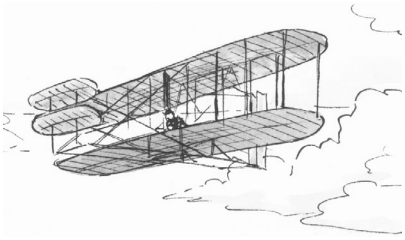
NOVA

Original broadcast: November 11, 2003 PBS

Wright Brothers' Flying Machine

PROGRAM OVERVIEW



NOVA presents the story of Orville and Wilbur Wright, who invented the first powered airplane to achieve sustained, controlled flight.

The program:

- chronicles the brothers' lives, from their first job running a bike shop to their invention of the airplane.
- relates the duo's avid pursuit of manned flight and their tenacious resolve to develop a workable aircraft, despite their lack of formal engineering training.
- shows how the Wright brothers obtained information about experiments by previous innovators, yet rejected key data when it conflicted with the results of their own tests.
- looks at the obstacles to manned flight that the brothers tackled, mainly the problem of maintaining control of the airplane in flight.
- explains how lift occurs with an airfoil.
- describes the first powered flight of the Wright brothers on December 17, 1903, and looks at improvements the brothers made to their first design.
- discusses the measures the brothers took to protect their invention and keep their designs secret.
- follows a modern-day team building and flying reproductions of the Wright brothers' gliders and powered planes.

BEFORE WATCHING

1 Discuss with students the meaning of the following terms: control surfaces, wing warping, elevator, rudder, and aileron.
- **control surfaces:** sections of the plane that can be moved to change the direction of flight
- **wing warping:** a concept first developed by the Wright brothers that allows control of the up-and-down movement of a plane's wing tips to roll the plane right or left
- **elevator:** horizontal flaps on tail that control pitch
- **rudder:** vertical flap on the tail that provides yaw control
- **aileron:** control surface that allows rolling to the right or left

2 To build an airplane, the Wright brothers studied existing technology—gliders and boat propellers—modified it, tested it, and modified it again. Organize students into three groups and have each group take notes on one of the following: observations the Wright brothers learned from studying existing machines, ideas the brothers gathered from other scientists, and new designs the brothers developed.

AFTER WATCHING

1 Have students review their notes and discuss how the Wright brothers learned to build a flying machine. What did they learn from studying existing machines? What ideas did they gather from scientists of their day? What new designs did they develop?

2 How has the invention of the airplane influenced the history of the past century? How has it changed people's lives? (Examples include changing the nature of warfare, permitting easier exchange of goods, and making long-distance travel easier and more affordable.)

CLASSROOM ACTIVITY

Objective

To test the effects of wing warping by manipulating the leading and trailing edges on the wings of a paper airplane.

Materials for each team

- copy of the "What's Wing Warping?" student handout
- copy of the "Paper Airplane Template" student handout
- copy of the "Flight Data Sheet" student handout
- 8 1/2-inch x 11-inch piece of tag board (125# basis weight)
- scissors
- large paper clip

Procedure

1. Explain to students that they will simulate wing warping in this activity, a concept that the Wright brothers developed.
2. Organize students into teams of two and distribute a copy of the "What's Wing Warping?," "Paper Airplane Template," and "Flight Data Sheet" student handouts and other materials to each team.
3. Have students follow the directions on the "What's Wing Warping?" student handout to construct their airplanes. Make sure students attach a large paper clip to the nose of their planes to counterbalance the lift effect that will be created by the main wing. Also check that students sharply score the wing tips along the fold lines so that the wings can be easily adjusted.
4. Review the challenge with the class. Students will fold the wing flaps up or down on the leading and trailing edges of their plane wings in order to get them to fly straight, right, and down.
5. Find an open area where students can test their planes. Have team members take notes on how they choose to fold the wing flaps for each design and record their notes on their "Flight Data Sheet" student handouts. Instruct students to throw their planes gently when they conduct their trials.
6. After students have completed the trials, meet as a class to share the results. Discuss students' answers to the questions listed on the "What's Wing Warping?" student handouts.
7. As an extension, ask students to make further modifications to their planes, such as changing the weight of the paper, changing the size or the position of the paper clip, or changing the design of the plane. Then have a contest to see whose plane can fly the farthest, turn the most sharply to the right, or complete the quickest dive.

STANDARDS CONNECTION

The "What's Wing Warping?" activity aligns with the following National Science Education Standards.

GRADES 5–8

Science Standard B
Physical Science
Motions and Forces

- The motion of an object can be described by its position, direction of motion, and speed.

GRADES 9–12

Science Standard B
Physical Science
Motions and Forces

- Objects change their motion only when a net force is applied. Laws of motion are used to calculate precisely the effects of forces on the motions of objects. The magnitude of the change in motion can be calculated using the relationship F = ma, which is independent of the nature of the force.

Video is not required for this activity.

Classroom Activity Author
A teacher for 34 years, Steven Branting serves as a consultant for gifted and innovative programs in the Lewiston, Idaho, public schools and is a cartographer for the Lewis & Clark Rediscovery Project. Branting and his students have won international honors in physics, engineering and digital mapping.

ACTIVITY ANSWER

Changing the shape of the wings can have a dramatic effect on the flight path. The Wright brothers used wing warping to control their plane. Modern aircraft use movable sections on the wings called ailerons or spoilers.

Straight Flight

Folding the leading edge down on both wings provides greater stability for a long, straight flight.

To the Right

Folding only the leading edge down on the right wing makes the plane veer to the right. (Folding the right leading edge down and the right trailing edge up will also work.)

Dive Down

Folding the trailing edge up on both wings makes the plane dive down.

Sample Results

trial #	left wing leading edge	right wing leading edge	left wing trailing edge	right wing trailing edge	results
1	no change	no change	no change	no change	straight flight
2	no change	no change	down	down	strong upward pitch, quickly stalls
3	no change	no change	up	up	downward pitch
4	down	down	no change	no change	long, straight stable flight
5	no change	up	no change	no change	twirls in mid-air
6	no change	no change	no change	up	twirls in mid-air
7	no change	no change	no change	down	tends to stall
8	up	up	no change	no change	downward pitch
9	down	up	down	no change	downward pitch, minimum yaw
10	up	down	down	up	pronounced yaw to right, pitch downward into dive to right, twirls in mid-air

Major funding for NOVA is provided by Google and BP. Additional funding is provided by the Howard Hughes Medical Institute, the Corporation for Public Broadcasting, and public television viewers.

Google
bp
HHMI
cpb

LINKS & BOOKS

Links

NOVA Web Site—Wright Brothers' Flying Machine
www.pbs.org/nova/wright/
In this companion Web site for the NOVA program, find out why the Wrights were successful, manipulate the controls of an online Wright Flyer, read reports about the Wrights' earliest flights, learn about lift, and experiment with various airfoil designs.

History of Flight
www.flight100.org/history_intro.html
Provides a timeline of flight including profiles of famous aviators from around the world.

Plane Math
www.planemath.com/activities/pmenterprises/training.html
Explains how airfoils work, the forces involved in flight, and other key factors involved in getting a plane off the ground.

Wing Warping
wright.nasa.gov/airplane/warp.html
Provides an interactive that allows users to control the wing warping of a Wright Flyer and shows the forces associated with each configuration chosen.

Books

To Conquer the Air: The Wright Brothers and the Great Race for Flight
by James Tobin.
New York, 2003.
Chronicles the lives of Orville and Wilbur Wright and details their contributions to aviation.

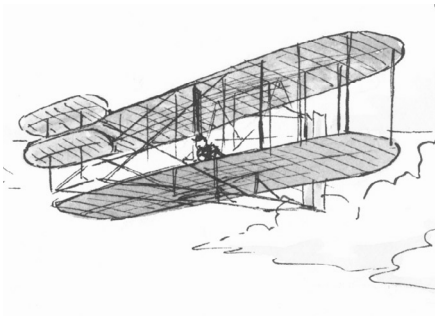
The Wright Brothers: A Flying Start
by Elizabeth MacLeod.
Toronto, 2002.
Describes achievements of the Wright brothers and provides a historical context for their inventions.

What's Wing Warping?

Wing warping is the twisting, or warping, of plane wings to control the roll of the plane. The Wright brothers first thought of this system and used cables to control the up-and-down movement of their wing tips to roll their aircraft to the right or left. In this activity, you will build paper airplanes and adjust the wing tips up or down to simulate wing warping. Then you will test how it affects the flight of your craft.

Procedure

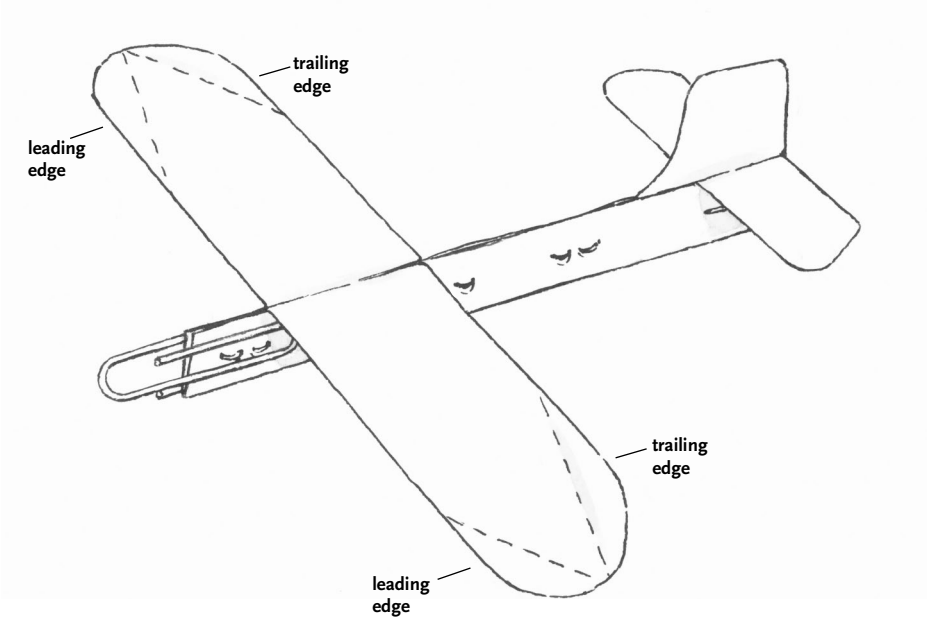
1. Cut out the paper airplane template. Trace this pattern on a piece of tag board. Copy the fold lines from the template onto the tag board.
2. Cut out the rudder. Fold the airplane body (fuselage) along its center line, and place the rudder into place in the tail position.
3. Staple the rudder into place. Staple the fuselage three more times, once near the front and twice in the center.
4. Attach a paper clip to the nose. Slide it forward or backward to adjust the center of gravity. Sharply score the wing tips along the fold lines so that they can be easily repositioned.
5. To steer your plane, decide whether the wing tips should be up or down on the leading and trailing edges of the plane's wings.
6. Your first challenge is to work with your team member to make your plane fly straight. Then change the way you fold the flaps to make it curve to the right. Finally, make it dive down. Throw your plane *gently* when you conduct your trials.
7. Use the charts on your "Flight Data Sheet" student handout to record your team's observations of the flight path and the wing flap positions for each different wing configuration your team tries.



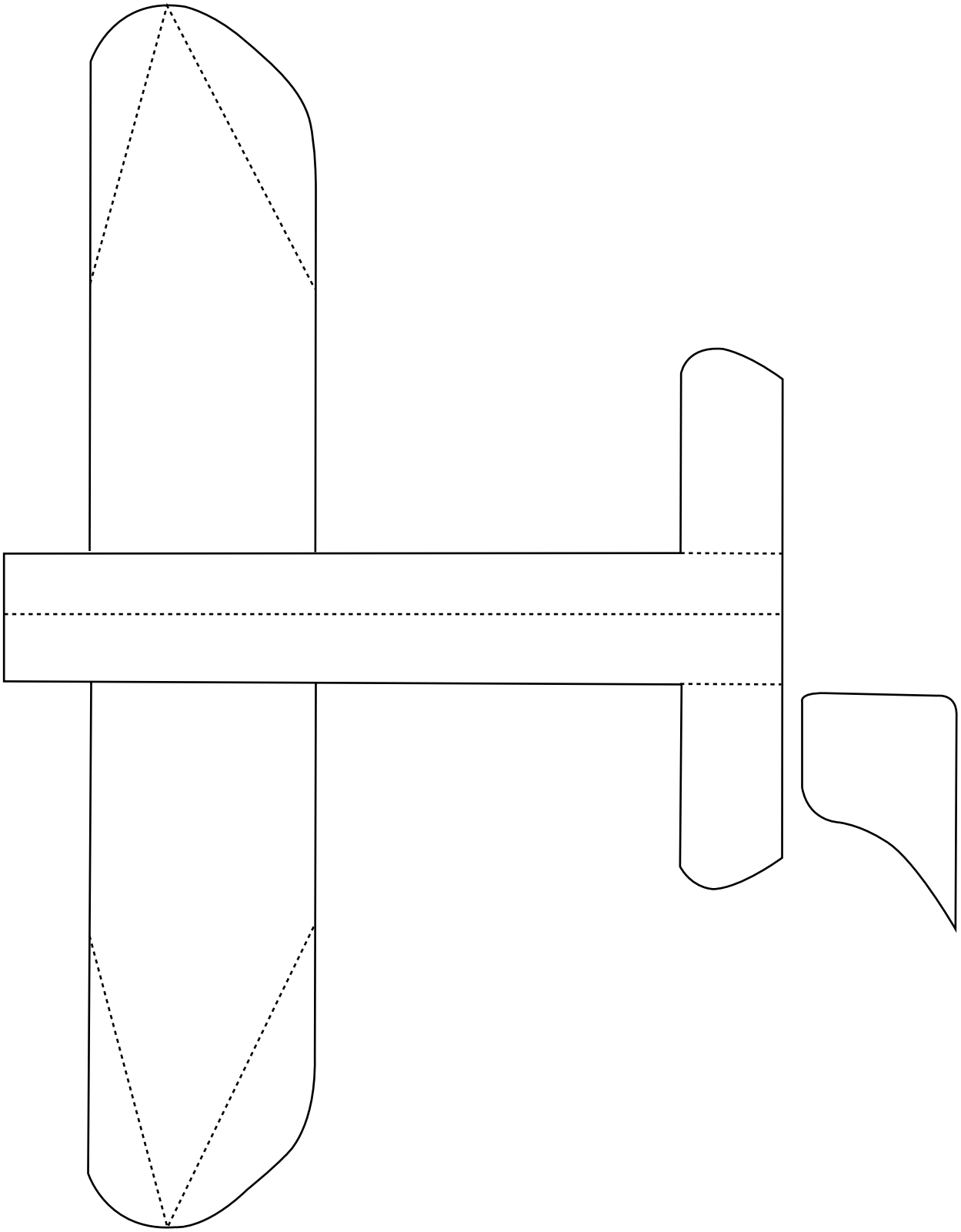
Questions

Write your answers on a separate sheet of paper.

1. How can you make the plane turn to the right? How can you make it dive?
2. If you move the paper clip, how does that affect the flight path?
3. Of the two adjustable wing areas—leading or trailing edges—which provides greater stability to the aircraft and allows it to fly farther?
4. Which wing configuration flies the longest and straightest? Why?



Paper Airplane Template



Flight Data Sheet

Sample

trial #	left wing leading edge	right wing leading edge	left wing trailing edge	right wing trailing edge	results
1	no change	no change	up	neither	twirls in mid-air

Straight Flight

trial #	left wing leading edge	right wing leading edge	left wing trailing edge	right wing trailing edge	results
1					
2					
3					
4					
5					

To the Right

trial #	left wing leading edge	right wing leading edge	left wing trailing edge	right wing trailing edge	results
1					
2					
3					
4					
5					

Dive Down

trial #	left wing leading edge	right wing leading edge	left wing trailing edge	right wing trailing edge	results
1					
2					
3					
4					
5					