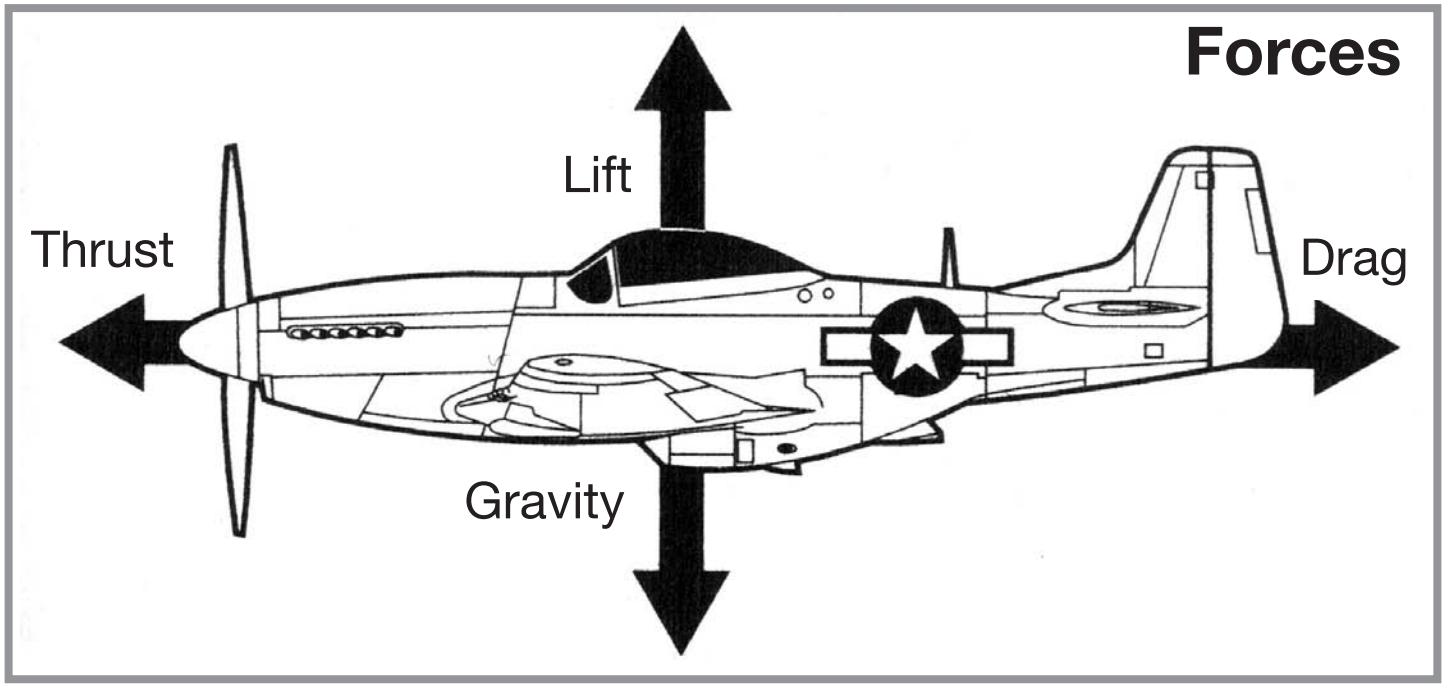
The Principles of Flight

All manoeuvres make use of one or more vectors of movement – pitch, yaw and roll. To initiate these movements, you use the aircraft's control surfaces. The rudder, elevators and ailerons cause the action listed below.

Physics

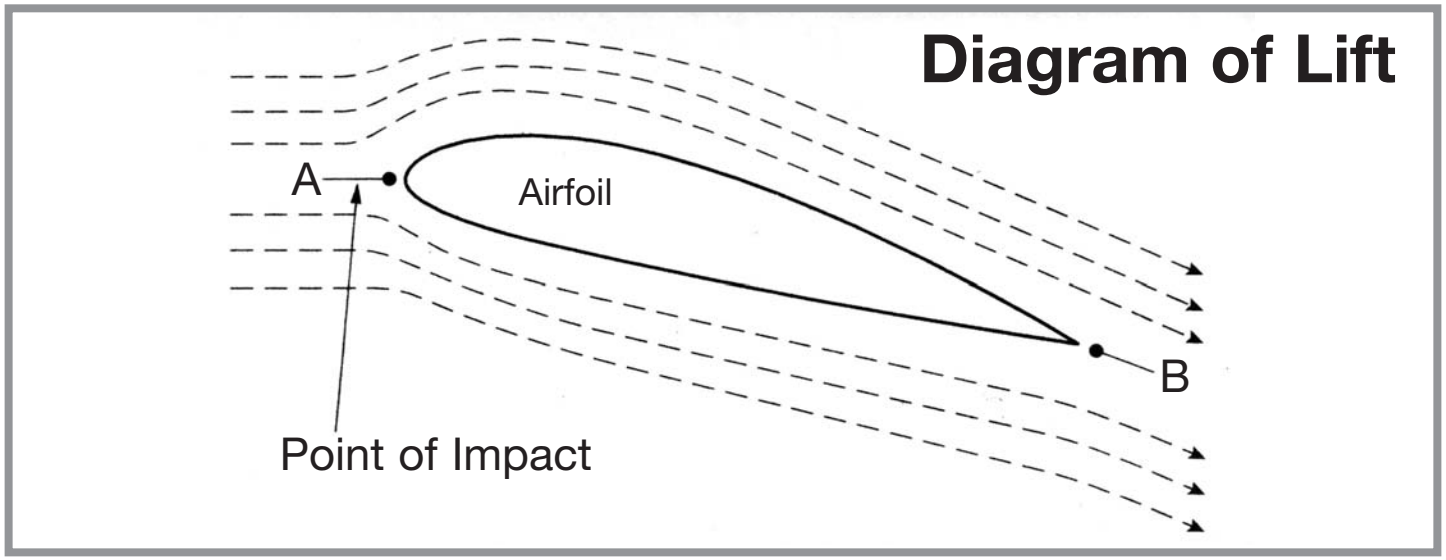


The miracle of flight exists because man has the technology to oppose natural forces that keep all objects on the ground. Four forces affect an aircraft – two assist flight (thrust and lift), and two resist flight (gravity and drag). The important thing to note here is that when an aircraft is flying straight and level, all four of these forces are balanced, or in equilibrium.

Thrust

Thrust is created by the engine/s. The engine turns the propeller which in turn pushes the air backwards to make the aircraft move forwards. As the wings move through the air, lift is created. This is the force that pushes an aircraft up into the air.

Lift



Two main factors determine how much lift is created.

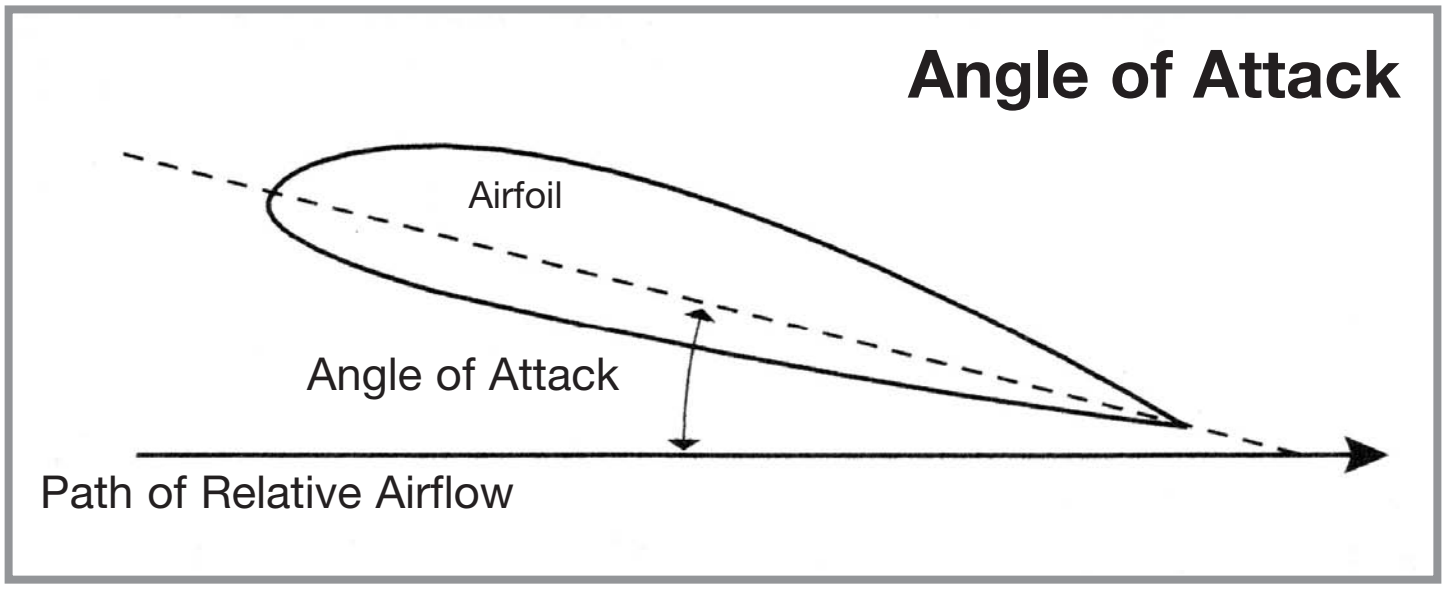
Firstly, lift depends upon the shape of the wing. Lift occurs because air flows both over and under the surface of the wing. The wing is designed so that the top surface is "longer" than the bottom surface in any given cross-section. In other words, the distance between points A to B is greater along the top of the wing than under it. The air moving over the wing must travel from A to B in the same amount of time as the air moving under it. Therefore, the air is moving faster along the top of the wing. This creates a difference in air pressure above and below – a phenomenon called the Bernoulli effect. The pressure pushing up is greater than the downward pressure, and lift is created.

Secondly, consider the angle at which the wing presents itself to the relative airflow. This is called the angle of attack. The steeper this angle, the more lift occurs. At angles steeper than approximately 15 degrees, however, airflow can be disrupted, and an aircraft stall occurs. During a stall, not enough lift is created. The aircraft's nose falls into a dive and it can recover lift only after gaining airspeed.

A flat plate will generate lift if it has enough speed and angle of attack, but it is not efficient and the stall characteristics are not really desirable for full size aircraft. Some successful models do use flat sheet wings.

Drag

Drag opposes thrust. Although it mainly occurs because of air resistance as air flows around the wing, several different types of drag exist. Drag is mainly created by simple skin friction as air molecules "stick" to the wing's surface. Smoother surfaces incur less drag, while bulky structures create additional drag.



Some drag has nothing to do with air resistance, and is actually a secondary result of lift. Because lift angles backward slightly, it has both an upward vertical force and a horizontal rearward force. The rearward component is drag.

Gravity

Gravity is actually a force of acceleration on an object. The Earth exerts this natural force on all objects. Being a constant force, it always acts in the same direction: downward. Thrust creates lift to counteract gravity. In order for an aircraft to take off, enough lift must be created to overcome the force of gravity pushing down on the aircraft.

Related to gravity are G-forces – artificially created forces that are measured in units equivalent to the force of gravity. See below for details.

G-Force

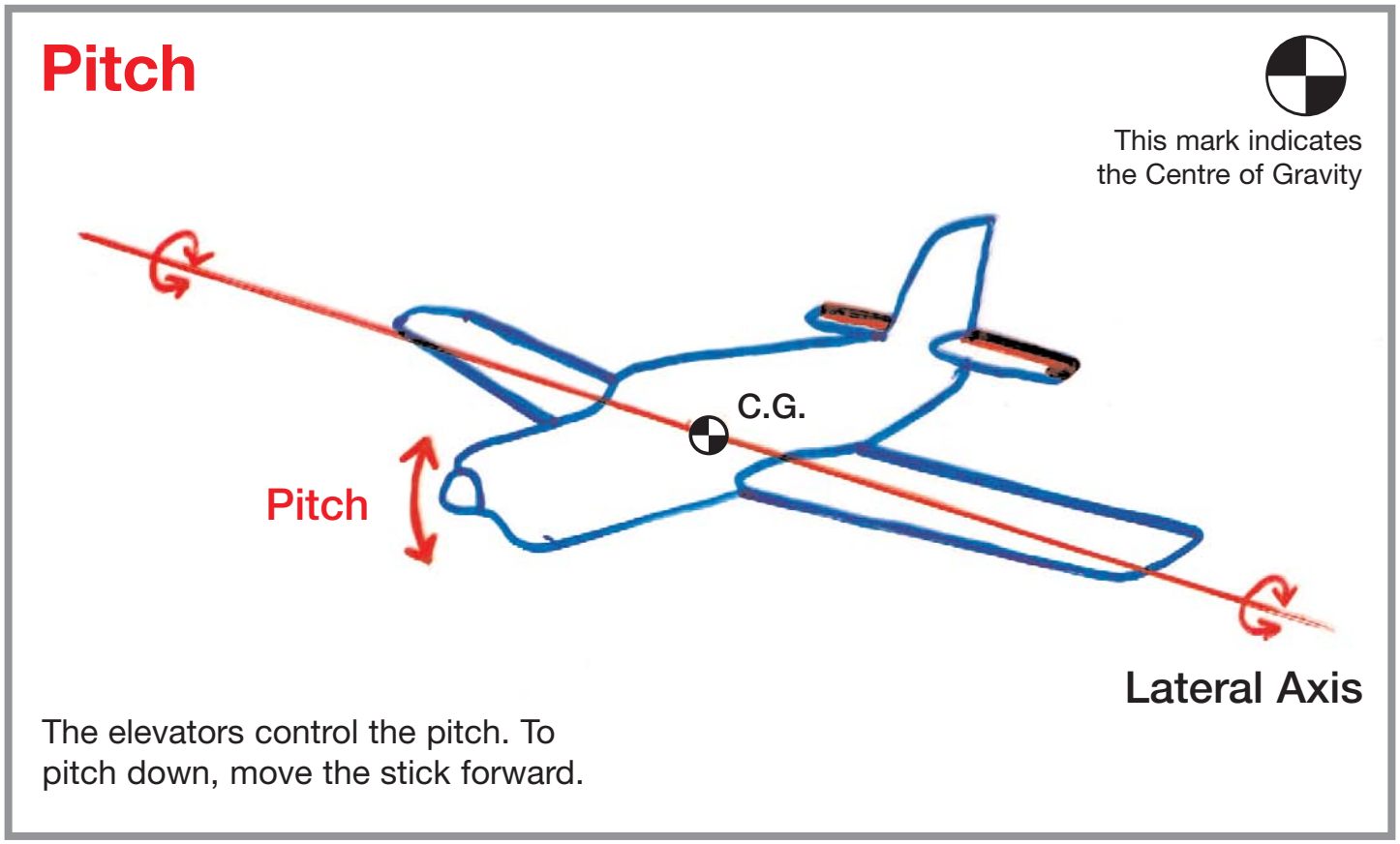
A “G” is a measurement of force that is equal to the force of gravity pushing down on a stationery object on the earth’s surface. Gravitational force actually refers to an object’s weight (Force equals Mass times Acceleration, or F=ma). An aircraft flying level at low altitudes experiences 1G. Extra G-forces in any direction can be artificially created by sudden changes in velocity or in the direction of motion. Good examples are a takeoff, in a tight turn in an aircraft at moderate to high speed.

G-forces can be either positive or negative. Positive Gs make you feel heavier because they act in a relative downward direction. They push you back into your seat and primarily occur during sharp turns or steep climbs. Negative Gs make you feel lighter because they pull you out of your seat.

Apparent Weight

Apparent weight refers to how heavy something seems considering the current direction and magnitude of G-forces acting on it. In level flight, 1G is acting on the aircraft and the pilot – both weigh the same as they do when stationary. If the pilot makes a steep climb, the positive G-force temporarily acts on both the pilot and the aircraft, making them in essence heavier throughout the climb. Any sudden increase or decrease in acceleration brings about a change in apparent weight of an object.

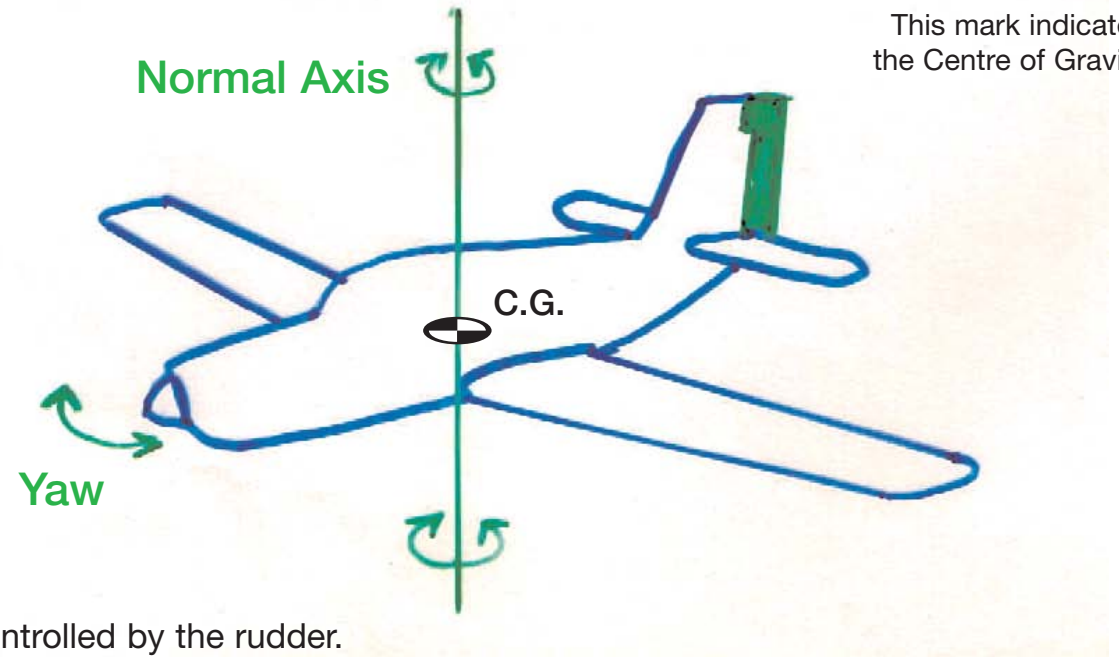
Movement Vectors



Pitch is the up and down movement of the aircraft’s nose around an axis line drawn from wingtip to wingtip (the lateral axis.) When you apply pitch by easing back on the stick, you angle the aircraft’s elevators up, causing the nose to rise.

Yaw

This mark indicates the Centre of Gravity

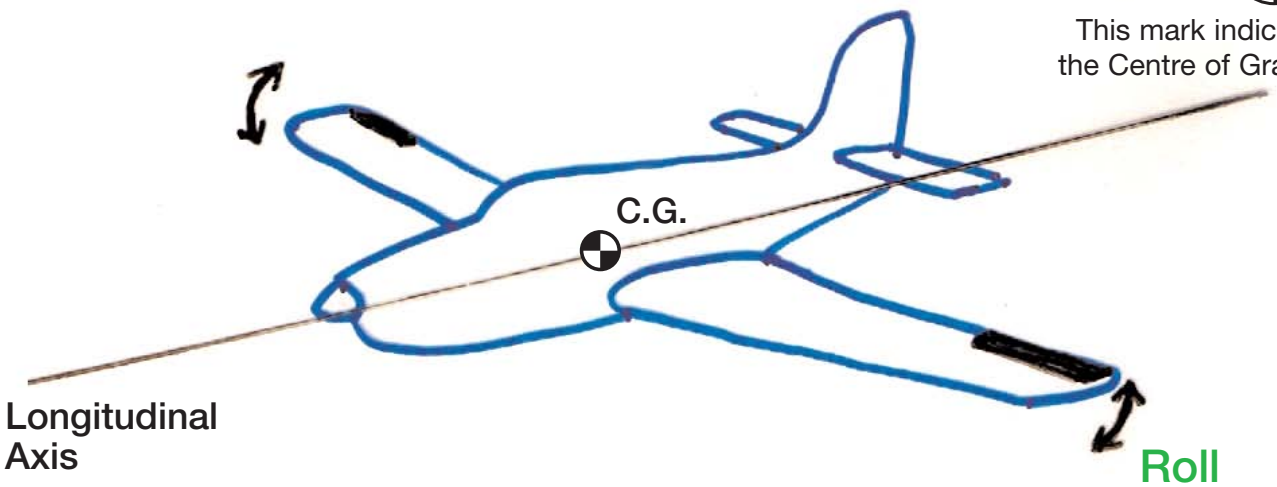


The Yaw is controlled by the rudder.
To yaw to the left move the stick to the left.

Yaw is the side-to-side rotation of the aircraft's nose around a vertical axis through the centre of the aircraft. It changes the direction of flight. You use the rudder to angle the aircraft's tail left or right, which creates yaw.

Roll

This mark indicates the Centre of Gravity



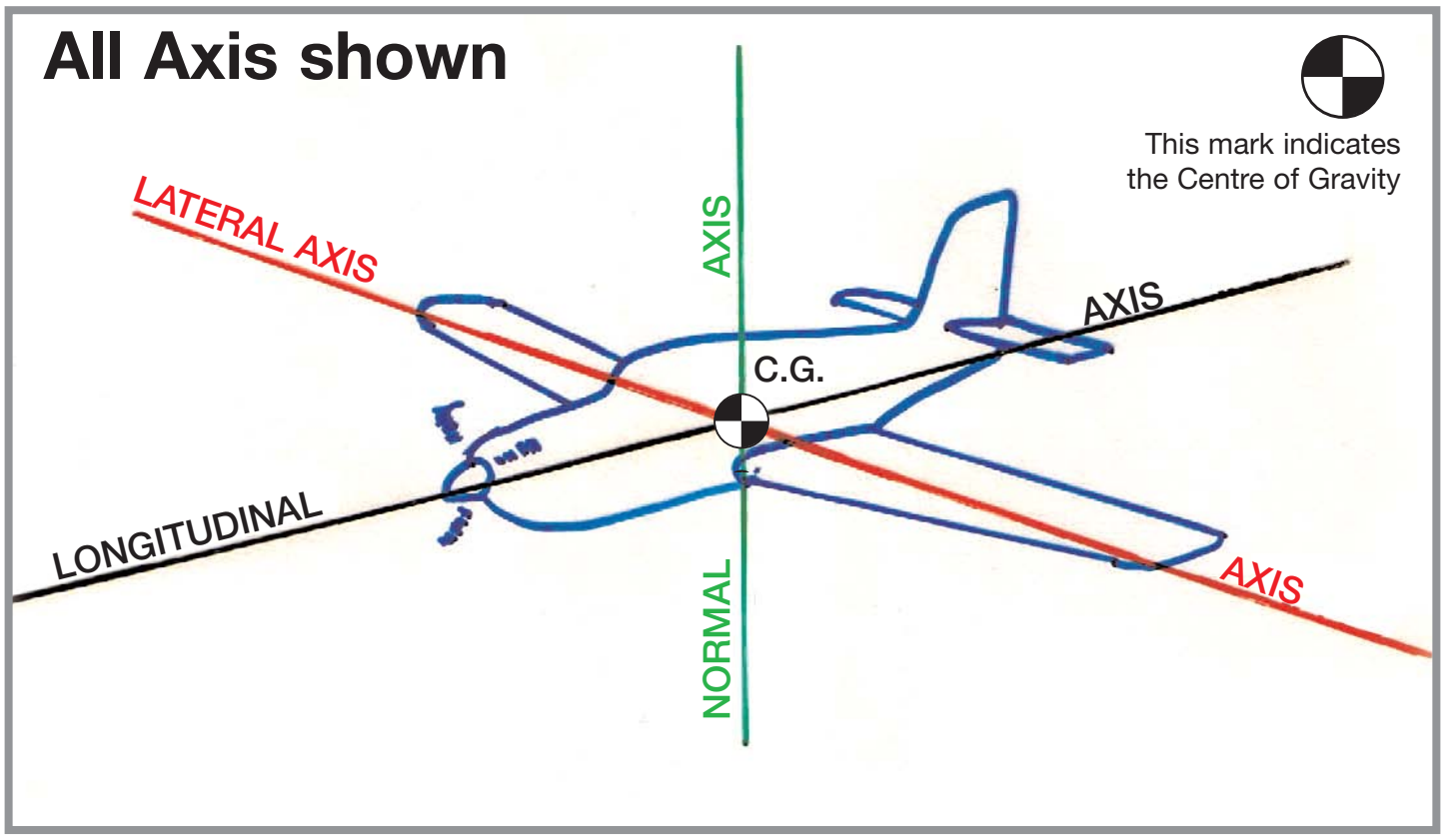
The ailerons control the roll. Move the stick to the left to roll to the left.

Roll is the tipping of the wings up or down around the longitudinal axis. The aircraft maintains its current direction of flight, but the wings roll around an imaginary line drawn from the nose through the tail. Roll occurs when you ease the stick left or right, causing one aileron to angle down and the other to angle up. This increases lift under one wingtip while decreasing lift under the other, creating roll.

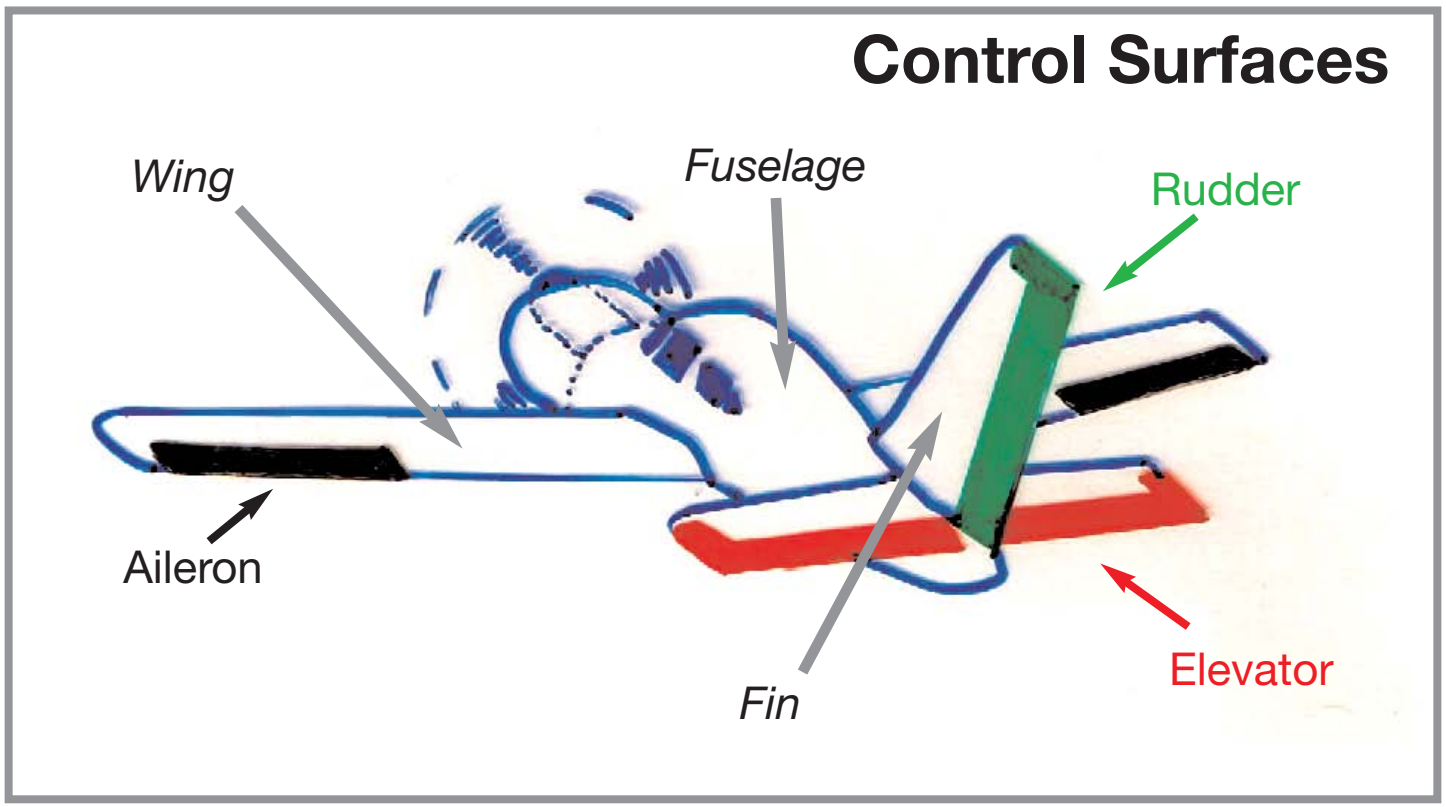
Bank

You can combine pitch and roll movements to make a banking turn. By applying right stick, you cause the aircraft bank to the right. You can accomplish a left bank by applying left stick. A banking turn changes both the angle of the nose (pitch) and the direction of flight. You may need to ease the nose up to compensate for the loss of lift due to the banked wing.

One side-effect of a banked turn is that you lose both lift and airspeed.



Control Surfaces



All control surfaces utilize the principles of lift, but they apply lift forces in different directions. These forces act either independently or in conjunction with one another to produce various

manoeuvres. Each manoeuvre is the net resultant force of all individual forces. (A resultant force is the average force that results when two forces are combined. For example, a pure vertical force and a horizontal force create an angled force.)

Elevators

Elevators are flat, hinged surfaces on the tailplane (the horizontal part of the tail assembly). While the entire tailplane surface helps stabilize the aircraft during flight, the elevators apply pitch by angling the trailing (rear) edge of the tailplane up or down.

To create pitch, gently ease the flight stick back or ease it forward. Take care not to perform pitch manoeuvres too quickly. If the angle of attack (angle that the air meets the wing) becomes too steep, the flow of air around the wings can become disrupted. Air no longer flows smoothly over the wing; instead, it buffets in several different directions and disrupts the air pressure around the wing's surface. This situation is called a stall. Stalls can also occur from lack of airspeed, when not enough air flows over the wings to create lift.

Rudder

The rudder is the vertical component of the tail assembly. The rear half of the vertical tail section is hinged, allowing it to yaw left or right. When you apply rudder, you redirect the aircraft's nose either left or right around the vertical axis.

Applying left rudder yaws the nose to the left, while applying right rudder yaws the nose to the right. Note that applying rudder also produces a slight rolling movement, known as a secondary effect.

Ailerons

Ailerons are thin, hinged surfaces on the outer, trailing edge of each wing. They angle in opposite directions to waggle the wings up and down or roll the aircraft about its nose-tail axis. If you apply stick left or right, one wing's aileron angles down and the other angles up. This rolls one wing up and forces the other wing down, effectively rolling the aircraft.

When you apply left stick, the left aileron raises and the right one drops, and the aircraft roll to the left. The opposite occurs if you ease the stick in the opposite direction.