

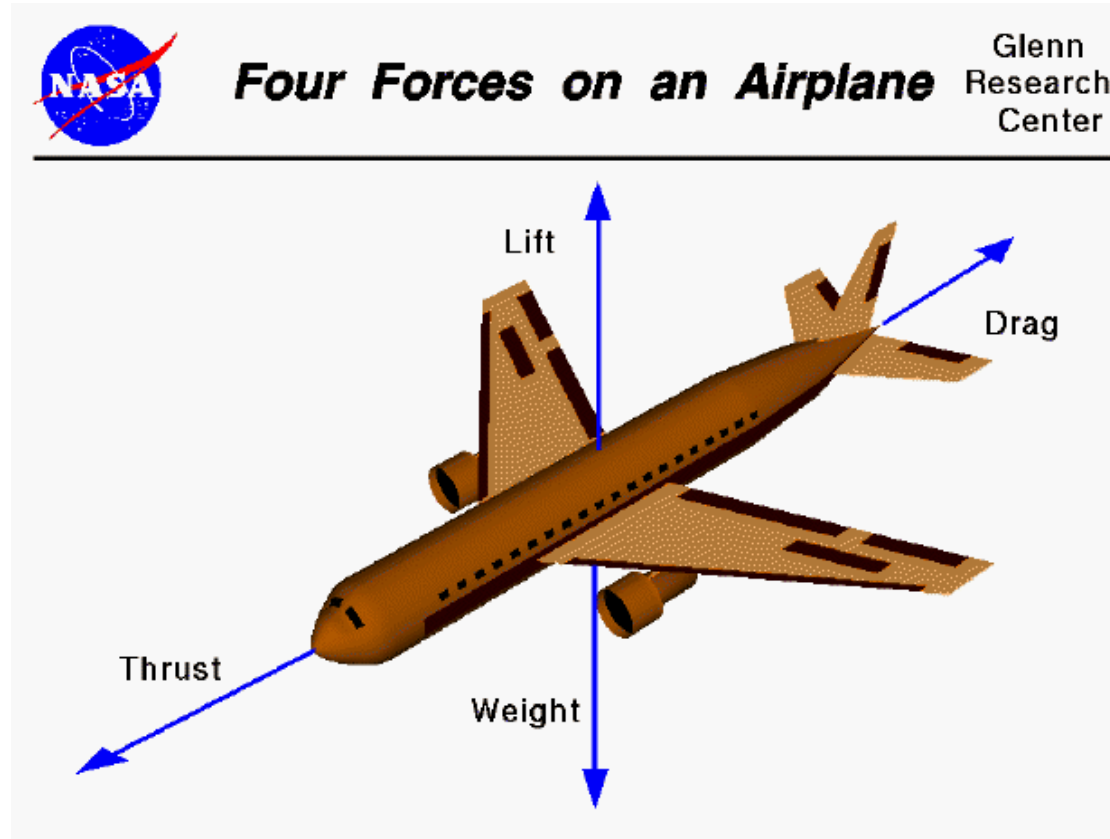
# **Fundamentals of Flight, Stability, and Control**

**GK-12 Wind Energy and Aerospace Workshop  
July 13th – 24th, 2009**

**Fundamentals of Flight, Stability, and Control**



# The Four Forces of Flight



The four forces act on the airplane in flight and also work against each other.

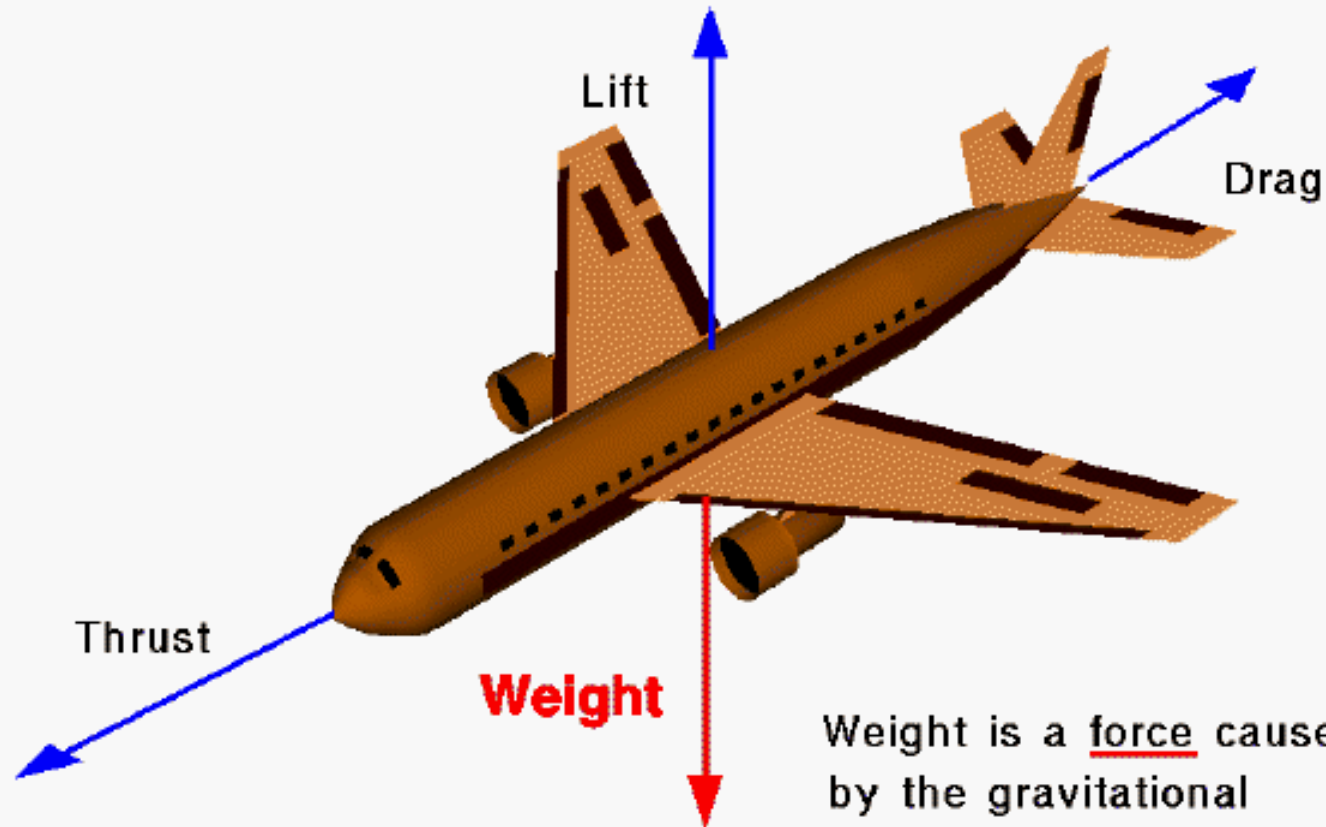


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## What is Weight?

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Weight is a force caused by the gravitational attraction of the Earth.



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# The Force of Lift

How do we explain lift?

Newton's Laws of Motion and Bernoulli's Principal are used to explain lift.



Daniel Bernoulli



Sir Isaac Newton



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# Newton's Laws

Newton's Second Law: force causes a change in velocity which in turn generates another force.

Newton's Third Law: net flow of air is turned down resulting in an 'equal and opposite' upward force.



## *Lift from Flow Turning*

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Lift is a force.

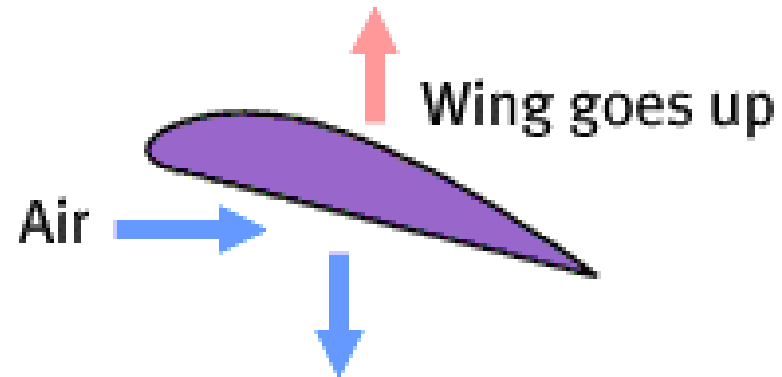


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# Newton's Third Law

Newton's Third Law states that for every action there is an equal and opposite reaction.

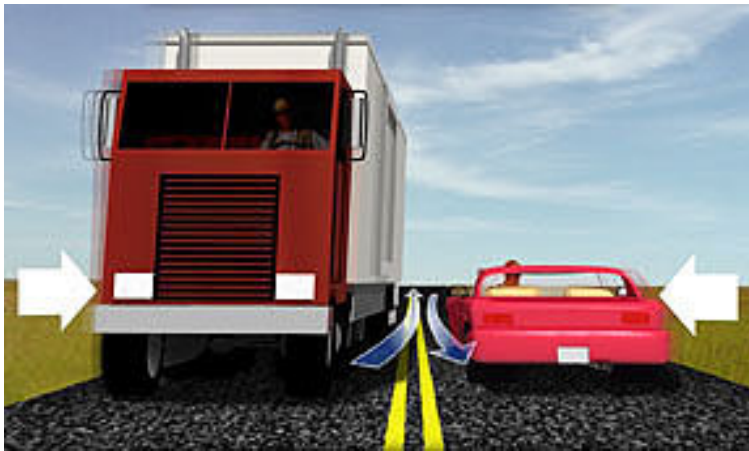


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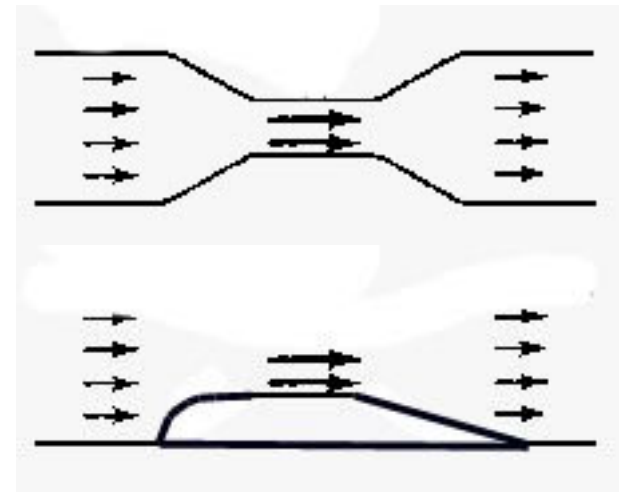


# The Venturi Tube

- Bernoulli's first practical use of his theorem
- Where are venturi tubes used today?



Air speeds up in the constricted space between the car & truck creating a low-pressure area. Higher pressure on the other outside pushes them together.



A wing is really just half a venturi tube!

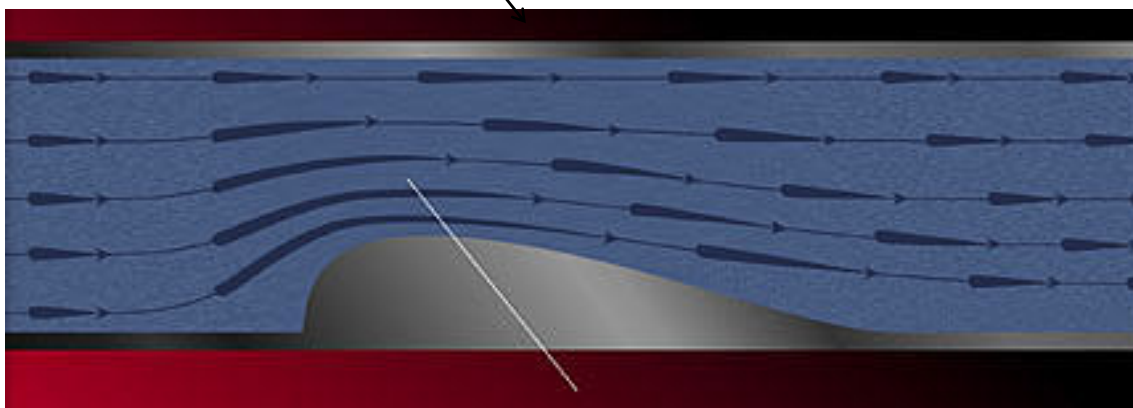


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# Bernoulli's Principle

Bernoulli's Principle states that, as air speeds up, its pressure goes down.



A fluid (and air acts like a fluid) speeds up as it moves through a constricted space



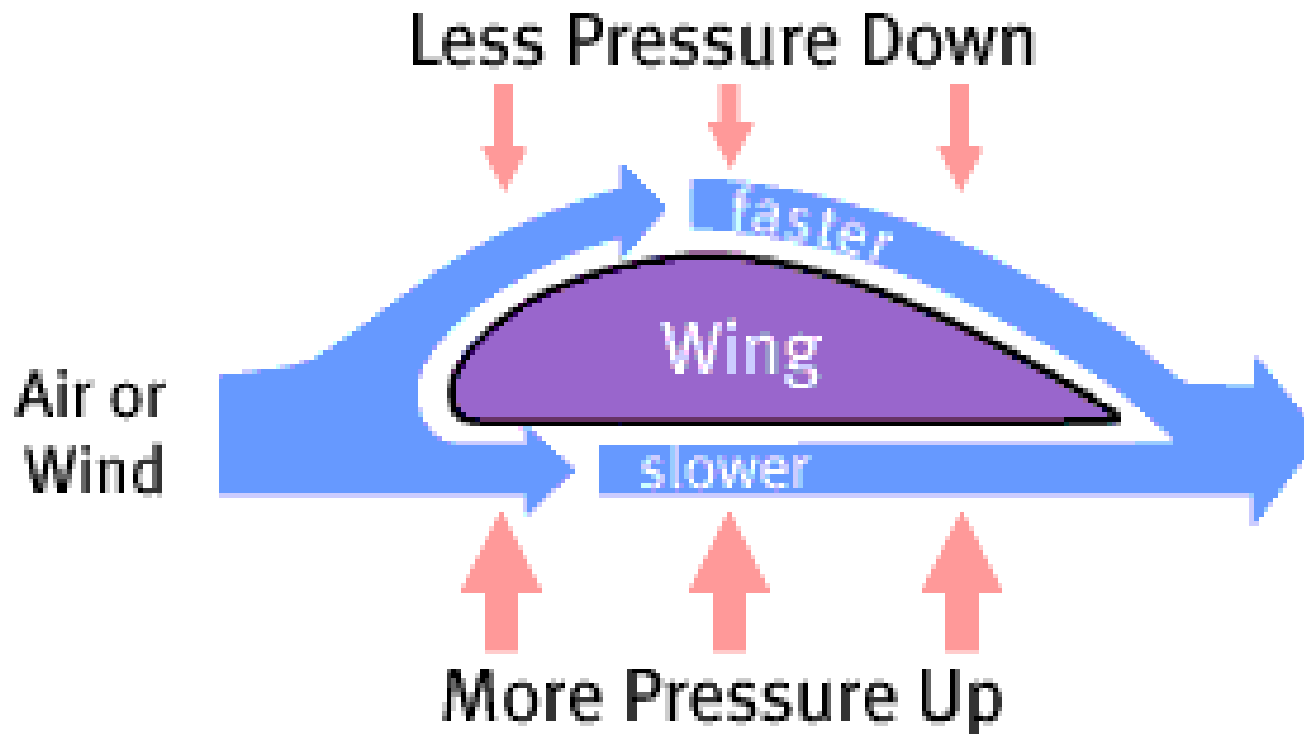
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# Bernoulli's Principle

Slower moving air below the wing creates greater pressure and pushes up.

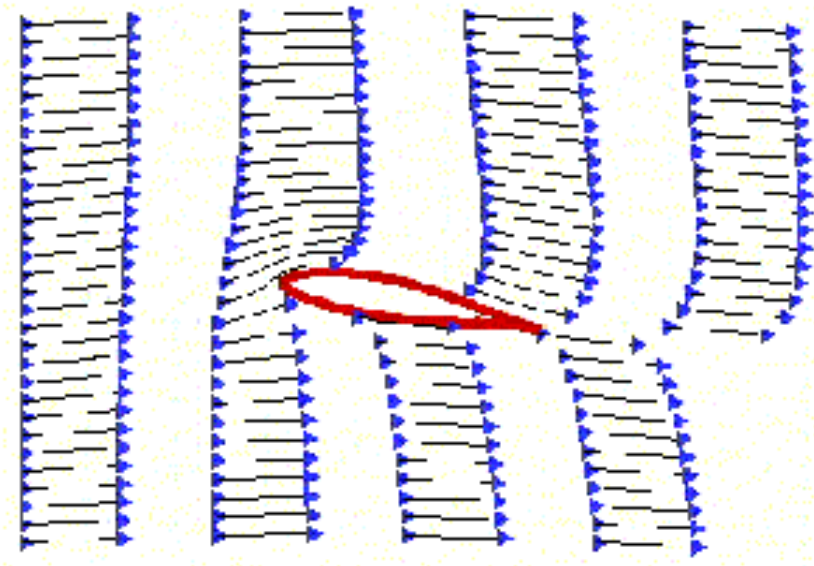
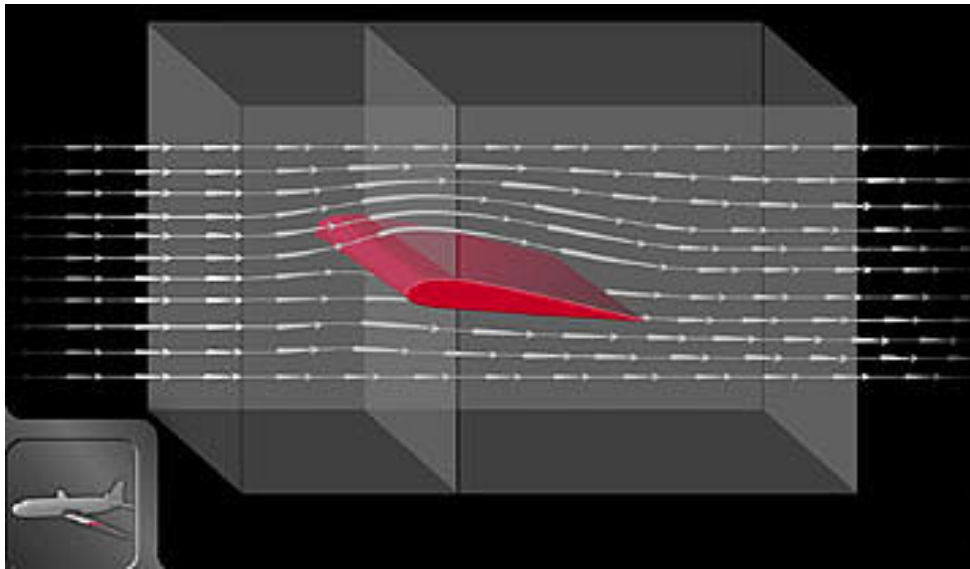


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# Bernoulli's Principle

Air moving over the wing moves faster than the air below. Faster-moving air above exerts less pressure on the wing than the slower-moving air below. The result is an upward pull on the wing from the top, and a push from the bottom--lift!

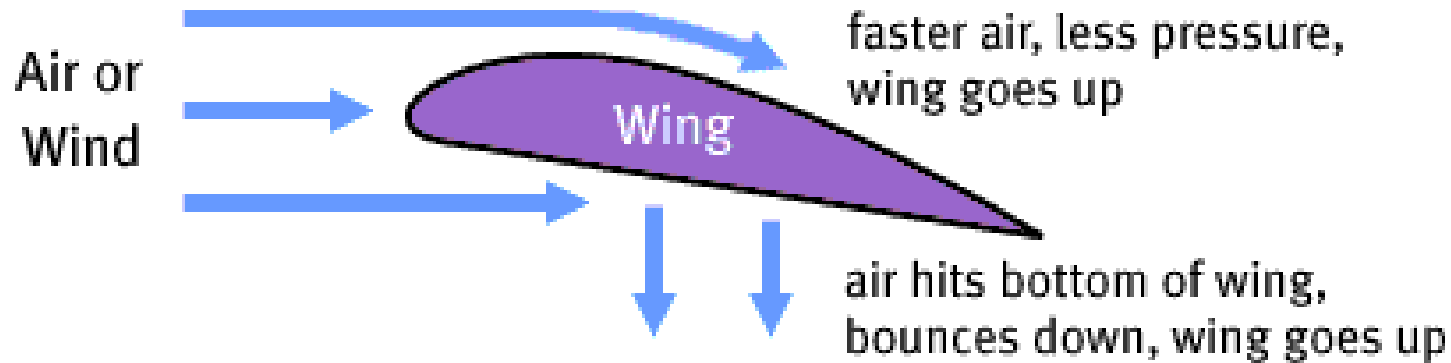


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# Creating Lift

A wing creates lift due to a combination of Bernoulli's principal & Newton's third law



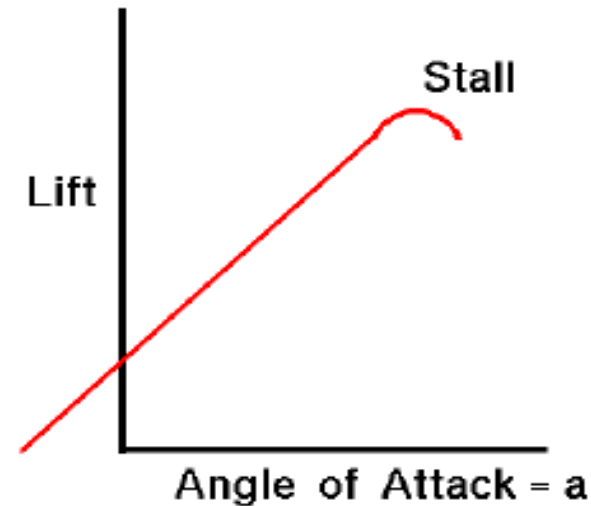
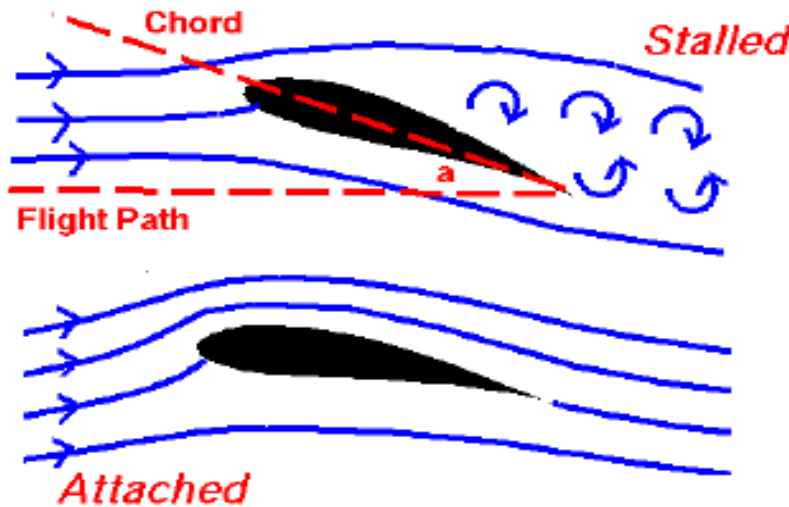
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# Lift vs Angle of Attack

## Inclination Effects on Lift

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For small angles, lift is related to angle.

**Greater Angle = Greater Lift**

For larger angles, the lift relation is complex.

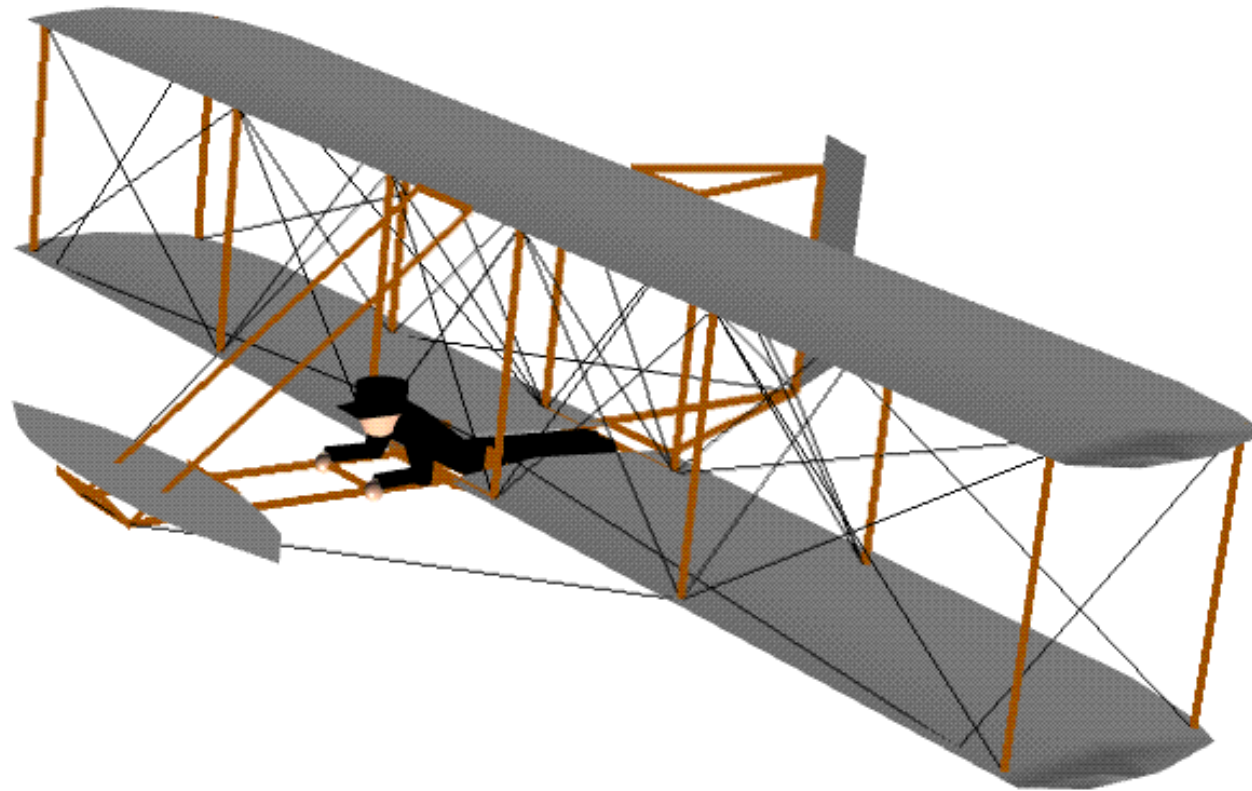
**Included in Lift Coefficient**



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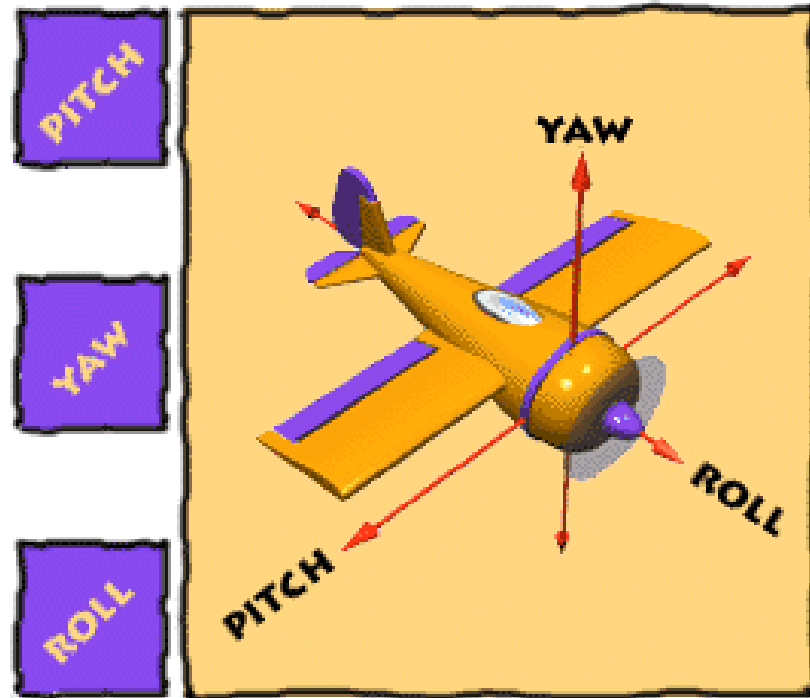
# Pitch Around the Lateral Axis



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# Elevator Controls Pitch

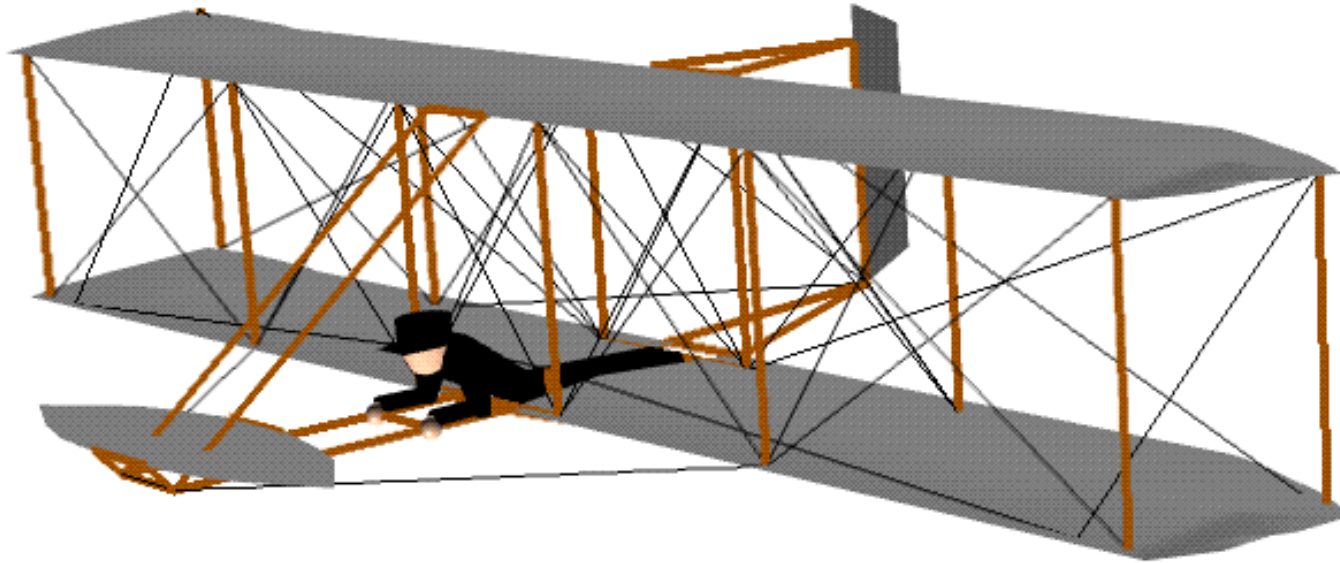


The elevator controls pitch. On the horizontal tail surface, the elevator tilts up or down, decreasing or increasing lift on the tail. This tilts the nose of the airplane up and down.





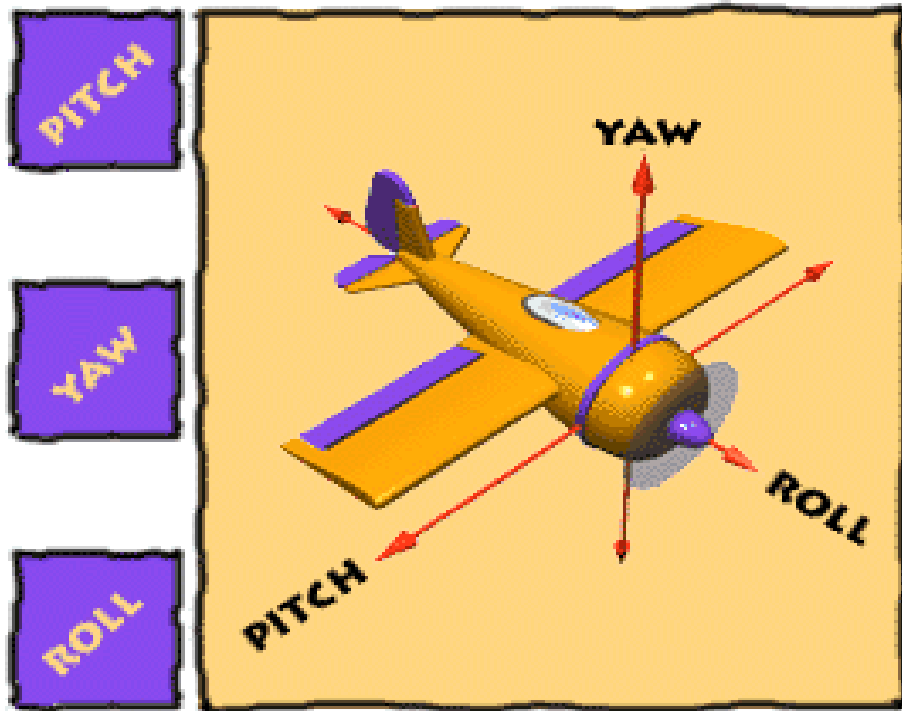
# Roll Around Longitudinal Axis



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# Ailerons Controls Roll



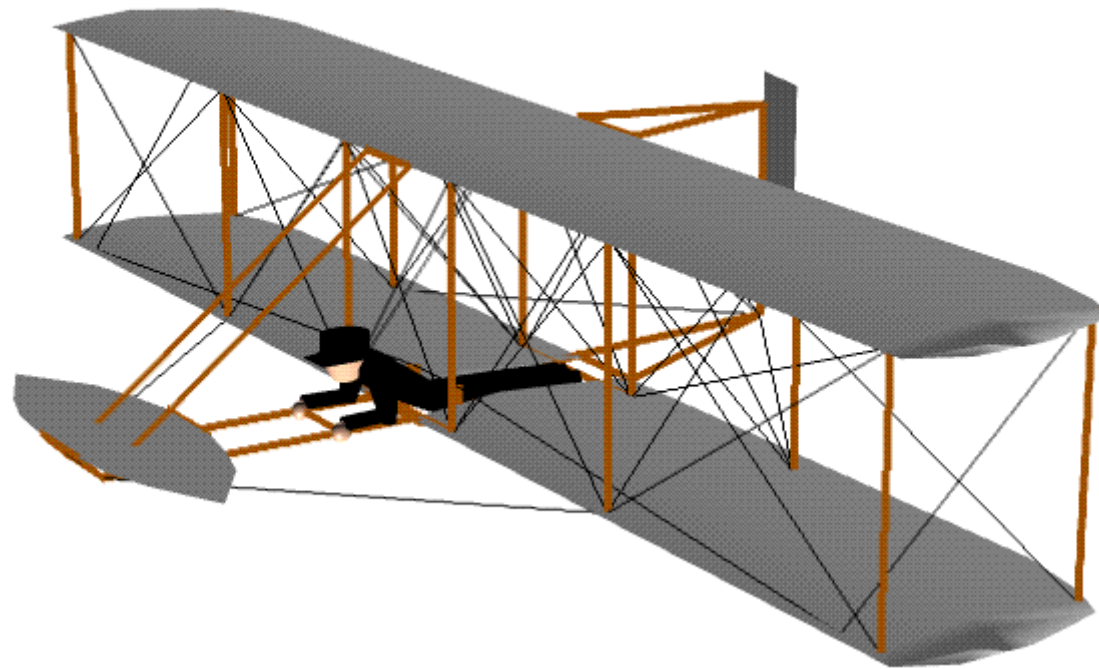
The ailerons control roll. On the outer rear edge of each wing, the two ailerons move in opposite directions, up and down, decreasing lift on one wing while increasing it on the other. This causes the airplane to roll to the left or right.







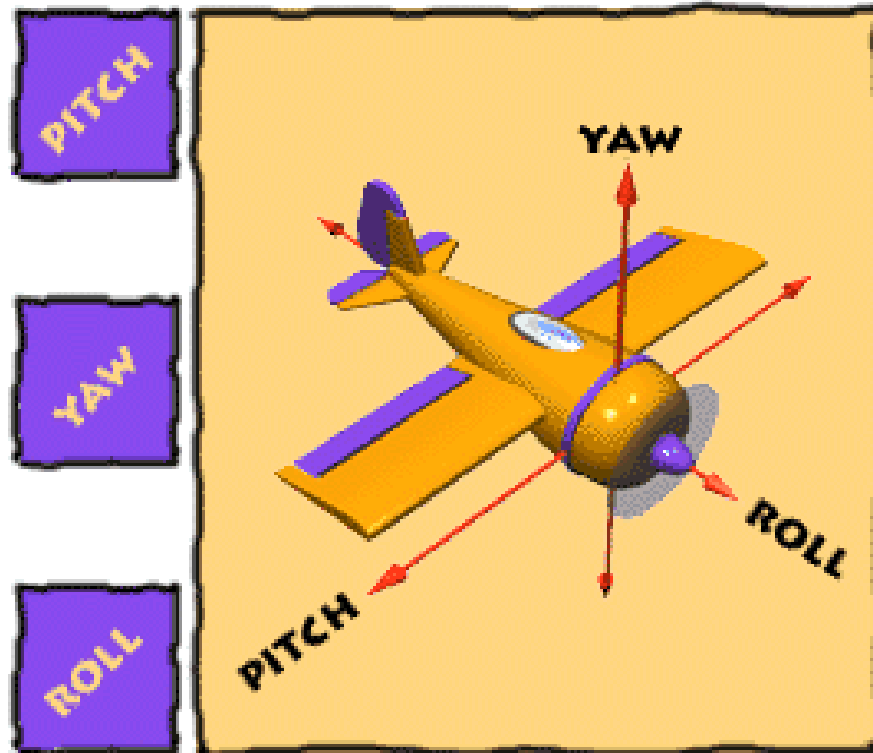
# Yaw Around the vertical Axis



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# Rudder Controls Yaw



The rudder controls yaw. On the vertical tail fin, the rudder swivels from side to side, pushing the tail in a left or right direction. A pilot usually uses the rudder along with the ailerons to turn the airplane.



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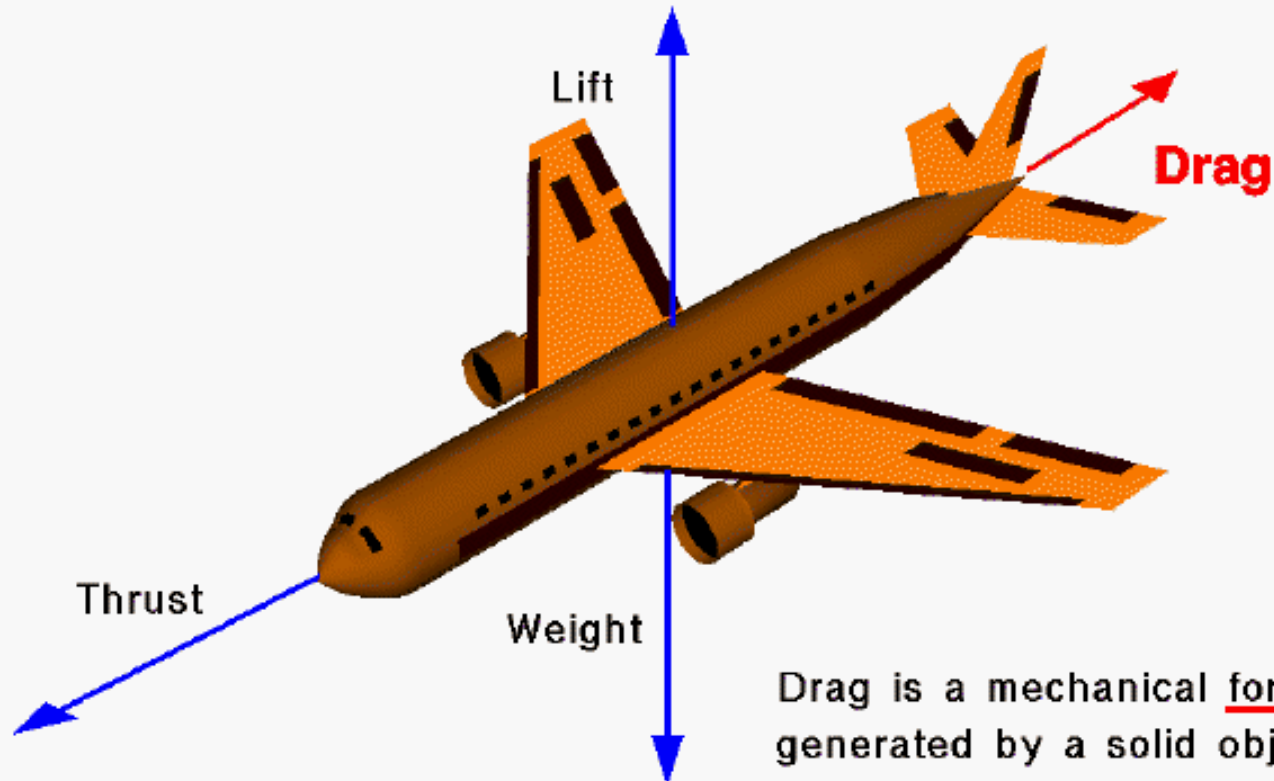


# The Force of Drag



## What is Drag?

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Drag is a mechanical force generated by a solid object moving through a fluid.

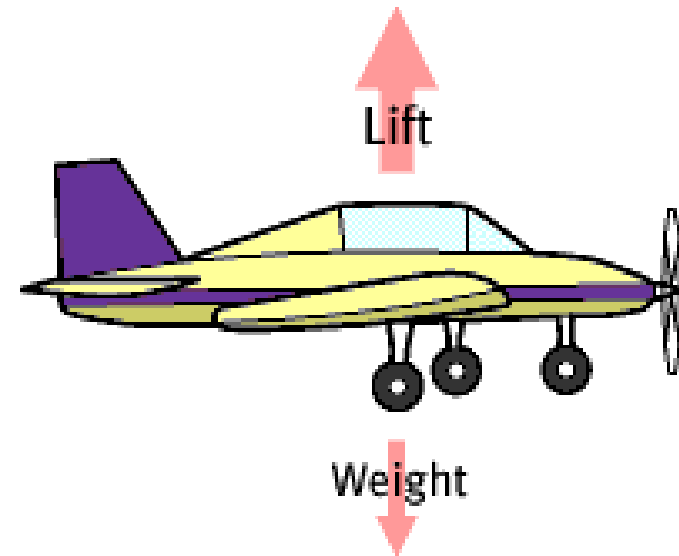


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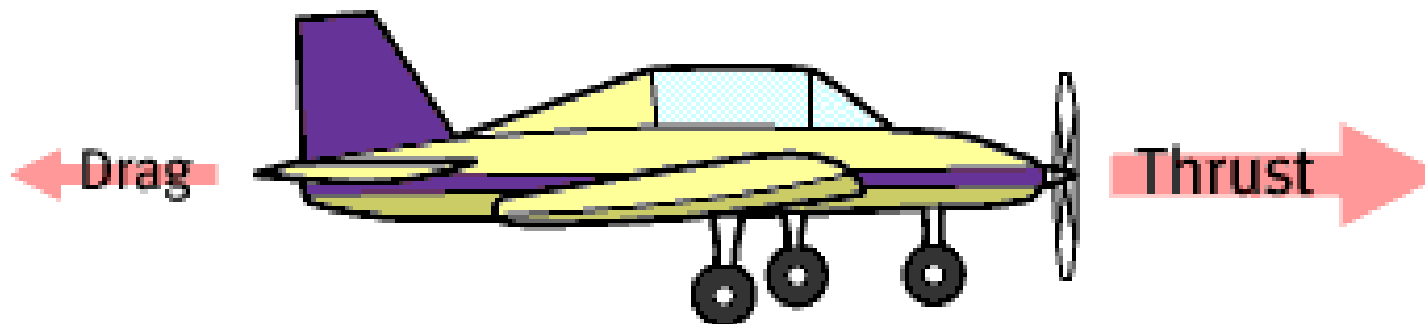


# Lift and Thrust

For an airplane to take off, lift must be greater than weight.



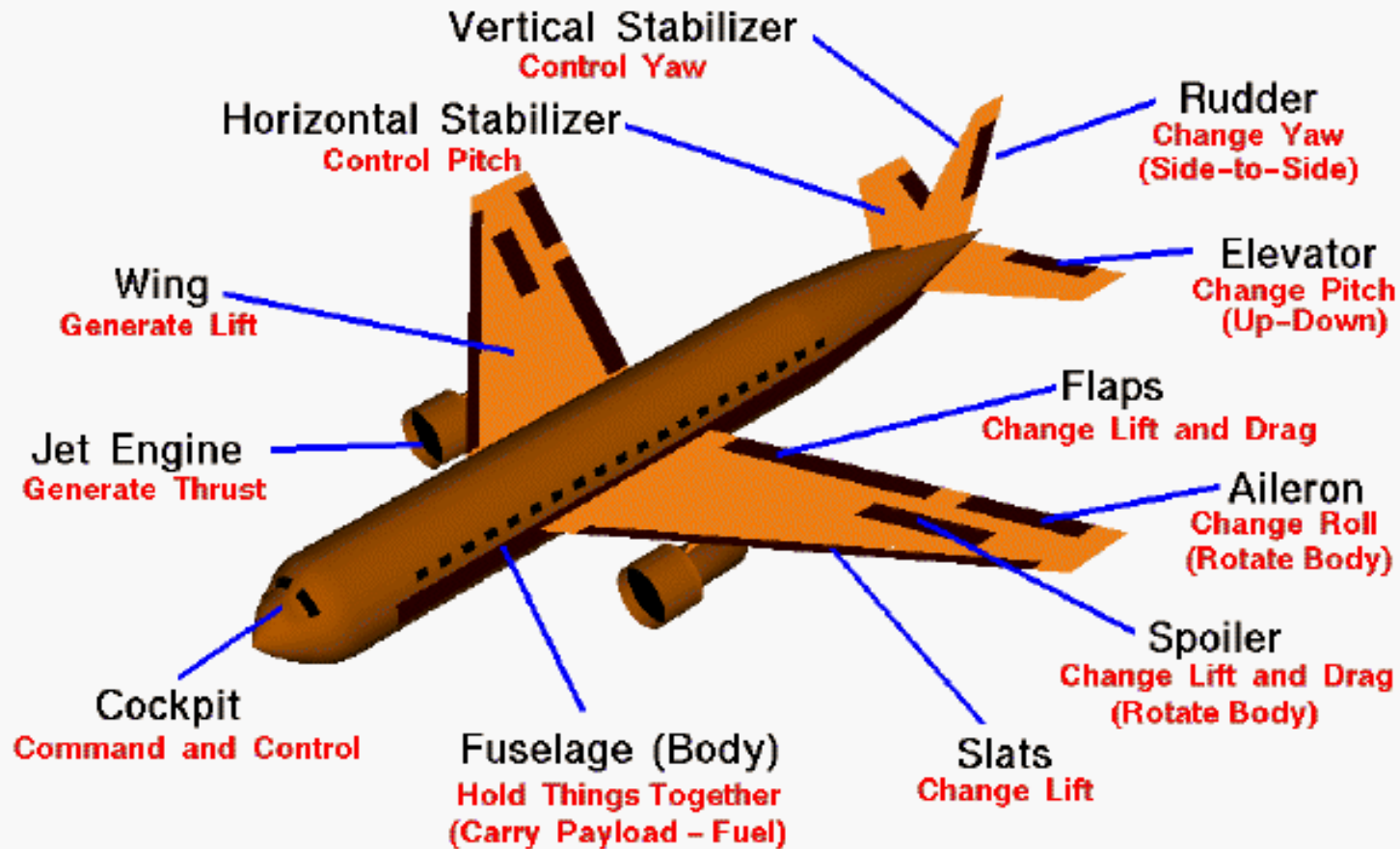
For an airplane to speed up while flying, thrust must be greater than drag. Thrust can be generated by a propeller or jet turbine.





## Airplane Parts Definitions

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