LIGERBOTS ▪ FIRST Robotics Team 2877
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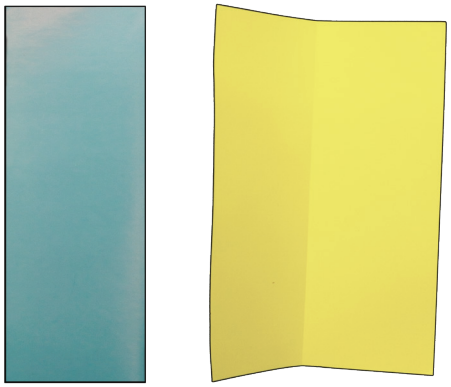
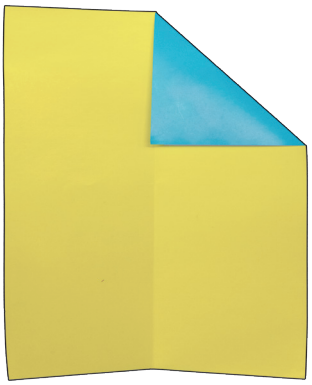
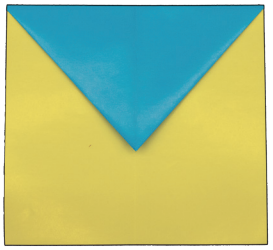
Dart Paper Airplane



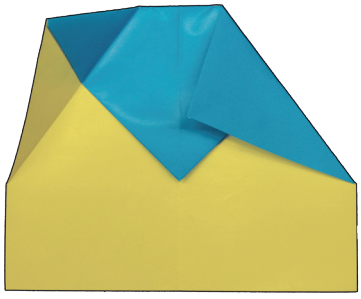
1. Fold paper in half and unfold



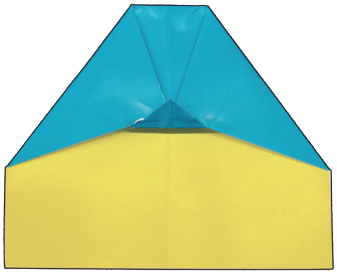
2. Fold the corners to the middle line



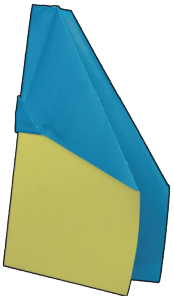
3. Fold the triangle down



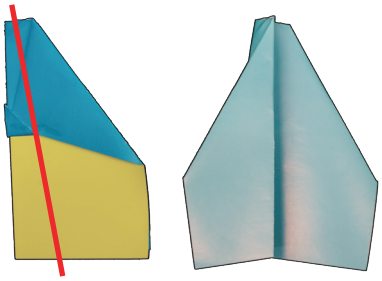
4. Fold the corners down to the line, 1 inch from the top!



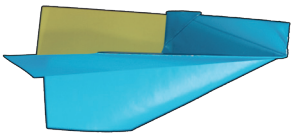
5. Fold the little triangle up



6. Fold the whole plane in half



7. Fold in half and unfold



8. Fold the other side to match the wings

When You're Done

- *Look at the back of the plane. Does it look like this?*

- *Make the wing tips have this curve*

Aerodynamics: The Science Behind Airplanes and Other Things that Fly

Paper airplanes obey the same laws of physics as anything that can fly: a jet, a bird, or a Frisbee. (This includes a sailboat "flying" across water, into the wind.) The four physics principles that affect flight are thrust, drag, lift, and gravity. These forces work together. Lift and drag are called aerodynamic forces because they exist when an object moves through the air. Gravity and thrust are external forces that can act on the airplane independent of the airplane's interaction with the air.

Thrust

Before the air can exert a force on an object, something has to cause the object to move. That's the thrust. For your paper airplane, the source of thrust is the throw. For an engine-equipped airplane, the source of thrust is the engine.

Drag

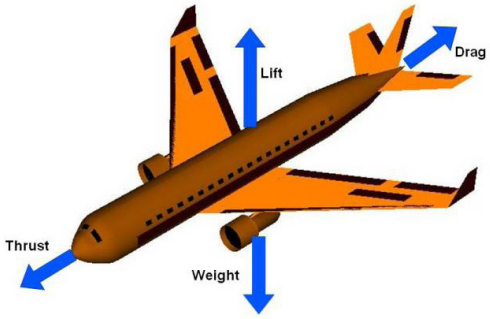
Drag refers to forces that oppose the motion of an object through the air. Friction caused by air moving over the surface of a plane causes drag. In order for the plane to stay aloft, drag must be overcome by thrust. The paper airplane in this flyer has flat wings, but curved wing tips that help prevent drag. Commercial, engine-driven airplanes, which have curved wings, also have these curved tips.

Lift

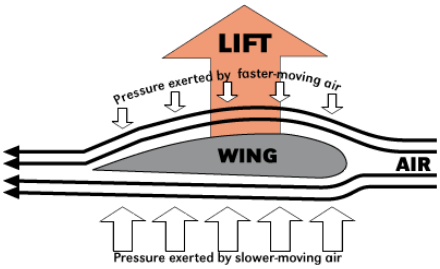
Lift is the upward force on the airplane, caused by Bernouilli's Principle, which states that an increase in the speed of a fluid (like air) occurs simultaneously with a decrease in pressure. (For more details, see "How Wings Work," below.)

Gravity

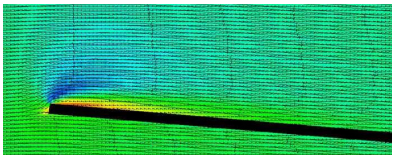
Just as drag opposes thrust, gravity (weight) is always working against lift, trying to pull objects in flight back down to earth.



The four physics principles that affect flight



Bernoulli's Principle



Air pressure during flow over a flat wing.

How Wings Work

Air flows over the top and the bottom of a wing as it flies. In order to create lift, there has to be more pressure on the bottom of the wing than on the top. This can be created either by the wing being curved on the top and flat on the bottom, or by angling a wing that is flat on both sides into the wind created by forward motion. (Picture holding your hand out a car window and feeling it pushed upward.)

There is a longer distance for the air to flow over the top of a curved wing than over the flat bottom. But the air from the top and from the bottom of the wing have to meet at the back of the wing. If the air on the top lags behind the air on the bottom, a lack of molecules will be created at the back end of the wing where the air hasn't flowed yet. To prevent this from happening, the air on the top speeds up so that it reaches the back of the wing at the same time as the air from the bottom. As they speed up, the molecules spread out, causing a reduction in air pressure.

The higher pressure on the bottom pushes upward harder than the lower pressure on the top pushes down, so the plane rises.

When we give a flat wing the correct "angle of attack," a bubble of air is created at the front of the wing top and a vortex (circular flow of air) is created at the back of the wing top. This causes the flat wing to behave just as if it were a curved wing, increasing the speed of air across its upper surface, decreasing air pressure, and creating lift.

A stall occurs when the speed of an airplane is too low to maintain the air pressure difference between the top and the bottom of the wing. Then, it cannot offset the force of gravity. The plane no longer has lift, and falls to the ground.