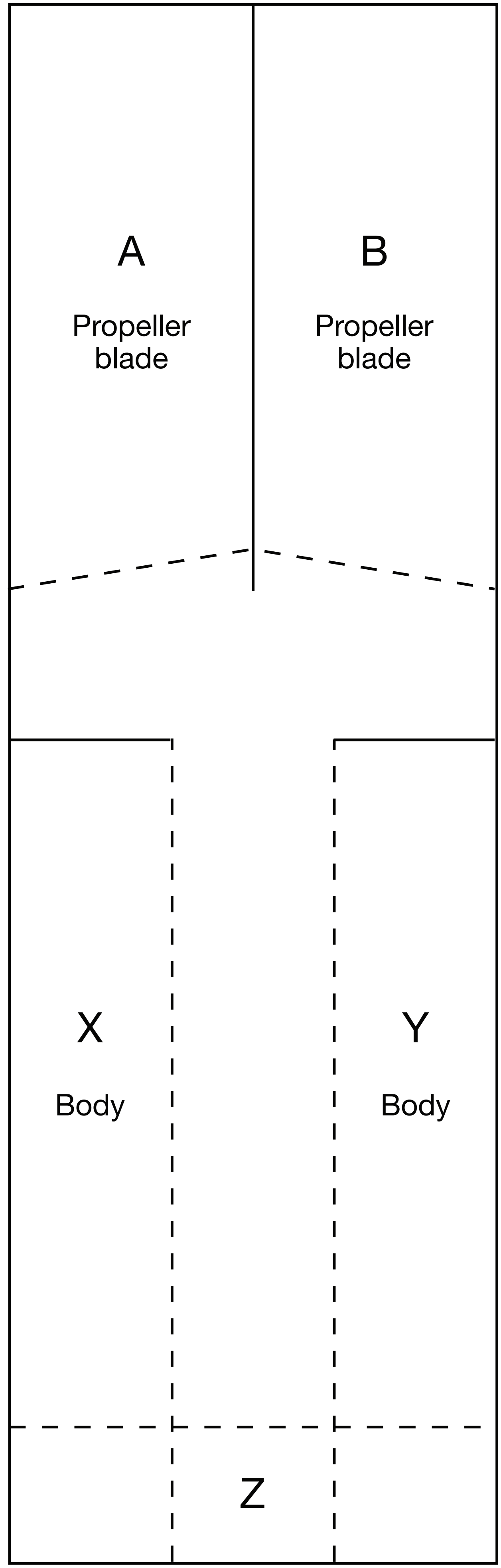

A
Propeller
blade
B
Propeller
blade
X
Body
Y
Body
Z


Image credit: NASA/Lockheed Martin

National Aeronautics and Space Administration

Glenn Research Center
21000 Brookpark Road
Cleveland, OH 44135

www.nasa.gov

NP-2016-09-036-GRC

PS-01985-1016