



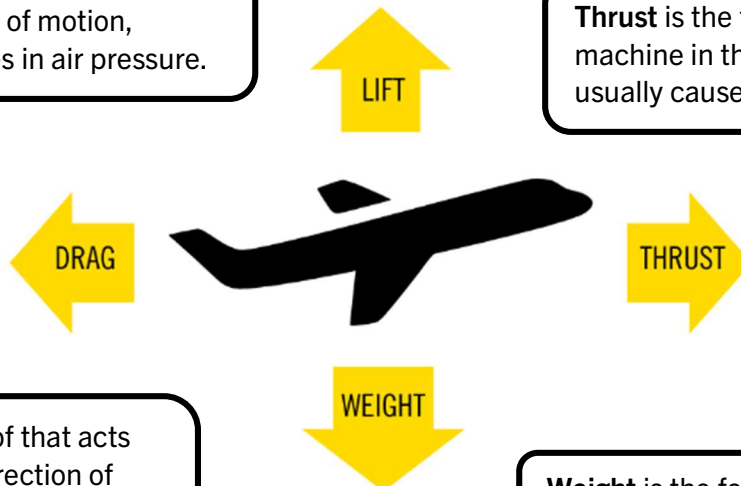
Forces of Flight

What makes airplanes fly? The answer is a complex puzzle, one that takes into consideration the four forces of flight. These four forces are interconnected - a change in one affects the others.

A **force** is a push or pull on an object, which has both magnitude and direction.

Lift is the force that acts at a right angle to the direction of motion, created by differences in air pressure.

Thrust is the force that propels the machine in the direction of motion, usually caused by an engine.



Drag is the force of that acts opposite to the direction of motion, caused by friction and differences in air pressure.

Weight is the force of gravity; it acts in a downward direction.

Flights of Fancy

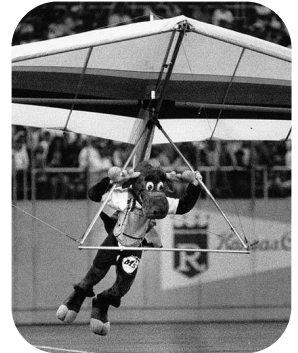


Hot Air Balloon at Alaska Yukon Pacific Exposition, 1909

The hot air balloon was the first flight technology capable of supporting human flight (1783, France). Hot air balloons generate lift by using heat to create a pressure difference between the air inside the balloon and the air outside the balloon. They have no powered means of propulsion and rely on winds for navigation and weights & counter-weights to control altitude.

Mariner Moose at the Kingdome, 1990

Gliders are unpowered aircraft that are designed to fall slowly and use currents of rising air (thermals) and other weather phenomena to stay airborne. To fly, a glider must first accelerate to flight speed, and often does so by running or using an airplane or automobile tow. Many different types of gliders exist such as paragliders, hang gliders, sailplanes, and paper airplanes.



Nike defense missile, Fort Lawton, 1955

Rockets are aircraft that produce thrust by igniting fuel inside a chamber. As the fuel burns, it gives off hot gas that is pushed out the back of the chamber. The force of the gas moving backward pushes the rocket forward in an action called jet propulsion. Rockets are used to launch spacecraft and are also used to shoot objects like missiles and fireworks.

Boeing B-1 sea plane, 1925

An airplane is a fixed-wing aircraft that is propelled forward by thrust from a jet engine, rocket engine, or propeller. Boeing's B-1 is a biplane (it has two sets of wings). It generates thrust from its engine that controls the propellers. The B-1's boat-shaped hull allows it to take off and land on the water which it did regularly from 1920 to 1927, carrying mail between Seattle and Victoria, B.C.



Explore flight at home by building and testing four different flying machines. How do each take the different forces of flight into consideration?

Watch the video introduction on the MOHAI YouTube Channel (@mohaiprograms)!

Hot Air Balloon

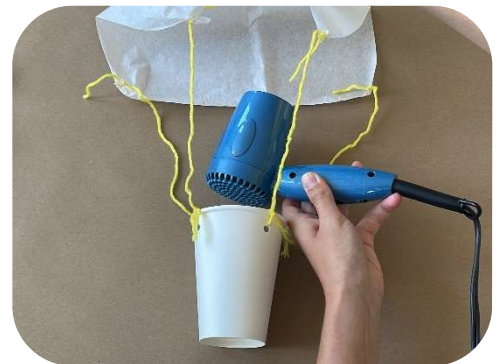
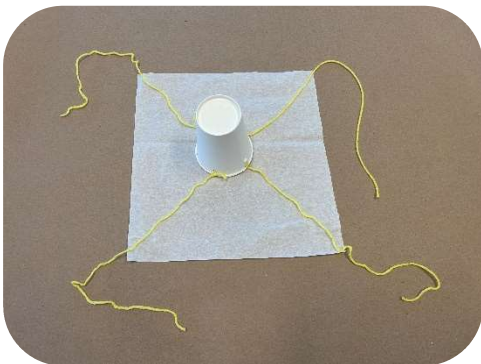
Materials:

- Tissue paper
- Scissors
- Hole punch
- Paper cup
- String
- Hair dryer



How to:

- Cut your tissue paper into a square.
- Punch four holes in the rim of your cup equal distance from each other.
- Cut four pieces of string of equal length.
- Use the four pieces of string to tie the four corners of your tissue paper to the cup.
 - Tip: flip your cup upside down on the paper to align the four holes with the four corners of the tissue paper.
- While supporting the tissue paper top, point the hair dryer up into the “balloon” and turn on the air!
- How does the size of the tissue paper, length of string, or weight in the cup change how your hot air balloon moves?



Straw shooter

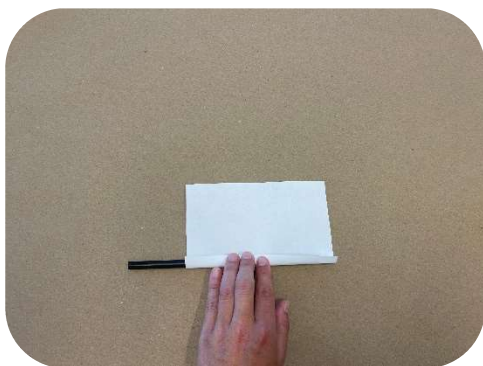
Materials:

- Drinking straw
- Paper
- Scissors
- Tape
- Decorating supplies (optional)



How to:

- Cut your paper so that is almost as long as your straw and wide enough to roll around it twice.
- Roll the paper around straw (not too tight!) and tape along its edge to make a tube.
- Pinch and tape one end of the paper roll closed.
- Decorate your shooter by drawing on it while the straw is inside for support.
- Place the shooter back on the straw, and blow into the straw to make your plane go!
- How does the length of the paper or straw, or thickness of the paper affect how your plane flies?



Balloon shooter

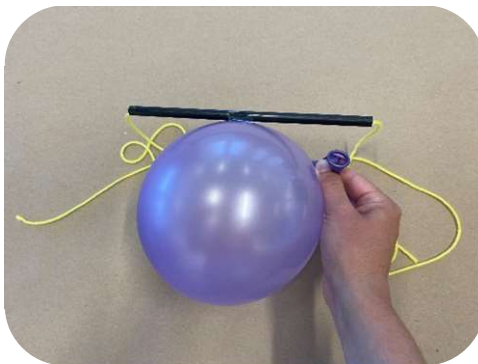
Materials:

- Balloon
- String
- Scissors
- Tape
- Straw



How to:

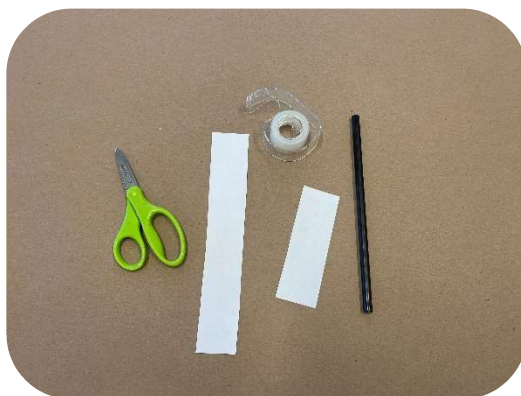
- Thread the string through the straw.
- Inflate the balloon and tape it to the straw, while holding it closed! Try to place the straw halfway between the opening of the balloon and the opposite end, and in line with the top and opening of the balloon.
- With a buddy or by tying one end of the string down, pull it taught and bring the balloon to one end.
- Release the air to make your plane go!



Hoop glider

Materials:

- Paper
- Scissors
- Tape
- Straw



How to:

- Cut your piece of paper into two strips of equal width and different lengths.
- Tape each strip to itself to form two loops of different sizes.
- With the straw inside the hoops, tape the small one to one end, and the large one to the other.
 - Make sure to tape the hoops on the same side of the straw as each other!
- Throw it much like you would a paper plane or ball to make it go!
- How does changing the size or position of the hoops on the straw affect how it flies?



Evaluate your flying machines!

Use the chart below to compare your different flying machines to each other. For each one, measure how far it went, time how many seconds it stayed in the air, and rate its speed. What else are you interested in observing about your flying machines? Record your observations in the extra column.

Flying machine	Distance traveled	Time in air	Speed (scale of 1-5)	Other: _____

What changes could you make to improve the design or get different results?

Share your flying machines on social media with us!

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  @mohai
  @seattlehistory