Back To The Basics — Paper Airplanes

OBJECTIVE – To create a meaningful lesson in controlled flight using a classic paper airplane design.

It's amazing how a simple sheet of paper can become a flying machine. For over one hundred years, most real airplanes, and many spacecraft, started out as a dream, on a sheet of paper.

NATIONAL STANDARDS

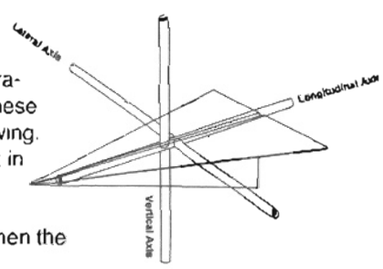
Science Standards:

- Content Standards A: Science as Inquiry
  - Abilities Necessary to do Scientific Inquiry
  - Understanding about Scientific Inquiry
- Content Standard B: Physical Science
  - Motions and Forces
- Content Stand E: Science and Technology
  - Abilities of Technological Design
- Unifying Concepts and Processes
  - Evidence, Models and Explanation
  - Form and Function

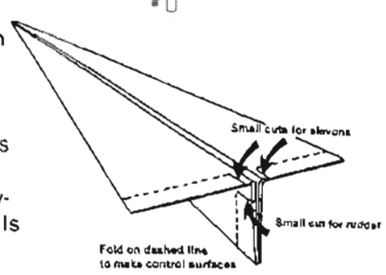
ROCKET SCIENCE 101

How to teach the principles of flight using a paper airplane

- A paper airplane is a flying machine. Our model has a delta, or triangular wing configuration.
- When small "elevons" are incorporated into the trailing (aft) edge of each wing, the paper airplane's flight can be controlled **(at this time, refer to the NASA illustration of the XB-70A Research Aircraft shown on page 30 of this activity. Study its shape and notice the elevons)**
- On the student's desk, it is two-dimensional; in flight, it becomes three-dimensional.
- In flight, it uses the energy of the atmosphere to keep it aloft and to make changes in direction.
- Because it is three-dimensional, it has three axes around which it can move The axis going through the middle (wingtip to winglip) is known as the **lateral**. Movement around this axis is known as "pitch," i.e., nose-up or nose-down. The axis going through from nose to tail is called **longitudinal**. Movement around this axis is known as "roll." The axis going through the paper airplane from top to bottom is the **vertical**. Rotation around this one is called "yaw."
- The elevons mentioned above can be used to control the flight of the paper airplane. This illustration shows how to build these control surfaces into the wing.



- When the elevons are put in the "up" position, this will cause the little aircraft to "pitch" its nose upward when the model is moving through the air. **This is a rotation around the lateral axis.**
- When the elevons are put in a position where one is up and the other is down, it will cause the model to "roll" when moving through the air. **This is a rotation around the longitudinal axis.**



- If a cut is made in the aft portion of the fuselage, a rudder will be created. This will make the model "yaw," or **rotate around its vertical axis.**
- We have now introduced **three-dimensional** control into the aircraft.
- When the model is launched, gravity starts to pull it back to the Earth. The aircraft will glide forward literally "skiing" on the air. This means that that it is getting some lift from the environment because lift opposes gravity. The actual landing zone is determined by the amount of thrust (the act of throwing the paper airplane), the amount of drag created by the air, and the settings of the elevons.
- As the model flies through the air, it immediately starts a descent. This creates an angle to the flat surface upon which it will land. This is called the **angle of descent**. Assuming the builder is standing straight up, and the floor is flat, the angle of descent creates a right triangle. The hypotenuse can be varied by settings on the elevons. With the elevons in a slightly up position, the nose will pitch up and create a longer glide path, thus extending the length of the hypotenuse!
- Looking at this from a historical standpoint, it should be pointed out that the Wright Brothers first experimented with glider control before adding power. In this way, they could achieve sustained flight by having control of the machine.
- If a paper airplane wants to turn to the left, use the aerodynamic controls (elevons and rudder) to correct it the other way. If the nose wants to pitch up or down, correct it by making it pitch in the opposite direction. In other words, use aerodynamic methods to correct the model in flight.
- It should be remembered that in flight, you (the pilot) are in control of the aircraft, or the aircraft is in control of you! Without control, it would be like driving a car without a steering wheel or brakes!"

BACKGROUND

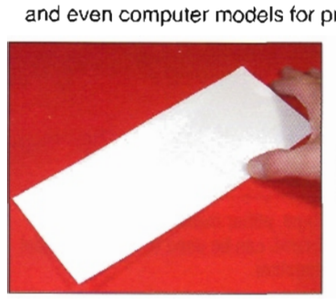
There are at least three significant historical examples of how paper was used in early experimentations with flight: (1) the Japanese and Chinese were both known to use paper for the construction of kites. (2) The French Montgolfier family had a paper business and early experiments with paper bags, over an open-hearth fire, led the way to a successful, man-carrying hot air balloon. (3) Sir George Cayley, an English inventor, used paper to construct small gliders. He is given credit with building several successful paper and wood gliders which had the shape of modern aircraft. The models had wings, a stick fuselage and stabilizers on the tail. George Cayley lived in the early 19th Century and his gliders were created around 1812.

At this point, the author would like to show the reader how to conduct a "flight" lesson using a paper airplane as the hands-on activity. A paper airplane is a real "flying machine." This means that it uses the energy of the atmosphere to provide lift and control. Depending upon the teacher's background, a significant amount of mathematics can be introduced with geometry, algebraic formulae and even computer models for predicted flight profiles.

PROCEDURE

TO BUILD A SUCCESSFUL FLYING PAPER AIRPLANE

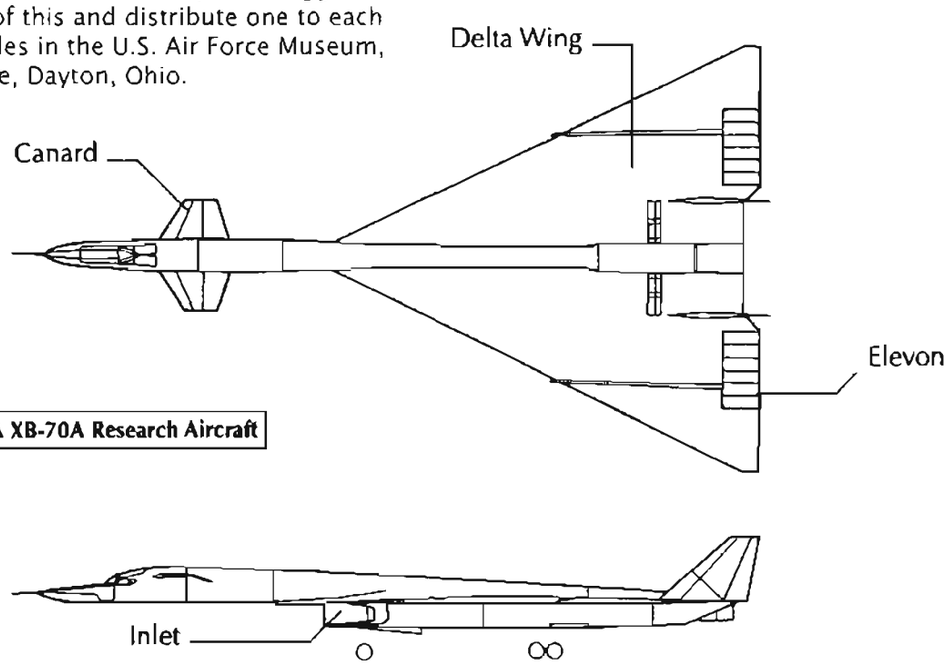
1. There are "jillions" of different ways to fold a paper airplane. It is recommended that teachers, squadron AEOs and students visit local libraries, or commercial bookstores, to find publications on the subject.
2. It is also suggested that teachers, AEOs, students and cadets look for designs on the Internet. There are several web sites that feature outstanding creations. Such web sites as **http://www.fiddlersgreen.net/** contain many paper models to build.



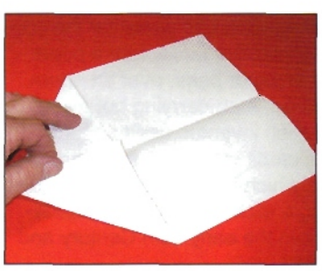
To make a traditional delta-wing paper airplane, the first fold is lengwise. Some teachers call this "folding it like a hot dog bun."

Using the illustration as a guide, first fold one of the edges back to the center as shown.

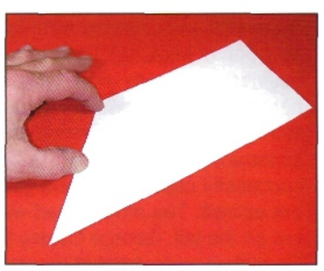
One of the great research airplanes in aerospace history was the XB-70A. It was designed to operate at speeds in excess of Mach 3, or three times the speed of sound. Notice that it is shaped like the paper airplane that was made in this activity. It is suggested that the teacher make copies of this and distribute one to each student. An actual XB-70 resides in the U.S. Air Force Museum, Wright Patterson Air Force Base, Dayton, Ohio.



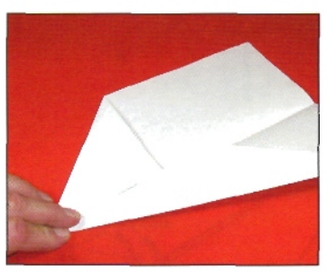
NASA XB-70A Research Aircraft



The same fold is made on the opposite side.

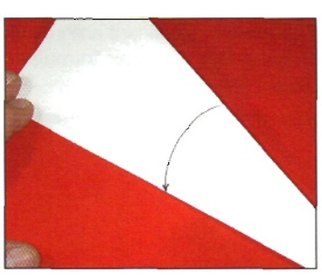


It has been found that creasing the folded edges with a thumbnail makes a better-looking finished model.

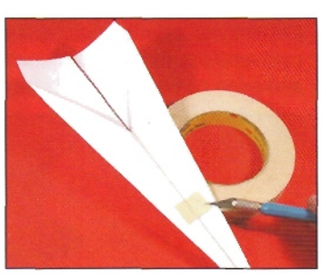


The next fold brings the outer edge to the center as shown. Refer to the illustration if you need help on this step.

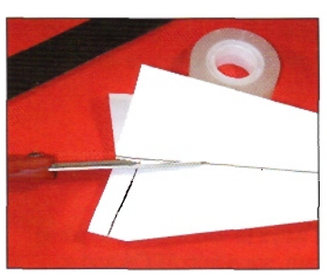
It is repeated on the opposite side. Make sure that the folds are crisp and that both sides are equal.



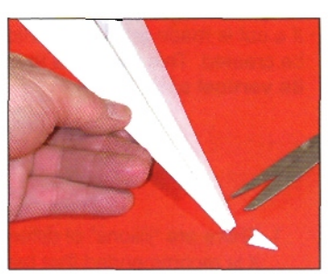
The author recommends that teachers instruct students to "make the upper edge of the wing match the lower edge of the fuselage." By matching the two edges, a perfect wing will be created. As before, use the illustration as a guide on this critical fold.



Tape, either masking or Scotch™ brand, can be used to hold the model together.



As explained in the text, and shown in the illustration, two elevons are made by cutting two slits into the back, or trailing edge of the wing. The slits allow the builder to make two equal control surfaces.



To make the model safer, it is recommended that the sharp nose be cut off as shown. This reduces the risk of injury in the event a student throws it at another student.

Place a target (hula hoop, plastic garbage bag, etc.) for students to land their paper airplane on. See who can land on the target. If missed, have them adjust one of the control surfaces and try again. Give them 5 tries and have them record changes and results.

Trial #	Change made	Results
1		
2		
3		
4		
5		

Great ideas often start on a sheet of paper. It is suggested that students use the Internet to research the NASA X-36 and then see if they can create a paper aircraft that looks, and flies, like it!

Web sites for X-36 are
http://www.dfrc.nasa.gov/gallery/photo/X-36/index.html
and http://www.fas.org/man/dod-101/sys/ac/x-36.htm