National Aeronautics and
Space Administration

Educational Product	
Educators	Grades 2-4

EG-2002-06-105-HQ

AERONAUTICS

An Educator's Guide with Activities in Science, Mathematics, and Technology Education

Aeronautics–An Educator's Guide with Activities in Science, Mathematics, and Technology Education is available in electronic format through NASA Spacelink–one of the Agency's electronic resources specifically developed for use by the educational community.

This guide and other NASA education products may be accessed at the following Address: *http://spacelink.nasa.gov/products*

Aeronautics

An Educator's Guide with Activities in Science, Mathematics, and Technology Education

What pilot, astronaut, or aeronautical engineer didn't start out with a toy glider?

National Aeronautics and Space Administration

EG-2002-06-105-HQ

Table of Contents

Acknowledgments 1

Preface/How to Use This Guide 2

Matrices

Science Standards 3
Mathematics Standards 4
Science Process Skills 5

Aerospace Technology Enterprise 6

Aeronautics Background for Educators 7

Activities

Air

Air Engines 12
Dunked Napkin 17
Paper Bag Mask 23
Wind in Your Socks 29
Air: Interdisciplinary Learning Activities 36

Flight

Bag Balloons 40
Sled Kite 44
Right Flight 52
Delta Wing Glider 60
Rotor Motor 69
Flight: Interdisciplinary Learning Activities 76

We Can Fly, You and I

Making Time Fly 80
Where is North? The Compass Can Tell Us 87
Let's Build a Table Top Airport 91
Plan to Fly There 97
We Can Fly, You and I: Interdisciplinary Learning Activities 107

Appendix

The Parts of an Airplane 110

Aeronautical Glossary 111

Suggested Reading 115

NASA Resources for Educators 118

Evaluation Reply Card .... Back Cover

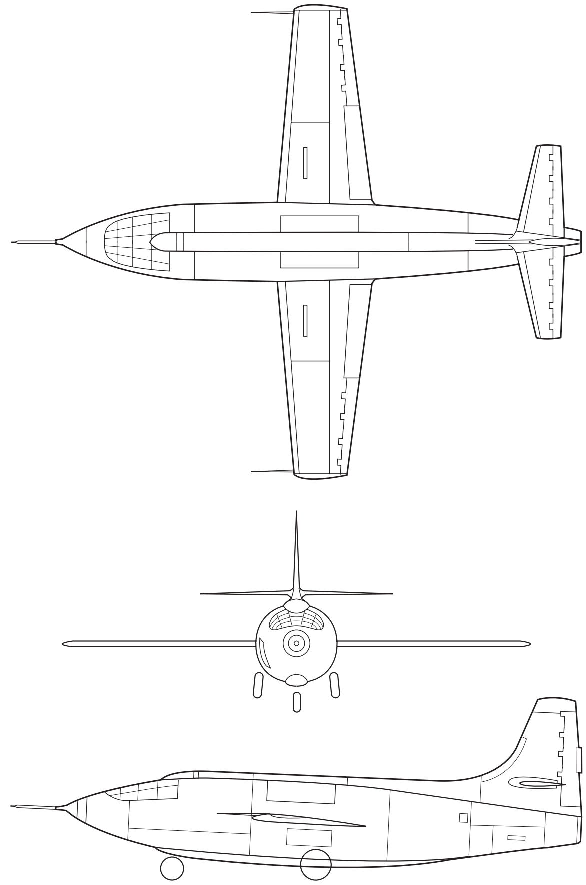
Acknowledgements

Editors
Pat Biggs
Ted Huetter

Contributors/Writers
Charles Anderson
Pat Biggs
Deborah Brown
Steve Culivan
Sue Ellis
James Gerard
Ellen Hardwick
Norm Poff
Carla Rosenberg
Deborah Shearer
Octavia Tripp
Ron Ernst

Art Direction and Layout
Ted Huetter

Graphic Illustration
Rod Waid



NACA X-1 Research Aircraft
1946

Photography
(Numbered clockwise from upper left) NACA file photos 2, 7,13,14,NASA file photo 5,
Nick Galante 3, Mike Smith 4, Jim Ross 11, 12, Ted Huetter 1, 6, 8, 9, 10 .... Cover
Ted Huetter .... Page 11
NASA file photo .... Page 39
Carla Thomas .... Page 79
Carla Thomas .... Page 109

Special thanks to:
Michelle Davis, Lee Duke, Jim Fitzgerald, Deborah Gallaway, Jane George, Doris Grigsby, Yvonne Kellogg, Marianne McCarthy, Joan Sanders, Greg Vogt, Deborah Dyer Wahlstrom, and Ralph Winrich. NACA/NASA aircraft technical drawings by Dennis Calaba and Marco Corona.

This guide was produced at NASA Dryden Flight Research Center, Edwards, CA, with graphics support from NASA Langley Research Center, Hampton, VA.

Preface

Welcome to the exciting world of aeronautics. The term aeronautics originated in France, and was derived from the Greek words for “air” and “to sail.” It is the study of flight and the operation of aircraft. This educator guide explains basic aeronautical concepts, provides a background in the history of aviation, and sets them within the context of the flight environment (atmosphere, airports, and navigation).

The activities in this guide are designed to be uncomplicated and fun. They have been developed by NASA Aerospace Education Services Program specialists, who have successfully used them in countless workshops and student programs around the United States. The activities encourage students to explore the nature of flight, and experience some real-life applications of mathematics, science, and technology.

The subject of flight has a wonderful power to inspire learning.

How to Use This Guide

This guide begins with education standards and skills matrices for the classroom activities, a description of the NASA aeronautics mission, and a brief history of aeronautics. The activities are divided into three chapters:

Air
Flight
We Can Fly, You and I

The activities are written for the educator. Each activity begins with (1) objectives, (2) education standards and skills, and (3) background material for the subject matter in the activity. The activity continues with by step-by-step instructions (and associated graphics) to help the educator guide students through the activity in the classroom. Each activity includes “student pages,” easily identified by this icon:

The student pages are as simple as a graphic of the activity, and as advanced as a work sheet. They are meant to supplement the educator’s presentation, serve as reminders, and inspire students to explore their own creativity. Activities requiring step-by-step assembly include student pages that present the project in a way that can be understood by pre-literate students.

Each chapter ends with a section listing suggested interdisciplinary activities.

Activity Matrix

	Science as Inquiry	Position and Motion of Objects	Physical Science	Properties of Objects and Materials	Unifying Concepts and Processes	Evidence, Models, and Explanation	Science and Technology	Science in Social and Personal Perspectives	History and Nature of Science
Air Engines	●	●					●		
Dunked Napkin	●		●	●		●			
Paper Bag Mask	●				●				
Wind in Your Socks	●		●					●	
Bag Balloons	●							●	
Sled Kite	●				●				
Right Flight	●		●		●		●		
Delta Wing Glider	●		●				●		
Rotor Motor	●	●	●				●		
Making Time Fly								●	●
Where is North?	●		●				●		
Let's Build a Table Top Airport							●	●	
Plan to Fly There		●							

Science Standards

Activity Matrix

	Problem Solving	Communication	Reasoning	Connections	Measurement	Verifying and Interpreting Results	Estimation	Prediction	Graphs
Air Engines	●				●				
Dunked Napkin						●			
Paper Bag Mask	●		●		●				
Wind in Your Socks									
Bag Balloons							●		
Sled Kite				●	●		●		
Right Flight	●		●		●			●	
Delta Wing Glider	●				●				
Rotor Motor	●				●		●		●
Making Time Fly	●	●							
Where is North?				●		●		●	
Let's Build a Table Top Airport		●	●						
Plan to Fly There	●	●		●					

Mathematics Standards

Activity Matrix

	Observing	Communication	Measuring	Collecting Data	Predicting	Making Graphics	Investigating	Interpreting Data	Inferring	Controlling Variables	Making Models
Air Engines	●				●	●	●				
Dunked Napkin	●							●			
Paper Bag Mask			●		●				●		●
Wind in Your Socks	●		●								●
Bag Balloons	●		●								●
Sled Kite	●		●		●						
Right Flight	●		●	●	●				●	●	●
Delta Wing Glider						●	●				●
Rotor Motor	●									●	●
Making Time Fly		●		●			●				
Where is North?	●								●		●
Let's Build a Table Top Airport		●	●				●				●
Plan to Fly There		●	●					●			

Science Process Skills

Aerospace Technology Enterprise

The NASA Aerospace Technology Enterprise's charter is to pioneer advanced technologies that will meet the challenges facing air and space transportation, maintain U.S. national security and pre-eminence in aerospace technology, and extend the benefit of our innovations throughout our society.

To benefit fully from the revolution in communication and information technology, we also need a revolution in mobility. To open the space frontier to new levels of exploration and commercial endeavor, we must reduce cost and increase the reliability and safety of space transportation. Both the economy and our quality of life depend on a safe, environmentally friendly air transportation system that continues to meet the demand for rapid, reliable, and affordable movement of people and goods.

Working with our partners in industry, Government, and academia, we have developed four bold goals to sustain future U.S. leadership in civil aeronautics and space transportation. These goals are as follows:

- revolutionize aviation;
- advance space transportation;
- pioneer technology innovation; and
- commercialize technology.

Revolutionize Aviation

NASA's goal to revolutionize aviation will enable the safe, environmentally friendly expansion of aviation in the following areas:

- Increase safety—Make a safe air transportation system even safer by reducing the aircraft accident rate by a factor of 5 within 10 years and by a factor of 10 within 25 years.
- Reduce emissions—Protect local air quality and our global climate.
- Reduce NO_x emissions of future aircraft by 70 percent within 10 years and by 80 percent within 25 years (from the 1996 ICAO Standard for NO_x as the baseline).
- Reduce CO_2 emissions of future aircraft by 25 percent and by 50 percent, respectively, in the same timeframes (from 1997 subsonic aircraft technology as the baseline).
- Reduce noise—Lower the perceived noise levels of future aircraft by a factor of 2 (10 decibels) within 10 years, and by a factor of 4 (20 decibels) within 25 years. The baseline is 1997 subsonic aircraft technology. The word "perceived" is key to the intended interpretation of this noise reduction goal. In subjective acoustics, a 10-dB reduction is perceived as "half" as loud, hence, the stated interpretation of the goal.
- Increase capacity—Enable the movement of more air passengers with fewer delays.
- Double the aviation system capacity within 10 years and triple it within 25 years. The baseline is 1997 levels.
- Increase mobility—Enable people to travel faster and farther, anywhere, anytime.
- Reduce intercity door-to-door transportation time by half in 10 years and by two-thirds in 25 years.
- Reduce long-haul transcontinental travel time by half within 25 years.

Advance Space Transportation

NASA's goal to advance space transportation is to create a safe, affordable highway through the air and into space.

- Mission safety—Radically improve the safety and reliability of space launch systems. Reduce the incidence of crew loss to less than 1 in 10,000 missions (a factor of 40) by 2010 and to less than 1 in 1,000,000 missions (a factor of 100) by 2025.
- Mission affordability—Create an economical highway to space.
- Reduce the cost of delivering a payload to low-Earth orbit (LEO) to $1,000 per pound (a factor of 10) by 2010 and to $100 per pound (an additional factor of 10) by 2025.
- Reduce the cost of interorbital transfer by a factor of 10 within 15 years and by an additional factor of 10 by 2025.
- Mission reach—Extend our reach in space with faster travel. Reduce the time for planetary missions by a factor of 2 within 15 years and by a factor of 10 within 25 years.

Pioneer Technology Innovation

NASA's goal to pioneer technology innovation is to enable a revolution in aerospace systems.

- Engineering innovation—Enable rapid, high-confidence, and cost-efficient design of revolutionary systems.
- Within 10 years, demonstrate advanced, full-life-cycle design and simulation tools, processes, and virtual environments in critical NASA engineering applications.
- Within 25 years, demonstrate an integrated, high-confidence engineering environment that fully simulates advanced aerospace systems, their environments, and their missions.
- Technology innovation—Enable fundamentally new aerospace system capabilities and missions.
- Within 10 years, integrate revolutionary technologies to explore fundamentally new aerospace system capabilities and missions.
- Within 25 years, demonstrate new aerospace capabilities and new mission concepts in flight.

Commercialize Technology

The NASA Commercial Technology Program enables the transfer of NASA technologies to the private sector to create jobs, improve productivity, and increase U.S. competitiveness. NASA provides assistance to a wide variety of companies, with special emphasis on small businesses.

Aeronautics

Background for Educators

"Birds fly, so why can't I?" That question was probably first asked by cave dwellers watching a bird swoop through the air. Perhaps even then, people understood the advantages of human flight. The desire to defy gravity and experience the freedom of flight compelled early attempts to unravel the mysterious technique the birds had mastered proficiently.

Piloted flight and the mobility it offered to humankind would have to wait many centuries. The more immediate goal of the cave dwellers was survival. The discovery of fire by early inhabitants helped assure a permanent place on Earth for descendants. While a small spark eventually produced the light and heat of fire, the spark for flight was imagination. Ironically, the discovery of fire would play a major role in our first flight. Fire and flight forever changed the way we lived.

The writings and voices of past civilizations provide a record of an obsession with flight. The aerial dreams of early writers are revealed in Roman and Greek mythology. The mythical father and son team of Daedalus and Icarus used artificial wings of wax and bird feathers to escape from Crete. In Greek mythology, Pegasus was a winged horse. Some writings contributed significantly to the emerging science. From the early 1480's until his death in 1519, the Florentine artist, engineer, and scientist, Leonardo da Vinci, dreamed of flight and produced the first drawings for an airplane, helicopter, *ornithopter*, and parachute.

In the early 17th century, serious aeronautical research was conducted by so-called "birdmen" and "wing flappers." These early experimenters were erroneously convinced that wings strapped to a human body and muscle power were the answer to flight. Their daring and often dangerous experiments made scant contributions to aeronautical knowledge or progress. By the mid-17th century, serious-minded experimenters had correctly decided that humans would never duplicate bird flight. They turned their attention to finding a device that would lift them into the air.

Two French paper makers, Joseph and Etienne Montgolfier, noting the way smoke from a fire lifted pieces of charred paper into the air, began experimenting with paper bags. They held paper bags, open end downward, over a fire for a while and then released them. The smoke-filled bags promptly ascended upward. Smoke, the brothers deduced, created a lifting force for would-be flyers. 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, a sheep, a rooster, and a duck were suspended in a basket beneath a Montgolfier balloon. The cloth and paper balloon was 17 meters high, and 12 meters in diameter. A fire was lit, and minutes later the balloon was filled with hot air; it rose majestically to a height of more than 500 meters. The farm animals survived the ordeal and became the first living creatures carried aloft in a human-made device. The dream of flight was now the reality of flight. Two months later on November 21, 1793, two volunteers stepped into the basket and flew for eight kilometers over Paris, thereby 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 balloon had become elongated and fitted with propulsion and steering gear. Ballooning had become a fashionable sport for the rich, a platform for daring circus acts, and provided valuable observation posts for the military. Yet none of this was flying the way birds fly – fast, exciting, darting, diving, and soaring with no more than an effortless flick of wings. To escape the limitations of a floating craft, early researchers began the search for another, more exciting form of lift.

A small but dedicated handful of 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 its principles might be adapted by humans. As early as 1796, Englishman George Cayley conducted basic research on *aerodynamics* by attaching bird feathers to a rotating shaft, thereby building and flying a model helicopter. In 1804, he built and flew the world's first fixed-wing flyable model glider. This pioneering model used a paper kite wing mounted on a slender wooden pole. A tail was supported at the rear of the pole providing 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 craft lifted a 10 year old boy a few meters off the ground during two test runs. Four years later, Sir George Cayley persuaded his faithful coachman to climb aboard another glider and make the world's first piloted flight in a fixed-wing glider.

In Germany, 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 superior lifting quality of the curved wing. By 1894, Lilienthal's unpowered flying machines were achieving spectacular glides of over 300 meters in distance. Lilienthal built a 2 1/2 horsepower carbonic acid gas engine weighing 90 pounds. He was ready to begin powered glider experiments. Unfortunately, Lilienthal was killed in an 1896 glider mishap before he could test his power-driven airplane.

Otto Lilienthal left behind an inspiration and a warning. If his life's work proved that we could fly, then his death was a somber warning. Humans would have to master the aerodynamics of wings before flight like the birds could be accomplished with confidence and safety. His extensive research and experiments in aviation brought the world closer to realizing the age-old dream of human flight.

Lilienthal's work was carried forward by one of his students, a Scotsman named Percy Pilcher. Like Lilienthal, Pilcher built his own four-horsepower engine in hopes of achieving powered flight. Ironically, before he could conduct any experiments with powered flight, Pilcher was killed in a glider accident during 1899.

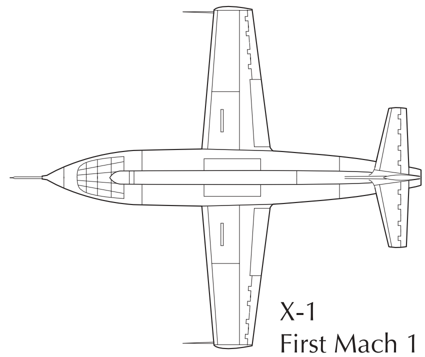
As the 19th century drew to a close, aviation pioneers continued to probe the mystery surrounding mechanical flight. Octave Chanute, Samuel Langley, and others experimented to produce further understanding of aeronautical principles and knowledge, yet controlled, powered flight was not realized. In 1900, the world waited for a lightweight power source and a method to control flight.

On May 30, 1899 Wilbur Wright wrote to the Smithsonian Institution in Washington, D.C. requesting information about published materials on aeronautics. By early summer of that year, Wilbur and his brother Orville had read everything they could find on the subject. The Wright brothers began a systematic study of the problem of flight by conducting research on the methods tried by previous experimenters. They conducted hundreds of wind tunnel experiments, engine and propeller tests, and glider flights to gain the knowledge and skill needed to fly.

On December 17,1903, four years after beginning their research, the world was forever changed. A fragile cloth and wood airplane rose into the air from a windswept beach at Kitty Hawk, North Carolina, and flew a distance of 36 meters. The brothers provided the world with a powered flying machine controlled by the person it carried aloft. Ingenuity, persistence, and inventiveness had finally paid a big dividend–the Wright Flyer was successful. This 12-second event marked the beginning of tangible progress in the development of human-carrying, power-driven airplanes.

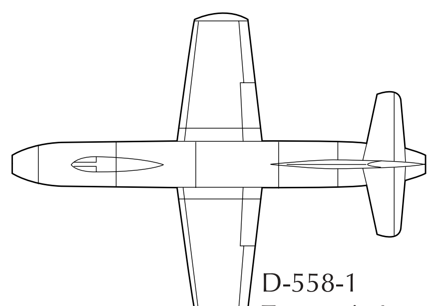
By 1905, an improved Wright Flyer could fly more than 32 kilometers and stay aloft almost 40 minutes. Five years later, the first international air meet in the United States was held in Los Angeles, California. Glenn Curtiss set a new world's speed record of 88 kilometers per hour and Frenchman Louis Paulhan set an altitude record of 1250 meters. At the outbreak of World War I, the airplane could fly at speeds of over 200 kilometers per hour and reach altitudes of 7500 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 interchange, commerce, foreign relations, and military strategy. Flight research in the United States got a significant boost in 1915. The National Advisory Committee for Aeronautics (NACA) was formed by the United States Congress "to supervise and direct the scientific study of the problems of flight, with a view to their practical solutions."


X-1
First Mach 1 Flight
1946-1951

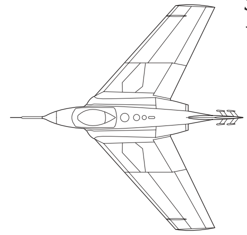
By the 1930's, NACA wind tunnels and flight test investigations led to improvements in aircraft performance and safety. Research produced new *airfoil* or wing shapes and propeller designs that increased the safety and efficiency of airplanes. New engine cowlings and aerodynamic streamlining reduced 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, agriculture development, electronics, efficiency, and safety. NASA is striving to make airplanes ecologically safe by lessening the sonic boom for aircraft traveling at *supersonic* speeds and developing propulsion systems that use pollutant-free fuel.


D-558-1
Transonic Jet
1947-1953

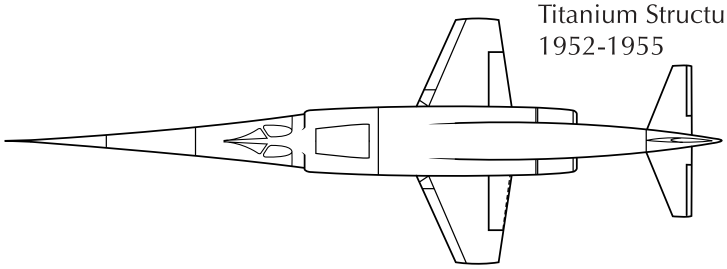
On August 17, 1978 near Paris, France, a hot air balloon descended from the sky and landed in a cornfield. Thousands of onlookers watched and cheered as the three crew members stepped down from the Double Eagle II. They had just completed the first nonstop crossing of the Atlantic Ocean in a balloon. Almost two hundred years earlier in 1783, Parisians cheered the Montgolfier brothers as they launched the first hot air balloon. The time span between the two events is filled with flight milestones that have taken humankind from the dream of flight to landing on the moon.

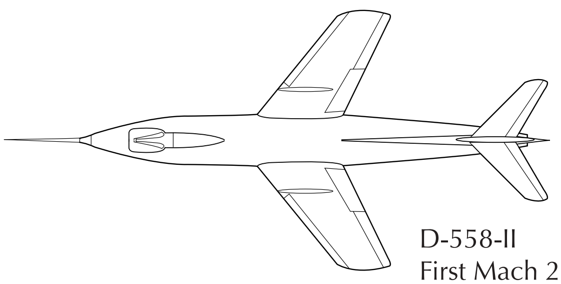
X-4
Semitailless Jet
1948-1953



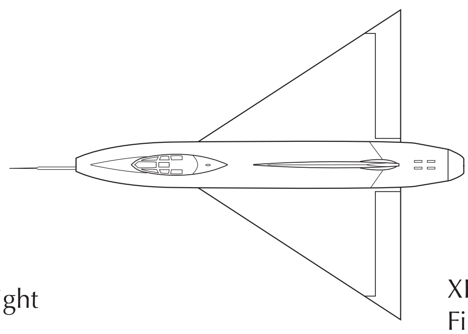
Exploring Supersonic Flight

X-3
Titanium Structures
1952-1955

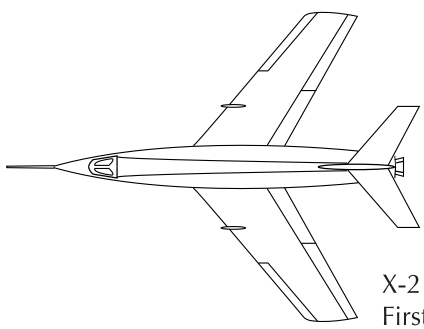




D-558-II
First Mach 2 Flight
1948-1956

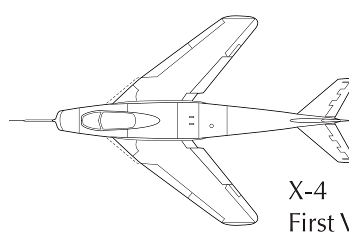


XF-92A
First Delta Wing Jet
1948-1953



X-2
First Mach 3 Flight
1955-1956

The NACA Experimental Research Aircraft Program which began in the 1940's took human flight to previously unexplored speeds and altitudes.



X-4
First Variable-Sweep Wing
1951-1955

Air

Air Engines ---------- *12*
Dunked Napkin ---------- *17*
Paper Bag Mask ---------- *23*
Wind in Your Socks ---------- *29*
Interdisciplinary Learning Activities ---------- *36*

Air engines

Objectives

The students will:
Observe how unequal pressure creates power.
Explain that air power can help airplanes fly.
Construct a working model of an air engine.

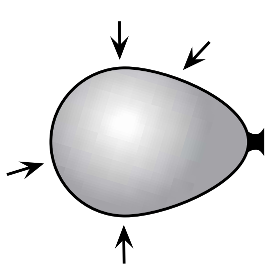
Standards and Skills

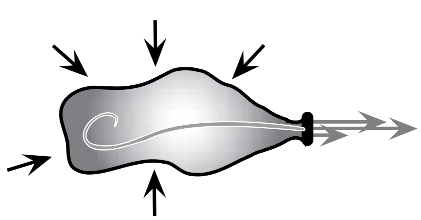
Science
Science as Inquiry
Science and Technology
Position and Motion of Objects

Science Process Skills
Making Models
Observing

Mathematics
Math as Problem Solving
Measurement

Background

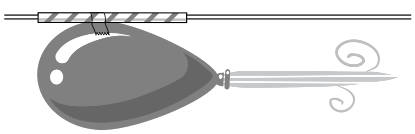




Aircraft powered by jet, piston, or rocket engines are capable of sustained flight. Remaining aloft longer means the aircraft offers greater utility and convenience to users. The aircraft engine provides a constant source of thrust to give the airplane forward movement.

This activity will allow students to build and demonstrate a source of thrust found in some research aircraft: the rocket engine. The straw represents the fuselage and the balloon represents the aircraft engine. Once the balloon is filled with air, there is a difference in air pressure between the outside and the inside of the balloon.

The inside of the balloon has higher pressure than the outside of the balloon. The air on the inside of the balloon equalizes with the air on the outside of the balloon when the balloon is released. Energy is generated as air equalizes from high pressure areas to low pressure areas.

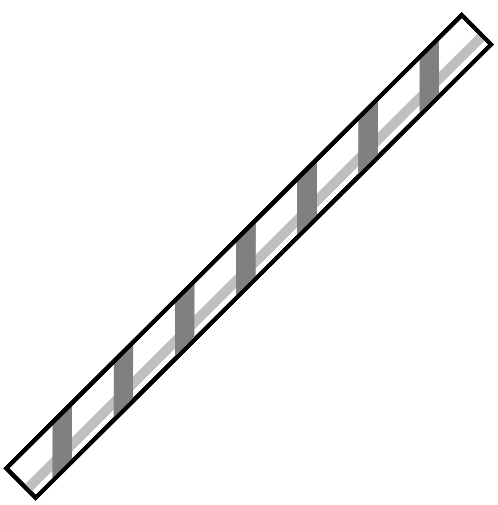


The balloon moves in the opposite direction of the flow of the released air because every action has an opposite and equal reaction. Since the air is released from one small hole, the release of the air is focused in one direction. Because it is focused in one direction, the balloon and straw are forced to move down the string in the opposite direction.

Materials

Balloon
Drinking straw
Fishing line
Tape

Preparation



1. Place a drinking straw inside a mystery container. Play a game of 20 questions with the students to see if they can identify what is in the container.

2. Share with them that what is inside has something to do with learning about how airplanes fly. After the students have asked all of the questions, show them the straw inside of the box. Let them know that they will be using the straw to build a model of an air engine.

3. Give the students a few minutes to investigate the straw. Give each student a straw and ask them to describe the straw and see if they can figure out a way to make the straw travel from one place to another (e.g., from the desk to the floor, or from one part of the room to another).

   Tell the students that they'll be learning another way to make the straw move—by making an air engine.

Activity

1. Group students in teams of four and provide each team with a set of materials.

2. Have the students inflate a balloon and let it go.
   Ask the students to make observations about what happened to the balloons when they were released.

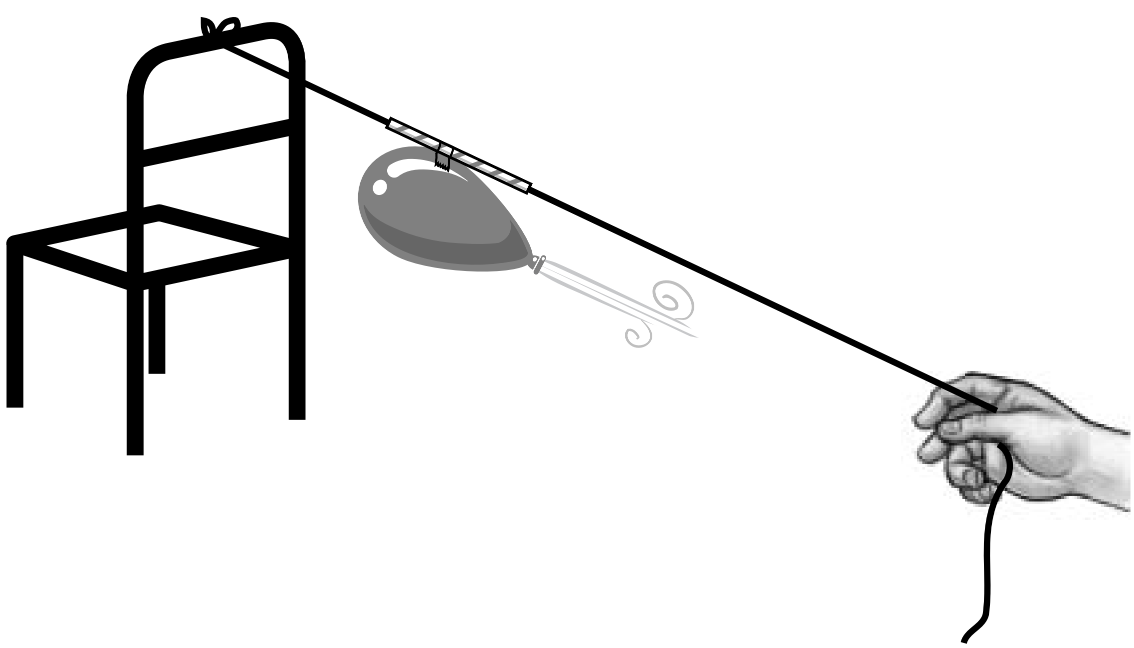
   Explain to the students that the balloons move because the air pressure on the outside and the inside is different. Have the students observe how the balloons go off in all different directions.

   The balloons will move. The energy inside the balloon propels it. Tell the students that the movement of the balloon can be directed toward one place.

3. Now have the students assemble their models.

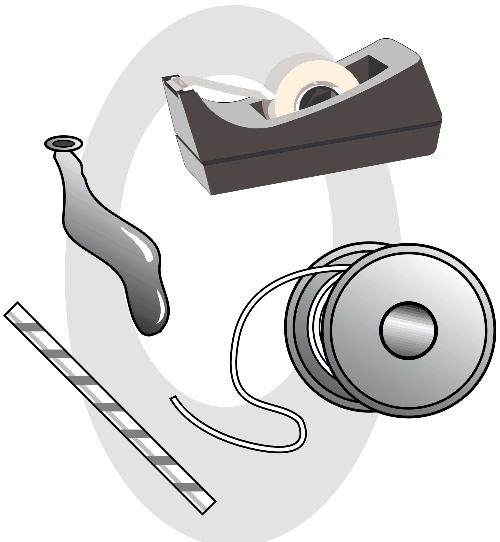
   Have the students place the fishing line through the straw. One student will hold one end of the fishing line, and the other end of the fishing line should be tied to the back of a chair. Then, have the students inflate a balloon with air and hold the end tight while another team member tapes the balloon to the straw. Once this is done, the students can release the balloon nozzle, and observe the balloon (air engine) as it moves across the fishing line.

   Have each team tape their engine parts (straw, balloon, and fishing line) to a piece of paper. Have the students use this to explain how the activity worked.



Discussion

1. Have the students identify the different parts of the air engine model: straw (fuselage), balloon (air engine), fishing line (track).



2. Ask the students to explain why the straw moved along the string. *The balloon moves along the string when the air pressure inside the balloon escapes out of the nozzle. Since the balloon is taped to the straw, the straw moves with the balloon when the air is released.* Help the students make the connections between this and airplanes moving through the air.

3. Ask the students to tell how moving the balloon along the string is different from how they tried moving the straw in the pre-activity. *In the pre-activity, students did not use directed air pressure to move the straw. They moved the straw by throwing it or dropping it. In the air engine activity, the students move the straw when they focus the air power.*

Assessment

Have the students make a drawing of their air engines, and then write or tell about how the air engine worked.

Have the students write how air power helps airplanes fly.

Extensions

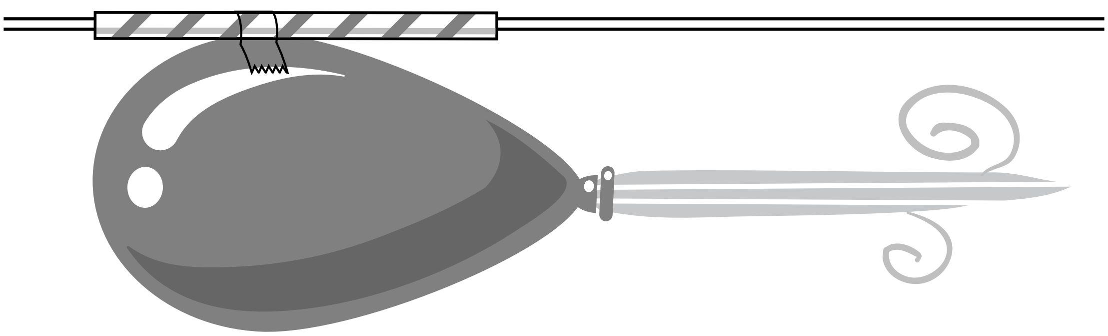
1. Have the students construct another air engine model, but this time let them investigate with different sizes and shapes of balloons.

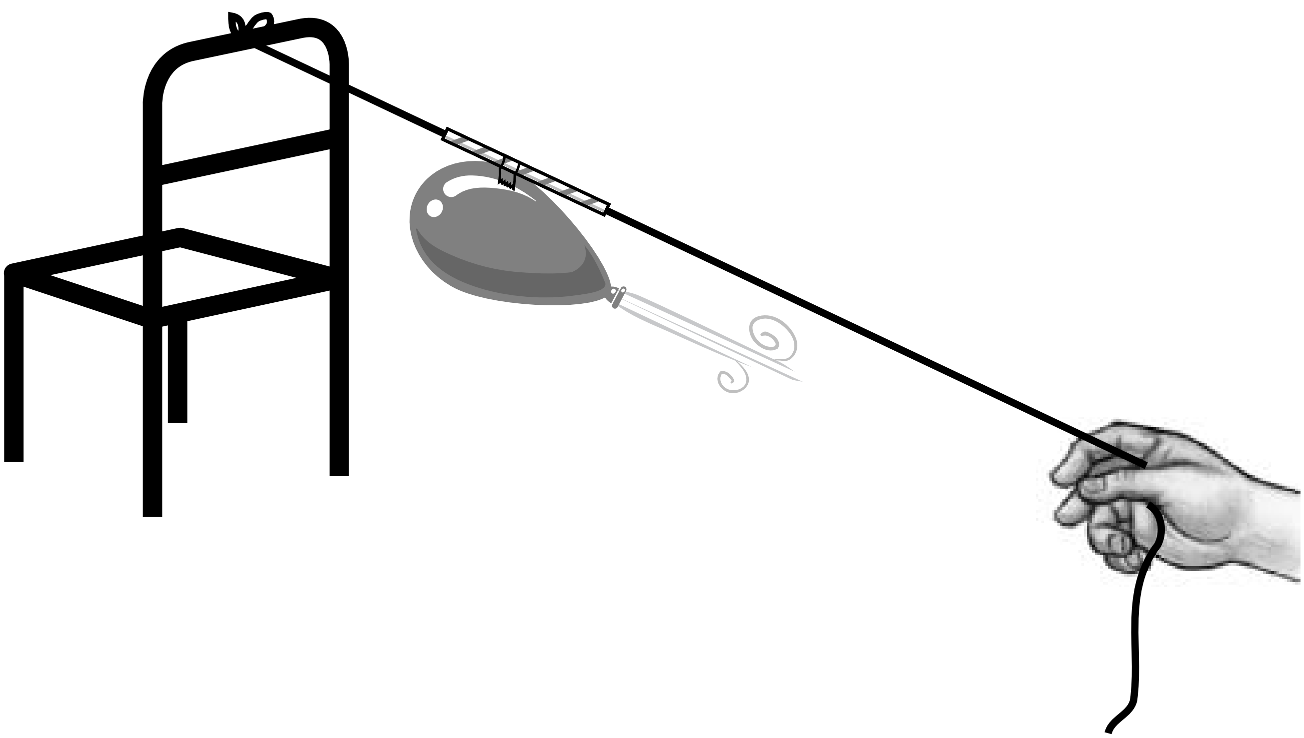
2. Have the students make a longer track and record the distance the engine moves the straw along the track.

3. Have the students make a vertical track and observe how the air engine moves the straw from the floor to the ceiling.

4. Hold air engine contests to see which team can make the air engine straw go the farthest distance.

Air Engines





DUNKED NAPKIN

Objectives

The students will:
Experiment to determine if air occupies space.

Standards and Skills

Science
Science as Inquiry
Physical Science
Properties of Objects and Materials
Evidence, Models, and Explanations

Mathematics
Verifying and Interpreting Results

Science Process Skills
Predicting
Observing
Investigating
Interpreting Data

Background

Gas, solid, and liquid are states of matter found on Earth. One of the basic characteristics of matter is that it occupies space. An observer can "see" a glass of milk sitting on a table. The milk and table are objects that occupy a measurable part of the total volume or space in the room.

Although air is present in the room with other matter, a visual aid is necessary for an observer to "see" that air occupies a portion of space as well. In this experiment a plastic cup containing air and a crumpled napkin are turned upside down and placed into a container of water. Air and water cannot occupy the same space at the same time, therefore the napkin remains dry.

When conducting scientific inquiry, scientists begin by asking questions about why something is a certain way. In this case, "does air take up space?" Based on the question, they predict what the answer is. This is called forming a *hypothesis*.

The next step is to test the hypothesis with an experiment. Scientists draw *conclusions* from the results of their experiment, which leads them to either accept or reject their hypothesis.

Materials

Clear plastic cup
Napkin
Water
Basin or small aquarium
Newspapers or drop cloth
Balloon

Warm-up

Have students discuss what they think air is. Which of the five senses lets them experience air? Can you taste or smell air? *Probably not*. Can they see it? *No, but you can see things like a wind sock blow in the wind.*

Can you feel air? *Try holding your hand over a heating vent, fanning your face with a folded paper fan, or whirling around with a paper lunch bag on your arm. You might not be able to see air, but you can feel air molecules moving.*

Does air take up space? To help students answer this question, take a deflated balloon and blow air into it so it is partly filled. Ask them what is in the balloon and then blow up the balloon until it is full. Is there more air in the balloon now than there was before? *Obviously air takes up space.*

The balloon has air in it, but does the cup? In this exercise have students predict if there is air in the cup and what will happen to a napkin inside the cup if you put the cup in the basin of water.

Management

This activity can be done as a teacher demonstration or student activity. It will take about 15 minutes to complete and there is a potential for water spillage. Students can work individually or in pairs.

Activity

1. Prepare a table for water spillage by covering it with newspapers or a drop cloth.

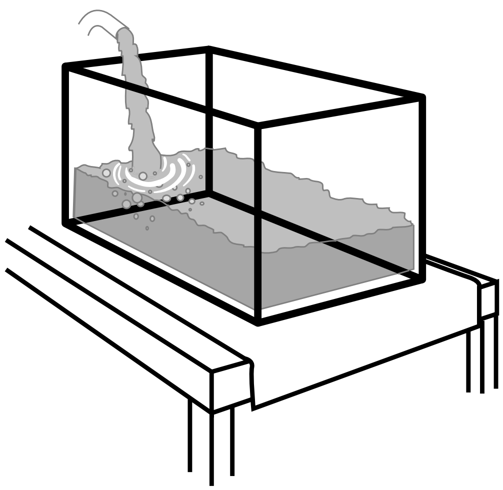
2. Fill an aquarium or other large container with water.

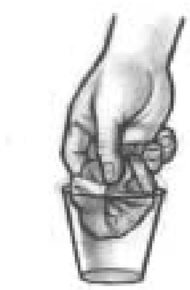
3. Crumple a napkin and stuff it into a plastic cup.

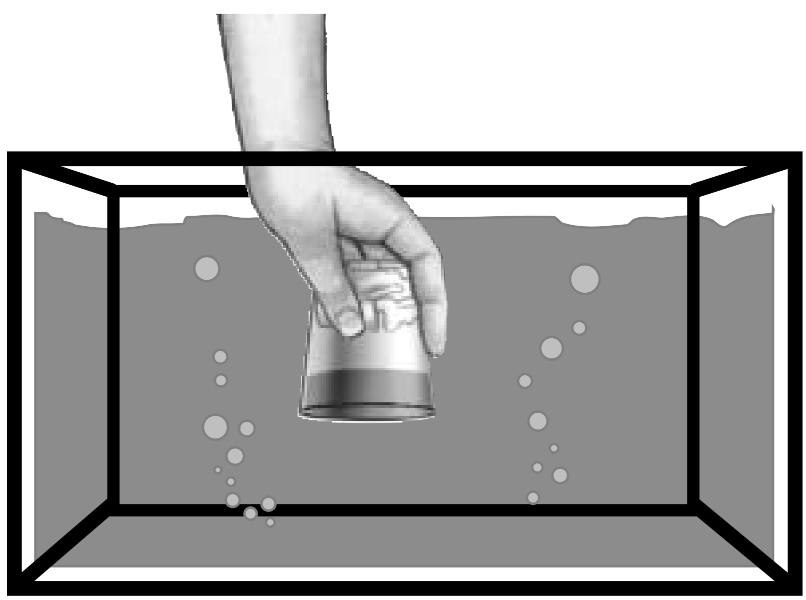
4. Turn the cup upside-down and plunge it completely into the water. Do not tilt the cup.

5. Remove the cup from the water, and extract the napkin.

6. Observe whether the napkin is wet or dry.







Discussion

1. What is an experiment and why is it conducted? *An experiment is an activity or action designed to answer questions.*

2. What is a hypothesis? *A hypothesis is a proposed answer to a problem, or an explanation that accounts for a set of facts and can be tested by further experimentation and observation. The results of experimentation provide evidence that may or may not support the hypothesis.*

3. What is a conclusion? *A conclusion is an answer based on the experiment.*

4. Why did the napkin stay dry? *Air trapped in the cup with the napkin prevented water from entering the cup.*

5. What is air? *Air is a mixture of gases that make up the Earth's atmosphere.*

6. Can you taste, see, feel, hear, or smell air? *Impurities in air will allow our senses to detect the presence of air. For example, smoke contains particles we can see and smell. Moving air or wind can be felt and heard.*

Assessment

Students will have successfully met the objectives of this activity by:

Conducting the experiment.
Stating a conclusion based on the experiment.

Extensions

1. Have the students alter variables like cup size, speed, and angle of insertion and removal, and liquids other than water.

2. Discuss where air pockets can occur: in landfills, underwater or underground caves, capsized canoes, etc.

3. Brainstorm a list of examples of air taking up space that students might see in school, at home, or on television: balloons, bubbles, basketballs, etc.

4. Discuss ways to store air. Space travellers and scuba divers must store air in tanks.

Dunked Napkin

This experiment will help answer the question "Does air take up space?"

Materials: Clear plastic cup, napkin, water, basin or small aquarium, and newspaper or drop cloth

1. Place a drop cloth or newspaper on your work surface. Fill a basin with water.

2. Crumple a napkin and put it at the bottom of the cup. The napkin should fit tightly, and not fall out when the cup is inverted.

3. Predict what will happen to the water and napkin when you turn the cup so that the mouth faces downward and place it in the basin of water.

   I predict ____

   ____

4. Place the inverted cup into the basin of water. Hold it under water for two minutes and observe what happens.

5. Write or draw what you saw happen to the napkin. ______________________

   ____

6. Carefully pull the cup out of the water and remove the napkin. Is the napkin wet or dry?

   ____

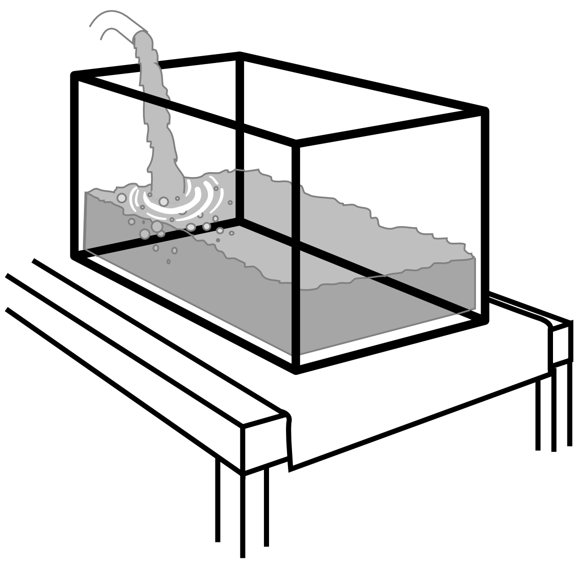
7. Can you explain the results of your experiment? ______________________

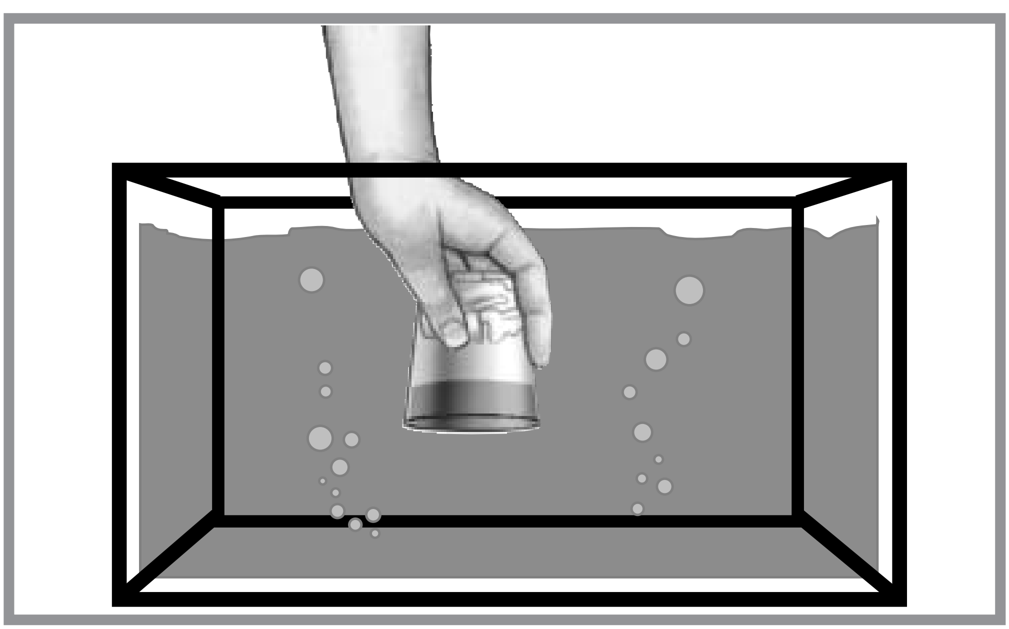
8. Use the results of your experiment to answer this question: Does air take up space?

   ____

   ____

Dunked Napkin





PAPER BAG MASK

Objective

The students will:
Construct a device that demonstrates Bernoulli's principle.
Understand the effect of air flowing over a curved surface.

Standards and skills

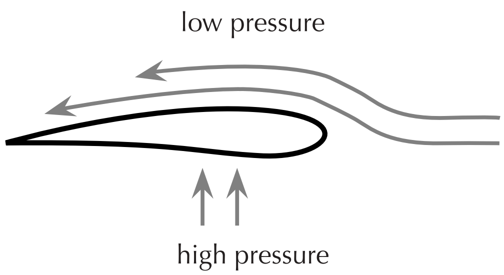
Science
Science as Inquiry
Unifying Concepts and Processes

Science Process Skills
Measuring
Inferring
Predicting
Science as Inquiry

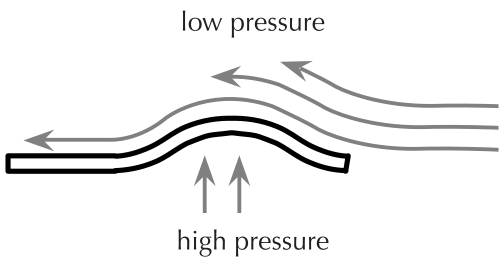
Mathematics
Geometry and Measurement
Problem Solving

Background

A change in the speed at which air is flowing will cause a change in air pressure. Daniel Bernoulli, a Swiss scientist in the 18th century, discovered what is now called *Bernoulli's principle*: the pressure in a fluid (gas and liquids) decreases as the speed of the fluid increases.



The wing of an airplane is a device that creates changes in the speed of air flow, thus creating a change in air pressure. Air moving over the curved top portion of a wing will travel at higher speed and produce lower pressure than the bottom, creating *lift*. Lift is a force caused by the equalization of pressures. Equalization always occurs from areas of high pressure to low pressure. An inflated balloon has higher air pressure inside than outside. The balloon will pop when the pressure difference becomes too great for the material.



The low pressure of the airflow over the top of the "tongue" creates lift in the same way that a wing produces lift.

Another example of Bernoulli's principle can be seen using the paper bag mask. When the student blows through the hole in the paper bag mask and over the curved surface of the "tongue," unequal air pressure will lift the tongue.

Materials

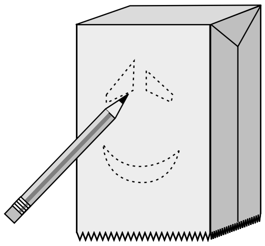
Large paper grocery bags
Scissors
Crayons or markers
Notebook or copier paper
Tape or glue
Metric ruler

Preparation

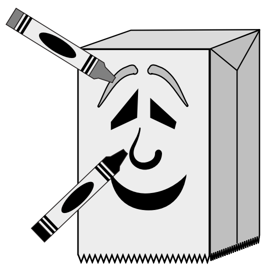
Have each student bring a large paper grocery bag from home.

Activity

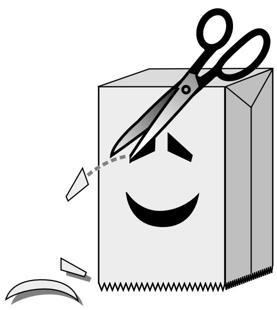
1. Place a bag over the head of one student and have a second student carefully draw small dots where the eyes, nose, and mouth are located.



2. Remove the bag from the head and draw a face around the marks made in step 1.

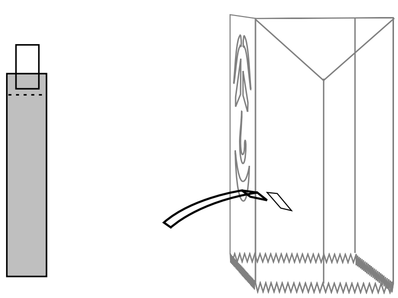


3. Cut out two holes (approximately 2 cm diameter) for the eyes.



4. Cut a hole (approximately 4 cm diameter) for the mouth.

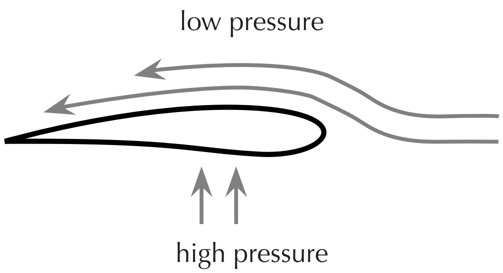
5. To make the tongue, cut a strip of paper, approximately 3 cm wide and 20 cm long.

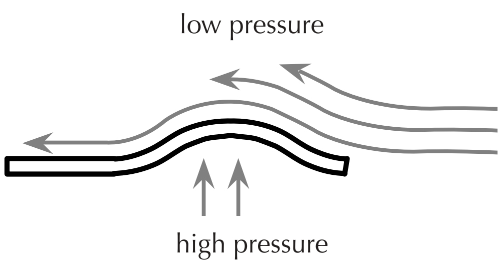


6. Tape or glue one end of the tongue inside the bag at the bottom of the mask's mouth. Allow the tongue to droop through the mouth on the outside of the bag.

7. Place the bag over the head and blow through the mouth hole. Observe the movement of the tongue.

Discussion





1. Why does the tongue move when you blow gently through the mouth? What happens when you blow harder? The *curved surface of the tongue creates unequal air pressure and a lifting action. Blowing harder will cause the tongue to move up and down faster.*

2. Attach a lightweight streamer to a fan or air conditioning vent. Ask the students to observe and describe what happens. How do the streamers relate to this activity? The *same force moves the tongue and streamers. Lift is caused by air moving over a curved surface.*

3. What are some other common examples of Bernoulli's principle? *Flags waving, sails, an umbrella that becomes impossible to hold in a strong wind.*

Assessment

1. Have a classmate observe the paper tongue and record what happens. Switch roles.

2. Write a paragraph or draw a picture to describe what happens to the paper tongue.

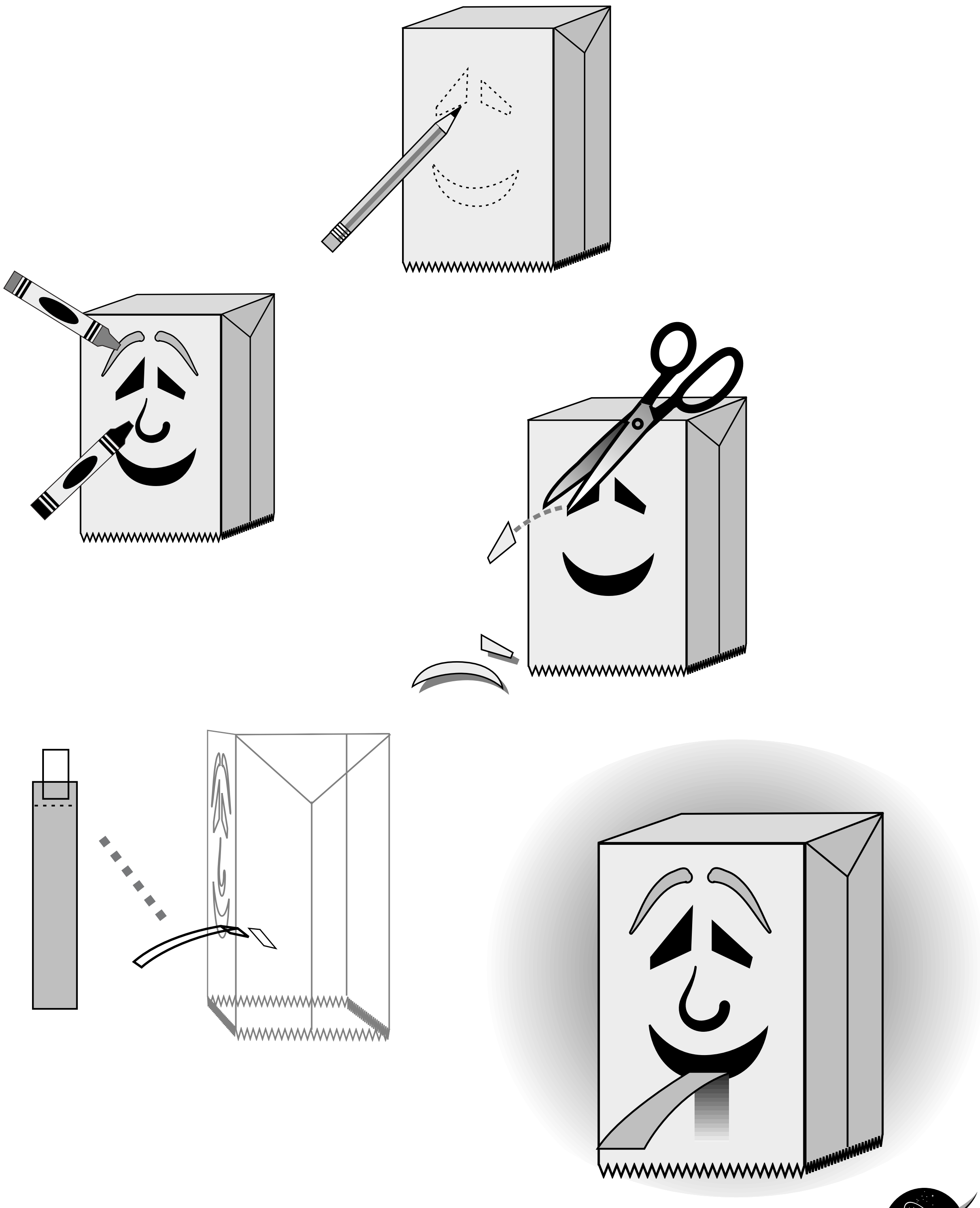
3. Write a paragraph or draw a picture to tell how airplane wings are similar to the paper tongue.

Extensions

1. Experiment with different tongue lengths.

2. Encourage the students to be creative with the designs on the bags – faces that say something about who they are, or who they want to be, maybe the face of a friend, relative, or classmate. The designs may also be abstract, or not human; consider holiday themes.

Paper Bag Mask



Paper Bag Mask

WIND IN YOUR SOCKS

Objectives

The students will:
Construct and use a simple wind sock.
Measure wind direction and speed using a wind sock.

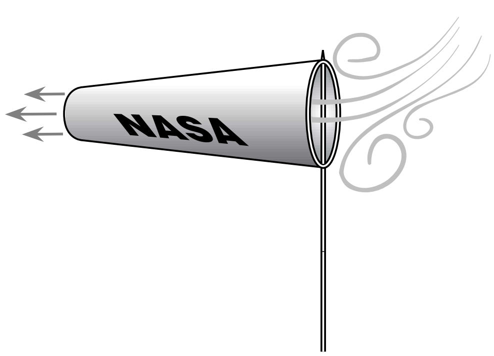
Standards and Skills

Science
Science as Inquiry
Physical Science
Science and Technology

Mathematics
Problem Solving
Reasoning
Measurement

Science Process Skills
Observing
Measuring

Background



A wind sock is a type of kite used to detect wind direction. It is a tapered tube of cloth that is held open at one end by a stiff ring. Wind is directed down the tube, causing the narrow end to point in the same direction the wind is blowing. Brightly colored wind socks are used at airports to help pilots determine the wind direction along the ground. *Meteorologists* use wind direction to help predict the weather.

Materials

1 sheet 8 1/2 X 11 inch printer or copy paper
1 piece tissue paper 28 cm X 28 cm
White glue or paste
Cellophane tape
Scissors
Single-hole paper puncher
1 Paper clip
Metric ruler
1.2 m kite string
Magnetic compass
Wooden dowel

Preparation

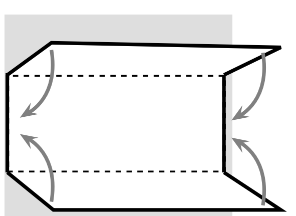
Cut the tissue paper into 28 cm X 28 cm squares before beginning the activity. One square is needed for each wind sock.

Management

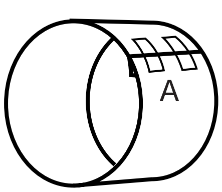
The students will need approximately 1 hour to build a wind sock. It can take several days to monitor wind direction. For younger students, make one wind sock for the class and use it to record data on the student page.

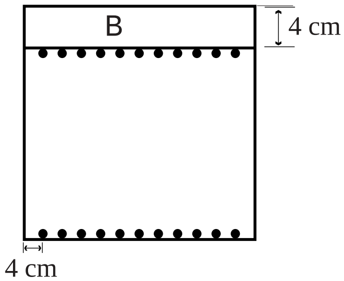
Activity

1. Fold a piece of 8 1/2 X 11 inch paper lengthwise to make the border strip for the wind sock.



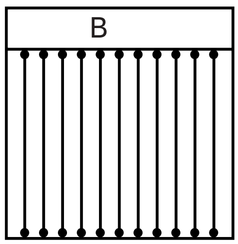
2. Form a loop from the strip and tape the ends of the paper together. Mark the outside edge with the letter A.





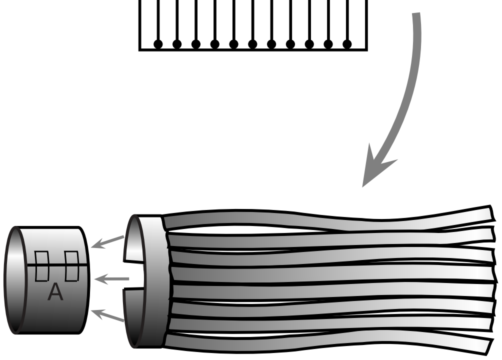
3. On the tissue paper use a marker to draw a line 4 cm from one edge and across the paper. Mark the 4 cm by 28 cm area with the letter B. (Illustrations shown not to scale.)

4. Beginning along one end of the line drawn in part 3 above, measure and mark a point 3 cm from the edge. Continue marking the edge with additional points each separated by a distance of 3 cm.



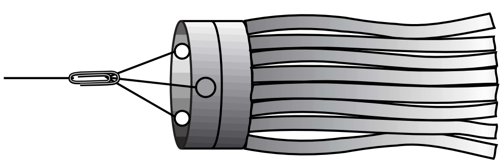
5. Repeat step 4 to mark points along the opposite end of the tissue paper.

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



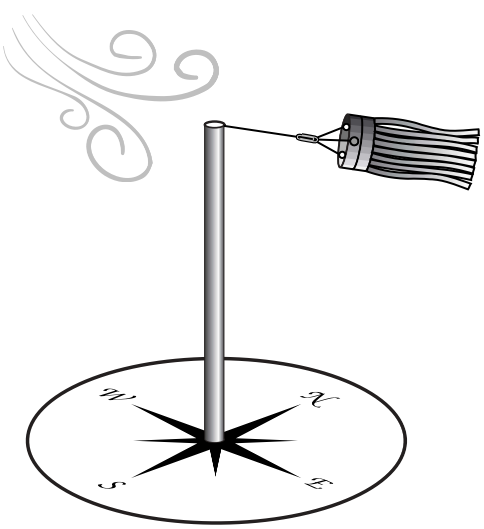
7. Glue edge B of tissue paper to edge A of the loop strip made in step 2. Allow time for the glue to dry.

8. Use a hole punch to punch three holes equal distance around the paper ring.



9. Cut 3 pieces of string 30 cm long. Tie one end of each string to the wind sock at each of the 3 holes.

10. Tie the 3 loose ends of the string to a single paper clip. Add an additional 30 cm length of string to the paper clip.



11. Test the wind sock by holding the single string in front of a fan.

12. Tape the wind sock to a wooden dowel and place outside to monitor wind direction and "speed" (refer to Student Page, the wind sock "speed" gauge determines the strength of the wind, but not actual speed). To help determine wind direction, use a compass to mark north, south, east, and west below the wind sock (with the dowel in the center).

Discussion

1. What does the wind sock do in the wind? *The wind sock aligns itself with the wind and the strips move toward a horizontal position.*

2. What are some ways wind socks can be used? *Pilots preparing for takeoff or landing observe wind socks to determine wind direction and speed, because they want to land and takeoff facing the wind to reduce the takeoff and landing distance. Meteorologists use wind socks to help forecast the weather. Some factories that must regulate the amount emissions they may put into the atmosphere use wind socks monitor wind conditions, wind speed and direction will have an effect upon the distance and direction the emissions will travel.*

3. Discuss how winds get their names (south, northeast, etc.). *They are named for the direction from which they blow. For example, a north wind blows from a northerly direction.*

Assessment

1. Place a fan on a table, then have students demonstrate wind direction using the wind sock.

2. Use the activities on the student pages to determine and record the strength of the wind: calm, a slight breeze, gentle breeze, moderate breeze, or strong breeze.

Extensions

1. Use garbage bags or nylon fabric instead of tissue paper to make a wind sock that is more weather resistant.

2. Use different colors of tissue paper to decorate wind socks

3. Make wind socks of different sizes.

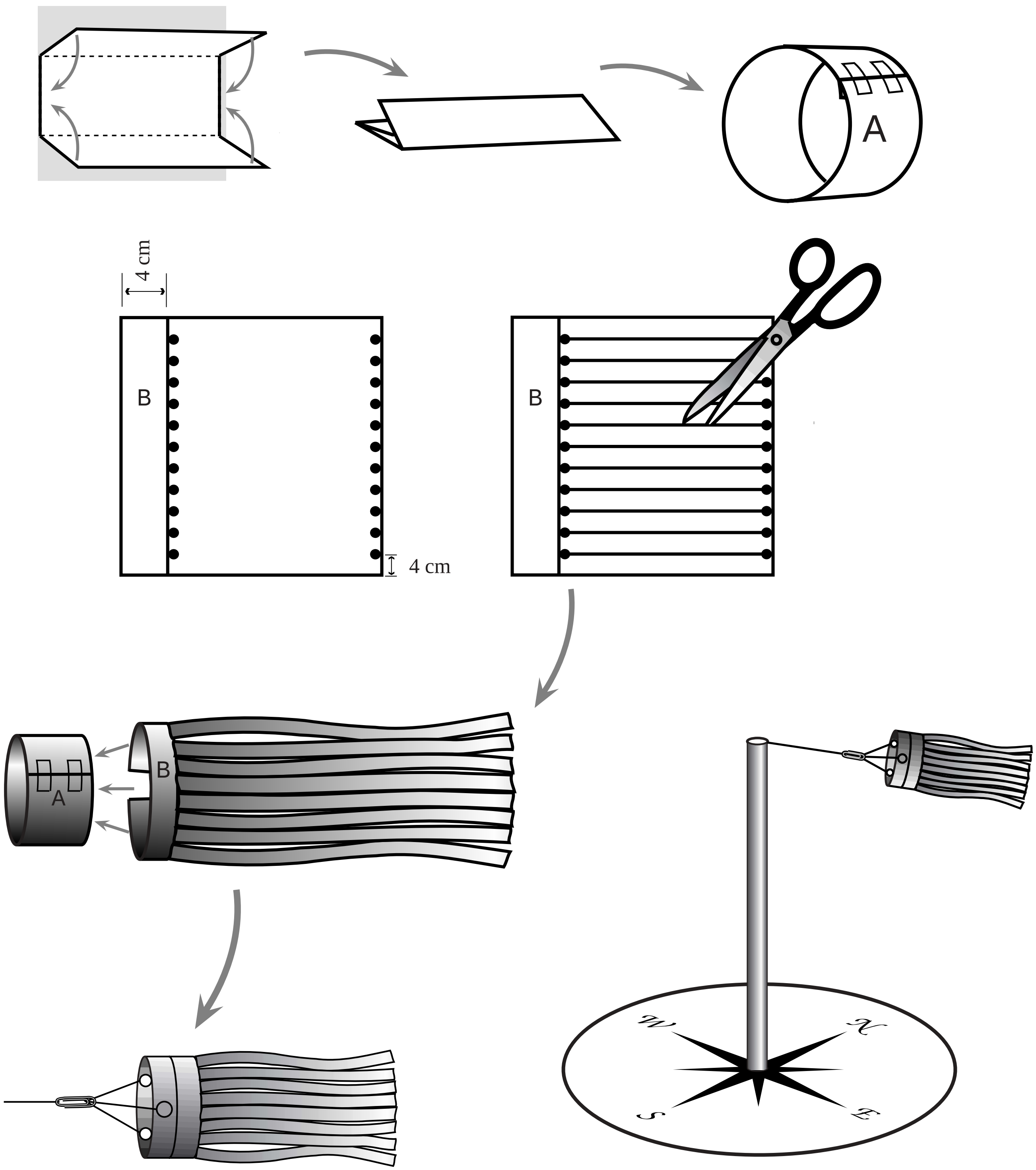
4. Place a wind sock in the classroom in different positions and ask the students to determine if there is air circulation in the room, and from which direction.

5. Ask the students to write down information about the wind on a specific day and time. Repeat this activity for several days.

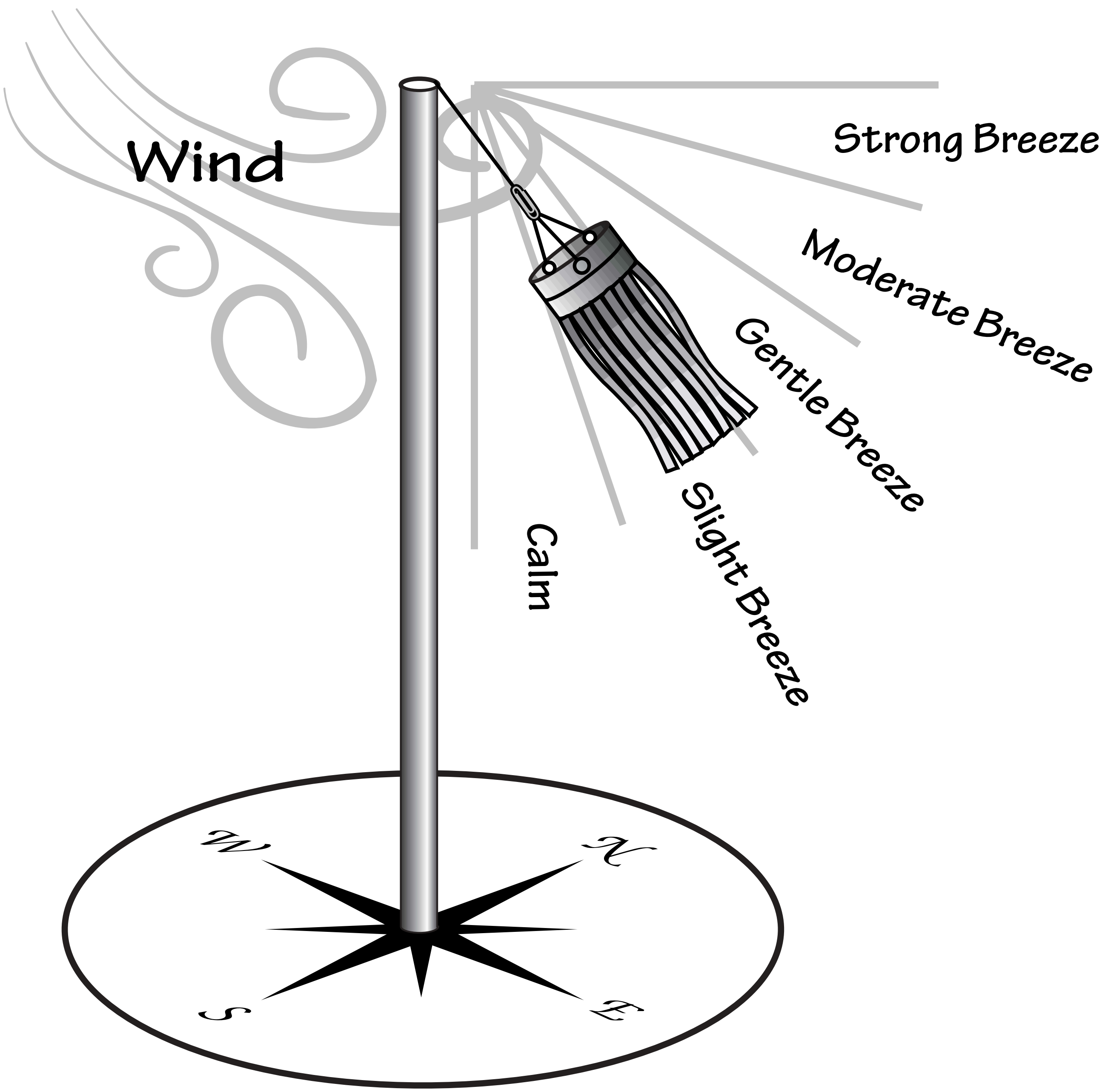
6. In the classroom, obstruct the airflow (using objects, or students) between the fan and the wind sock and observe how the wind sock responds. Discuss how objects in nature may change the flow of wind.

7. Put the wind sock at different distances from the fan throughout the classroom. Ask the students to observe the various ways the wind sock responds.

Wind in Your Socks

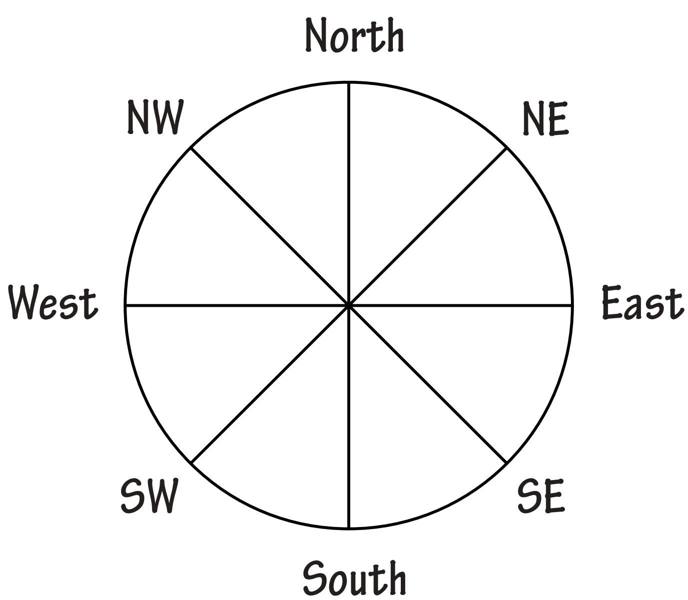


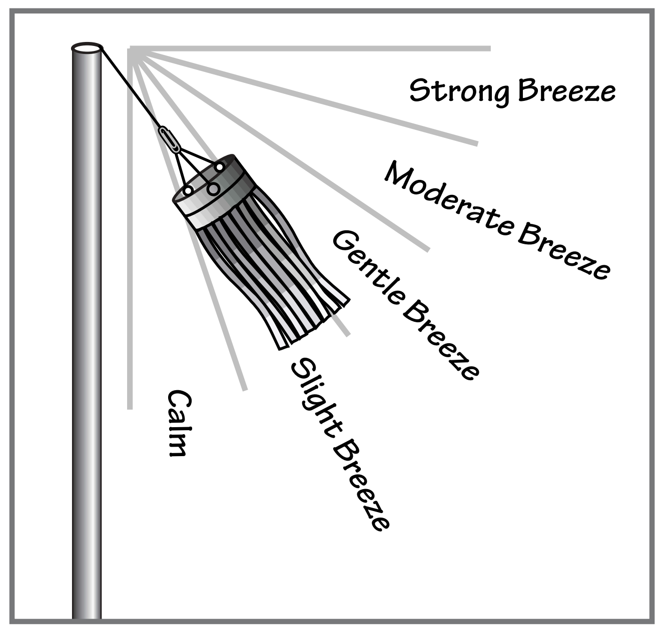
Wind in Your Socks



Wind in Your Socks

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





Day:

Time:

Weather:

How is the weather related to the wind strength and wind direction?

Air

Interdisciplinary learning activities

Science

- Show that an empty, clear plastic soda bottle is not really empty but full of air. Place it under water and observe the air bubbles that come out of the opening.
- Identify objects that are full of air.
- Explain that a wind or breeze is really the movement of air.
- Discuss what would happen to Earth if it were not surrounded by air.
- Research other planets and moons in our solar system that have some type of air (atmosphere). Could humans live there? Does weather exist there?
- Collect a variety of natural and synthetic objects. By tossing and dropping the objects, test which ones stay in the air the longest. Discuss why certain objects "float" longer than others.
- Observe clouds forming. Point out that clouds are formed by changes in temperature and the motion of air.
- Watch weather information broadcasts at home or school. Record the wind information for your locality for a week, also record the type of weather (hot, cold, stormy, rainy, etc.). Discuss the relationship between wind and the rest of the weather for the week.

Mathematics

- Measure how much a student can inflate a balloon with one breath of air. Measure the balloon's circumference after each breath.
- Fill up various sizes of balloons with air and determine which balloon stays in the air longer when released. Discuss why.
- Count the number of breaths it takes to inflate a balloon. Compare that number with other students in the class. Graph and discuss the results.

Fine Arts

- Draw pictures of how things look when the wind (air) blows across them (examples: trees bend, leaves float, lakes become wavy).
- Make paper spirals and hang them in the classroom. The spirals will move with the air currents in the room.
- Discuss musical instruments that use the force of air (wind instruments such as flute, saxophone, oboe, horn, and harmonica).

Technology Education

- Design a kite, parachute, or parasail using household items.
- Invent and build an air-driven device using household items.
- Explore objects and materials you can use to move air, such as paper fans, straws, and pinwheels.
- Determine what devices move air in your home and your school (examples may include air conditioners, heaters, fans in computers and other equipment).

Social Studies

- Make a collage showing objects and machines from different cultures that harness the power of air.
- Invite a person whose job deals with air, such as a meteorologist or a pilot, to speak to the class about his or her profession.

Language Arts

- Read about and discuss air as a force in fantasy, such as in books like *The Three Little Pigs,The Wizard of Oz, Alberto and the Wind, and A Windy Day*. Compare air in fact and fantasy.

- Keep a journal for a week or two that keeps record of the direction and force of the wind near your home and/or school. Also add temperature and air quality. Do different types of weather come from different directions?

- Write a story about what happens on a very windy day.

- Write a letter to local meteorologists asking questions about air and weather.

Health/Physical Education

Try different ways to feel the air:

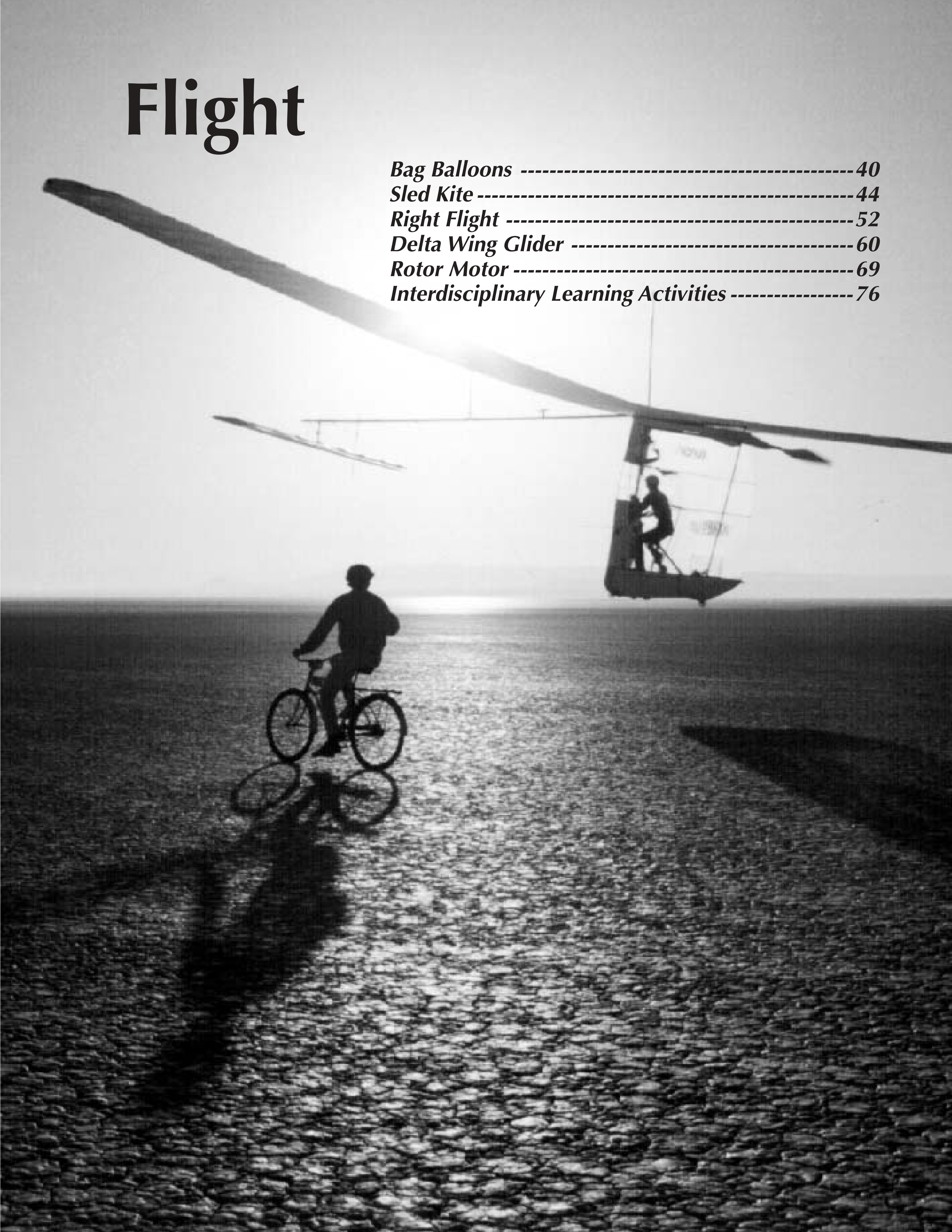
- Run with streamers.

- Place a paper bag on your arm and move your arm back and forth.

- Use a small parachute in the school gymnasium to observe how it slows down falling objects.

Flight

Bag Balloons -- *40*
Sled Kite -- *44*
Right Flight --- *52*
Delta Wing Glider --------------------------------------- *60*
Rotor Motor -- *69*
Interdisciplinary Learning Activities ----------------- *76*



BAG BALLOONS

Objectives

The students will:
Demonstrate that heat can change air.
Determine that hot air rises.
Construct a working model of a hot air balloon.

Standards and Skills

Science
Science as Inquiry
Science and Technology

Mathematics
Estimation

Science Process Skills
Communicating
Observing

Background

Hot air balloons are one type of aircraft. (The four categories of aircraft are airplanes, gliders, rotorcraft, and hot air balloons.) In this activity, students construct a working model of a hot air balloon.

There are two ways a balloon can rise: it can (1) be filled with a gas that is lighter than air, such as helium, or (2) it can be inflated with air that is heated sufficiently to make it "lighter" than the air outside of the balloon.

Helium is the second-lightest element, and the main sources for helium are natural gas fields (especially those in the states of Texas, Oklahoma, and Kansas). Heating air makes it less dense, rendering it essentially "lighter." Gas balloons and hot air balloons float because they are lighter than the air they displace.

Materials

Plastic bag ("dry cleaners" bag or 5-gallon trash bag)
Paper clips (used for weight)
Small pieces of paper or stickers (decorations)
String
One hair dryer per classroom (heat source)
Party balloons

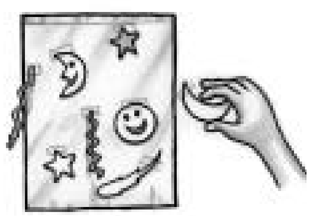
Preparation

Show students pictures of hot air balloons. Ask the students to share their ideas about how the balloons rise. Also ask students to share what they know about hot air balloons, or what they think about the uses of hot air balloons.

Show the students a helium balloon. Ask the students to share what they think makes the helium balloon rise when you let go of the string.

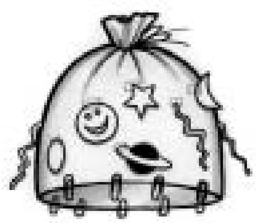
Activity

1. Divide the class into groups of four, and provide each team with a set of materials.



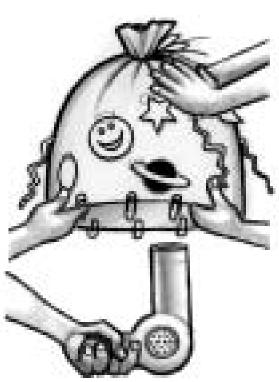
2. Have the students decorate their plastic bags. Decorations should be small and light, such as small scraps of paper or stickers.

3. Have the students tie a string around the top of the plastic bag.



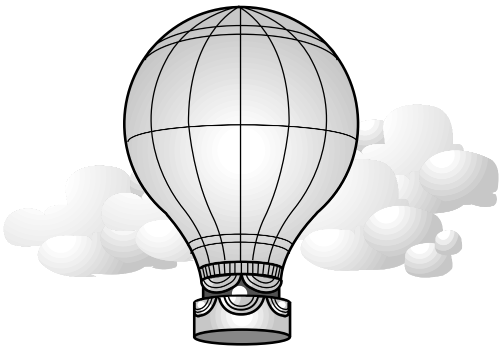
4. Add paper clips evenly spaced around the bottom of the plastic bag.

5. Have the students hold the plastic bag over the hair dryer (on the high setting) and let the plastic bag fill with hot air.



6. The plastic bag becomes buoyant as it fills with hot air. When the students feel the bag tugging, have them release it. *The hot air inside the balloon is lighter than the air in the classroom and begins to float.*

Discussion



1. Have the students identify the different parts of the hot air balloon: plastic bag—hot air balloon; hair dryer—heat source; paper clips—weights for balance and stability.

2. Ask the students to explain why the hot air balloon works. *The hot air balloon rises when the air inside the balloon becomes heated. The heated air is lighter than the classroom air and enables the balloon to float.*

3. Ask the students to tell how hot air balloons are different from balloons filled with helium. *Helium is a gas that is lighter than air, even when it's not heated. Helium though, just like heated air, floats in the surrounding air because it's lighter. Helium should not be confused with hydrogen, which is an inflammable gas that was often used in balloons and airships until the explosion of the airship Hindenburg in 1937.*

4. Have the students inflate a party balloon. Ask them to explain why it does not rise. *A person's breath may be warmer than room temperature, but it is not hot enough to overcome the weight of the balloon.*

Assessment

Using their actual models, have the students explain why their hot air balloons rise.

Extensions

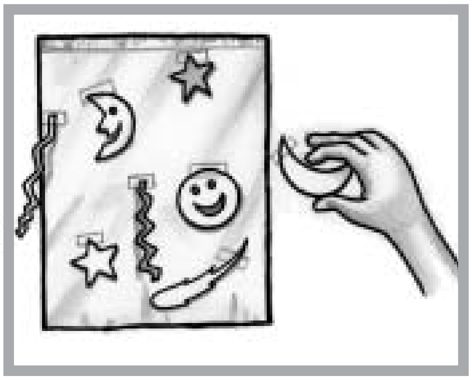
1. Have the students construct another hot air balloon using different sizes and types of plastic bags.

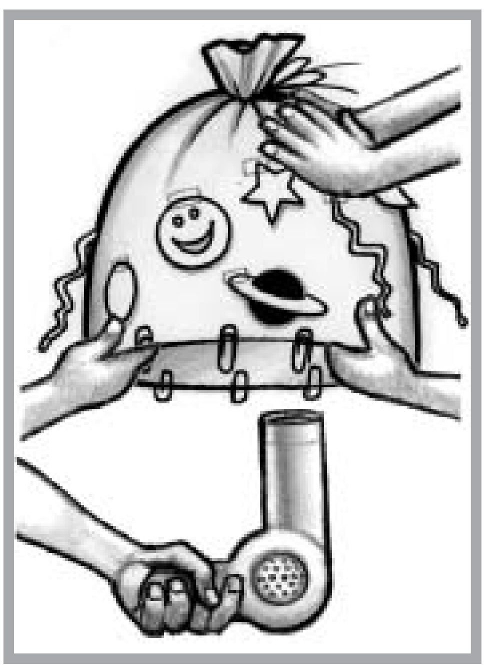
2. Have students experiment with paper clips—different sizes and numbers—to see the effects of weight on their model balloons.

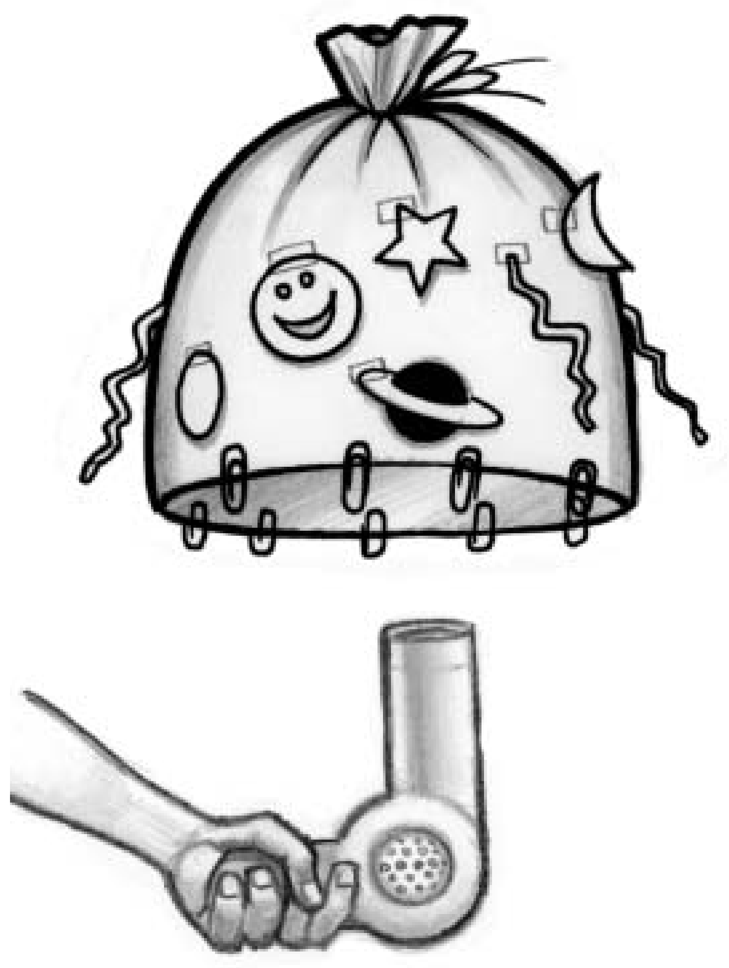
3. Have the students research the part that balloons played in the history of flight.

4. Have the students role play a reporter interviewing one of the Montgolfier brothers. (Refer to background information included in this guide about the Montgolfier brothers.)

Bag Balloons







SLED KITE

Objectives

The students will:
Construct and fly a simple sled kite.
Demonstrate how to make the kite fly at varying heights.

Standards and Skills

Science
Science as Inquiry
Unifying Concepts and Processes

Science Process Skills
Observing
Measuring
Predicting
Controlling Variables

Mathematics
Connections
Estimation
Measurement

Background

NASA Paresev

The sled kite in this activity is a model of a type of airfoil called a parawing. Like any wing, the parawing depends on the movement of air over its shape to generate a lifting force. (Parasails, parafoils, and paragliders are similar lift-generating devices.)

The NASA Paraglider Research Vehicle (Paresev) was the first flight vehicle to use the Francis Regallo-designed parawing. The little glider was built and flown by NASA during the early 1960's to evaluate the parawing 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. Hang gliders use a parawing to glide from cliffs or mountain tops.

There are kites of all 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 parallel to each other on opposite sides of the cloth or paper. This arrangement shapes the kite like a sled when it catches the air. The string attachment points are placed toward one end of the kite, which causes the opposite end to hang downward, and stabilizes the kite in flight.

Materials (per kite)

Sled Kite Template
Two drinking straws
Cellophane tape
Scissors
Two 45 cm lengths of string
One 1 m length of string
Metric ruler
Single-hole paper puncher
One paper clip
Markers, crayons, pencils
Selection of paper (crepe, tissue, newspaper)

Management

Approximately 30 minutes are needed to build the sled kite. Additional time is needed to allow the students to fly and evaluate their sled kites outside.

Activity

1. Make a copy of the Sled Kite Template. Carefully cut out the sled kite.

2. Decorate the top of the sled kite using crayons, markers, or other media.

3. Trim the length of the two drinking straws so they will fit in the area marked for the straws. Tape them in place.

4. Place two or three pieces of tape in the marked areas covering the black circles.

5. Using a single-hole paper puncher, carefully punch the two holes marked by the black circles.

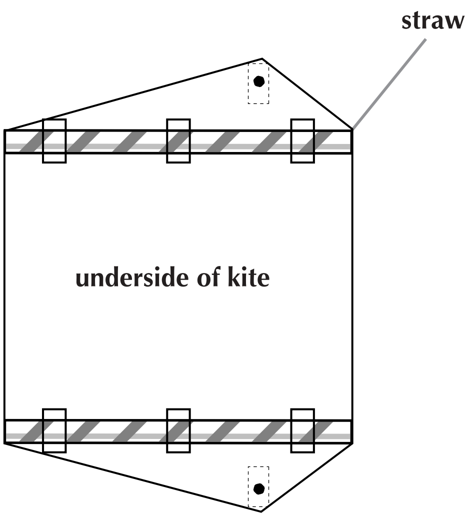
6. Cut two pieces of kite string 45 cm each. Tie a string through each hole. Tie them tight enough so you do not tear the paper.

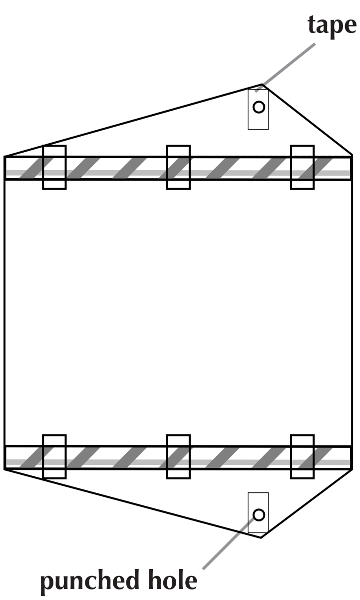
7. Tie the opposite end of both strings to a paper clip.

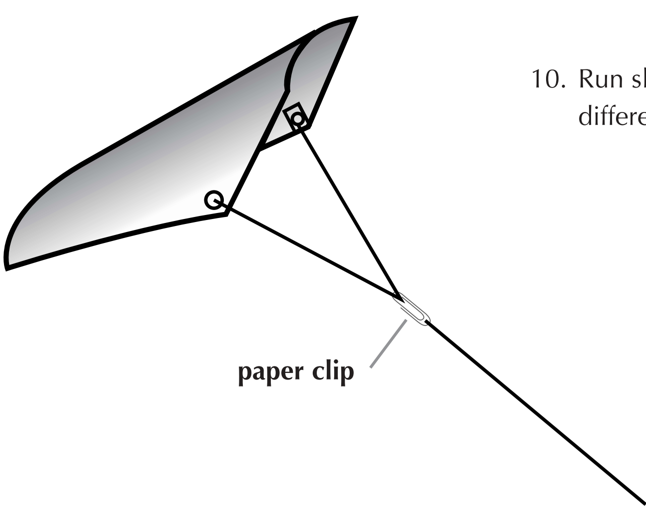
8. Pick up the 1 m long piece of string. Tie one end of this string to the other end of the paper clip. Your sled kite is ready to fly!

9. Outside in a clear area, hold the 1 m length of string and run with the kite to make it fly.

10. Run slow and run fast, and observe how the kite flies at different towing speeds.







Discussion

1. Can kites be used to lift objects? *Yes, a popular beach activity uses a large kite (parasail) towed by a speed boat to lift a person high into the air.*

2. Why are kites made of lightweight material? *Lightweight materials insure the kite will weigh less than the "lift" produced by the kite.*

Assessment

1. Have students explain how their kite was built.

2. Have students demonstrate ways to make the kite fly higher, and to fly lower.

Extensions

1. Have the students decorate their kite using a minimum of three colors.

2. Record the length of time for each flight.

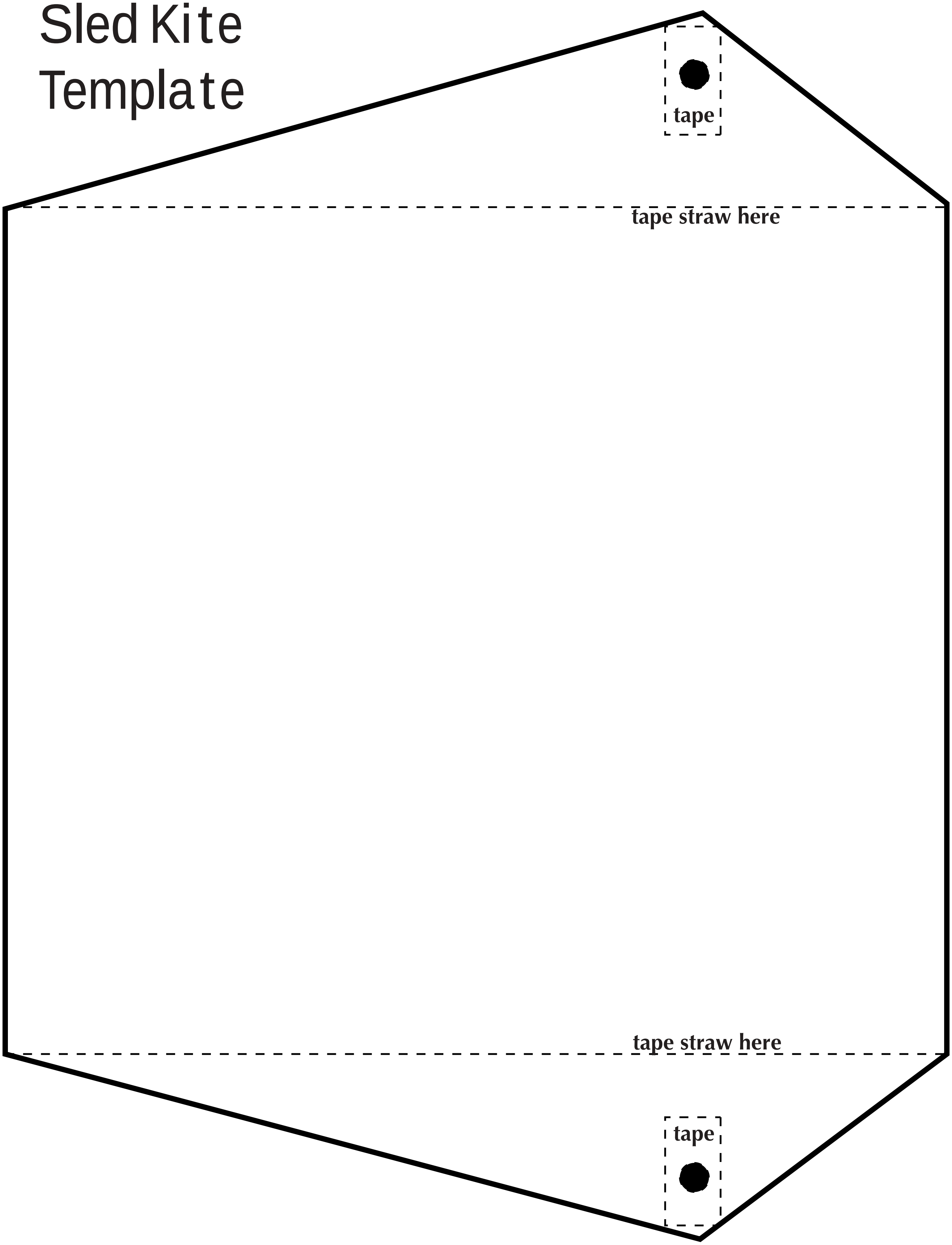
3. Have the students run a relay with a kite as a means to sustain its flight.

4. Design a kite and write the directions on how to build it.

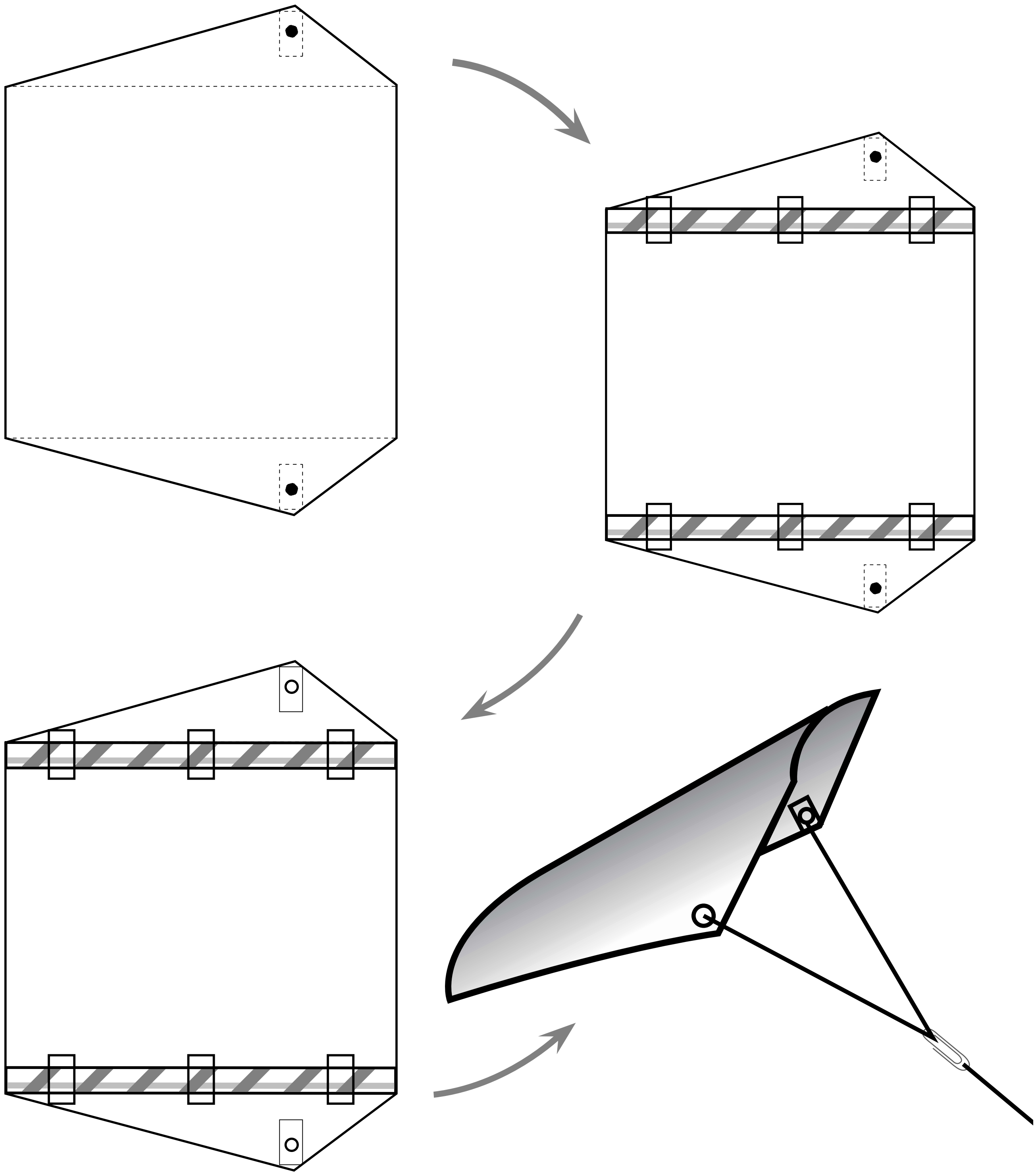
5. Add a tail to the sled kite using crepe paper, strips of newspaper, tissue paper, or garbage bags. Have students predict what, if any, changes will occur in the kite's flight characteristics. Conduct flights to test the predictions.

6. Research the history of kites.

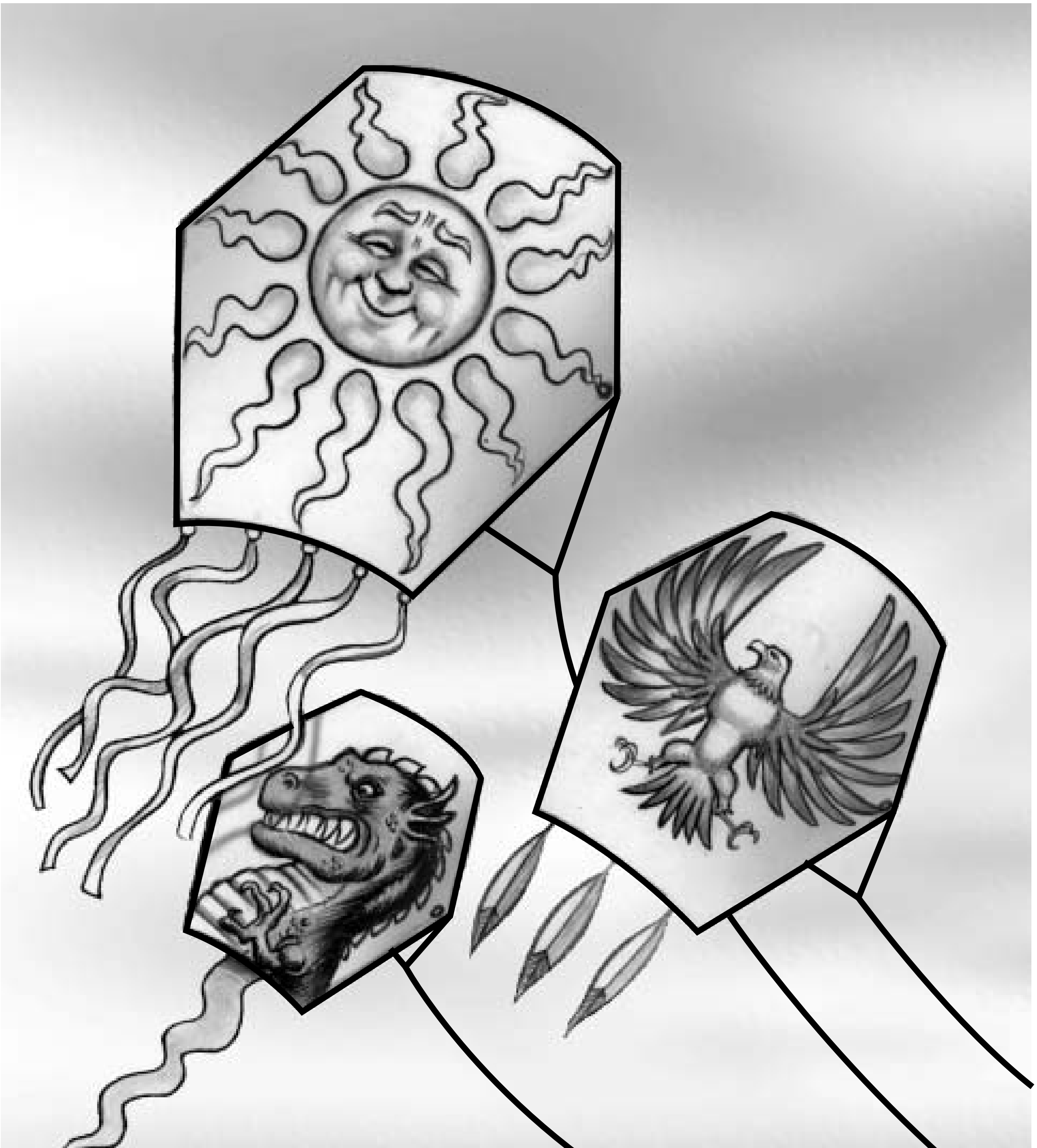
Sled Kite Template



Sled Kite



Sled Kite



Sled kite flying journal

Date ______________________ Student name ___________________________

Weather ____

Sled Kite Flight

What happened when I...

1. When I walked with my sled kite, my sled kite:

____

2. When I ran with my sled kite, my sled kite:

____

Sled Kite Tail, What if...

What if I add a tail to my sled kite? I think a tail will make my sled kite fly like this:

____

After I added a tail to my sled kite, it flew like this:

____

What if I shorten the tail, I think it will make my sled kite fly like this

____

What if I lengthen the tail, I think it will make my sled kite fly like this:

____

Conclusions

If the tail is shortened, then the sled kite will fly like this:

____

If the tail is lengthened, then the sled kite will fly like this:

____

RIGHT FLIGHT

Objectives

The students will:
Construct a flying model glider.
Determine weight and balance of a glider.

Standards and Skills

Science
Science as Inquiry
Physical Science
Science and Technology
Unifying Concepts and Processes

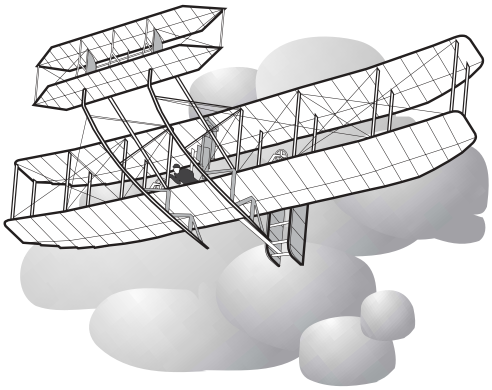
Science Process Skills
Observing
Measuring
Collecting Data
Inferring
Predicting
Making Models
Controlling Variables

Mathematics
Problem Solving
Reasoning
Prediction
Measurement

Background

On December 17, 1903, two brothers, Wilbur and Orville Wright, became the first humans to fly a controllable, powered airplane. To unravel the mysteries of flight, the Wright brothers built and experimented extensively with 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 of 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.

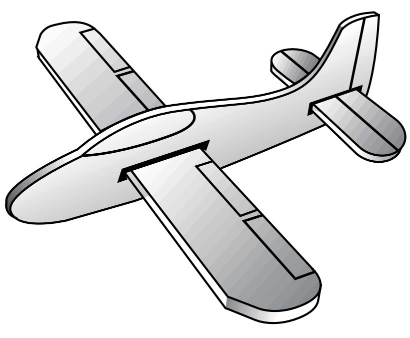


Wright Flyer

Wilbur and Orville also learned that the design of an airplane was very important. Experimenting with models of different designs showed that airplanes fly best when the *wings*, *fuselage,* and *tail* are 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* are control surfaces that make the nose of the airplane *pitch* up and down. A *rudder* is used to 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.

At NASA, model airplanes are used 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. The goals of NASA research are to make airplanes fly safer, perform better, and become more efficient.



Right Flight Glider

This activity is designed to help students learn about basic aircraft design and to explore the effects of weight and balance on the flight characteristics of a model glider. Students use science process skills to construct and fly the Styrofoam glider.

Management

This activity will take about one hour.

Materials

Styrofoam food tray, size 12
Glider template
Plastic knife
Toothpicks
Sand paper or emery board
Binder clips
Paper clip
Markers
Goggles (eye protection)

Part 1
Building the Glider

Preparation

1. Ask students to name some materials that might be used to build a model glider. *Responses might include balsa wood, paper, cardboard, plastic, and Styrofoam.*

2. Gently toss a Styrofoam tray into the air and ask the students to describe how the tray "flew." *The tray does not fly because it is not designed to fly. Instead of flying (gliding) it drops.*

3. Explain to students that Styrofoam is lightweight and strong which makes it an ideal material to construct model gliders. Styrofoam trays can be obtained from the meat department of a grocery store.

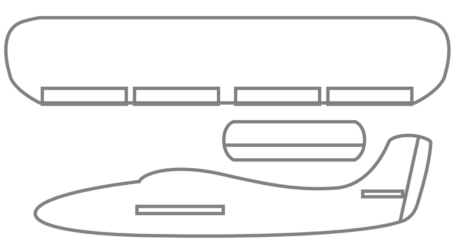
Activity

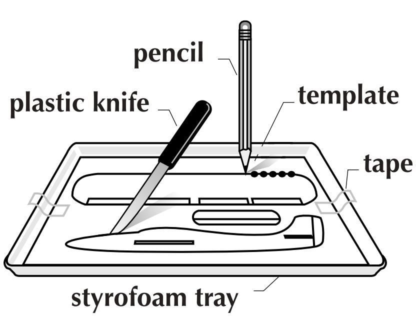
1. Hand out the materials (Student Page 1, tray, template, cutting and marking devices). Follow the steps listed on the Student Page.

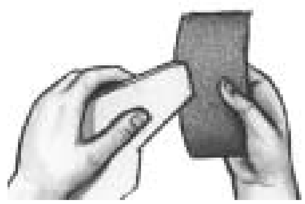
2. Explain that the template is a guide to cut the wings, fuselage, and elevator from the Styrofoam. Cutting can be done in a variety of ways depending on grade level.

   For younger students, the teacher or older students can cut out the parts beforehand and have the students assemble the glider. For older students, the teacher can demonstrate cutting out the parts using a serrated plastic knife.

   Another way to cut out the parts is by punching a series of holes approximately 2 mm apart around the outside edge of each piece and then pushing the piece out. A sharp pencil or round toothpicks can be used to punch the holes.

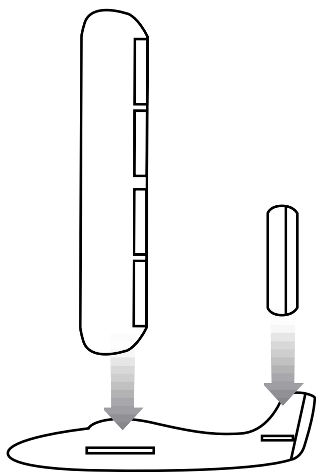


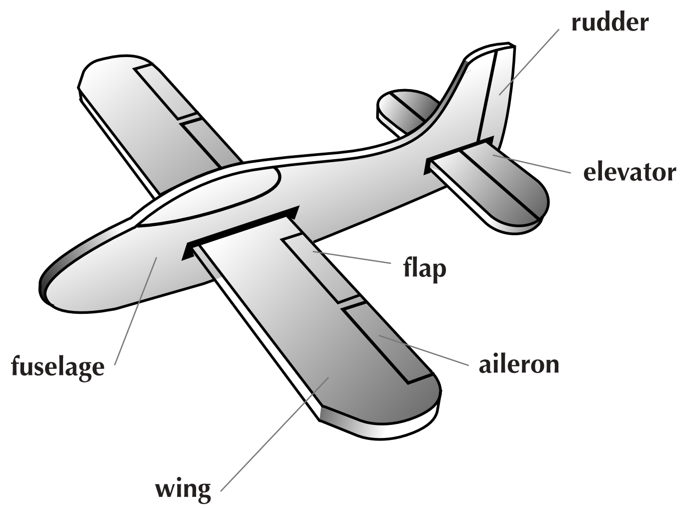




3. Use sandpaper or an emery board to sand the edges smooth.

4. Have students assemble the glider by inserting the wings and elevator into the fuselage slots.





Extension

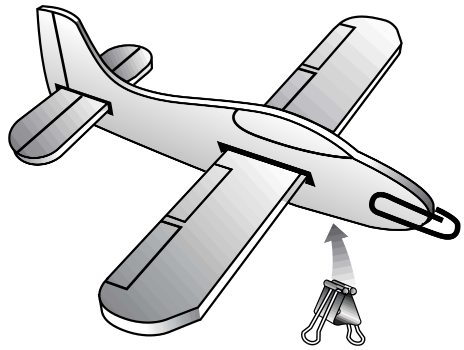
1. Students may apply personal and finishing touches to the model by drawing the canopy outline and adding color, name, aircraft number, squadron logo, icons, or emblems.

2. Ask students to label the parts of an airplane on the model glider.

3. Civilian aircraft have a letter or letters preceding the aircraft's identification number indicating in which country the aircraft is registered. Mexico uses the letter "X," Canada uses the letters "CF." Aircraft registered with the Federal Aviation Administration in the United States are assigned identification numbers that begin with the letter "N." The airplane's identification number is called an N-number. Students may apply N-numbers to their model, or "register" their model with other countries.

Part 2

Caution students not to throw gliders toward other students. The teacher may want to provide eye protection for each student.

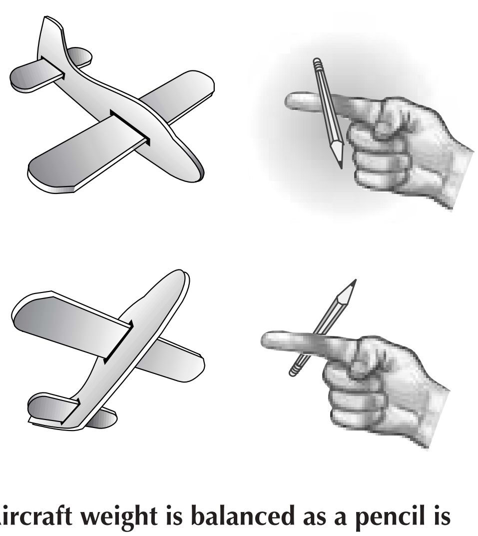


1. The model glider's weight must be balanced or distributed properly before it will fly. To demonstrate this, ask a student to launch a glider before adding weight and balance. Have students describe the flight characteristics.

2. 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. Ask the students to test fly the glider and observe the flight characteristics.

3. 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 can be defined as one that allows the glider to fly the greatest distance.

Discussion



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

1. Is weight and balance important on “real” airplanes? *Yes, all airplanes are required to have correct weight and balance. The pilot is responsible for making sure the total weight of the cargo and passengers is within certain limits and is distributed to keep the plane properly balanced. Flights should not be attempted if the aircraft is overloaded, or if the cargo distribution makes the plane too "nose heavy" or "tail heavy."*

2. Why does the model glider fall erratically during test flights before its proper weight and balance is determined? *Lift is a force generated by the wing. This force must be in balance with the weight distribution of the airplane before the model will fly successfully.*

Assessment

1. Students will successfully meet one objective of the activity by constructing the model glider.

2. Using the model glider, have students explain how they determined the weight and balance for their glider.

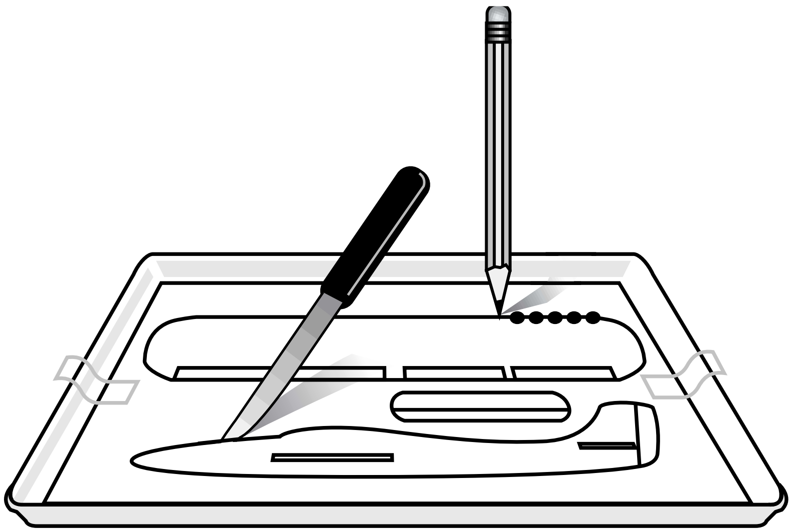
Extensions

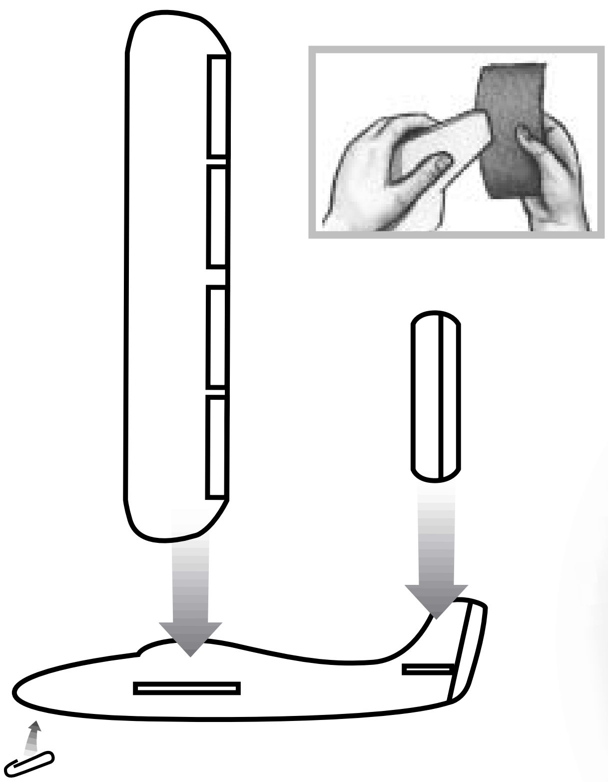
1. Set up a flight course and have the students demonstrate the flight characteristics of their gliders.

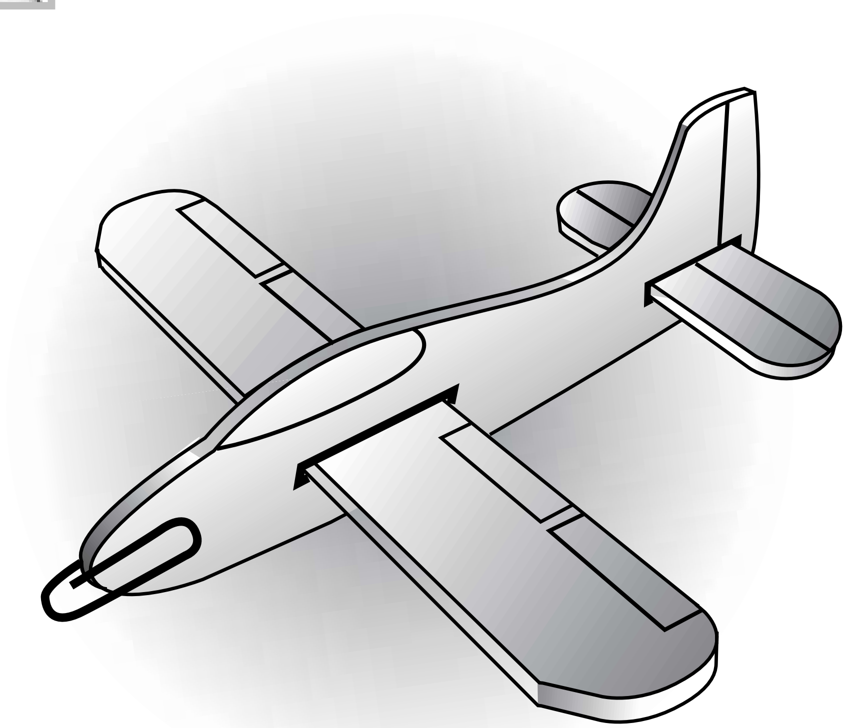
2. Have students cut 2 cm off of each wing tip, and begin a new series of flight tests.

3. Have students design and make new wings for the glider. Experiment with wings of various sizes and shapes.

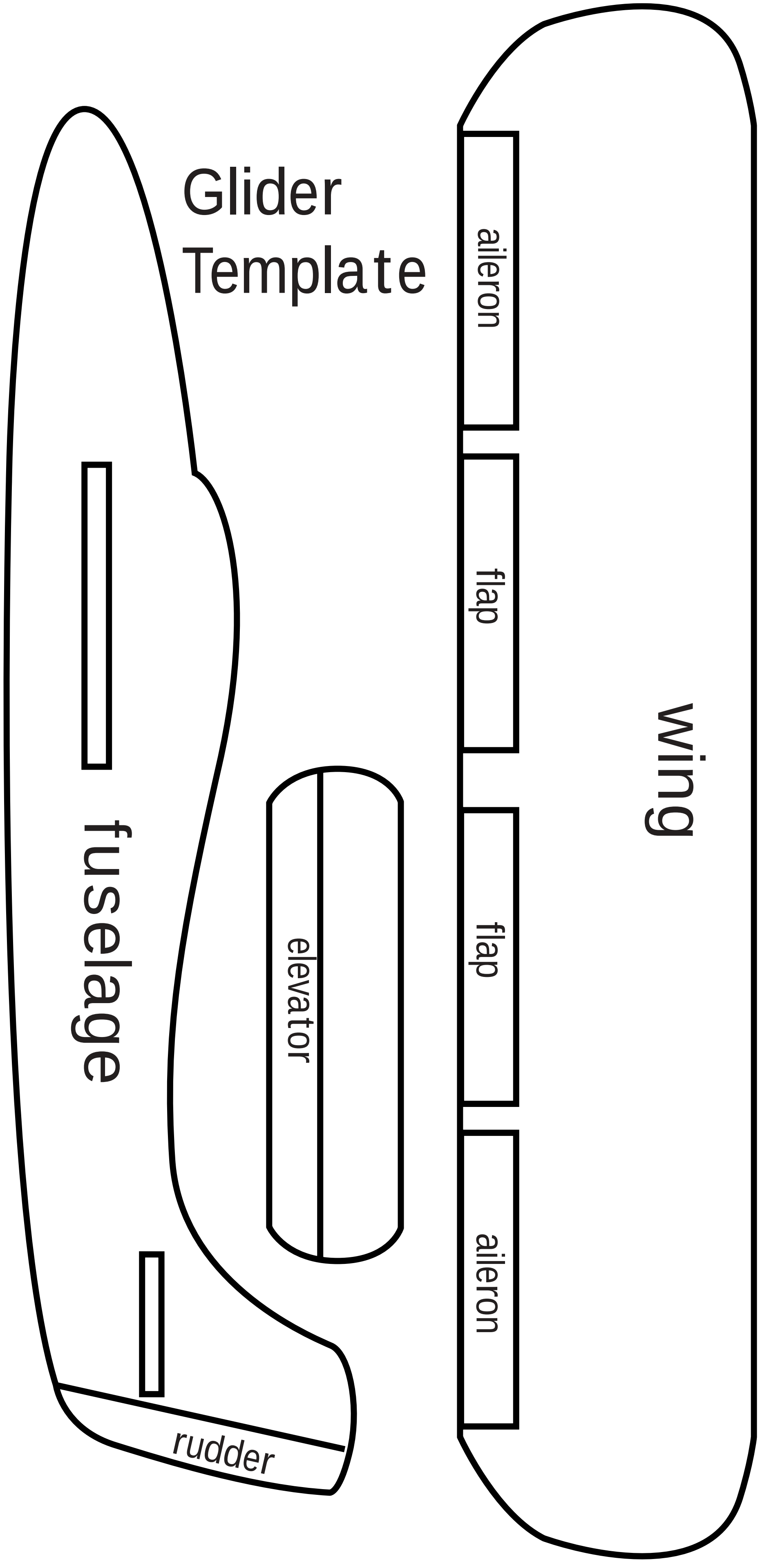
Right Flight







Glider Template



Delta Wing Glider

Objective

The students will:
Learn how to change the flight characteristics of a glider.
Conduct an experiment to answer a question.

Standards and Skills

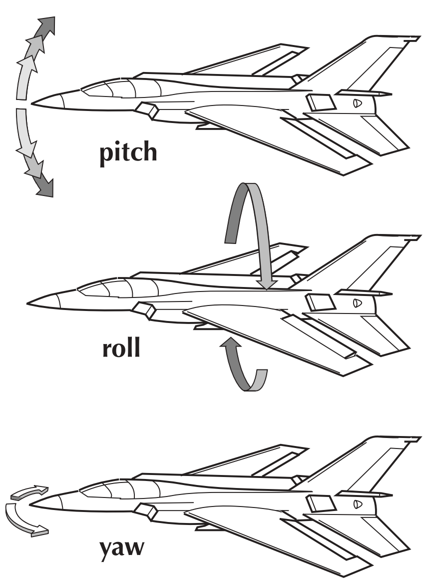
Science
Science as Inquiry
Physical Science
Science and Technology

Mathematics
Measurement
Problem Solving

Science Process Skills
Making Models
Investigating
Predicting

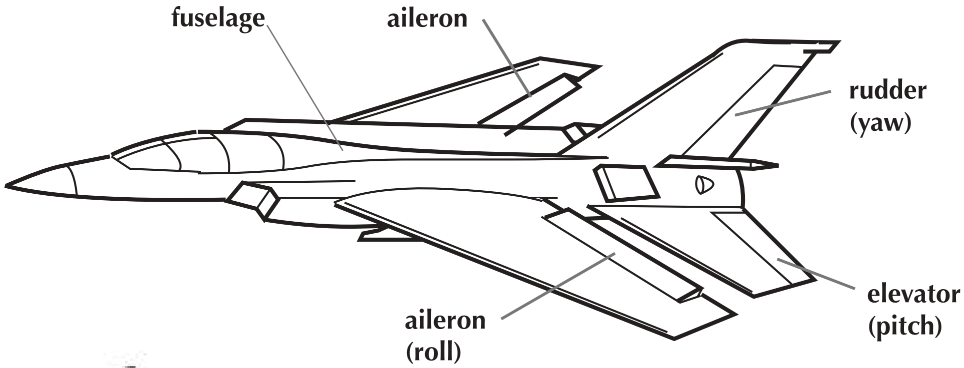
Background

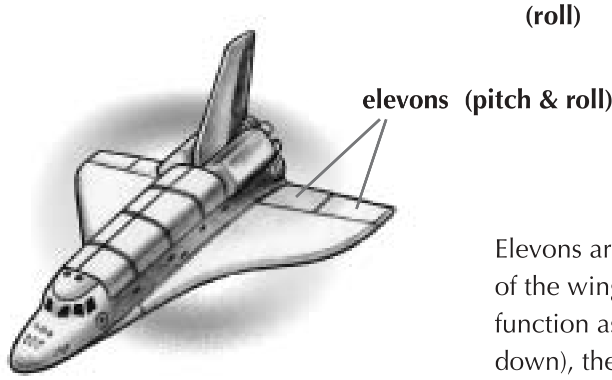
There are many types of vehicles used to transport people and objects from place to place on Earth. How are these vehicles guided to a destination? Turning the steering wheel changes a car's direction. The rudder is used to control the direction of a boat. A bicycle is controlled by turning the handle bars and shifting the rider's weight. For most land and sea vehicles, directional control is accomplished by moving the front end right or left. Movement in this one axis of rotation or direction is called *yaw*.



Flying an airplane requires control of three axes of rotation or movement. The nose of the plane can be moved right and left (*yaw*), rotated up and down (*pitch*) and the fuselage can be rolled left and right (*roll*). A pilot uses the control wheel or stick inside the airplane to move control surfaces on the wings and tail of the plane. These control surfaces turn the airplane by varying the forces of lift.

Airplanes with conventional wings use *ailerons* to control roll, a *rudder* to control yaw, and *elevators* to control pitch. Airplanes with delta or triangular shape wings have a rudder, but only one control surface (*elevon*) to control pitch and roll. An elevon serves the same function as an *elev*ator and an ailer*on*.





Elevons are moveable control surfaces located on the trailing edge of the wings. Working in unison (both up or both down) they function as elevators. Working differentially (one up and one down), they function as ailerons. The Space Shuttle uses elevons for control in the air close to the Earth as it descends from space.

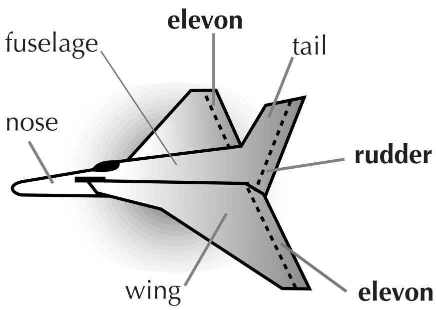
Materials

Styrofoam food tray, about 28 cm X 23 cm (Size 12)
Cellophane tape
Paper clip
Ball point pen
Plastic knife or scissors
Toothpicks
Goggles (eye protection)
Emery boards or sandpaper

Preparation

1. Show the class a Styrofoam food tray and ask them to identify it. Ask the students to list other uses for Styrofoam. Responses may include cups, fast food containers, egg cartons, packaging material, and insulation.

2. Discuss with the students some reasons for using Styrofoam in the construction of a model glider. Materials for building airplanes must be lightweight, strong, and readily available. These qualities make Styrofoam a good material for the

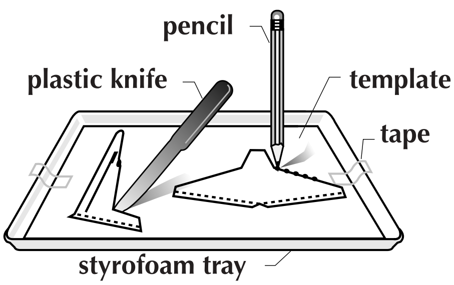


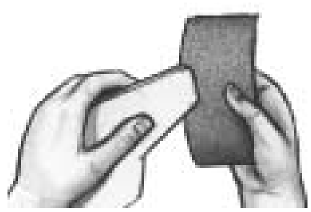
construction of flying models. Real airplanes are made from another lightweight, strong, and readily available material called aluminum.

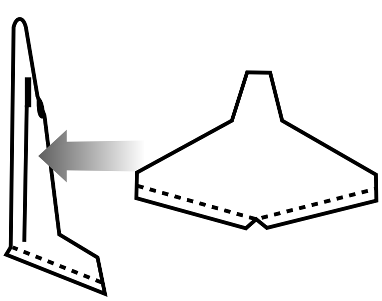
3. Styrofoam can be cut using scissors or a serrated plastic knife. Students can also use a sharp pencil or round toothpick to punch a series of holes approximately 2 mm apart around the outside edge of the part. The part can then be pushed out from the tray. Pre-cut the Styrofoam parts for younger students.

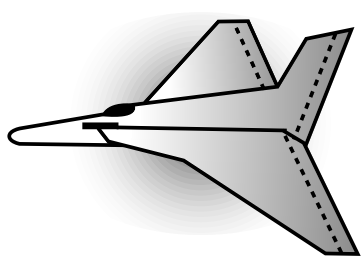
4. Provide the student with a word list for parts of the glider. *Fuselage (body of the glider), wing (provides lift), rudder (yaw control), elevons (roll and pitch control).*

Activity









1. A student page contains a template used to cut out the Styrofoam parts of the glider, and instructions for assembling the parts. Educators of K-2 students may want to cut out the gliders ahead of time.

2. Ask the student to write the name of each airplane part on the template.

3. Tape the glider template to the Styrofoam meat tray.

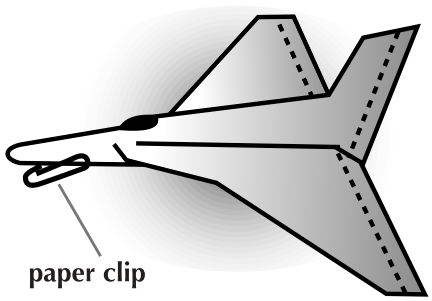
4. Use a sharpened pencil or toothpick to punch holes around the outline of the wing and fuselage. Make sure the hole goes through the Styrofoam.

5. Remove the template and trace around the outline of the wing and fuselage on the tray using a pencil or toothpick. Punch out each part.

6. Smooth the edges of each part using sandpaper or an emery board.

7. Mark both elevon hinges with a pencil. (Note: to make the elevons hinge up and down, use a pen to lightly score the hinge line on the Styrofoam wing. If a break occurs at the hinge line, use clear tape to repair the break.)

8. Carefully cut a slot in the fuselage and slide the wing into it.



9. After constructing the glider, the students determine the "weight and balance" by attaching a paper clip or binder clip to the fuselage. Students should vary the position of the clip with each flight until the glider flies the greatest distance in a straight line.

10. The flight test questions found on the Student Page can be answered by conducting flight experiments. The students change the position of the elevons and draw a diagram to record the flight path of the glider. Test fly the glider and record the results.

Discussion

1. Do all gliders fly alike? *No. Small differences in construction can change the flight characteristics of a model glider.*

2. Why do we predict what will happen before a test? *Predictions help scientists decide what questions the experiment will answer.*

Extensions

1. Have students measure and record the distance of the longest flight.

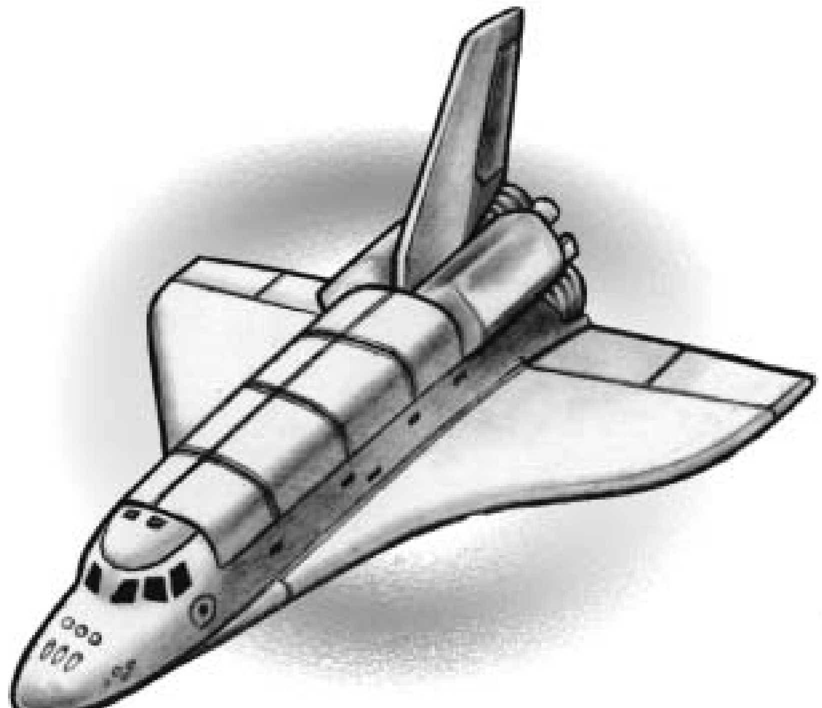
2. Have the students change the size or shape of the wing. Test fly the redesigned glider and record any changes in the flight characteristics.

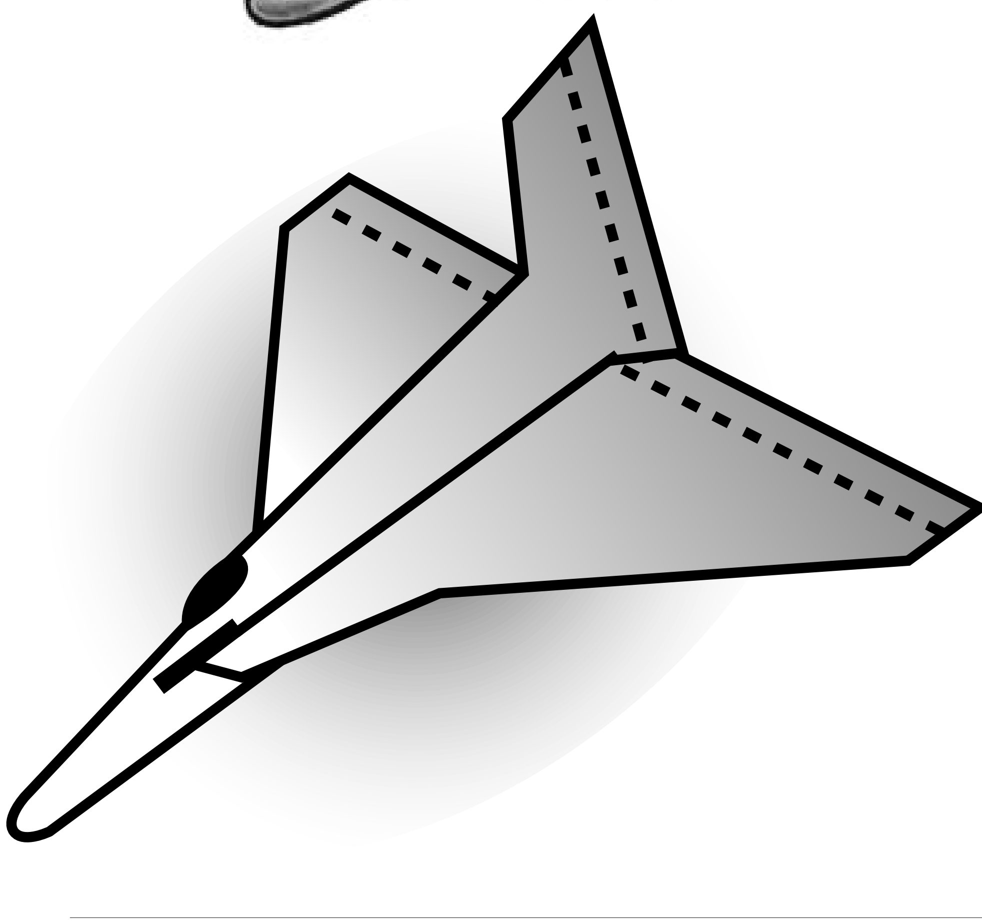
Assessment

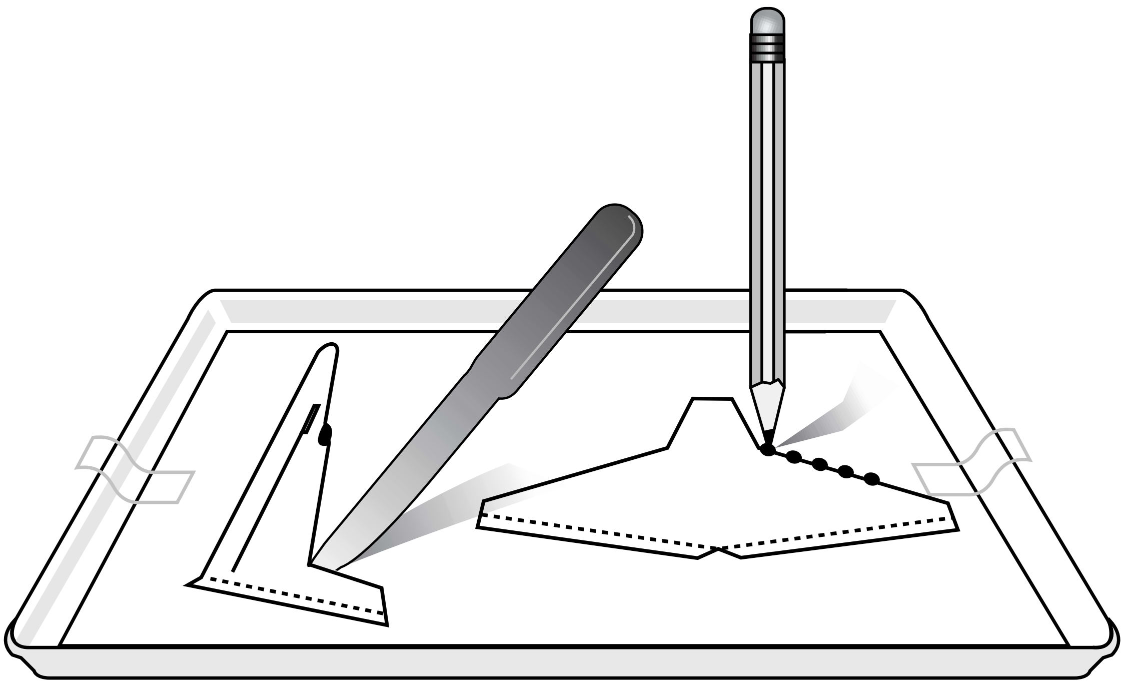
1. Bend the control surfaces on a model glider and ask the students to predict what flight path it will follow. Students can walk the predicted flight path, and launch a glider to test the prediction.

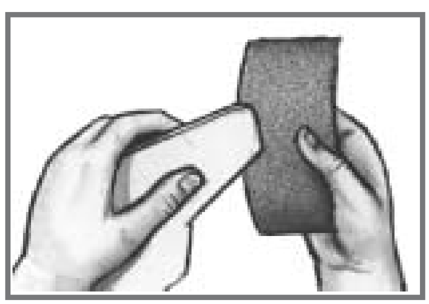
2. Group students together and have them submit a Team Student Record Sheet that summarizes the experimental flight test results.

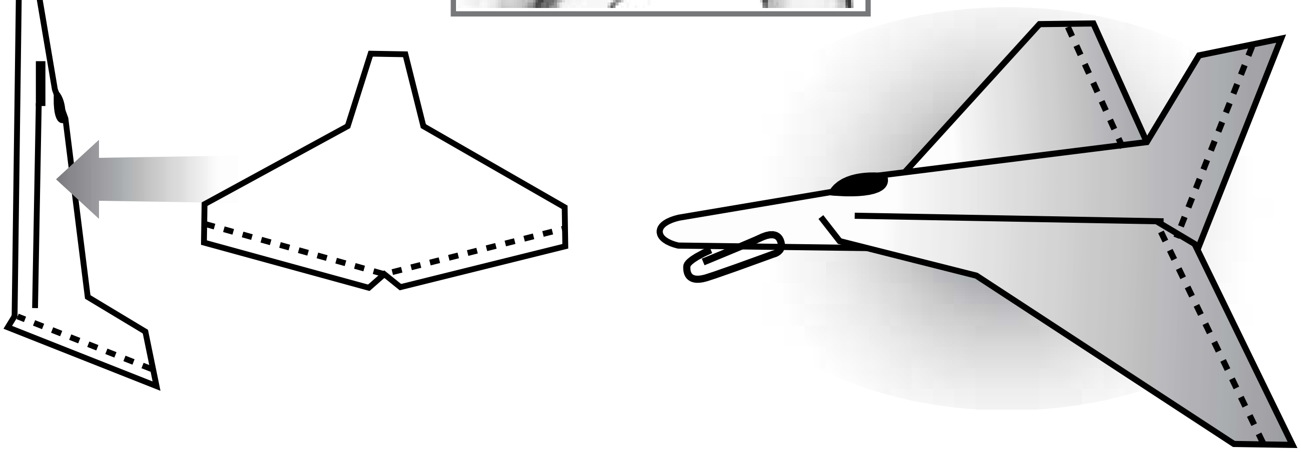
Delta Wing Glider



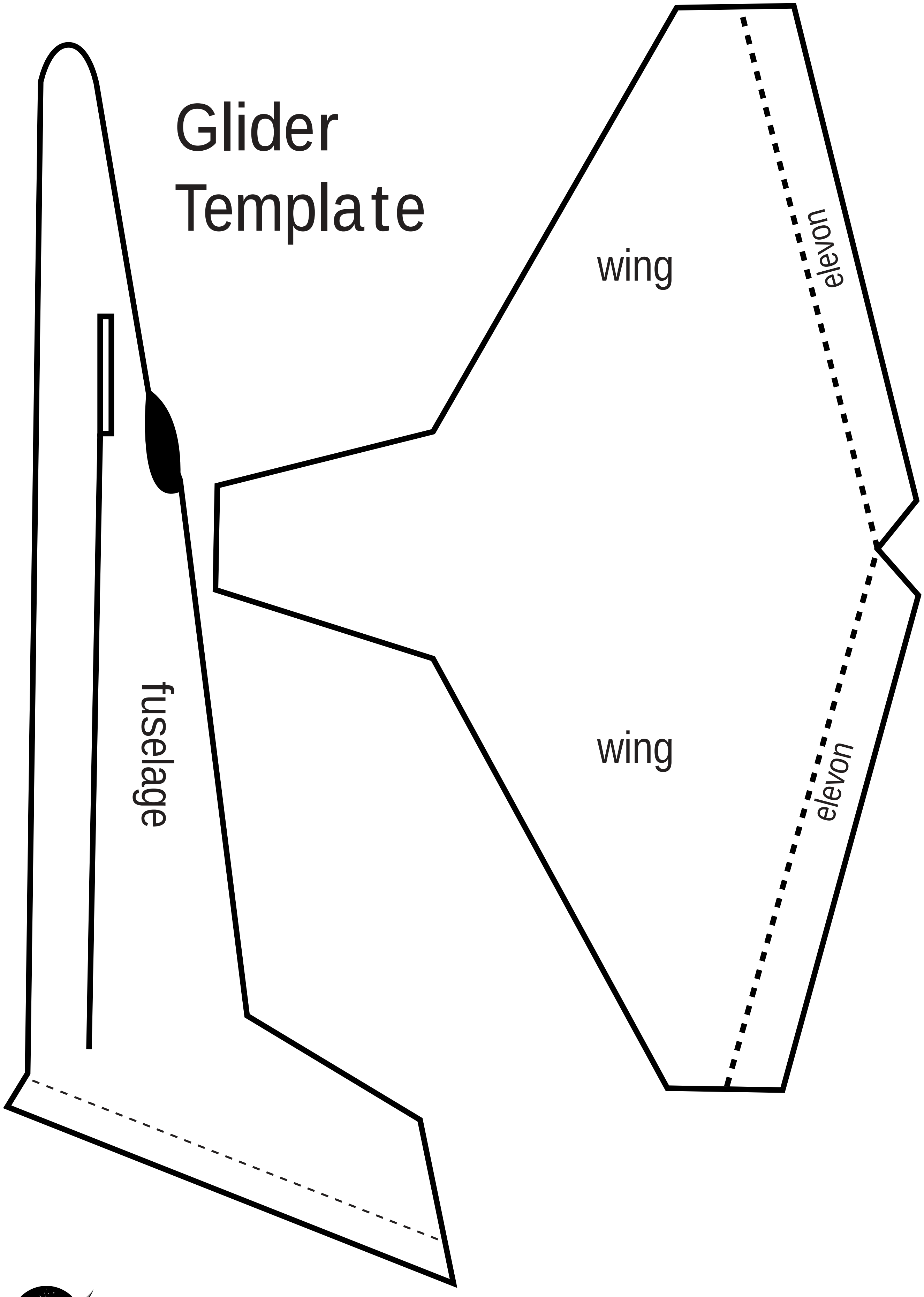








Glider Template

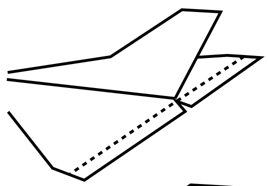
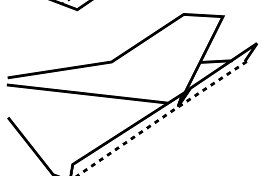
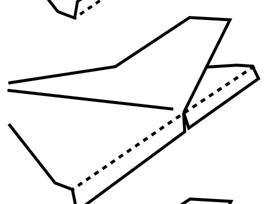
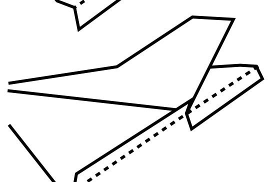
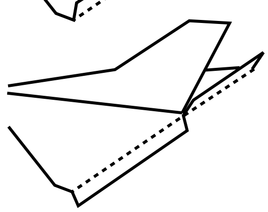


Delta Wing Glider

Test Question: Does changing the position of the elevons on a delta wing glider change its flight path?

Directions: Bend the elevons into the positions listed below. Be sure to predict the flight path before flying the glider. Test fly the glider and record the results (up, down, left, right).

Student Test Pilot Record Sheet (What I Observed)

Position of elevons		Predicted Flight Path	*Path of Test Flight*
Right and left straight		_ _ _ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _
Right and left up		_ _ _ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _
Right and left down		_ _ _ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _
Right down, left up		_ _ _ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _
Right up, left down		_ _ _ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _

Does moving the elevons change the way the glider flies?

What happens when both elevons are in the up position?

What happens when both elevons are in the down position?

Does changing the position of elevons on a delta wing glider change its flight path?

Delta Wing Glider

Draw the flight path