The NASA "Why?" Files
The Case of the Challenging Flight

Program 4 in the 2000-2001 Series

Educator's Guide	
Teachers & Students	Grades 3-5

EP-2001-02-15-LaRC

The NASA "Why?" Files

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Educator's Guide	
Teachers & Students	Grades 3-5

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The American Institute of Aeronautics and Astronautics (AIAA) provides classroom mentors to educators who register for the NASA "Why?" Files. Every effort will be made to match a teacher with an AIAA member who will mentor the teacher either in person or by e-mail. To request a mentor, e-mail nasawhyfiles@aiaa.org

*Contact the AIAA to get a classroom mentor at **nasawhyfiles@aiaa.org**.*

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Program Overview

In *The Case of the Challenging Flight*, the tree house detectives are onto a new case as they try to win the Egg-tra-ordinary Plane Contest. They do not want to repeat their unsuccessful performance of years past; therefore, they decide that they need to build a better plane. The tree house detectives use their skills in scientific investigation to learn about the four forces of flight and then use their newfound knowledge as they design and construct a plane.

As the tree house detectives actively pursue this challenge, they learn of other competitions in flight throughout history. They meet with General John (Jack) R. Dailey, director of the National Air and Space Museum in Washington, D.C. to learn more about the Wright Brothers, Charles Lindbergh, the race for space, and other contests of the past.

As the tree house detectives endeavor to learn more about the four forces of flight: lift, thrust, drag, and weight, Dr. D, a retired science professor, guides them to seek help from NASA researchers. The tree house detectives receive a surprise visit from Jackie Chan, the human flying machine, who offers advice on how to attack a problem and the value of education. They are also invited as guests of the U.S. Navy to visit an aircraft carrier, the *USS Theodore Roosevelt*. They have a once-in-a-lifetime experience as they land and are catapulted off the flight deck of one of the world's largest carriers.

The Case of the Challenging Flight is one of the tree house detectives' most challenging cases and promises not to be a "drag." Even though the rival schools are good, the tree house detectives are determined to "foil" their winning streak and become the new champions of the Egg-tra-ordinary Plane Contest. Tune in to see the how the tree house detectives "pitch, yaw, and roll" and to learn who the winner will be!

National Geography Standards (grades 3–5)

Standard	Segment 1	Segment 2	Segment 3	Segment 4
The geographically informed person knows and understands:				
The World in Spatial Terms				
How to use maps and other graphic representations, tools, and technologies to acquire, process, and report information from a spatial perspective		✖		

National Math Standards (grades 3–5)

Standard	Segment 1	Segment 2	Segment 3	Segment 4
Numbers and Operations				
Understand numbers, ways of representing numbers, relationships among numbers, and number systems.		✖		
Algebra				
Understand patterns, relations, and functions.			✖	
Measurement				
Understand measurable attributes of objects and the units, systems, and processes of measurement.	✖	✖		
Apply appropriate techniques, tools, and formulas to determine measurements.	✖	✖		✖
Data Analysis and Probability				
Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them.	✖	✖	✖	
Select and use appropriate statistical methods to analyze data.	✖	✖	✖	
Develop and evaluate inferences and predictions that are based on data.	✖	✖	✖	
Problem Solving				
Build new mathematical knowledge through problem solving.		✖		
Solve problems that arise in mathematics and in other contexts.	✖		✖	✖
Apply and adapt a variety of appropriate strategies to solve problems.	✖	✖	✖	✖
Monitor and reflect on the process of mathematical problem solving.			✖	✖
Connections				
Recognize and apply mathematics in contexts outside of mathematics.	✖	✖	✖	✖
Representation				
Select, apply, and translate among mathematical representations to solve problems.		✖		
Use representations to model and interpret physical, social, and mathematical phenomena.	✖	✖	✖	✖

National Science Standards (grades k-4)

Standard	Segment 1	Segment 2	Segment 3	Segment 4
Concepts and Processes				
Systems, orders, and organization	✖	✖	✖	✖
Evidence, models, and explanations	✖	✖	✖	✖
Change, constancy, and measurement		✖	✖	
Evolution and Equilibrium	✖		✖	
Form and Function	✖	✖	✖	✖
Science and Inquiry (A)				
Abilities necessary to do scientific inquiry	✖	✖	✖	✖
Understanding about scientific inquiry	✖	✖	✖	✖
Physical Science (B)				
Properties of objects and materials			✖	✖
Position and motion of objects	✖	✖	✖	✖
Life Science (C)				
Characteristics of Organisms			✖	
Science and Technology (E)				
Abilities of technological design		✖	✖	✖
Understanding about science and technology	✖	✖	✖	✖
Abilities to distinguish between natural objects and objects made by humans			✖	
Science in Personal and Social Perspective (F)				
Science and technology in local challenges	✖	✖	✖	✖
History and Nature of Science (G)				
Science as a human endeavor	✖	✖	✖	✖

National Science Standards (grades 5-8)

Standard	Segment 1	Segment 2	Segment 3	Segment 4
Concepts and Processes				
Systems, order, and organization	✖	✖	✖	✖
Evidence, models, and explanations	✖	✖	✖	✖
Change, constancy, and measurement		✖	✖	
Evolution and equilibrium	✖		✖	
Form and function	✖	✖	✖	✖
Science as Inquiry (A)				
Abilities necessary to do scientific inquiry	✖	✖	✖	✖
Understandings about scientific inquiry	✖	✖	✖	✖
Physical Science (B)				
Motion and forces	✖	✖	✖	✖
Transfer of energy		✖		
Life Science (C)				
Structure and function in living systems			✖	
Regulation and behavior			✖	
Diversity and adaptations of organisms			✖	
Science and Technology (E)				
Abilities of technological design	✖	✖	✖	
Understanding about science and technology	✖	✖	✖	✖
Science in Personal and Social Perspectives (F)				
Science and technology in society	✖	✖	✖	✖
History and Nature of Science (G)				
Science as a human endeavor	✖	✖	✖	✖
Nature of science	✖		✖	
History of science	✖			

National Educational Technology Standards (grades 3–5)

Performance Indicators for Technology-Literate Students

Standard	Segment 1	2	3	4
Basic Operations and Concepts				
Discuss common uses of technology in daily life and the advantages and disadvantages those uses provide.	✖			✖
Social, Ethical, and Human Issues				
Discuss common uses of technology in daily life and the advantages and disadvantages those uses provide.				✖
Technology Productivity Tools				
Use general purpose productivity tools and peripherals to support personal productivity, remediate skills deficits, and facilitate learning throughout the curriculum.		✖	✖	
Technology Communication Tools				
Use technology tools for individual and collaborative writing, communication, and publishing activities to create knowledge products for audiences inside and outside the classroom.	✖		✖	
Use telecommunication efficiently and effectively to access remote information, communicate with others in support of direct and independent learning, and pursue personal interests.			✖	
Use telecommunication and on-line resources to participate in collaborative problem-solving activities for the purpose of developing solutions or products for audiences inside and outside the classroom.	✖	✖	✖	
Technology Research Tools				
Use telecommunication and on-line resources to participate in collaborative problem-solving activities for the purpose of developing solutions or products for audiences inside and outside the classroom.	✖	✖	✖	
Use technology resources for problem solving, self-directed learning, and extended learning activities.	✖	✖	✖	
Technology Problem-Solving and Decision-Making Tools				
Use technology resources for problem solving, self-directed learning, and extended learning activities.	✖	✖	✖	
Determine when technology is useful and select the appropriate tools and technology resources to address a variety of tasks and problems.	✖			

The NASA "Why?" Files
The Case of the
Challenging Flight

Segment 1

The tree house detectives are determined to win the Egg-traordinary Plane Contest. They start by studying the history of flight and learn how other contests have helped to advance aviation. A visit with General John (Jack) R. Dailey at the National Air and Space Museum in Washington, D.C. gives them much needed information about the Wright Brothers, Charles Lindbergh, and the race to space. The tree house detectives also visit the "How Things Fly" exhibit and are introduced to the four forces of flight: lift, thrust, drag, and weight.

When the tree house detectives visit Dr. D's lab, he directs them to Luther Jenkins and a NASA wind tunnel to learn more about lift. The tree house detectives also get some help from the NASA "Why?" Files Kids Club at Achievable Dreams School in Newport News, VA. A class is performing an experiment to determine how the size of a wing affects lift. The tree house detectives visit the school to test their new hypothesis and receive a surprise visit from Jackie Chan, the human flying machine!

Objectives

The students will

- learn the significance of the Wright Brothers' historic flight on December 17, 1903.
- learn how competitions such as the Orteig Prize won by Charles Lindbergh have accelerated advancement in flight.
- learn how the U.S. and Russia were in a "race for space" to be the first to put a man on the Moon.
- learn the four forces of flight: lift, thrust, drag, and weight.
- learn how lift is created.
- learn how the "angle of the wing" affects lift.
- discover that the size of the wing affects lift.

Vocabulary

aeronautics - word derived from the Greek word for "air" and "to sail." It is the study of flight and the operation of aircraft.

airfoil - section of a wing, rudder, aileron, or rotor blade used for testing the reaction from air through which it moves

airplane - a heavier than air winged vehicle that is capable of flight and is propelled by jet engines or propellers

aviation - the operation of aircraft

curvature - a curving or bending

drag - the air resistance acting on airplanes. Drag acts in the opposite direction to thrust.

force - a push or pull used to lift something, start it moving, or hold it in place against another force, such as gravity

fuselage - the main structural body of an aircraft to which the wings and tail unit are attached

gravity - the force of attraction that makes objects fall toward the Earth

lift - a force that acts upward against gravity and makes it possible for airplanes, airships, and balloons to rise in the air

surface area - the sum of the areas of all the faces of a three-dimensional figure

third law of motion - Sir Isaac Newton's law of motion that states that for every action there is an equal and opposite reaction

thrust - a forward force that pushes an airplane through the air

weight - a response of mass to the pull of gravity

wind tunnel - a chamber where air or smoke is blown over an object such as an airfoil to calculate its aerodynamic forces, such as lift and drag

Video Component (15 min)

Before Viewing

1. Introduce the video by reading its title and synopsis. Ask students if they have ever made an airplane. Have them describe the

types of planes they created and the problems with each. Make a chart of the types made and list the problems that students encountered. For example, model airplanes: pieces too small, glue didn't stick, didn't understand the directions, wouldn't fly, and so on.

2. To assess students' background knowledge on flight, choose one or more of the following:
   - Have students define key vocabulary terms such as flight, lift, drag, weight, thrust, wing, fuselage, and rudder.
   - Have students write and illustrate a story of their favorite airplane flight.
   - Have students illustrate how a plane flies.
   - Discuss how a plane flies.

3. Introduce or review scientific inquiry and the scientific method. For additional information and worksheets on scientific inquiry and the scientific method, visit the NASA "Why?" Files web site at **http:whyfile.larc.nasa.gov**

4. Ask students to predict what the tree house detectives will need to do to learn more about flight and where they need to begin their investigation. Create a K-W-L chart (What you **know**, What you **want** to know , and What you have **learned**) for various predictions. You may download a copy of a K-W-L chart from the NASA "Why?" Files web site.

What do we **know**?	What do we **want** to find out?	What have we **learned**?

After Viewing

1. Discuss the questions at the end of the first video segment.
   What size should the tree house detectives plan for their plane's wings?
   What should they do next?
   How can they get more lift?

2. The tree house detectives begin their investigation of the four forces of flight: lift, thrust, drag, and weight. Divide up the class in small groups and ask each group to demonstrate one of the forces after a short research and preparation time. The demonstration may take the form of a short skit, puppet show, or mime.

3. The experiment shown in this video segment studies the relationship between the size of wings and flight. Review with the students the results of the experiment and how they might affect the construction of their own plane.

4. Make a display board showing the parts of a scientific investigation. Include the following words: problem statement, research, materials, hypothesis, procedure, data, conclusion, variables, information, experiments, questions. Some of these words may be used several times during an investigation. As a class, ask the students to write down the steps that the tree house detectives use to solve the problem during the four video segments.

5. Have students find out about prizes and the history of flight. Some examples are the Orteig Prize and Charles Lindbergh's Atlantic crossing, the Vin Fiz cross-country flight and the Hearst Prize, and the ten million dollar X-Prize for the international race to develop a commercial space plane. Sample web sites for information include **http://www.xprize.org/, http://aerofiles.com/vinfiz.html, http://www.centennialofflight.gov/,**

Careers

actor
museum director
astronaut
teacher
inventor

http://www.flight100.org/history_intro.html

6. If the students defined key vocabulary terms prior to viewing the video, ask if they would like to change any definitions and why. Select activities in this lesson guide or on the NASA "Why?" Files web site to help reinforce the concepts and objectives emphasized in this segment.
7. Continue to add to the K-W-L chart. Discuss the process of scientific inquiry. Ask students to predict what the tree house detectives will do next in their quest to learn more about flight. Add predictions to the K-W-L chart.
8. Choose from the activities in this guide or on the web site at **http://why-files.larc.nasa.gov** to help reinforce the concepts and objectives being emphasized in segment 2.

Resources

Books

Boyne, Walter J.: *The Smithsonian Book of Flight for Young People*. Macmillan Publishing Company (1988), ISBN 068971212

Chaikin, Andrew: *Air and Space: The National Air and Space Museum Story of Flight*. Bulfinch Press (2000), ISBN: 0821226703

Demerest, Chris L: *Lindbergh*. Crown Books for Young Readers (1993), ISBN: 0517587181

Hart, Philip S.: *Flying Free: America's First Black Aviators.* Lerner Publications, Co. (1992), ISBN: 0822515989

Krensky, Stephen: *Taking Flight: The Story of the Wright Brothers.* Simon and Schuster Children's Pub. (2000), ISBN: 0689812258

Scott, Phil (Editor): *The Pioneers of Flight: A Documentary History.* Princeton University Press (1999), ISBN: 0691011176

Sobol, Donald J.: *The Wright Brothers at Kitty Hawk.* Scholastic, Inc. (1986) ISBN: 0590429043

Shea, George: *First Flight: The Story of Tom Tate and the Wright Brothers (I Can Read Chapter Book Series).* HarperCollins Children's Books (1997), ISBN: 0064442152

Activity Books

Wilbur and Orville Wright—An activity book packed full of facts, games, and puzzles. A single copy of this publication may be ordered on school letter-head from: Nat'l HQ CAP/ETD, Maxwell AFB, AL 36112-6332.

Charles A. Lindbergh—An activity book packed full of facts, games, and puzzles. A single copy of this publication may be ordered on school letterhead from: HQ CAP/EDE, Maxwell AFB, AL 36112-5572.

Web Sites

NASA "Why?" Files
http://whyfiles.larc.nasa.gov/

Aerospace Team On-line
Features the Wright Flyer. Students can learn about the Wright Flyer Project, meet the people involved in the project, go back in time to the early days of aviation, and talk about science. Include some additional resources/activities.
http://quest.arc.nasa.gov/aero/wright/

The U.S. Centennial of Flight Commission
Features the history of aviation and shares the future of flight. A calendar of

events links to air show listings throughout the U.S.
http://centennialofflight.gov/

The Beginner's Guide to Aerodynamics
Includes the study of forces and the resulting motion of objects through the air. The guide allows you to move at your own pace and depth of study. Graphics throughout the site make it easy to understand the principles of flight.
http://www.grc.nasa.gov/WWW/K-12/airplane/bga.html

WayBack - U.S. History for Kids
Cool facts about important pilots, inventors, other aviation pioneers, a modern-day aerial stunt artist, and more.
http://www.pbs.org/wgbh/amex/kids/flight/

Do you ever wonder how things fly? An interactive and colorful site with information on the properties of air, the four forces of flight, and more.
http://www.aero.hq.nasa.gov/edu/

National Air and Space Museum
Click on "Exhibitions" and explore the "How Things Fly" exhibit or discover the milestones of flight. Learn about space exploration, rocketry, and much more.
http://www.nasm.edu/

Aeronautical Terms
Learn how to use sign language for aeronautical terms, learn the principles of aeronautics (various reading levels), explore possible careers, or check out experiments for flight. For teachers, there are lesson plans and curriculum bridges.
http://wings.ucdavis.edu/

Activities and Worksheets

In the Guide

On the Web

You can find the following activities on the Web at http://whyfiles.larc.nasa.gov.

Aviation Pioneers
Activity to learn more about the historic flight of the Wright Brothers.

Flight Museum
Design your own classroom flight museum.

Newton's In the Driver's Seat
Learn about Newton's Third Law of Motion.

A Time to Remember

Purpose

To create a timeline of historic aviation pioneers and aircraft.

Procedure

1. In advance of the activity, the teacher may wish to prepare the timeline or he/she may elect to have the students create it. See steps 6-8 for advance preparation.
2. Divide class into groups of 3-4 students.
3. Assign or let students choose 4-5 aviation pioneers and 2-3 famous aircraft.
4. Students begin their timeline by researching the significance and date of importance for each pioneer and aircraft they have chosen.
5. Using a white square of paper for each pioneer or aircraft, students should draw a picture depicting the pioneer or aircraft, color, and label it with the name and date.
6. To create the timeline, measure and cut 6 m of adding machine tape. If adding machine tape is not being used, measure and cut strips of paper 5 cm wide and glue together for a length of 6 m.
7. Use a marker and draw a vertical line every 25 cm.
8. Label one end of the timeline 1500 AD and continue labeling each line drawn in 25-year increments. The opposite end of the tape ends with the year 2100.
9. Have students present their aviation pioneers and aircraft and place them appropriately on the timeline.
10. Have the students brainstorm and discuss ideas for the future of aviation.
11. Have members of each group choose an idea and draw a square to represent their idea of the future of aviation. This idea could be a futuristic plane or who they think will be a great future aviator, it may even be one of them!
12. Display the timeline in the hall or other centralized area of the class or school.

Materials

- roll of adding machine tape or strips of paper
- white paper cut into 10-cm X 10-cm squares (enough for each pioneer and each aircraft on timeline)
- list of aviator names and aircraft
- crayons or markers
- scissors
- glue

Conclusion

1. Which pioneer do you think is the most important person in the history of aviation and why?
2. Which aircraft do you think is the most important aircraft in the history of aviation and why?

Extensions

1. Have the students create individual timelines.
2. Have the students choose an aviation pioneer and research him/her in-depth to present to the class. Have the students dress in character for presentation.
3. Write at least five "Who Am I?" riddles about famous aviators or aircraft and try them on a friend.

Aviation Pioneers

- Leonardo da Vinci
- Amelia Earhart
- Charles Lindbergh
- Etienne and Joseph Montgolfier
- Marquis d'Arlandes
- Wilbur and Orville Wright
- Samuel P. Langley
- Sir George Cayley
- Clyde Cessna
- Neil Armstrong
- Charles "Chuck" Yeager
- Bessie Coleman
- James H. Doolittle
- Otto Lilienthal
- Oakley Kelly
- Wiley Post
- Calbraith O. Rodgers
- Anthony H. G. Fokker
- Daedalus
- Glenn Curtiss
- William Piper
- Donald Douglas
- Jean F. Pilatre
- John Glenn

Aircraft

- X-15
- Douglas DC-3
- Cessna 150
- *Winnie Mae*
- *Chicago*
- AEA Hydro Aircraft
- Learjet
- *Wright Flyer*
- Mitsubishi Zero-Fighter
- F-18
- Space Shuttle
- *Gossamer Condor*
- Ford Tri-Motor
- Piper Cub
- *EX Vin Fiz*
- Northrop Alpha
- *Daedalus*
- X-1
- *Spirit of St. Louis*
- F-14
- Saturn 5 Rocket

Wright 1903 *Flyer*

Materials

- plastic foam
- scissors
- 18 toothpicks per plane
- glue
- marker or pen
- pin
- pattern

Purpose

To construct a model of the Wright Flyer.

Procedure

1. Trace pattern pieces of the Wright Flyer onto rigid plastic foam.
2. Using a pin, mark all holes in the diagram by pushing the pin through the paper and into the plastic foam.
3. Using a marker, mark dotted lines as shown.
4. Using scissors, cut out all pattern pieces.
5. Shape the wings and rudder by cutting on the dotted lines.
6. Push one toothpick lengthwise through the center of each rudder. Glue each rudder upright at one end of the body with one on each side.Then glue onto the top of the rudder. See diagram.
7. Dip 18 toothpicks in glue and place the toothpicks upright on the dot marks made by the pin. Dab glue on the toothpick tops and lay the second wing carefully on them, using the dots as a guide.
8. Press together carefully.
9. To create the propellers, cut a toothpick in half and glue one piece to each of the two middle toothpicks.
10. Set the plane aside to dry.
11. Cut three toothpicks in half and dip the end of five halves into glue.
12. Place the toothpicks upright on the dots on one section of the elevator. Dab glue on the tops and place the second section of the elevator on them.
13. Press together carefully and set aside to dry.
14. Once the glue has dried, glue the set of wings to the center of the body.
15. Glue the set of elevators to the other end of the body.
16. Tape a dime or penny to the bottom of the Flyer between the wings and the elevators.
17. Set aside to dry.
18. Once the glue is dry, you are ready to fly your plane.

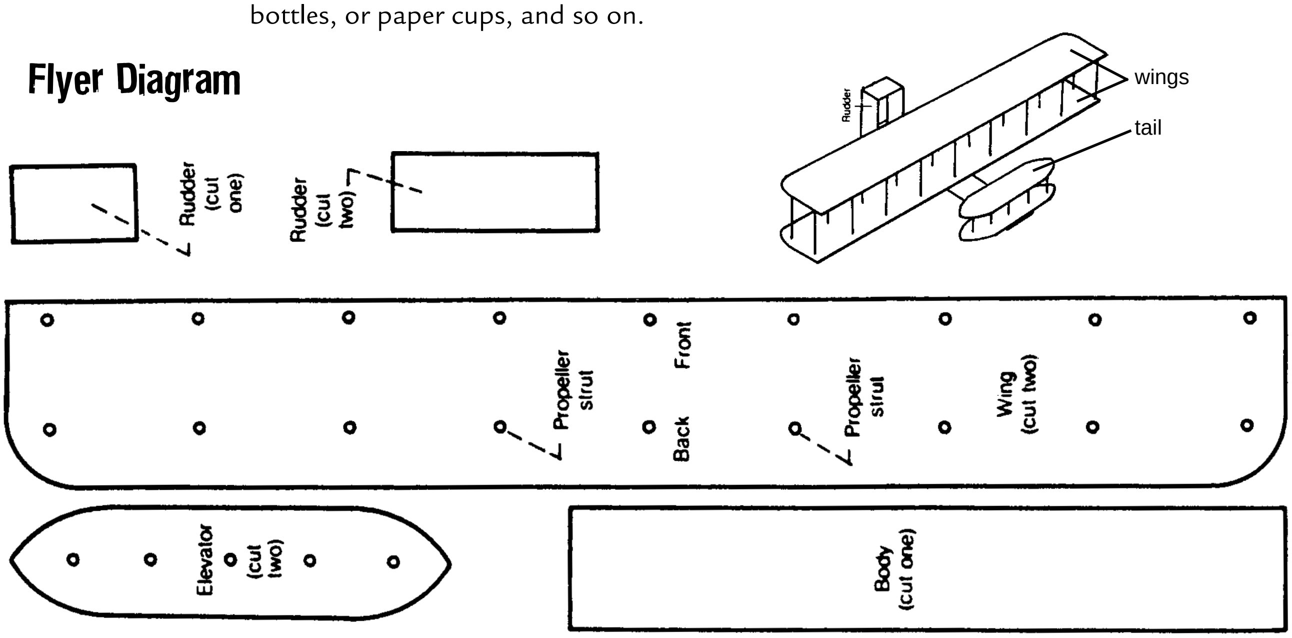
Conclusion

1. How did the Wright Flyer differ from airplanes of today?

Extensions

1. Create models of airplanes of the past and present or imaginary ones of the future from various recyclable materials such as juice or soda cans, cardboard, paper tubes, plastic bottles, or paper cups, and so on.

Flyer Diagram



Lucky Lindy and the Spirit of St. Louis

Research Charles Lindbergh to discover the flight path he flew in 1927 in his famous 33 1/2-hour flight across the Atlantic Ocean. On the map below, draw the path. Write a description of what the flight might have been like for Charles Lindbergh. Be sure to include the prize that he won for his accomplishment!

Lift Experiment

Purpose

To determine if the size of a wing affects lift.

Materials (per group)

completed egg crate plane, less main wing and propeller/rubber band (see page 68-69)
two pennies
box fan
62 cm length of balsa wood for fuselage stick
hinge (you may be able to substitute heavy tape for the hinge)
tape, masking and cellophane
two dozen pennies for measurement purposes
pushpin
one 20 cm X 6 cm wing (test wing #1)
one 28 cm X 6 cm wing (test wing #2)
one 28 cm X 12 cm wing (test wing #3)

Procedure

1. To make the test setup, anchor one end of the hinge to the side of a desk with masking tape. (For a more permanent setup, use a wooden box and screws to anchor the hinge to the wooden box.)

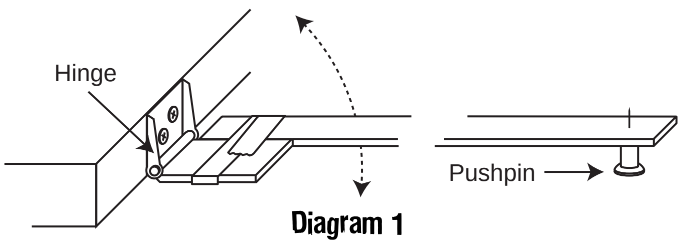


Diagram 1

2. Tape the fuselage stick to the end of the hinge. Stick should pivot freely up and down. See diagram 1.
3. On the end of the stick that is not attached to the hinge, push the pushpin through the wood so that you have a point on top of the stick.
4. To replace the weight of the propeller, tape two pennies to the front of the egg crate plane on either side of the fuselage. See diagram 2.
5. To attach a test wing, you must first find the balance point. Place the wing in a centered position on the fuselage, then place your finger under the wing. If the wing is positioned correctly, it should balance. If not, adjust the position forward or back until a balance is achieved. Adjust the tilt of the wing so that it is tilted approximately 15 degrees to give it a positive incidence (upward tilt).

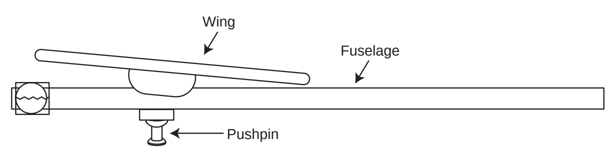


Diagram 2

6. Attach test wing 1, find balance, add the tilt, and tape it into place.
7. Place the egg crate plane with test wing onto the pushpin. The plane should be positioned on the pushpin with the pin directly under the wing. See diagram 2. Rest the plane on a desk.
8. Position the fan on a desk or stool so that it is in front of the test setup with the plane in front of the middle of the fan.
9. Turn the fan on low and tighten any loose tape.
10. Increase the fan speed until the plane lifts off the desk.
11. Once the plane is stable, begin adding pennies to the pylon cavity in the center of the wing until the plane will no longer fly. See diagram 3.

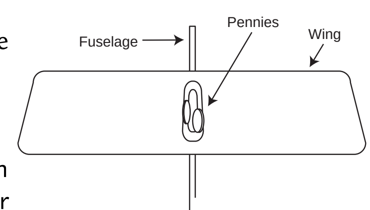


Diagram 3

12. Calculate the amount of weight/mass added to the plane. You can use a balance to find the weight/mass of the pennies, or you can multiply the number of pennies by 2.5 grams (average weight/mass of a penny). Record weight/mass in chart.
13. Repeat for two more trials and find the average number of pennies and weight/mass lifted.
14. Repeat with test wing 2 and test wing 3.
15. Compare results among groups and discuss.

Lift Experiment (continued)

Test Wing	Number of Pennies Lifted	Weight/Mass of Pennies
Test Wing 1 Trial 1		
Test Wing 1 Trial 2		
Test Wing 1 Trial 3		
Average of Test Wing #1		
Test Wing 2 Trial 1		
Test Wing 2 Trial 2		
Test Wing 2 Trial 3		
Average of Test Wing #2		
Test Wing 3 Trial 1		
Test Wing 3 Trial 2		
Test Wing 3 Trial 3		
Average of Test Wing #3		

Conclusion

1. Which wing held the most pennies and why?____________________
2. Why was it important to perform more than one trial? ____________________
3. Why did you average the number of pennies and weight?____________________
4. Design a wing that would lift more weight.

Extensions

1. Find a class average for the number of pennies lifted and the weight of the pennies.
2. Test other sizes of wings.
3. Test other shapes of wings.

Bernoulli's Principle

Purpose

To understand the effect of air flowing over a curved surface. To understand Bernoulli's principle.

Materials

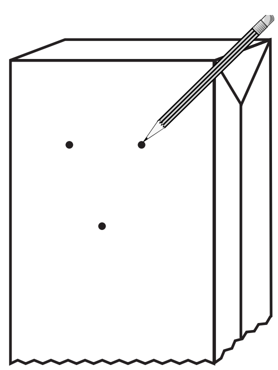
large paper grocery bags
scissors
crayons or markers
notebook paper
tape or glue
metric ruler

Procedure

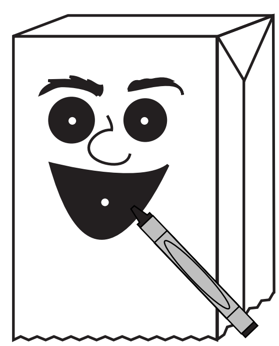
1. Working in pairs, have one student place a bag over his/her head and have the second student carefully draw small dots where the eyes, nose, and mouth are located.
2. Remove the bag from the head and draw a face around the markings and color mask.
3. Cut out two holes (approximately 2 cm in diameter) for the eyes.
4. Cut a hole (approximately 4 cm in 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.
8. Discuss and explain Bernoulli's principle.

Conclusion

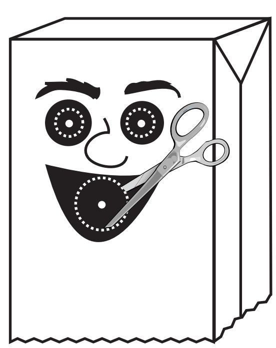
1. Why does the tongue move when you blow gently through the mouth?
2. What happens when you blow harder?
3. Draw a diagram of the flow of air over the strip of paper.
4. Explain how Bernoulli's principle applies to the lift of a wing on a plane.
5. List some common examples that demonstrate Bernoulli's principle.



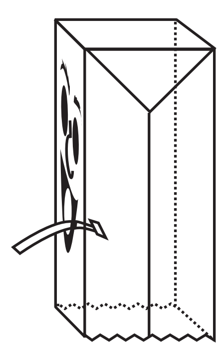
Step 1



Step 2



Step 3 and 4



Step 6

Thar She Blows

Purpose

To demonstrate a wind tunnel.

Materials

large paper tube or heavyweight paper
fan or blow-dryer
tape
30 cm of string for each model
plastic foam to make various models of airplanes or geometric shapes (These may be created by the teacher prior to experiment.)

Procedure

1. To create the wind tunnel out of heavyweight paper, cut the paper approximately 1.5 m by 30 cm and roll into a tube shape. Roll the paper so that the smaller dimension creates the circle. Overlap ends and tape into place. See diagram 1.
2. Create various shaped airplanes or geometric shapes for testing, and using tape, attach a string to each.
3. Have one student place the wind tunnel in front of a fan or blow-dryer.
4. Place one of the test objects in front of the wind tunnel and turn on the fan or blow-dryer (see diagram 2).
5. Observe motion of test object and record.
6. Continue testing objects and record observations of each object in science journal.

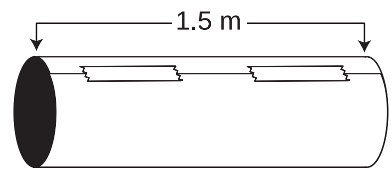


Diagram 1

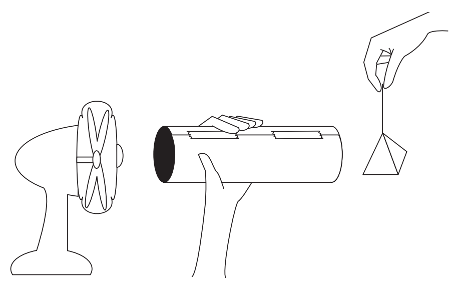


Diagram 2

Conclusion

1. What happened when the test objects were placed in the wind tunnel?
2. Which objects had "lift"?
3. Explain why some objects "lifted" better than others.
4. Other than testing a plane, what uses are there for wind tunnels?

Object	Observation

Airfoils

Purpose

To demonstrate how an airfoil creates lift. To understand Bernoulli's principle.

Materials

protractor
desk fan
wooden block (length of protractor)
50 cm stiff wire
bead
scissors
glue
tape
six 10-cm pieces of yarn
thin cardboard 11 cm X 31 cm
small nail
hammer
drill (optional)
science journal

Procedure

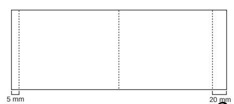


Diagram 1

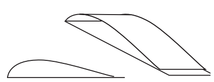


Diagram 2

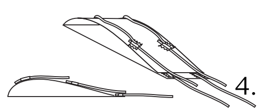


Diagram 3

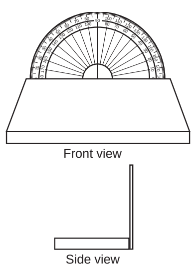


Diagram 4

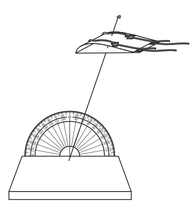


Diagram 5

1. Lay cardboard flat and measure 15 mm from one end of the cardboard and draw a line and measure 24 mm from the other end of the cardboard and draw a line. See diagram 1.
2. Fold the cardboard in half and fold the 15-mm edge of the cardboard so that it fits flat against the 24-mm edge. You should have a shape with a curved top (see diagram 2). This is an airfoil.
3. Lay the airfoil on its flat surface and make two holes through the center of the airfoil's widest part, one directly above the other. You may need adult help with this part.
4. Using tape, attach yarn to the airfoil as shown. See diagram 3.
5. Place the bead on one end of the stiff wire and loop or bend the wire so that the bead is secured to the end of the wire.
6. Guide the wire through the holes in the airfoil so that the curved side is on top and the flat side is on the bottom
7. Using a nail and hammer or drill, make a hole in the middle of the wooden block just big enough to hold the end of the wire.
8. Attach the protractor to the wooden block with either tape or glue. See diagram 4.
9. At a 70 degree angle, push the wire into the block so that it stands firmly (but not too firmly) so that the angle can be changed. See diagram 5.
10. On a flat surface, place the stand with the airfoil in front of the fan, making sure that the rounded edge of the airfoil is facing the fan. This edge is called the leading edge of the airfoil. The opposite edge is called the trailing edge. See diagram 6.
11. Turn the fan on low speed and observe. Record observations in science journal.
12. Adjust wire to decrease angle to a 40-degree angle and repeat step 12.
13. Take the wire out of the wooden block and flip the airfoil over so that the flat side is on the top and the curved side is on the bottom. See diagram 7.
14. Repeat Steps 10-13 and record observations.

Conclusion

1. What happened to the airfoil at a 70-degree angle?
2. What happened to the airfoil at a 40-degree angle?
3. Explain why there was a difference.
4. What happened when you flipped the airfoil over? Explain.
5. What conclusions can you draw from this experiment about the angle of a wing?

Extensions

1. Experiment with various other angles.
2. Create other test objects to place on wire.

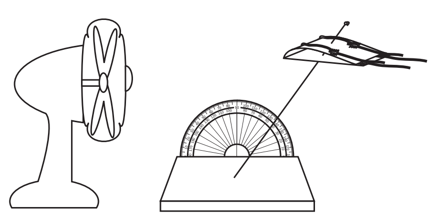


Diagram 6

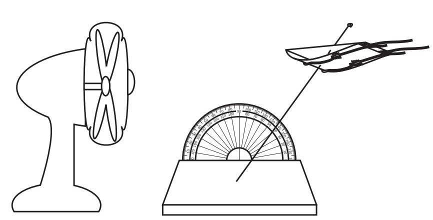


Diagram 7

Answer Key

Lift Experiment

1. The largest wing (28 cm X 12 cm) held the most pennies because it had a larger surface area that created more lift.
2. It is important to perform more than one trial to get accurate data. A scientist never relies on the data from just one trial because it might have been a faulty experiment or other factors may have skewed the data.
3. It was important to average the number of pennies and weight to a more accurate number. Each trial may have had slight variances, and by averaging the data, you come closer to an accurate answer.
4. Designs will vary.

Bernoulli's Principle

1. The tongue moves when you blow gently through your mouth because the air molecules are attracted to and attach to the surface. The fast-moving air travels along the paper's surface. Lift occurs because the pressure on the upper surface of an object is less than the pressure on the lower surface.
2. When you blow harder, the tongue will move up and down faster.
3. Diagrams will vary.
4. Bernoulli's principle applies to the lift of a wing on a plane the same as it does to the paper. Air molecules flow over the curved surface of a wing, creating less pressure on the upper surface than on the lower surface, allowing the wing to lift.
5. Other examples are flags waving, sails, and an umbrella that becomes impossible to hold in a strong wind.

Newton's In the Driver's Seat

1. When the cars made contact, they hit and then bounced away from each other.
2. As you pushed the cars, you exerted a force on each. When they hit, the cars pushed against each other and traveled away from the point of contact. Newton's Third Law of Motion states that for every action there is an equal and opposite reaction. The action was when the cars hit, and the reaction was when they moved away from each other.
3. If you applied a greater force on the cars, they would travel a greater distance away from each other.

Thar She Blows

1. Answers will vary depending on objects.
2. Answers will vary depending on objects.
3. Some objects will lift better than others due to their shape and/or surface area.
4. Other uses for wind tunnels are to test race cars, passenger cars, and space-related items.

Airfoils

1. The airfoil at a 70-degree angle moved up the wire.
2. The airfoil at a 40-degree angle moved up the wire more than it did at the 70-degree angle, and it moved more quickly.
3. The size of the lift force increases with the angle of the airfoil to the wind.
4. When the airfoil is flipped over, the air forces it to the ground because the curved surface of the wing was not on top.
5. From this experiment you can conclude that a wing needs to have the curved surface on top, and it needs to have an upward angle for the best lift.