CORE SUBJECTS: PHYSICS, AERODYNAMICS

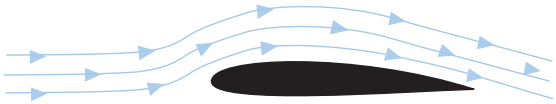
WHEN AN AIRPLANE PASSES OVERHEAD

its flight looks effortless. You probably wonder how gravity allows something that large to stay aloft. An airplane is a machine that balances the forces of gravity with lift to make it fly.

Gravity acts on the airplane in flight just as it does on people and objects on the ground. ***Lift*** overcomes gravity and allows the airplane to fly. Lift is created when the forward motion of the airplane causes air to flow over those wings (also called an airfoil).

Several principles combine to explain how lift is created. These include Newton's laws of motion and Bernoulli's principle on the motion of fluids.

You may be familiar with Newton's third law of motion that states "for every action there is an equal and opposite reaction."

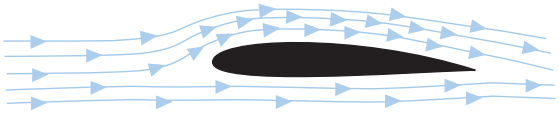


Newton's third law of motion applied to an airfoil

Well, that's one law that the wings obey as they move through the air. As the air flows over a wing's upper surface, it bends downward. The "opposite reaction" is a push upwards, which is part of lift.

Also, air flowing over the longer distance of the curved upper wing surface, must travel faster than the air flowing the shorter distance under the flatter bottom surface of the wing.

A Cirrus SR20 flies over a dense forest. Trees can block wind on the ground and force it to change direction. (see module 7)



According to Bernoulli, air must move faster to cover more distance in the same time as air moving the shorter distance below the wing.

According to Bernoulli's principle, the difference in the speed of the air, which behaves like a fluid, produces lower pressure above the wing than below it. This pressure difference produces lift as well.

Most small airplanes have engines and propellers mounted in the front. The power produced by the engine is translated into ***thrust*** by the propeller, which pulls the airplane through the air. You feel a similiar kind of thrust when a driver pushes the accelerator pedal in a car.

Thrust also works to counter the effects of ***drag***, which is created by resistance against all of the surfaces of the airplane that impact the wind (and the development of lift). If you've ever been on a roller coaster and waved your arms as you sped along the track, or held your arm out an open car window, you have felt the drag created by air resistance.

ACTIVITY: Airfoil design

Photocopy this activity for classroom use.
Go to www.aopa.org/path for student worksheets.

TEACHERS:

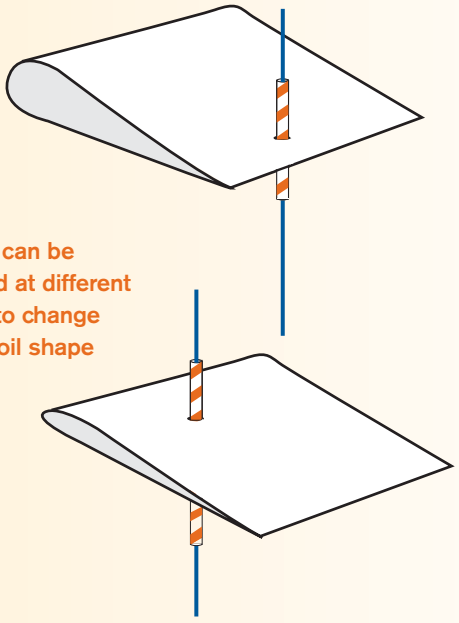
From this activity, students will learn how the shape of an airfoil influences how well that airfoil develops lift.

MATERIALS:

Paper
Tape
Plastic straw (cut in thirds)
String
Scissors
Single-hole punch
Electric box fan

TO DO IT:

- Bend the paper in half without creasing the fold.
- Punch a hole in the paper through both sides of the paper. Where you place the hole will determine the shape of your airfoil, or wing.
- Slide the straw through the holes and secure the straw to the paper with tape.
- Look at the wing from the side. Can you guess how well it will create lift, based on what you have just learned about Newton's and Bernoulli's theories?
- Insert the string through the straw so that the airfoil can slide up and down on the string freely. Hold both ends of the string so that your airfoil does not fall off.
- Set up the fan so that you can hang the airfoil in the air stream. With the fan off, position the airfoil and hold it so that it is perpendicular to the airflow, just as an airplane might fly its wing through the air.
- Holding both ends of the string, turn the fan on low, and watch the airfoil to see if it rises on the string—a sign that lift is being produced.
- Try different speeds on the fan, and various airfoils created by other students. Compare how well they work with the shape of each airfoil.



Straws can be inserted at different points to change the airfoil shape