

# Adopt-A-Pilot<sup>®</sup> Experiments

Southwest<sup>®</sup> 

# The Forces of Flight

## Four Forces of Flight:

The four forces on an airplane are what make it fly. During level and unaccelerated flight, the opposing forces of Lift and Weight, and Thrust and Drag are equal to each other.

**Lift** - The upward force generated by airflow over the wings.

**Weight** - The downward force created by the mass of the aircraft.

**Thrust** - The forward force created by the airplane's engine(s).

**Drag** - The rearward force created because the airplane is moving through air.

## Four Forces Activity:

Use the space below to label the four forces of flight.



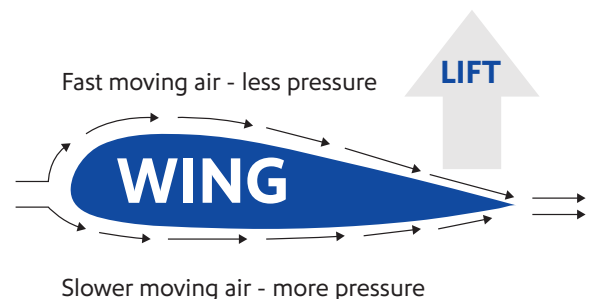
# The Force of Lift

## Bernoulli's Principle:

Slower moving fluids (i.e. air) exert more pressure than faster moving fluids.

## Lift:

Lift is mainly created by Bernoulli's Principle. The air flowing over the top of the wing moves faster than the air moving below the wing. Mathematician and Scientist Daniel Bernoulli discovered this principle in 1738.



## Ping-Pong Ball Lift Experiment:

What do you think will happen to a ping-pong ball or balled up piece of aluminum foil if it is placed above a running hairdryer?

1. Turn the hair dryer on maximum cool air flow, and point the nozzle towards the ceiling.
2. Gently place the ping-pong ball or foil ball in the air flow about 1" above the nozzle and release. This isn't easy so don't give up, keep trying.
3. Observe how the ball floats inside of the column of air.
4. Slowly tilt the hair dryer left and right. The ball will continue to float, even when not directly above the hairdryer. This is because a low pressure is being created on the top side of the ball due to the rounded shape.
5. For added fun, place an empty toilet paper tube above the ping-pong ball or foil. Air flowing through the tube will create a low pressure inside, and will shoot the ball towards the ceiling.

## What did you observe?

The ball represents the rounded upper surface of an aircraft wing. Lift is created when high velocity air flows over the rounded surface, keeping the airplane airborne.

# The Force of Drag

## Form Drag:

Drag that is created by the displacement of air around an airfoil. Form Drag is increased when you add flaps to the wing of an airplane.

## Paper Airplane Drag Experiment:

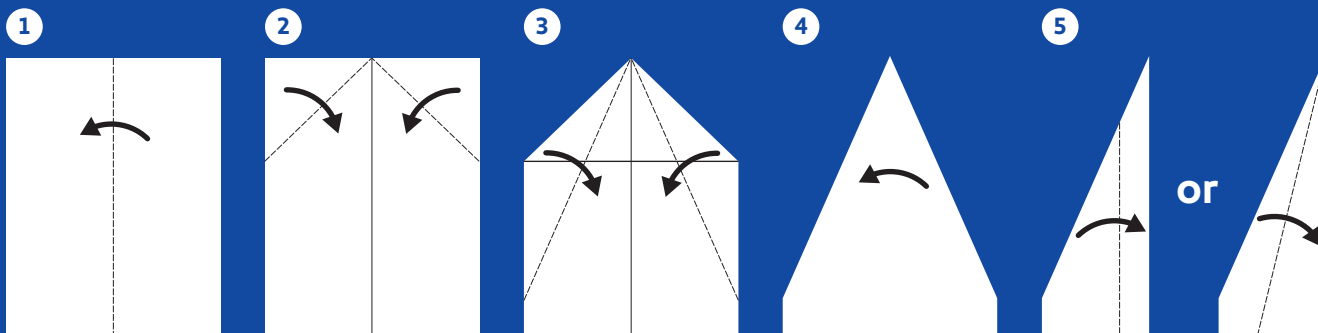
What do you think will happen when you add flaps to a paper airplane?

1. Make a standard 'dart' design paper airplane. Use the instructions below.
2. Clear an area, and throw the paper airplane. Place an object where it lands to mark how far it flew.
3. Now add 'flaps' to the plane by cutting approximately 1" slits in the wing and folding the paper down.
4. Start at the same location, and throw the modified paper airplane.

## What did you observe?

The added flaps increased Form Drag on the paper airplane. This increased Form Drag shortened the distance that the airplane flew.

### "Dart" Paper Airplane Instructions:



# The Force of Thrust

## Newton's Third Law of Motion:

Newton's Third Law of Motion says that for every action there is an equal and opposite reaction. Mathematician and Physicist Sir Issac Newton discovered the three laws of motion in 1678.

## Thrust:

Thrust is created when air is exhausted out the back of the engine, moving the airplane forward in the opposite direction.

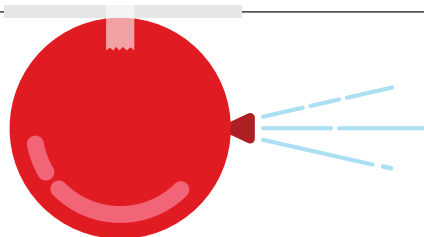
## Balloon Powered Thrust Experiment:

What you think will happen when you release air out of a balloon?

1. Blow up a balloon and tie it shut.
2. Cut a straw so it's 2-3 inches long. Tape a straw on the top of the balloon.
3. Run a string through the straw, and get two helpers, one to hold each end so that the string is taut and level.
4. Place the balloon at one end of the string, and start a launch countdown.
5. When you reach "one", cut the end of the balloon off with a pair of scissors.

## What did you observe?

The air rushing out the cut end of the balloon (action) made the balloon travel in the opposite direction (reaction). This was Newton's Third Law of motion in action.



# The Force of Weight

## **Weight:**

Weight is the predictable force that pulls all objects towards earth. The heavier an object, the more gravity affects it. Sir Isaac Newton discovered gravity in the 1680's.

## **Heavy Objects Weight Experiment:**

What do you think will happen when you continue to add books to one outstretched arm but not the other?

1. Collect several different sized books from the around your house - the heavier the better.
2. Hold both arms straight out, palms up, at the same height. The goal is to keep both hands at the same height throughout the experiment.
3. Grab a helper and have them start placing books on one hand, but not the other. Have them keep adding books until you are unable to maintain the same height with both hands.

## **What did you observe?**

You were unable to hold your arms at the same height due to the weight of the books. Now think about how much an airplane weighs. Lift has to counteract the weight of the airplane to keep it flying.

