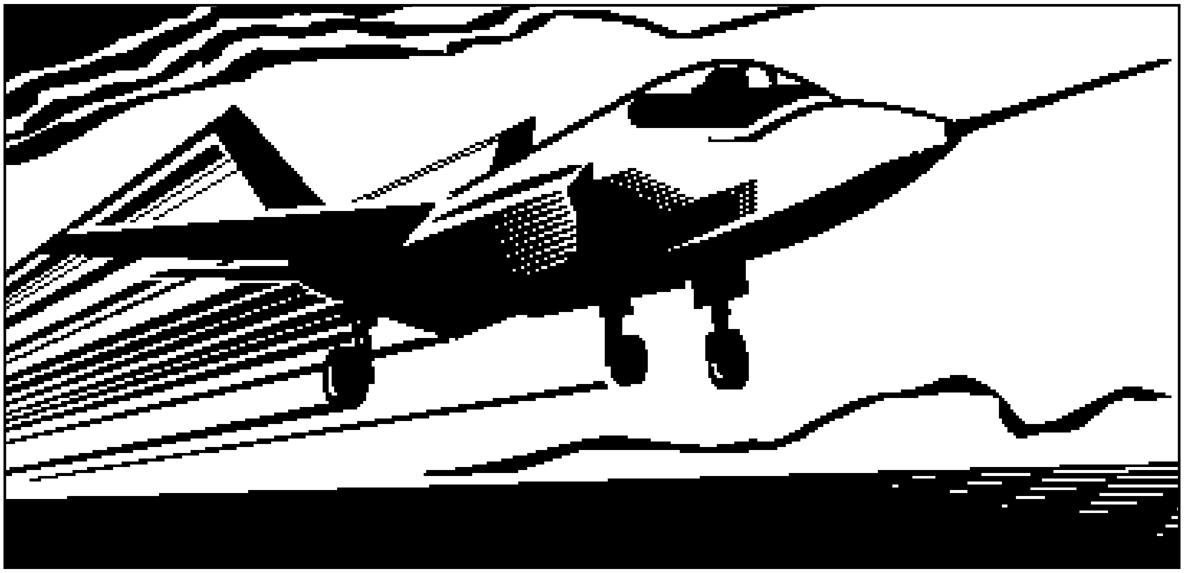

Grade level: All Ages

In this activity, students conduct an extended experiment in which they change and test different flight conditions. By working in pairs or small groups, they will better understand how research teams of engineers and scientists must work together cooperatively to complete large projects.

Materials:

- 8 ½" x 11" paper, some cut into 2" x 11" strips
- masking tape
- scissors
- measuring tape

Objectives of this activity:

- Understand what forces act on an airplane
- Learn how an airfoil affects air pressure
- See how design differences influence airplane performance

Introduction:

December 17, 2003, marks the 100th anniversary of the first powered, piloted flight, when Orville Wright flew 120 feet in 12 seconds at Kitty Hawk, North Carolina. Ask older students to figure out how many miles per hour that would be.

120 feet/12 seconds = X feet/60 seconds = 600 ft. per minute

600 ft. per minute times 60 minutes = 36,000 ft. per hour divided by 5280 = 6.8 mph

Background:

How is it possible that heavy airplanes (some weighing almost half a million pounds) are able to be supported by air high above the ground?

Because of the shape of the wings, the air under the wings pushes up more than the air on top of the wings pushes down. This difference in air pressure is called LIFT. What's really amazing is why this happens. If we look at an airplane's wing from the side, we can see that it is a special shape called an airfoil. *[See Figure 1]*

As airplanes fly, air is pushed above and below their wings. The air passing over the wing reaches the back of the wing at the same time as the air passing under the wing. The air moving over the wing - which has further to travel around the curved surface - has to go faster than the air moving underneath.

Air that moves slowly (the air going under the wing) creates MORE pressure than air that moves quickly (the air going over the wing). This creates LIFT.

The principle of lift was first proved by a Swiss mathematician named Daniel Bernoulli in the 18th century. Have the students demonstrate Bernoulli's Principle: give them each a strip of paper and have them blow over the top of it. Ask students to **predict** what they think will happen. (The paper will rise.) *[See Figure 2]*

What happened? The students lowered the pressure that was pushing down on the top of the

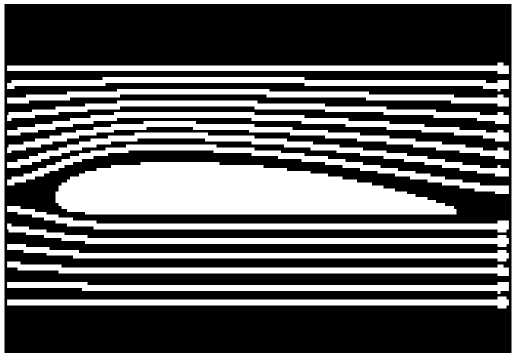

Figure 1

Figure 2

paper, causing the pressure on the bottom side of the paper to push the paper strip up. The same thing happens when air pushes on the bottom side of an airplane's wing.

What forces act on an airplane?

There are four forces acting on an airplane in flight: lift, weight, thrust and drag. *[See Figure 3]*

Lift comes from the wings. What about the other forces?

Weight is a force caused by gravity, directly opposite to the lift force that is pulling the airplane up. For level flight, lift and weight must balance each other out.

Thrust, caused by the airplane's engines, is the force that moves the airplane forward. If an airplane did not keep moving, air would stop moving over and under the wings. Without this movement of air, the wings could not create lift, and the airplane would start to fall back to the ground.

Drag is the force that tries to slow down a moving object. To lessen the drag on an airplane, most airplanes are made more aerodynamic, or streamlined. Just like lift and weight are opposite forces, thrust and drag are opposites to each other too. For an airplane to keep flying, its thrust must be bigger than its drag.

Activity:

Getting Started:

Airplanes are equipped with special control surfaces to give the pilot a way to change the direction and altitude of flight. In this activity the AILERONS (flaps on the back edges of the wings) are the focus. Turns are aided by raising one aileron while the other is lowered.

Help students mark off several target areas on the floor. The target areas should be made with two pieces of masking tape, each at least 4 feet long, placed at right angles as shown, and at least 15 feet away from the launch zone. *[See Figure 4]*

Part 1: The Control Flight

Distribute the paper and ask each student to make the airplane shown in the drawing. *[See Figure 5]*

Demonstrate how to fly the airplane into the target by using the same controls for all 10 test flights: stand in the same location, hold the airplane in the same manner, and use the same force/thrust to throw the airplane. Instruct students how to record their test flight results with an X on the appropriate grid of a data-recording sheet to show the location of each landing.

Students work in teams of 2 to 4 people. First the team conducts a test flight of each partner's airplane. The team then selects the best plane. Next, one team member flies the airplane 10 times into the target spot from 15 feet away, and the other students record each landing. After all teams have completed this first series of test flights, the class is brought together to discuss their findings. Have

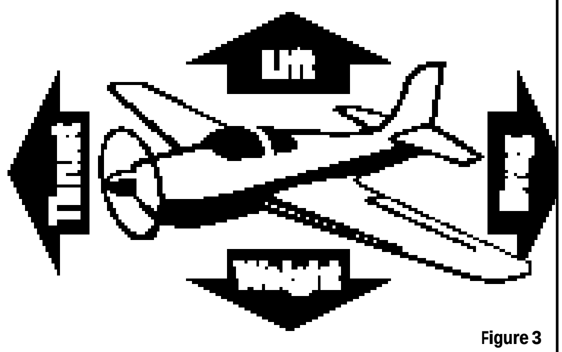

Figure 3

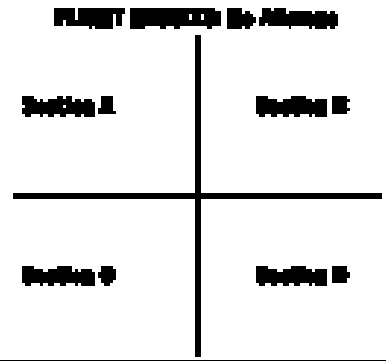
Figure 4

one student at the chalkboard to consolidate all results onto one large grid.

Part 2: Flights with Changes

Show students a sample airplane in which ailerons have been cut as shown. Explain that they are going to experiment by changing the position of ailerons to see how the change affects the direction of the airplanes. Then present this task.

Notice where the ailerons are on the wings of this airplane. Make an aileron on each wing of your airplane by making cuts in about the same locations. On each wing, the two cuts should be about 1 inch long and should be about 1 inch apart.

Ask the students to predict what effect the ailerons will have on the landing patterns. (Remind students that if one aileron is raised, the other must be lowered.)

Teams should use a separate grid to record results for each series of 10 test flights that teams conduct with the ailerons in different positions. Teams should follow the same procedures as in Part 1 when conducting the series of test flights for each airplane.

Closing the Activity:

When all data have been collected, help teams organize and analyze their findings.

Conclusion:

Engineers constantly experiment with test designs and materials to improve existing airplane designs and create new ones. They work to improve safety, to increase performance, and to reduce costs. They ask questions, develop a theory or a model, test their ideas, create designs, and build working models. They change their experiments by varying the conditions.

Further Explorations:

- Ask students what other experiments they would like to conduct to further test their conjectures about flight direction.
- Students may want to design and test different airplanes by varying the width of the wings and the size and placement of the ailerons.
- Students might like to build a wind tunnel on their own to test their different models. Refer them to the American Institute of Aeronautics and Astronautics web site for simple instructions: *http://www.flight 100.org/learn/exp-nqwwt.html*.

This activity was provided by the National Aeronautics and Space Administration, *www.nasa.gov*.

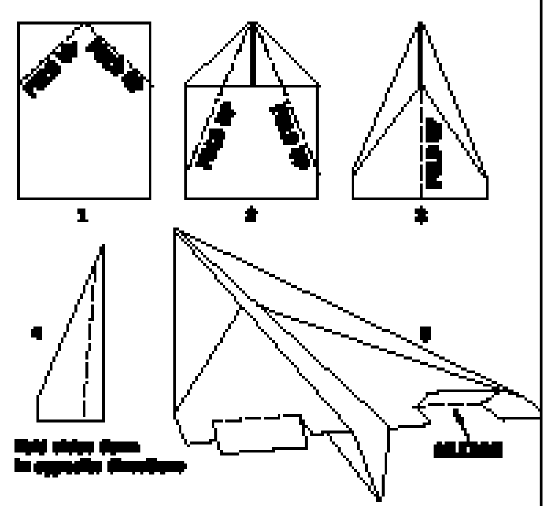
Figure 5