Paper Winglets

Objective:	To test the design of a paper airplane with and without winglets.

Grade Level: 9-12
Subject(s): Science, Technology
Prep Time: < 10 minutes
Duration: 50 minutes
Materials Category: Classroom

National Education Standards	
Science	2a, 3d, 6a, 6b
Mathematics	
Technology (ISTE)	
Technology (ITEA)	3a, 3b, 3d, 8, 11a, 11d
Geography	

Materials:

- Copy paper
- Construction paper
- Ruler

Related Link(s):

How To Build A Paper Jet Model
http://www.grc.nasa.gov/WWW/K-12/WindTunnel/Activities/foldairplane.html

Simple Paper Airplane
http://edu.larc.nasa.gov/fdprint/a9.html

Supporting NASAexplores Article(s):

Taming Twin Tornados
http://www.nasaexplores.com/show2_articlea.php?id=02-025

Paper Winglets

Teacher Sheet(s)

Guidelines

1. Read the 9-12 NASAexplores article, "Taming Twin Tornados." Ask a student to describe or define the term vortex. Ask the student to explain how a vortex can affect an airplane.

2. Divide students into groups of two to three. Distribute the materials.

3. Have students fly their planes in the gym, hallway, or other large indoor area (to eliminate wind effects), each time trying for maximum distance. Stress trying to duplicate the same launch angle and speed.

Discussion / Wrap-up

1. Have each student write a summary of experimental results and relate the variables tested.

2. Allow each group to make a presentation on their airplane and what made its design successful.

3. Discuss the following questions with the students.

   a) How does plane's weight affect flight?
   The weight in the airplane needs to be centered forward. In every object, there is a center of gravity—a neutral point where all of the mass is balanced. If an airplane has a center of gravity ahead of the neutral point, then this plane is stable. If this center of gravity is behind the neutral point, then it becomes unstable causing nose-dives and spins.

   b) What is the importance of winglets?
   Bending the wingtips up on paper airplanes helps to add directional stability. This stability is provided in real airplanes by a vertical tail.

   c) Does material matter?
   Paper airplanes usually have short "stubby" wings, called "low-aspect ratio" wings. The distance from wingtip to wingtip is called wing span, and the distance from the front to the back of the wing is called the chord. The ratio of wing span to average chord is called "aspect ratio." Although high-aspect ratio wings reduce drag, they also require better building materials. The low strength of paper does not allow the use of high-aspect ratio wings. With a thicker material or paper, it is easier to make planes with high-aspect ratio wings.

Extensions

- Develop a bulletin board that illustrates historical flight.
- Make a mural showing the story of flight.

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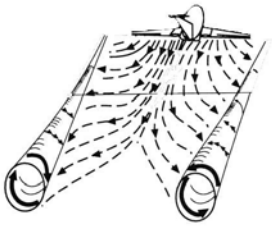
Student Sheet(s)

Background

Among the other important contributions made by NASA's Dr. Whitcomb are winglets (first used on Learjet). A winglet's purpose is to reduce turbulence at the tips of an airplane's wings. The air pressure on the bottom of a wing is greater than the pressure on top, so when air flowing across the two surfaces meets at the wingtip, it forms a vortex—a miniature tornado. The vortices created by a large airplane are strong enough to flip a smaller plane that is following too closely.

An airfoil produces lift because of a difference in pressure on the upper and lower surfaces. At the tips of the wings this pressure differential causes air to flow from the lower to the upper surface. This results in a swirling of air that trails behind the aircraft, a phenomenon known as wingtip vortices. The more lift a wing is producing, the greater is the strength of the vortices. The wingtip vortex effect increase drag and decrease the lift produced by the wing. Dr. Whitcomb came up with the winglet, a remarkably simple solution to reduce the strength of wingtip vortices.



By breaking up vortices, winglets reduce the drag on an airplane, which translates into fuel savings. Conventional upright winglets are currently used on a number of airliners, including the Boeing 747-400 and the Airbus A330 and A340. On some of its 737 models, Boeing uses "blended" winglets, which curve up from the wing instead of sticking straight up.

Materials

- Copy paper
- Construction paper
- Ruler

Procedure

1. Fold an 8 1/2 x 11 sheet of paper down the middle of the 11" dimension.

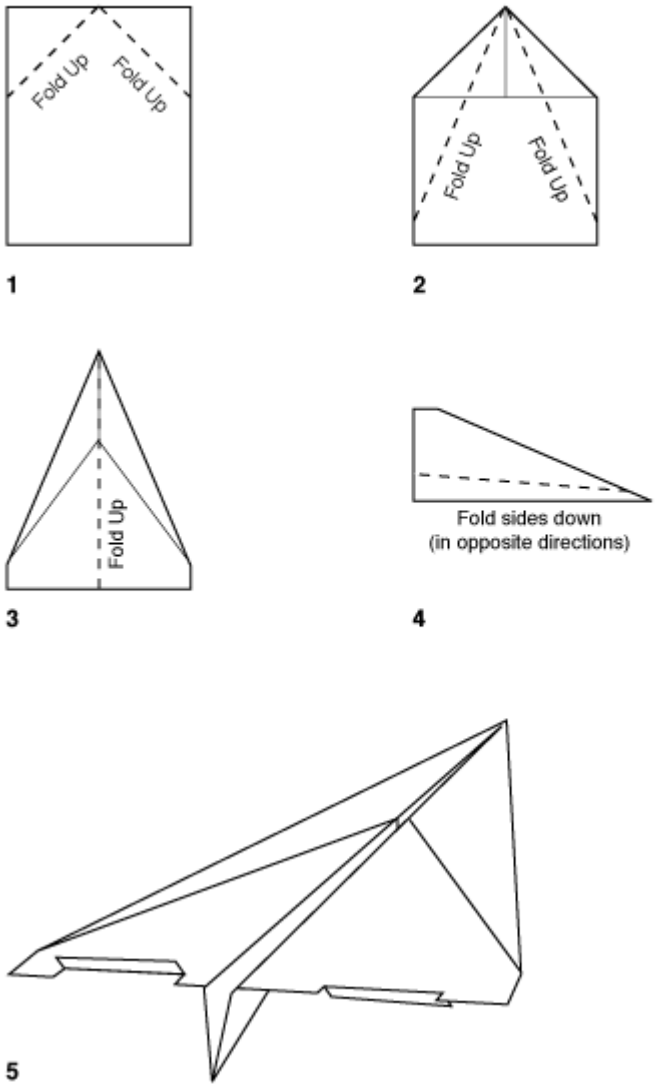
2. Next fold the upper two corners in at a 45 degree angle. Be careful here to line these up, and do not let the flaps cross the middle of the paper. Use the middle fold as a guide.

3. Fold each side, again using the middle as a guide. The two sides should be even.

4. Fold it in half along the fold that you made in step 1. Now, fold the wing down to the bottom of the plane.

5. Below is a diagram of another simple paper airplane design.

SIMPLE PAPER AIRPLANE



Create the following charts.
Stability describes if the plane flies in a straight line or does it wobble or nose dive.

a) To vary the weight of your airplane, fold the nose over varying lengths to make a shorter body after step 3. Measure the size of the fold in centimeters (cm).

	Hypothesis	Length of Flight	Stability
Control Plane			
Size of Fold 1 = __cm			
Size of Fold 2 =__cm			

b) To vary the stability of your plane, create winglets by folding the **ends** of the wings up or down after step 3.

	Winglets up/down?	Hypothesis	Length of Flight	Stability
Control Plane				
Size of Fold 1 =				
Size of Fold 2 =				

c) Now use construction paper to vary the weight of the material that your plane is made out of.

	Hypothesis	Length of Flight	Stability
Control Plane			
Construction Paper Plane =			

Conclusion(s)

1. How does plane's weight affect flight?
2. Will adding weight (such as a paper clip or a penny) make it fly better or worse?
3. Does it matter where you put the extra weight?
4. What is the importance of winglets?
5. Does material matter?
6. How can you make your airplane better?
7. Do larger paper airplanes fly better than smaller paper airplanes?
8. Based on what you have observed, make the plane that you think will fly the longest.