



“What Are Flight Dynamics & Flying Qualities?”

Or

"How Do Things Fly?"

"How Well Do Things Fly?"

Grades 5-8

Objective: Upon completing this lesson, the student will be able to describe the dynamics of flight and how well vehicles fly. They will be able to identify flight vehicles and the forces that define their movement.

National Science Standards:

- Standard A: Science as inquiry - Abilities necessary to do scientific inquiry
- Standard B: Physical Science - Position and motion of objects

Vocabulary:

- Flight Dynamics - study of a vehicle's motion through the air.
- Flying Qualities – study of how well a vehicle flies through the air.
- Flight Vehicle - airplane, helicopter, balloon, rocket, anything that flies through the air.
- Force – a push or pull that causes movement of an object
- Moments – rotation of a body that occurs when a force is applied
- Lift - upward force
- Thrust - forward force
- Weight/gravity - downward force
- Drag - backward force

Activity Websites:

- <http://www.grc.nasa.gov/WWW/K-12/airplane/forces.html>
Forces of flight
- http://www.ehow.com/how_2247750_explain-bernoullis-theorem-experiment-kids.html#ixzz1PIpjwHo6

How to Explain Bernoulli's Theorem Experiment to Kids | eHow.com

- <http://www.grc.nasa.gov/WWW/Wright/index.htm>
Wright Brothers
- <http://www.grc.nasa.gov/WWW/Wright/activities.htm>
Wright Brothers Activities
- <http://www.grc.nasa.gov/WWW/K-12/BGA/BGAindex.html>
Aerospace Activities and Lessons
- <http://www.grc.nasa.gov/WWW/K-12/TRC/Aeronautics/AeronauticActivitiesHome2.htm>
Aeronautics Classroom Activities
- <http://www.grc.nasa.gov/WWW/K-12/aerores.htm>
Aerospace Resources
- <http://women.nasa.gov/a2i/>
Women in Science, Technology, Engineering & Math Careers Info

What Are Flight Dynamics and Flying Qualities?

The word Aeronautics is made up of two parts. “Aero” is Latin for air or sky and “Nautics” is Latin for sailor. Therefore, Aeronautics literally means sailing in the air. As a vehicle flies through the air, its motion is described by Flight Dynamics and how well the vehicle flies through the air is called Flying Qualities. A vehicle could be an airplane, a helicopter, a rocket, or anything else that uses the air to move around. [Orville](#) and [Wilbur](#) Wright were early experts in Flight Dynamics. They flew the first airplane at Kitty Hawk, North Carolina in 1903.

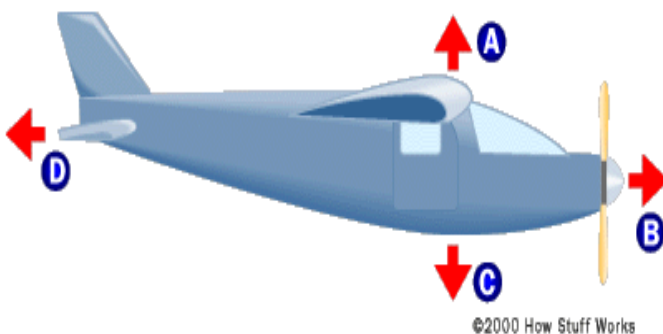
What Causes a Vehicle to Move In the Air?

As the vehicles flies around, its motion is caused by forces and moments. Both forces and moments tend to move things; the difference is how they move things. A force moves something in a straight line, like pushing on the side of a box. A moment rotates something in a circle, like turning a screwdriver.

In an airplane, when the engine pulls the plane straight forward, it does so by creating a force. When the tail rotates the airplane by moving the nose of the aircraft up while the tail goes down, it does so by creating a moment. Most of the forces come from aerodynamics, which is a study of how air moves around objects.

What Are the Forces On an Airplane?

The [forces on an airplane](#) shown in Figure 1 include “[lift](#)” that keeps the airplane from falling, “[thrust](#)” that speeds the airplane up, “[drag](#)” that slows the airplane down, and forces from the wing and tail that make the airplane turn in different directions. Another force is “[weight](#)” (or gravity) that makes the aircraft come down when there is not enough lift. To know more about these 4 forces, click on A, B, C, or D below.



- A. [Lift](#)
- B. [Thrust](#)
- C. [Weight](#)
- D. [Drag](#)

What is Aerodynamics?

The study of flight dynamics is closely linked to the study of aerodynamics of wings and bodies. In flight dynamics, we focus on how the aerodynamic forces press or pull on the vehicle to achieve a desired motion. So in flight dynamics, we study aerodynamics to know how air flows over wings and airplane bodies. Aerodynamics tells us how the forces act on the airplane wing and tail so the airplane can fly smoothly, but still move around enough to do things like take off, turn, and land.

How Do Airplanes Move In the Air?

When an airplane is flying smoothly through the air and not turning, we say the airplane is in equilibrium or “[steady flight](#).” For an aircraft to be in equilibrium, the thrust from the engines must balance the drag from the air, so the plane is not speeding up or slowing down. Also, the lift from the wing and tail must balance the weight of the airplane, so it is not falling down or zooming up. The following table explains [what a plane does because of the 4 forces](#).

If Lift is more than Weight	The Plane Rises
If Weight is more than Lift	The Plane Falls
If Drag is more than Thrust	The Plane Slows Down
If Thrust is more than Drag	The Plane Speeds Up

What Is Stability?

If a gust of wind hits the aircraft and causes it to climb or fall, or to speed up or slow down, we want the plane to only do this for a little bit, and then go back to the way it was flying before the gust. We want airplanes to be stable so it is easier for pilots to fly them. Stability allows a flight vehicle to come back to its equilibrium condition after a disturbance. Control is the ability to change the aircraft from one equilibrium condition to another (for example, to change flight speed) and to be able to maneuver the aircraft as desired. If it does this, we call the airplane “stable”. If it doesn't go back to the way it was flying before, but keeps getting

faster or slower, or climbing or falling more and more, we call the airplane “unstable.” An example of stability (or instability) is the “ball in the bowl” example in Figure 2.

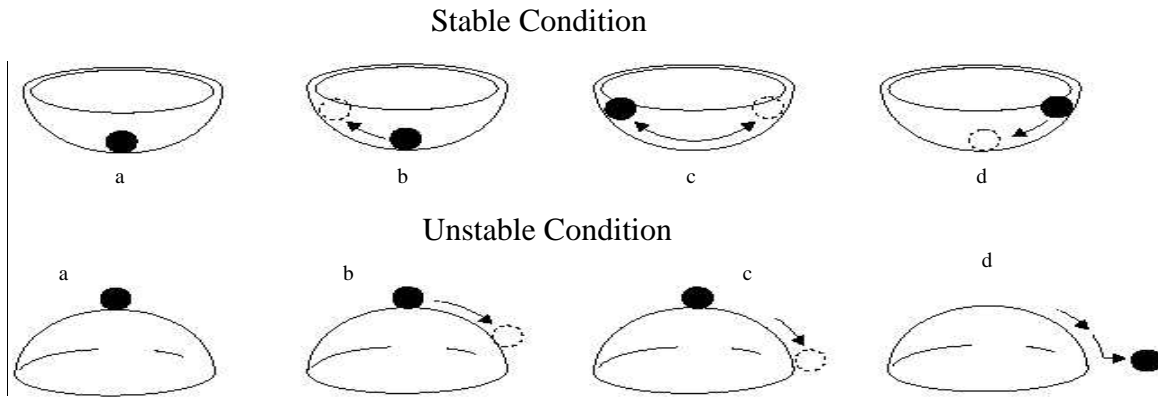


Figure 2

The bowl is set on a flat surface with a ball placed inside it. The ball rests in the bottom of the bowl; but, if you push the ball in any direction, the ball rolls to the bottom of the bowl again. This is referred to as “stability.” Turn the bowl upside down, position the ball anywhere on the bowl’s bottom surface and the ball rolls away from the bottom of the bowl and does not return. This is an “unstable” condition.

What Are the Parts of an Airplane?

While equilibrium and stability are achieved through proper sizing of wings and tails and correctly locating the aircraft’s balance point (or [center of gravity](#)), control is achieved by deflecting movable surfaces on the wings and tails, such as elevators, ailerons and rudder. All the parts of the airplane are shown in Figure 3. [How they are used](#) is very important in the motion of the airplane, whether turning, climbing, or landing.

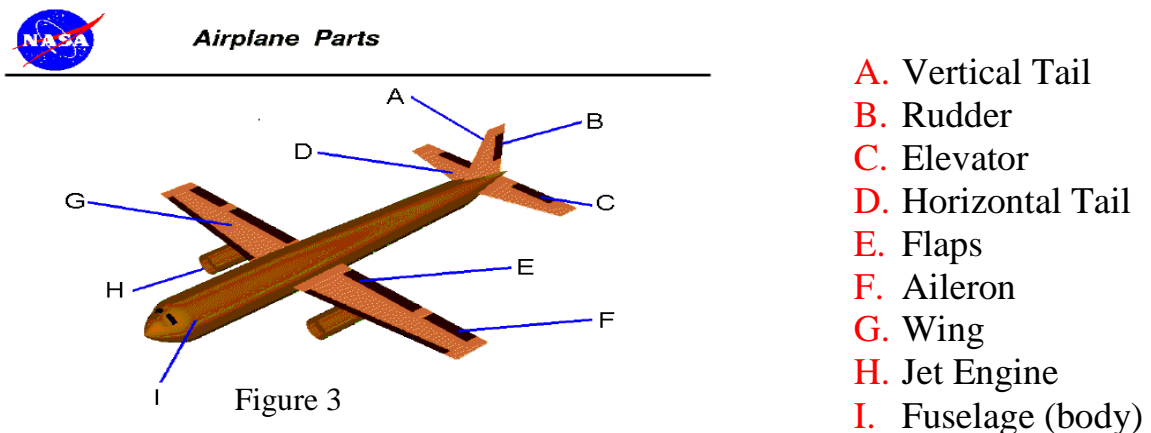


Figure 3

How Do Planes Land?

Sometimes we want the airplane to do something different, like when we are flying high and need the airplane to fly lower so we can land. When we are high and flying fast from one point to another, we are in steady flight. If we reduce the power from the engines a little bit and move the tail so that we start to fly down toward the ground so we can land, we will be in another steady condition. It is important for an airplane to be able to move from one steady condition (like flying high and fast) to another steady condition (like flying slower and closer to the ground getting ready to land).

How Does a Pilot Control the Airplane?

The flying qualities of the airplane deal with stability and how well the pilot can control the aircraft while in flight. Being able to move from one steady condition to another is what we call “[control](#).” A pilot controls the aircraft by changing the speed of the [engine](#) (H) or moving parts of the wing (G) or tail. The tail (A, D) has a horizontal (flat) part called the “[Elevator](#)” (C) that is used for [pitch control](#) and can make the nose of the aircraft move up and down. The tail also has a vertical (tall) part called the “[rudder](#)” (B) that is used for [yaw control](#) by creating a yawing moment that makes the nose of the aircraft move left and right. The wings have small surfaces called “[ailerons](#)” (F) used for [roll control](#) by creating a rolling moment, where one wing goes up and the other goes down. How well the aircraft responds to the pilot’s commands is very important.

So, next time you see an airplane flying in the sky, remember that flight dynamics and flying qualities play a key role in how the airplane flies.



Fact Sheet

Flight Dynamics & Flying Qualities

"Forces of Flight"

Four Forces of Flight

Lift, thrust, weight, drag

Sir Isaac Newton (1642 - 1727)

First presented his three laws of motion in the "Principia Mathematica Philosophiae Naturalis" in 1686.

Newton's Laws of Motion

Newton's First Law of Motion states that a body at rest will remain at rest unless an outside force acts on it, and a body in motion at a constant velocity will remain in motion in a straight line unless acted upon by an outside force.

The Second Law of Motion states that if an unbalanced force acts on a body, that body will experience acceleration (or deceleration), that is, a change of speed.

The Third Law of Motion states that for every action force there is always an equal and opposite reaction force.

Bernoulli's Principle

States that an increase in the speed of moving air or a flowing fluid is accompanied by a decrease in the air or fluid's pressure.



Flight Dynamics

K-W-L

K - What do I know about flight dynamics?

W - What do I want to know about flight dynamics?

L - What did I learn about flight dynamics?



Flying Qualities

K-W-L

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W - What do I want to know about flying qualities?

L - What did I learn about flying qualities?
