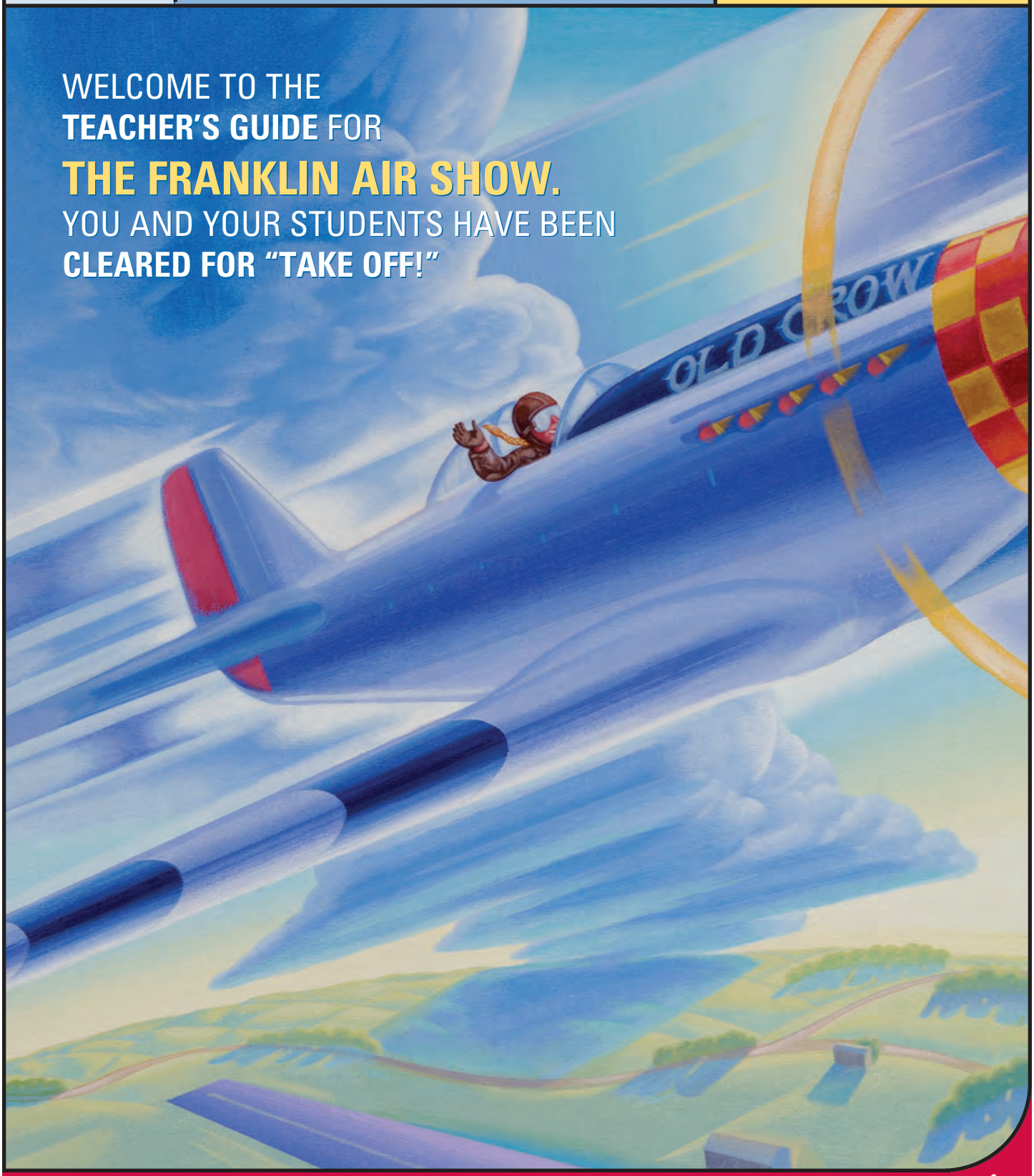
THE FRANKLIN AIR SHOW

TEACHER'S GUIDE

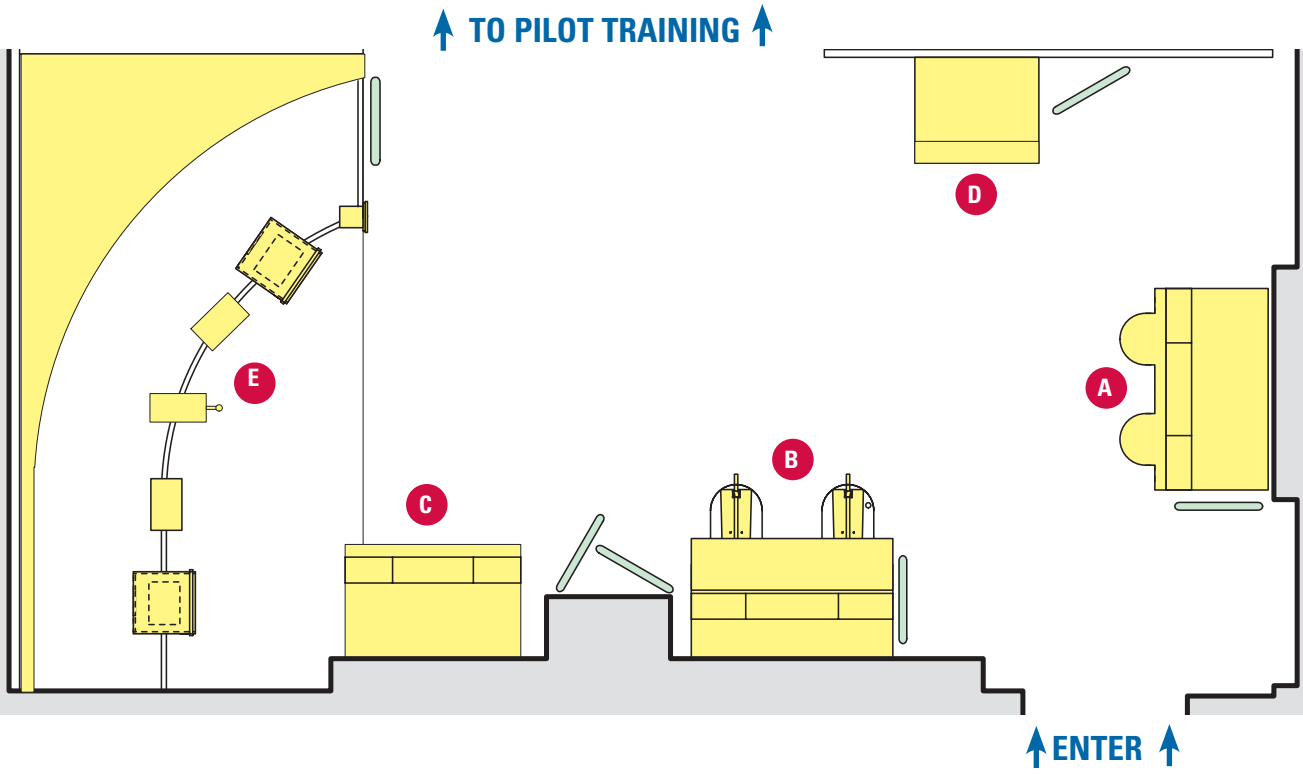
THE FRANKLIN INSTITUTE



WELCOME TO THE
TEACHER'S GUIDE FOR
THE FRANKLIN AIR SHOW.
YOU AND YOUR STUDENTS HAVE BEEN
CLEARED FOR "TAKE OFF!"

TEACHER'S GUIDE

MAP-THE MIDWAY



A

Raise The Ball: Students learn about the Bernoulli principle as they adjust air pressure to raise and lower a ball through a tube. As their ball is raised, they go from a trainee to a captain!

B

Balloon Race: In true "midway" fashion, students learn how air takes up space as they compete against each other to be the first to fill a balloon with air.

C

Drag Race: Students learn about the principle of drag as they race two cars: one in a tube with room air and one in a tube with no air.

D

Bernoulli Bottle: Students are challenged to keep a plastic bottle afloat in an air stream blowing sideways. Daniel Bernoulli would be proud!

E

Shimmer Wall: Students stand in front of a wall that is covered in hundreds of light metallic disks, and direct airflow to move the disks.

THE FRANKLIN AIR SHOW

TEACHER'S GUIDE

MAP-PILOT TRAINING

F **Airplane Launcher:**
Students design and make paper airplanes. Then they use a motorized launcher to launch their planes and test the effects of design changes on their planes' performance.

G **Control Surfaces:**
Students move the rudder, elevator and ailerons of a large model plane while an interactive device simulates their moves on a nearby screen.

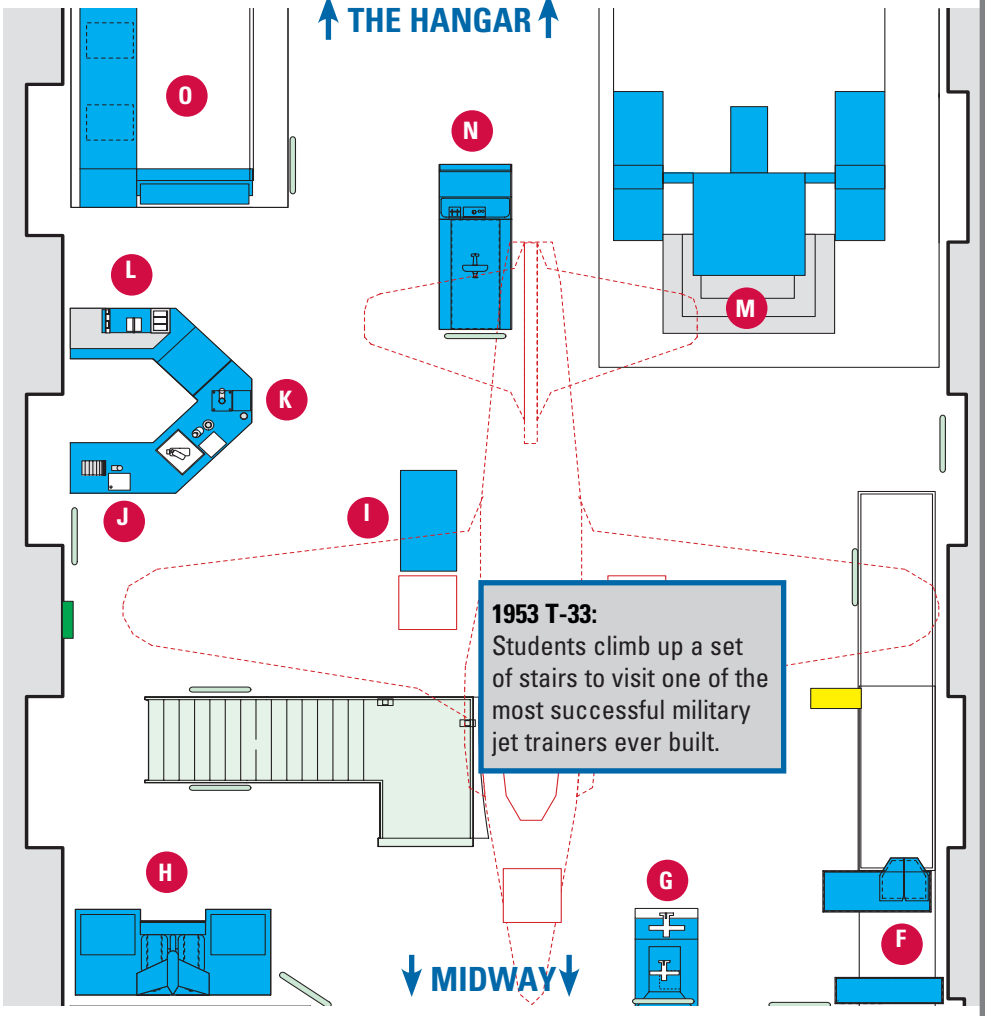
H **Feel the Drag:**
Students learn which shapes are more aerodynamic than others by testing objects of different shapes inside an air stream.

I **Airflow over an Airfoil:**
Students learn which shapes are more aerodynamic than others by testing objects of different shapes inside an air stream.

J **Hinged Wing:**
Students watch the effect of air moving across an airfoil.

K **Raise the Ball:**
Students lift a ball in a tube by changing the speed of a flowing air stream.

L **Wings Fly:**
Students watch a wing rise as wind blows into a wind tunnel. Then they can see what happens when they block that air with a paddle.



M **Simulator:**
Students step inside and take control of a state-of-the-art, full motion flight simulator. **Note: This interactive takes five minutes per every two children and is an additional fee.**

N **Cockpit Controls:**
Using a joystick and rudder pedals, students get the feeling of what it's like to control a plane! They experience the plane's pitch, yaw and roll by simulating the main cockpit controls.

O **Wearable Wings:**
Students attach wings to their arms, stand in front of a wind tunnel and get "lifted" like an airplane!

MAP-THE HANGAR

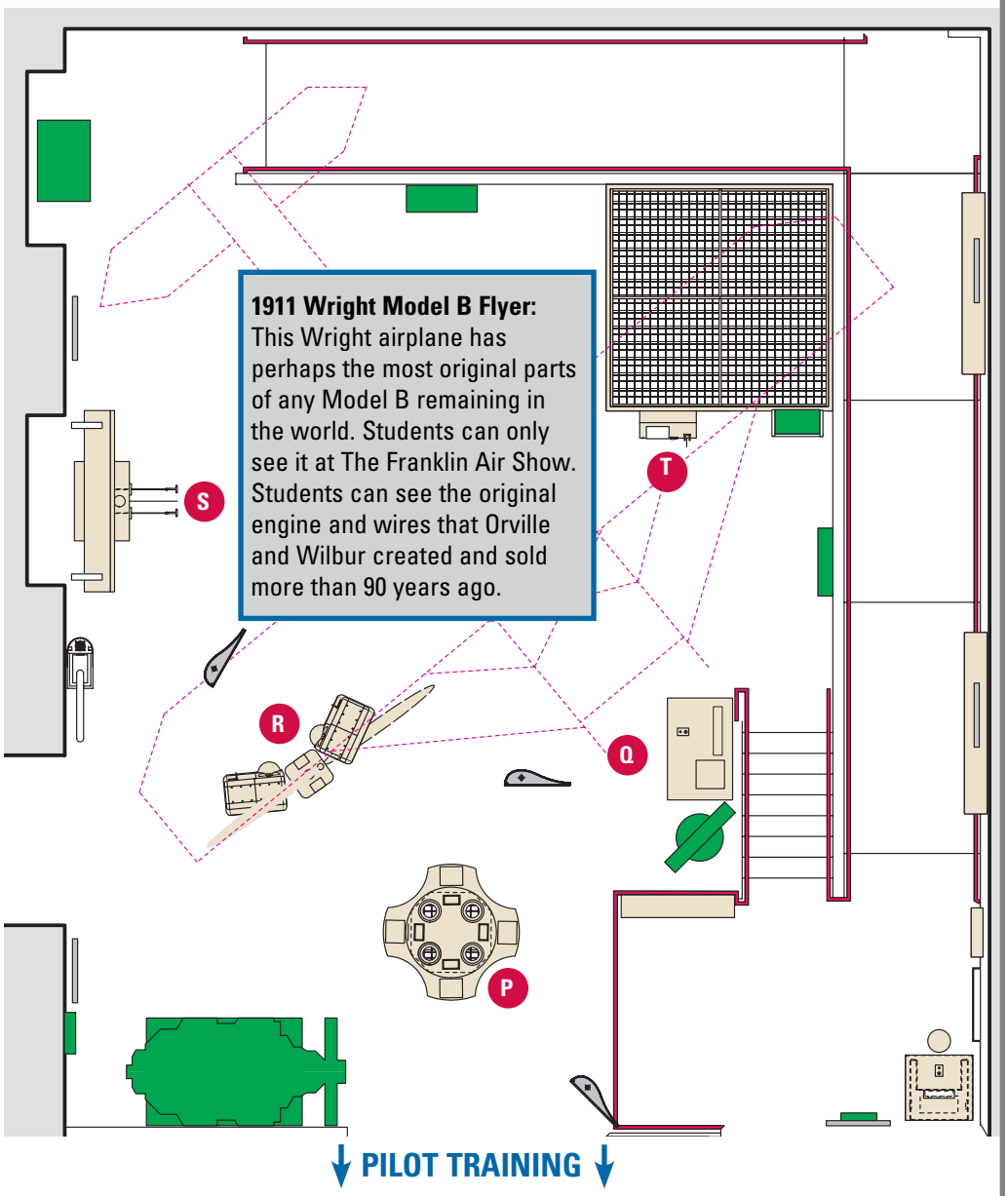
P **Blower with Whirligigs:** Students create whirligigs and send them spinning into the air!

Q **Design a Plane Computer:** Students use a state-of-the-art computer to design one of four planes: a stunt plane, a commercial plane, a spy plane or a Helios plane. They must make the right choices to get their plane off the ground.

R **Test a Propeller:** Students test two different propellers to see which one generates the most thrust.

S **Fly a Wright Kite:** Students gain insight into the Wright brothers' advanced scientific processes as they use two ropes to control a digital image of a kite on a screen.

T **Angle of Attack:** By adjusting the speed and angle of a wing, visitors cause a wing to soar in the air, or to drop in an instant!



THE FRANKLIN AIR SHOW

TEACHER'S GUIDE

K-3

CONTENTS

At The Franklin Air Show, your students will enter a lively air show with the roaring sounds of planes overhead. Students can explore the principles of aviation at more than 20 hands on exhibits that are part of three separate areas – a midway, a pilot training center, and an aircraft hangar. Throughout the exhibit, students will discover the history of aviation through rare artifacts and the life stories of a broad spectrum of aviation pioneers.

Student pilots will earn their wings during several training sessions, including a new flight simulator. Along the way, they will view the restored Wright brothers' Model B Flyer, possibly the most intact Wright airplane in the world; several artifacts willed to The Franklin Institute by Orville Wright; and a 1948 T-33 jet trainer.

To help plan your visit to The Franklin Air Show, you can find customized resources. See the content listing to the left.

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- List of additional print and Web resources.

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While your students are encouraged to explore all parts of The Franklin Air Show, the following list details the most appropriate interactives for students grades K-3:

K-3

Shimmering Wall
Balloon Race
Thrust Chair
Wearable Wings
Wings Fly
Control Surfaces
Airplane Launcher
Design for Thrust
Blower with Whirligigs

TEACHER'S GUIDE

SECTION ONE: PROPERTIES OF AIR

AIR WEIGH

Objective

Students conduct an experiment that helps them observe and explain the impact of weight in air.

Relevant National Science Education Standards

Unifying Concepts and Processes: Evidence, models, and explanation
Physical Science: Properties of objects and materials
Science Standards for Pennsylvania, New Jersey & Delaware are available online at www.fi.edu/teachers/standards

Materials

Yardstick, two empty balloons of equal size, tape, string

Things to discuss before

Ask students to share what they already know about air. Do they think that air has weight? Why or why not? How might they learn the answer?

Things to do

1. Create, or have students create, a scale by tying string to the middle of a yardstick and taping the string to a table or door jam. Note: The center of mass may not be the measured center of the yardstick.
2. Tape an empty balloon to each end of the scale. It should balance. Have students describe what they observe. Ask them to explain their observations.
3. Remove one of the empty balloons from the scale, and blow air into it. Have students make predictions about how the scale may change if you place the air-filled balloon back on the scale.
4. Tape the air-filled balloon back in the same location. The scale will be tilted, with the air-filled balloon weighing more. Were predictions correct? Have students draw conclusions.

Things to discuss after

Have students share what they know about air after conducting their experiment. When the balloons are both empty, they weigh the same, and therefore balance. When one balloon is filled with air, they no longer have the same weight. The balloon filled with air is heavier than the balloon with no air inside it, and therefore tips the scale.

Extensions

Replace the balloons with paper bags, and pour air into one bag from a pitcher that has been in the freezer for a while. Have students explain their observations.

Exhibit Connections

Balloon Race, Shimmer Wall

SECTION TWO: FORCES OF FLIGHT

IT'S A DRAG

Objective

Students discover how a change in an object's shape can impact its movement through the air.

Relevant National Science Education Standards

Unifying Concepts and Processes: Evidence, models, and explanation
Physical Science: Properties of objects and materials
Science Standards for Pennsylvania, New Jersey & Delaware are available online at www.fi.edu/teachers/standards

Materials

Several pieces of 8 1/2" x 11" paper, cellophane tape

Things to discuss before

1. Have students predict if two pieces of 8 1/2" by 11" paper will hit the ground simultaneously if they are dropped at the same time from the same height. Do this demonstration.
2. Now tell students that you are going to change the shape of one of the pieces of paper. Do students predict that a change in shape will affect the speed at which the paper drops?

Things to do

1. Take one piece of 8 1/2"x 11" paper, and fold it in half. Fold it in half again at a 90-degree angle to the first fold. Continue to fold the paper in half until you can no longer fold it.
2. Tape the folded paper tightly with tape. Loosely crumple the second piece of paper.
3. Have students predict what will happen when you drop both pieces of paper at the same time from the same height.
4. Drop both pieces of paper. The one that is folded should hit the ground first. Since both pieces of paper weigh the same, can students explain this result? (The folded paper drops first because it has less drag.)

Things to discuss after

Ask students to apply this principle to flight. How might the shape of an airplane affect its drag?

Extensions

Ask students if they have ever seen someone jump out of a plane with a parachute. What happens when that person opens their parachute? Illustrate the force of drag by making a parachute using paper towels, string, and a weight. Ask students if they would be willing to jump out of a plane using a parachute. Why or why not?

Exhibit Connections

Drag Race, Race Tubes

SECTION THREE: HISTORY OF FLIGHT

HUMAN TIMELINE

Objective

Students create a human timeline about the Wright brothers.

Relevant National Science Education Standards

History and Nature of Science: Science as a human endeavor
Science Standards for Pennsylvania, New Jersey & Delaware are available online at www.fi.edu/teachers/standards

Materials

Books about the Wright brothers [see rescources page 23], index cards, markers, notepaper

Things to discuss before

1. Have students create an individual or class list of what they already know about the Wright brothers. Then have them create an individual or class list about what they'd like to learn.
2. Discuss what steps may have been involved in building, testing, and flying the 1903 Flyer.

Things to do

1. Read one or more books to or with students about the Wright brothers. Have students raise their hand each time an important step in the Wright brothers' invention process is read.
2. Create cards with these important milestones and have each student select one card to illustrate. Make sure there is at least one card for each student.
3. Have students line up in the order of their milestones, creating a human timeline of the Wright brothers' story.

Things to discuss after

Have students retell the story in chronological order, with each student summarizing his or her milestone and explaining why it was an important part of the Wright brothers' story.

Extensions

Have students write a journal entry from the point of view of one of the following people that details his or her perspective about one of the important milestones students selected: Orville, Wilbur, a member of the lifesaving squad, Octave Chanute, or someone else.

Have students visit the online collection of Wright artifacts http://sln.fi.edu.wright/collection and identify those that correspond to important dates on the human timeline.

Exhibit Connections

1911 Wright Flyer, 1903 Drawing of the First Plane, Airfoil #12.

SECTION FOUR: DESIGN OF FLIGHT

DESIGN A SLED KITE

Objective

Students will be introduced to the wonder of flight by building and flying a kite.

Relevant National Science Education Standards

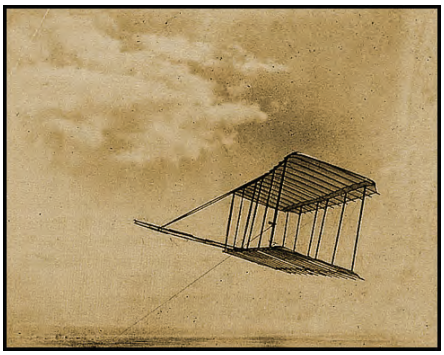
Physical Science: Position and motion of objects
Science and Technology: Abilities of technological design
Science Standards for Pennsylvania, New Jersey & Delaware are available online at www.fi.edu/teachers/standards

Materials

A gusseted bag without a foot (like Kinko's or card store bags), cellophane or clear packing tape, glue, nylon string (6' of 20 to 30 lb string), scissors, yardstick, hole punch

Things to discuss before

1. Share with students that, years before the Wright brothers flew their first airplane, they tested their ideas by building and flying kites.
2. Ask students how flying kites helped the Wright brothers learn about flight. What do kites and airplanes have in common? What's different?



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Things to do

1. At the following web address you will find instructions on how to make sled kite. http://members.aol.com/GEngvall/k_sled.html Read the directions carefully, and determine what you might want to do to prepare your students to make the kite.
2. Demonstrate each step as your students make the kite.
3. When they are finished, have them decorate and fly their kites.

Things to discuss after

After they've flown their kites, have students share or write one fact they learned about flight.

Extensions

Have students test kites made of different-sized bags to see if the results differ.

Have students read books about the Wright brothers to learn how they used kites in their research.

Exhibit Connections

Fly a Wright Kite, Drag Race, Shimmer Wall

THE FRANKLIN AIR SHOW

STUDENT GUIDE

K-3

IN EXHIBIT GUIDE

1. Make the **Shimmer Wall** move! You can blow air onto the disks using air cannons and fans. The air will make the wall shimmer and move. Write down three other things that show you that air is moving. *Hint: One answer would be leaves in the wind.*

   1. _____
   _____
   2. _____
   _____
   3. _____
   _____

2. At **Wearable Wings,** put on the wings and see what happens when you tilt the wings. Which position gives your wings the most lift?

   _____
   _____

3. At **Cockpit Controls,** use the joystick and pedals to control an airplane, just like a real pilot! Think about what it feels like to be a "pilot," and complete the following sentence: "Being a pilot is _____ because _____
   _____ .

4. At **Paper Airplane Launcher,** you will make and fly your own paper airplane. Try this with a friend, and see which paper airplane goes the furthest.

5. Inside **The Franklin Air Show**, you will see two real planes: a Wright Flyer and a T-33 training plane. See if you can find the following parts on both planes: tail, seats, wing, landing gear, and engine. Then think about which plane would be most fun to fly.

THE FRANKLIN AIR SHOW

TEACHER'S GUIDE

4-8

CONTENTS

At The Franklin Air Show, your students will enter a lively air show with the roaring sounds of planes overhead. Students can explore the principles of aviation at more than 20 hands on exhibits that are part of three separate areas – a midway, a pilot training center, and an aircraft hangar. Throughout the exhibit, students will discover the history of aviation through rare artifacts and the life stories of a broad spectrum of aviation pioneers.

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While your students are encouraged to explore all parts of The Franklin Air Show, the following list details the most appropriate interactives for students grades 4-8:

4-8

Drag Race
Raise the Ball in the Tube
Bernoulli Bottle
Hinged Wing
Wing Fly
Bernoulli Bottle
Cockpit Controls
Simulator
Fly a Wright Kite

ACTIVITIES

SECTION ONE: PROPERTIES OF AIR

THE PRESSURE OF AIR

Objective

Students conduct an experiment that helps them observe and explain the impact of air pressure.

Relevant National Science Education Standards

Unifying Concepts and Processes: Evidence, models, and explanation

Physical Science: Properties and changes of properties in matter

Science Standards for Pennsylvania, New Jersey & Delaware are available online at www.fi.edu/teachers/standards

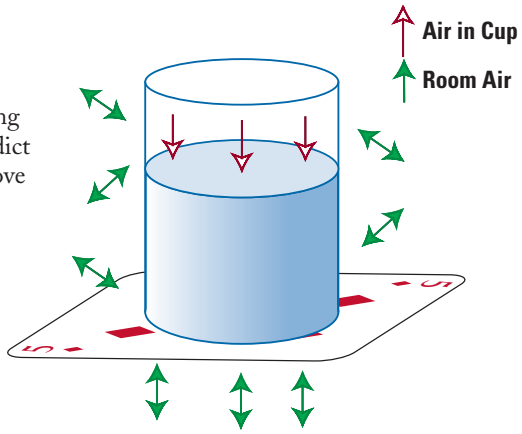
Materials

Water, plastic cups, playing cards that are marginally larger than the top of the cups

Thing to discuss before

Ask students if they think that air has pressure and if so, how they know this.

Things to do



1. Fill a glass three-quarters full of water. Place a playing card on the top of the glass, and ask students to predict what will happen if you turn the glass over and remove your hand from the card. Have them justify their predictions.
2. Conduct the demonstration described above, and have students describe their observations. Students should observe that the water stays inside the glass.
3. Have students conduct the demonstration themselves. Is the result the same?
4. Have students use scientific principles to explain their observations. They should note that the water stays inside the cup because the air below the card is pushing up, trying to get inside of the cup. This pressure prevents the water from running out.
5. Have students make a pressure arrow diagram of the water, cup, air and the card that explains their observations. A sample diagram is included here.

Things to discuss after

Do students think there is a limit on the size of containers that can be used?

Extensions

Try the experiment with soda. The air bubbles should create too much pressure inside the glass for the experiment to work.

Exhibit Connections

Balloon Race, Raise the Ball, Bernoulli Bottle

SECTION TWO: FORCES OF FLIGHT

DESIGN A PROPELLER

Objective

Students design and test a model propeller.

Relevant National Science Education Standards

Unifying Concepts and Processes: Evidence, models, and explanation
Physical Science: Motions and forces
Science Standards for Pennsylvania, New Jersey & Delaware are available online at www.fi.edu/teachers/standards

Materials

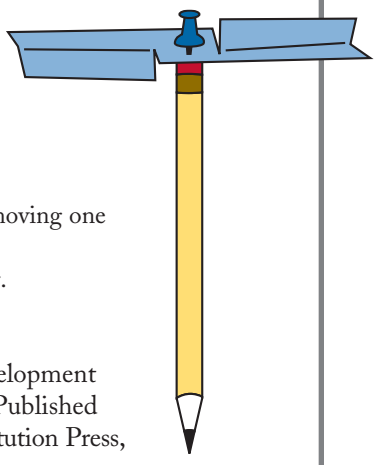
New unsharpened pencil, pushpin, white glue or super glue, mat board

Things to discuss before

1. Ask the students which force – lift, weight, thrust, or drag — makes a plane move forward. (thrust) Can students list any parts of a plane that thrust a plane forward? (engine, propellers, and blades).
2. Ask students if they know how a propeller thrusts a plane forward. (The engine turns the propeller, which is shaped to push air backward. This results in a reaction force on the propeller that moves the aircraft forward. Swimmers move forward in a similar way, pushing water backward.)

Things to do

1. Give pairs of students one set of the following materials: one new unsharpened pencil, two 8" x 1.5" strips of mat board, scissors, white glue, ruler and a pushpin.
2. Have the groups find the exact center of their strip of mat board and mark it. Make a half-inch cut in the mat board on both sides, one inch away from the center.
3. Push the pin through the center of the mat board, and bend the mat board down at the site of each cut. Be careful not to further tear the mat board.
4. Put a dot of white glue or super glue on the eraser of the pencil.
5. Push the pin first through the center of the board and then into the center of the eraser.
6. Make sure the glue is completely dry before testing; 24 hours is best.
7. Have students test the propeller by putting it between their flat hands and moving one hand quickly past the other. The propeller should take off into the air.
8. Have each student group demonstrate and explain the thrust of their propeller.



Things to discuss after

Have students read the Wright brothers' writings where they discuss the development of the propeller, and discuss the challenges they faced. (Jakab, Peter L. The Published Writings of Wilbur and Orville Wright, Washington, DC: Smithsonian Institution Press, 2000, pgs 29-30.) http://www.cr.nps.gov/history/online_books/hh/34/hh34k.htm

Extensions

Have students twist their propeller in both directions and note the change in movement. Then have them try to thrust their propeller while it's upside down. What happens?

Exhibit Connections

Whirligigs, Thrust Chair, Test a Propeller

ACTIVITIES

SECTION THREE: HISTORY OF FLIGHT

TELL IT LIKE IT WAS

Objective

Students create a "living history" document, Web site, or other project about life before commercial aviation was common.

Relevant National Science Education Standards

History and Nature of Science: History of science
Science Standards for Pennsylvania, New Jersey & Delaware are available online at www.fi.edu/teachers/standards

Materials

A tape recorder, camera or video camera; access to an older family or community member

Things to discuss before

Read and discuss the following information from www.centennialofflight.gov with students.

By the end of the 1920s, travelers could still cross the country faster by train than by air. Airplanes had to fly around mountains, could not fly safely at night, and had to land frequently to refuel. Flying by air was uncomfortable and some passengers wore overalls, helmets, and goggles. The airplanes were uninsulated, thin sheets of metal, rattling in the wind, and passengers stuck cotton in their ears to stop the noise. Cabins were unpressurized—passengers chewed gum to equalize the air pressure. Nevertheless, more and more people were flying. The number of airline passengers in the United States grew from less than 6,000 in 1926, to approximately 173,000 in 1929. Businessmen comprised most of the passengers, and more and more companies would pay for their employees to travel by air.

Things to do

1. Have students research how many people fly commercially today. What conclusions can they draw about how commercial flight has changed our lives? What questions might they have for someone who lived before commercial aviation was common? Have students create a list of questions.
2. Ask students to identify a family or community member who was born before commercial aviation was common. (someone at least 75 years of age) Have students contact this person to ask if they would be willing to be interviewed.
3. Have students prepare for the interview by selecting and practicing their questions and gathering necessary equipment (they may want to use a tape recorder or video recorder.)
4. Have students conduct the interview and record the answers.
5. Have students design a project (Web site, book, or videotape to preserve these memories.)

Things to discuss after

Have students draw conclusions about how people's lives have changed since commercial aviation became common.

Extensions

Have students write an advertisement from the 1930s that persuades people to fly commercially. They should consider what people's concerns may have been at this time.

Exhibit Connections

1911 Wright Flyer, 1903 Drawing of the First Plane, Airfoil #12

ACTIVITIES

SECTION FOUR: DESIGN OF FLIGHT

PAPER AIRPLANE DESIGN COMPETITION

Objective

Students learn about design by creating a paper airplane and competing for the longest flight.

Relevant National Science Education Standards

Unifying Concepts and Processes: Evidence, models, and explanation
Unifying Concepts and Processes: Change, constancy, and measurement

Materials

8.5" x 11" paper, paper clips, stopwatch, books about paper airplanes, photographs of different airplanes, access to the Internet

Things to discuss before

1. Discuss the four forces of flight — lift, thrust, weight, and drag.
2. After looking at photographs of different airplanes, ask students why airplanes would be different shapes. Discuss how an airplane's "job" might determine its design and shape. (Ex: Student and supersonic planes have different wing shapes.)

Things to do

1. Divide students into groups. Once they construct their planes, teams will compete to see which plane remains in the air the longest.
2. Student teams can use only the following materials: two sheets of 8.5" x 11" paper, one paper clip, three staples, a dab of glue, and three inches of masking tape. All materials are optional except the paper.
3. Students can get ideas for their planes' designs from books about paper airplanes or by going to http://www.fiddlersgreen.net/paper-airplanes/dart/dart.htm.
4. Allow each team five flight trials. Each plane's structure must remain the same for all five flights. Use a stopwatch to record flying times.
5. Have each team organize its data and calculate the average flight time. Compare results, and have students draw conclusions. Why might some planes have more lift than others?
6. Have each student group make one adjustment to their plane that they predict will increase its lift. Repeat the time trials.

Things to discuss after

What conclusions can students draw now?

Extensions

Have students enter their planes in different events such as farthest distance, most accurate landing, and most number of loops.

Bring student airplanes to The Franklin Air Show exhibit and test them in the Paper Airplane Launcher.

Exhibit Connections

Paper Airplane Launcher, Paper Airplane Simulator, Design a Plane

STUDENT GUIDE

1. Some people in the early 1900s thought the Wright brothers were crazy bicycle mechanics who were just lucky when they unlocked the mysteries of flight. Find at least two pieces of evidence that prove that the Wright brothers relied on science rather than luck when they made their famous flight. _____

   _____

   _____

   _____

2. Do you know which three control surfaces control an airplane? Hint: Each surface moves the airplane in a different way. You will learn these answers and more at **Control Surfaces**. Give it a try, and use the space below to write the names of the three surfaces, and describe how the plane turns as each surface moves. *Bonus: What surfaces do you move to turn down and to the right?* _____

   _____

   _____

3. Throughout **The Franklin Air Show,** you will read the stories of people who have played an important role in the first 100 years of flight. Like the Wright brothers before them, many had to overcome obstacles to reach their goals. Read these amazing stories, write below which one inspires you most, and why. _____

   _____

   _____

   _____

4. Inside **The Franklin Air Show,** you will see two real planes: a Wright Flyer and a T-33 military training plane. Visit each plane, and note the similarities and differences between them. Then imagine you have been given a chance to be the pilot of only one of these planes. Which one would you choose, and why? _____

   _____

   _____

5. At **Paper Airplane Launcher** you will use a motorized launcher to test the effects of design changes on a paper airplane that you create. Give yourself an extra challenge at **Airplane Launcher** by trying to figure out how to design a plane that can do a loop when launched.

THE FRANKLIN AIR SHOW

TEACHER'S GUIDE

9-12

CONTENTS

At The Franklin Air Show, your students will enter a lively air show with the roaring sounds of planes overhead. Students can explore the principles of aviation at more than 20 hands on exhibits that are part of three separate areas – a midway, a pilot training center, and an aircraft hangar. Throughout the exhibit, students will discover the history of aviation through rare artifacts and the life stories of a broad spectrum of aviation pioneers.

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9-12

Drag Race

Raise the Ball in the Tube

Bernoulli Bottle

Feel the Drag

Hinged Wing

Cockpit Controls

Simulator

Fly a Wright Kite

Design for Thrust

ACTIVITIES

SECTION ONE: PROPERTIES OF AIR

BERNOULLI SHAPES

Note: If students complete this activity before your visit to The Franklin Institute, they can test their bottles at the Bernoulli Bottle inside The Franklin Air Show exhibit.

Objective

Students conduct an experiment that helps them observe and explain Bernoulli's principle.

Relevant National Science Education Standards

Unifying Concepts and Processes: Evidence, models and explanation

Physical Science: Motions and Forces

Science Standards for Pennsylvania, New Jersey & Delaware are available online at www.fi.edu/teachers/standards

Materials

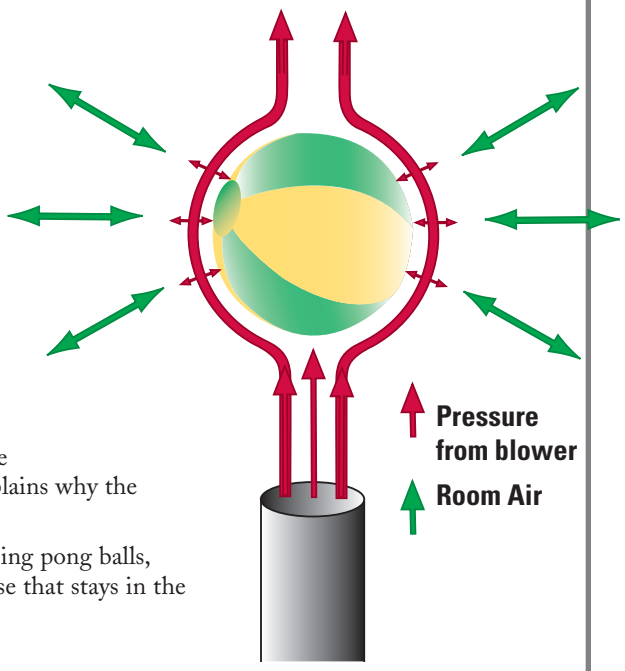
Two-liter bottles, beach ball, panty hose eggs, ping pong balls, and other light items to test in the air stream

Things to discuss before

Have students discuss what they know about Bernoulli's principle.

Things to do

1. Place a beach ball in the air stream of a shop vacuum or leaf blower going in reverse. Ask students what they observe.
2. Have them make a pressure diagram using arrows of different sizes to represent the high and low pressure that is keeping the ball suspended in the air stream.
3. Change the angle of the vacuum, and repeat. Have students create a second pressure diagram that explains why the ball stays in the air stream.
4. Have students experiment with two liter bottles, ping pong balls, and other items to see if they can find anything else that stays in the airstream.



Things to discuss after

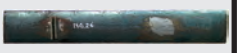
Have students explain how this principle applies to flight.

Extensions

Experiment to make a bottle that spins as it floats in the air stream.

Exhibit Connections

Bernoulli Bottle, Lift Booth, Raise the Ball



Wright brothers Air foils. For more information visit http://sln.fi.edu/flights/first/foil1.html

ACTIVITIES

SECTION TWO: FORCES OF FLIGHT

MAKE YOUR OWN AIR FOIL

Objective

Students build a model airfoil that helps them understand Bernoulli's principle.

Relevant National Science Education Standards

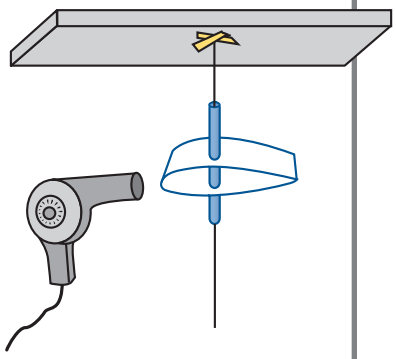
Unifying Concepts and Processes: Evidence, models and explanation
Physical Science: Motions and forces
Science Standards for Pennsylvania, New Jersey & Delaware are available online at www.fi.edu/teachers/standards

Materials

Several index cards (4" x 6"), duct tape, drinking straws, fishing line, hair dryer

Things to discuss before

Look at the Wright Brother's model airfoils on the left. What can students observe about the airfoils in these photos? What challenges did the Wright brothers document? How did they overcome these challenges?



Things to do

1. Have students fold an index card in half, leaving an overlap of half an inch. Have them push the overlapping ends together (One side of the folded index card will curve up).Tape the ends together.
2. Use a pen to punch two holes through the middle of the airfoil (one on top and one on bottom).
3. Carefully push a drinking straw through both holes.
4. Pull a piece of fishing line through the straw. Cut the line long enough to fit between the underside of a table and the floor. Hold the line in place, making sure it is perpendicular to the floor and table.
5. Tape the fishing line in place between the table and floor. The airfoil should be able to easily slide up and down the line.
6. Lift up the wing slightly and aim the hair dryer at the leading edge.
7. Turn on the dryer. Have students observe what happens.
8. Have them explain how this airfoil experiment demonstrates Bernoulli's principle.
   (In motion, air hits the leading edge of the wing. Some air moves under the wing and some goes over the top. The air moving over the top of the curved wing must travel faster than the air moving under the wing, to reach the back edge at the same time. This makes the air pressure on top less than that on the bottom. This combination of pressure produces lift.)
9. Have students experiment with different angles of attack and observe results. Then have them build and test airfoils of different sizes and shapes.

Things to discuss after

What conclusions can they draw, based on their observations?

Extensions

Airplane wings are shaped differently depending on the airplane's purpose. Have students examine the wing shapes of other planes, such as stunt planes, jets, military fighters, supersonic planes, and solar aircraft. Have them draw conclusions about design criteria that governed the wing design.

Exhibit Connections

Lift Booth, Design a Plane, Paper Air Launcher

ACTIVITIES

SECTION THREE: HISTORY OF FLIGHT

THE WRIGHT PATENT

Objective

Students research and defend a position statement about the impact that the Wright brothers' patent struggles had on them and on the advancement of aviation technology.

Relevant National Science Education Standards

History and Nature of Science: Science as a human endeavor
History and Nature of Science: Historical perspectives
Science Standards for Pennsylvania, New Jersey & Delaware are available online at www.fi.edu/teachers/standards

Materials

The Franklin Institute's online Wright collection, Internet, resource books about the Wright brothers

Things to discuss before

1. Ask students why it is important for inventions to be patented. They may want to go to the U.S. Patent and Trademark Office at www.uspto.gov to learn more.
2. How do they imagine the patent process for the Wright brothers was different than it is today? Do they imagine it was easier or more difficult?

Things to do

1. Share the following information: *In 1903, nearly 10 months before their first flight, the Wright brothers applied for The Flying Machine Patent Number 821,393. The U.S. Patent Office granted them a patent for their "Flying Machine" more than three years later. The scientific principles in the patent are the basis for the design of all airplanes made since. This allowed the brothers to request a modest fee for using their design; other aviators were furious. They refused to pay and argued that the Wright brothers didn't deserve the patent. Orville and Wilbur had quite a challenge convincing people that their success was real. Some reactions were very negative. Defending their patent took a toll; it's thought that Wilbur's early death resulted from related stress.*
2. Have students research the challenges and lawsuits the Wright brothers waged and faced in obtaining and defending their patent. What was the impact to the brothers, the advancement of aviation, and other innovators?
3. Have students write a one-page position statement that defends one of the following statements. They should provide primary and secondary source evidence to support their position:
   a. The Wright brothers' patent struggle (helped/hurt) the advancement of aviation.
   b. The Wright brothers' patent struggle (helped to solidify/hurt) their place in history as the inventors of powered flight.
   c. The Wright brothers were (right/wrong) to staunchly defend their patent.
4. Have students present their positions to the rest of the class.

To discuss after

What lessons can be learned from the Wright brothers' patent struggles?

Extensions

Have students debate opposing positions.

Exhibit Connections

1911 Wright Flyer, 1903 Drawing of the First Plane, Airfoil #12

ACTIVITIES

SECTION FOUR: DESIGN OF FLIGHT

PAPER AIRPLANE LAUNCHER DESIGN COMPETITION

Objective

Students learn about design and testing by creating a paper airplane launcher and competing for the most consistent series of launches.

Relevant National Science Education Standards

Unifying Concepts and Processes: Evidence, models, and explanation
Physical Science: Motions and forces
books about the Wright brothers,

Materials

8.5" x 11" paper, measuring tape, access to the Internet, various office supplies such as rubber bands, paper clips, books, shoe boxes, desks, and chairs

Things to discuss before

Ask students if they have ever participated in a paper airplane contest. How were the airplanes launched? What are the scientific challenges of having a paper airplane contest that is launched by hand?

Things to do

1. Divide the class into groups. Each group's challenge is to design a paper airplane launcher that will launch a plane at the same distance ten or more times. They may use any of the materials from those you have gathered, or any other common office materials. Groups should consider the plane's angle and the amount of thrust with which they are launching the plane.
2. Have each group make a basic dart paper airplane for the challenge. This design can be found at http://www.fiddlersgreen.net/paperairplanes/dart/dart.htm.
3. Have groups present their finished launcher, as well as the materials and process used to make it, to the rest of the class.
4. Have each group test its launcher. The launcher with the most consistent average over ten launches is the winner!

Things to discuss after

Have students draw conclusions about the contest's results and what they would change about their own launcher, if given the chance.

Extensions

Have each group make one adjustment to its launcher or plane to see how it impacts the launch.

Exhibit Connections

Paper Airplane Launcher, Paper Airplane Simulator, Design a Plane

STUDENT GUIDE

IN EXHIBIT GUIDE

1. In **Drag Race,** you will race small cars through two tubes: one filled with room air and the other without any air. Stop at this interactive. Try to determine what you would need to do to make the white tube (the one with room air) win. Write your answer below.

   _____

   _____

   _____

2. At the **Airplane Launcher,** you will use a motorized launcher to test the effects of design changes on a paper airplane that you create. Give yourself an extra challenge at the **Airplane Launcher** by trying to figure out how to design a plane that can do a loop when launched!

3. Inside **The Franklin Air Show,** you will see an authentic Wright Flyer that the Wright brothers built and sold in 1911, as well as a T-33 military training plane that was built in 1948. Take some time to view each plane. Then determine which plane you would choose if given the opportunity to pilot one of them today. Provide reasons for your decision. __

   _____

   _____

   _____

4. Some people in the early 1900s thought the Wright brothers were crazy bicycle mechanics who were just lucky when they unlocked the mysteries of flight. During your visit, find at least two pieces of evidence that prove that the Wright brothers relied on advanced scientific processes rather than luck when they made their famous discoveries._____

   _____

   _____

5. In **Raise the Ball,** you will be challenged to move a ball up and down a tube by using air pressure above and below the ball. You will go from "trainee," to "co-pilot," to "pilot," to "captain" if you can raise the ball all the way up the tube. Once you reach "captain," challenge yourself to go back down to "pilot," and remain there for ten seconds. It's not as easy as it looks

TEACHER'S GUIDE

ADDITIONAL RESOURCES

BOOKS

Blackburn, Ken, and Lammers, Jeff
Kids' Paper Airplane Book
New York: Workman Publishing Company, 1996
Materials and information to make 16 paper airplanes fly. Includes a field guide to real planes, a log to record flight distances, and ideas for activities.

Blackburn, Ken, and Lammers, Jeff
The World Record Paper Airplane Book
New York: Workman Publishing Company, 1994
Features 100 full-color, ready-to-fold paper airplanes, ranging from the simple to the sophisticated. Also includes information about aviation and flying, how to perform tricks, a flight log, and a full-color landing strip.

Carson, Mary Kay, and DArgo, Laura
The Wright Brothers for Kids: How They Invented the Airplane With 21 Activities Exploring the Science and History of Flight
Chicago: Chicago Review Press, 2003.
Extensive time line, well-developed glossary, and suggested Web sites make this a valuable resource for student reports and projects, and for classroom units. The author introduces 21 hands-on activities for students, and numerous photographs.

Crouch, Tom D., and Jakab, Peter L.
The Wright Brothers and the Invention of the Aerial Age
Washington, DC: National Geographic, 2003.
Written by two of the world's leading experts on the Wrights, this book provides a definitive, richly illustrated look at the lives of the brothers and their world-changing invention. Poignant archival photographs are included throughout.

Heppenheimer, T.A.
First to Fly: The Wright Brothers and the Invention of the Airplane
New York: John Wiley & Sons, 2003.
Heppenheimer shows the Wright brothers as driven, visionary individuals and presents a detailed portrait of their groundbreaking and painstaking work. An historical record of their adventures after the famous flight at Kitty Hawk is included.

Jakab, Peter L.
The Published Writings of Wilbur and Orville Wright
Washington, DC: Smithsonian Institution Press, 2000
Wilbur and Orville Wright's published writings are brought together in a single, annotated reference. From their turn-of-the-century experiments with gliders until Orville's death in 1948, the articles describe the design of their aircraft, early test flights, and camp life at Kitty Hawk.

Shea, George
First Flight : The Story of Tom Tate and the Wright Brothers
New York: HarperCollins Children's Books, 1997.
Tells the story of Tom Tate, a boy who assisted the Wright brothers with their flying machine experiments. Children will identify with the spirit of this boy who enthusiastically volunteered to try out the glider when there wasn't enough wind to lift the grown men.

Sullivan, George
The Wright Brothers in Their Own Words
New York: Scholastic, 2003.
Readers will discover the Wright brothers' lives by reading and seeing Orville and Wilbur's own letters, notebooks, and diaries.

Yolen, Jane
My Brothers' Flying Machine
New York: Little Brown & Co, 2003.
Katherine Wright tells the story of her brothers' fascination with flight, from their childhood toy flying machine to their famous first flight. The narrative focuses on the brothers' achievements, but is underlined by Yolen's appreciation of the woman who believed in their dream.

ADDITIONAL RESOURCES

WEB SITES

Paper Airplane Sites

http://www.paperplane.org/
Site of Ken Blackburn, the world record holder for paper airplane flight duration. Explores the science behind paper airplanes and includes many sample planes for kids to build.

http://www.workmanweb.com/fliersclub/simulator2.html
Students to simulate the actual flight of a paper airplane by first selecting its angle, thrust, and elevator.

http://www.josephpalmer.com/planes/Airplane.shtml
Paper airplane site with advanced designs.

How Stuff Works

Thorough, accurate, easy-to-read sites designed to explain "how stuff works."

http://travel.howstuffworks.com/airplane.htm
How an airplane works

http://www.howstuffworks.com/helicopter.htm
How a helicopter works

http://www.howstuffworks.com/hot-air-balloon7.htm
How a hot air balloon works

http://www.howstuffworks.com/glider1.htm
How a glider works

Additional Web Links

http://www1.faa.gov/education/documents/curriculum/kinder/
Aviation curriculum guide, designed by the FAA for early elementary students. Available in both PDF and Microsoft Word formats.

http://www.fi.edu/wright/index.html
Comprehensive collection of Wright brothers information. Provides thorough information about The Franklin Institute's Wright brothers' artifact collection. Highlights include actual footage of the 1911 Model B flyer from The Franklin Air Show.