Fort Mifflin

#MakeItBetterMonday

Why did they build the Fort so close to the Airport? Let's learn about aviation!

HISTORICAL BACKGROUND

Fort Mifflin was originally commissioned in 1771 to defend Philadelphia from invasion and piracy. During the Revolutionary War it was the site of a six-week siege and six-day bombardment in October-November 1777. It was rebuilt in the late 1790s/early 1800s as part of America's first coastal defense network. During the Civil War it was a Union Army prison and it served as part of the Naval Ammunition Depot during World War I.

The US Navy removed live ammunition from the Ammo storage depot following public criticism in 1929, leaving the Fort to fall into disrepair. In 1930, with the outset of the Great Depression, President Herbert Hoover, at the urging of Philadelphia mayor Harry A. Mackey, set up a restoration project for the aging Fort Mifflin. Col. Earl L. Brown, District Engineer of the Army Corps of Engineers, oversaw the $37,000 restoration of the Fort, which concluded in 1932. (1)

Meanwhile the City of Philadelphia established an aviation training ground for the Pennsylvania National Guard adjacent to the Fort. In 1930, the city set up a plan to expand the airfield into a municipal airport. Construction began in 1937 and Philadelphia Municipal Airport officially opened on June 20, 1940. (2)

During World War II, the airport closed for commercial flights in 1943. Fort Mifflin in the meantime served once again as part of the Naval storage depot and housed anti-aircraft guns that could be used to defend the Naval Shipyard as well the the airport. Service at Philadelphia Municipal Airport resumed in the closing weeks of the war (June 26, 1945), and the airport's name was officially changed to Philadelphia International Airport later that year. (3) Fort Mifflin meanwhile became inactive and the federal government officially decommissioned the Fort in 1954, bringing the Fort's 183 years of service to an end.

Today Philadelphia International Airport is one of the busiest airports in the country; it is the site of over 400,000 flights per year (there were 432,884 flights in 2013), many of which fly directly over the Fort! (4)

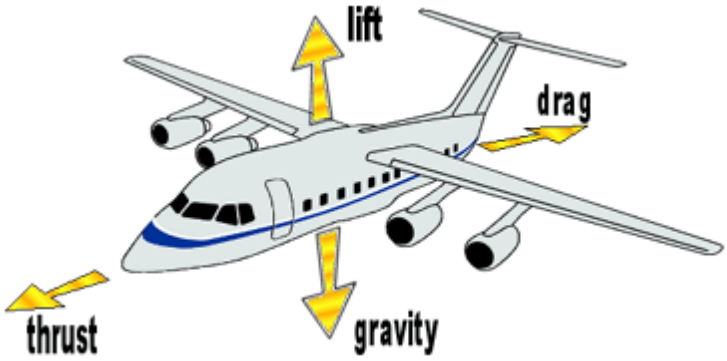
BASICS OF FLIGHT

Air is like a liquid in the sense that it has ***volume***, and a plane's movement is determined by how it moves the air around it.

There are four kinds of forces acting on a plane while it is in the air:

Lift: The force of air pressure pressing up on the plane.
Gravity: The force pulling the plane down toward the ground.
Thrust: The force pulling or pushing the plane through the air.
Drag: The force pushing against the plane's movement through the air.

Figure 1: Forces at work on an airplane (5)



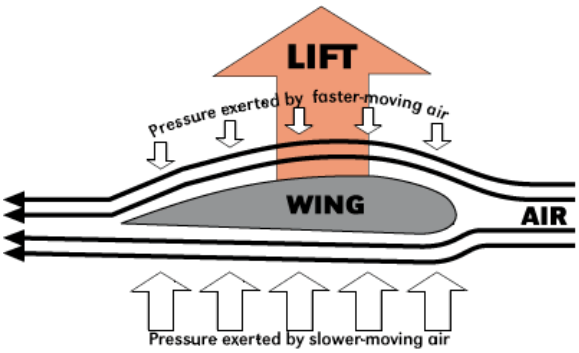
If these four forces are balanced, the plane with fly at a steady height (***altitude***) and speed (***velocity***). However, if one force is greater than the others it will affect the plane's motion through the air.
If...
...lift is the strongest force, the plane will ascend.
...gravity is the strongest force, the plane will descend.
...thrust is the strongest force, the plane will accelerate.
...drag is the strongest force, the plane will decelerate.

To show how these forces work, here are several simple demonstrations you can try:

Lift:
The design of the wing or *airfoil* is made to generate lift as it moves through the air. The design is based on *Bernoulli's Principle,* which states that the increase in velocity of any fluid, including air, results in a decrease in pressure.

As the plane moves, air is forced under and over the airfoil. The air that goes over the curved top has to travel farther to reach the back of the wing than the air that goes under the flat bottom. To reach the back of the wing at the same time, the air above must go faster than the air below. This causes the air pressure on the bottom of the wing to be greater than that on the top. This pressure causes lift, pushing the plane upward.

Figure 2: Demonstration of Bernoulli's Principle (6)

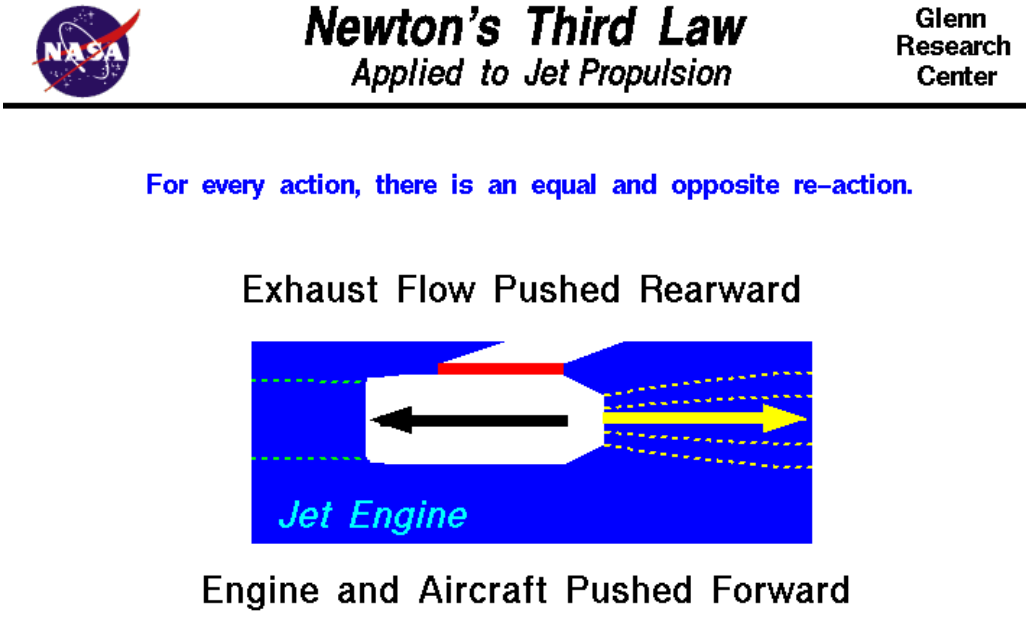


Try it! To demonstrate life, hold two sheets of notebook paper about four inches apart. Blow between them. Instead of flying apart they come together! The air moving rapidly between the two pieces of paper has less pressure than the air pressing on the outer sides of the paper.

Thrust:

Thrust is created through a method of propulsion that generates the forces needed to push or pull the plane. Modern airplanes use engines to generate thrust by pulling in air, either through a propeller or jet turbine, then pushing the air out. Sir Isaac Newton's Third Law of Motion states that *"for every action there is an equal and opposite reaction."* As the engine pushes the plane in one direction, it creates an equal force in the opposite direction.

Figure 3: Illustration of Newton's Third Law (7)



Try it! You can demonstrate thrust just like an aircraft engine:
Propeller: Put a small fan on top of a skateboard and turn it on. The propellers of the fan should pull the skateboard forward. As the air is pulled through the fan blades, it generates a force in the opposite direction that pulls the skateboard forward.

Jet: Blow up a balloon; pinch the neck to keep in the air. Let the balloon go, and it shoots across the room. The air inside the balloon is pushing in all directions to get out. Some of the air escapes through the open neck, but the air at the opposite end of the balloon cannot get out, so it pushes the balloon forward.

Drag:
Drag is created by the push of air against the plane as it moves through the air. It is the opposite force of thrust.

Try it! Take a piece of paper and wave it quickly. The force of the air will push against the material and push it backward.

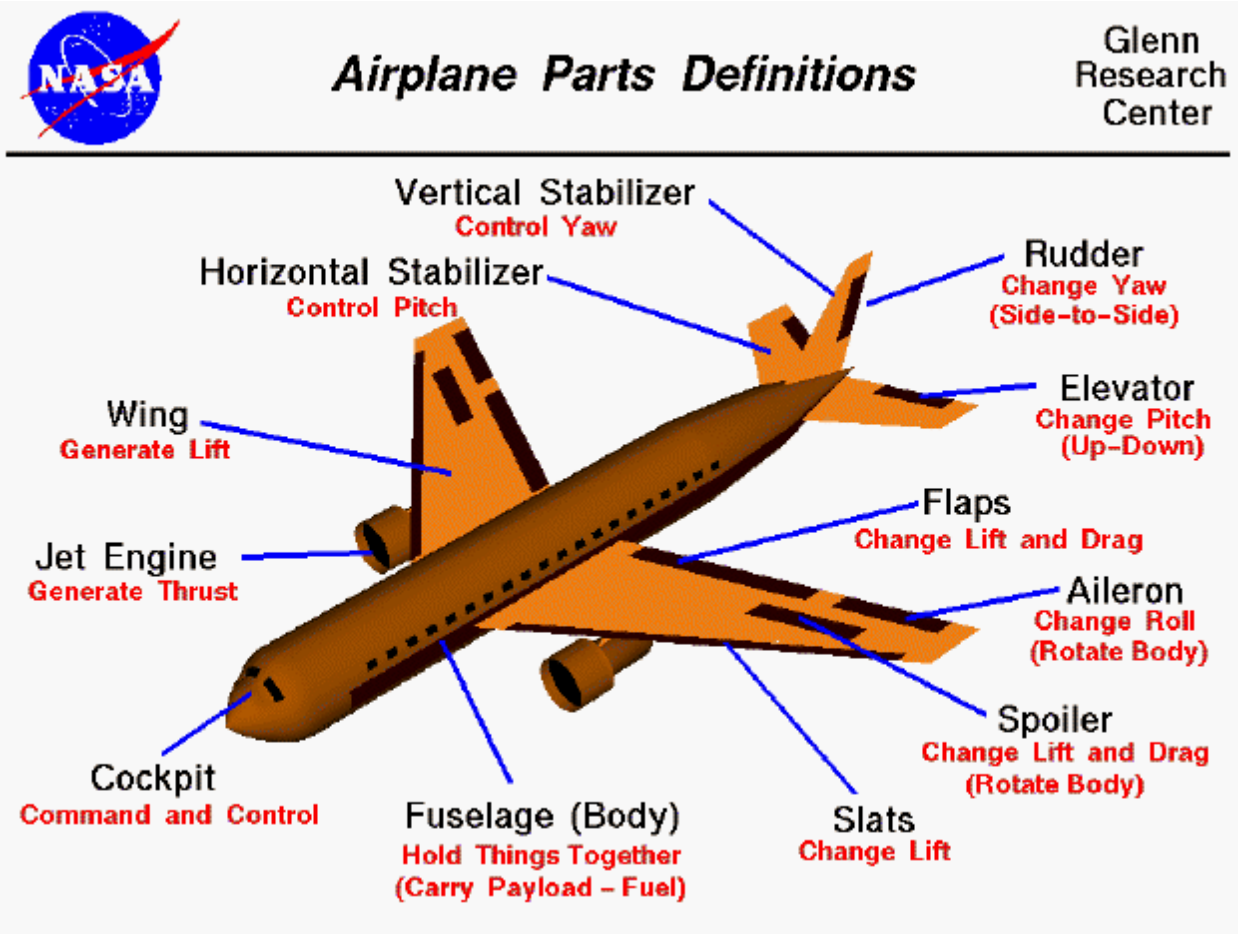
Gravity/Weight:
Gravity is the force that pulls the plane down toward the center of the earth. It is the opposite force of lift. The degree of force pulling the plane toward the ground is affected by the design and shape of the plane as well as the amount of cargo and passengers it carries.

Try it!
Take a small object (ideally something that is not fragile,) hold it up and then let it go. The earth's gravitational force pulls it toward the center of the Earth.

How does a plane steer?
Pilots steer planes using movable flaps on the wing (called an *aileron*) and tail (a *rudder* and *elevators.*) Changing the position of the ailerons, rudder, and elevators changes the air pressure around the plane, allowing it to ascend, descend, or change direction.

Climb.....The elevators are up.
Glide or dive…The elevators are down.
Right turn.....Turn the rudder right.
Right bank.....The right aileron is up; left aileron is down.
Left turn.....Turn the rudder left.
Left bank.....Turn the left aileron up; right aileron down.

Figure 4: Parts of a plane (8)



Try it! Build and pilot your own FPG-9

To demonstrate steering, make your own FPG-9! Short for Foam Plate Glider, the FPG-9 is a model glider made from a Styrofoam plate that exhibits the basic principles of flight and steering.

Materials needed:

9-inch Foam paper plate
Scissors
Tape
A penny, or similar weight (to create a center of gravity)
Markers (optional, for decorating the glider).

You can find a template and instructions for assembly HERE https://amaflightschool.org/diy/fpg-9-foam-glider

When your FPG-9 is complete it's time for Flight Test! Does your aircraft fly straight? What happens to the flight path when you adjust the rudder or aileron?

Want to learn more? Check out these resources:

Academy of Model Aeronautics, "FPG-9 Stuff," http://www.modelaircraft.org/education/fpg-9.aspx

Aircraft Owners and Pilots Association, *PATH to Aviation: Airplanes!*, http://www.aopa.org/path/airplanes.pdf.

Mary Coleman, et. al., *Aviation Science Activities for Elementary Grades*, https://www.aiaa.org/uploadedFiles/Education_and_Careers/STEM_K-12_Outreach/Kids_Place/Airplane_Activities/Aviation%20Science%20Activities%20for%20Elementary%20Grades.pdf .

National Aeronautics and Space Administration, *Beginner's Guide to Aeronautics*, http://www.grc.nasa.gov/WWW/k-12/airplane/index.html .

National Aeronautics and Space Administration, *How Does a Jet Engine Work?*, http://www.grc.nasa.gov/WWW/k-12/UEET/StudentSite/engines.html.

National Aeronautics and Space Administration, *Dynamics of Flight*, http://www.grc.nasa.gov/WWW/k-12/UEET/StudentSite/dynamicsofflight.html.

NOTES

1 Dorwart 145-6.
2 "1920's-1930's," *Philadelphia International Airport, http://www.phl.org/AboutPHL/History/Pages/history_1920.aspx*.
3 "1940's-1950's," *Philadelphia International Airport*, http://www.phl.org/AboutPHL/History/Pages/history_1940.aspx.
4 "Facts," *Philadelphia International Airport*, http://www.phl.org/AboutPHL/Pages/facts.aspx.
5 Image source: http://www.grc.nasa.gov/WWW/k-12/UEET/StudentSite/images/Yaday/forces.gif.
6 Image Source: http://ffden-2.phys.uaf.edu/211_fall2002.web.dir/josh_palmer/berni%20wing.gif
7 Image Source: http://www.grc.nasa.gov/WWW/K-12/BGP/Images/newton3.gif
8 Image Source: http://www.grc.nasa.gov/WWW/k-12/VirtualAero/BottleRocket/airplane/Images/airplane.gif