

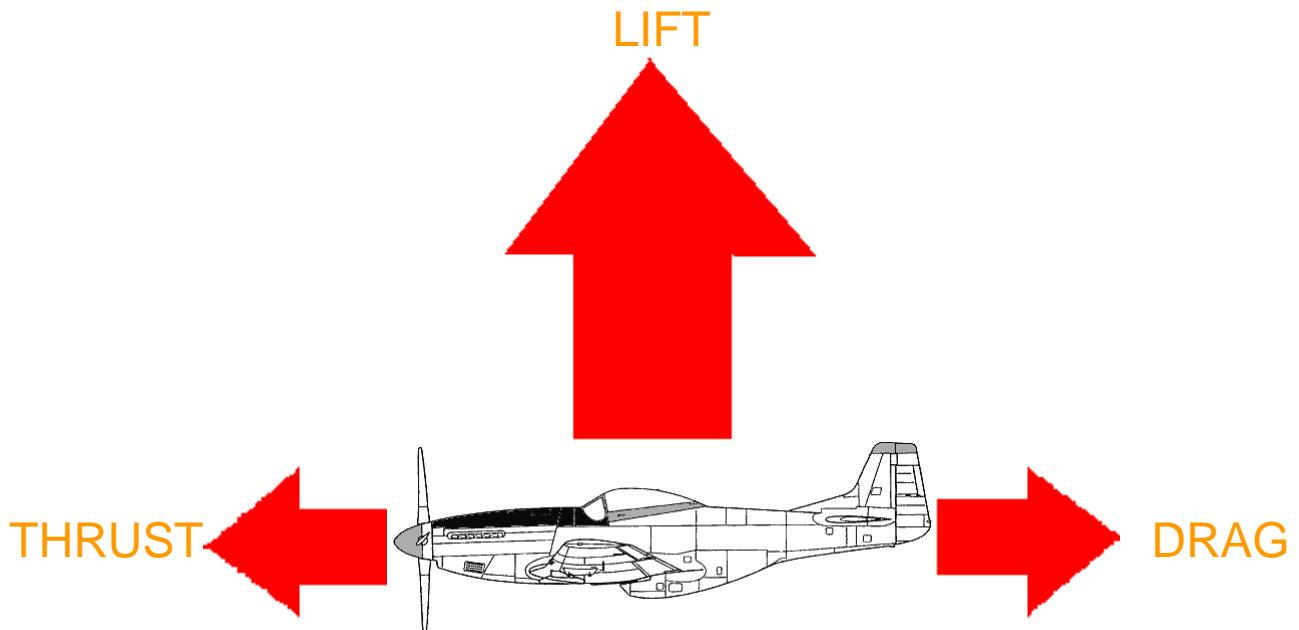


HILL AEROSPACE MUSEUM

HILL AIR FORCE BASE, UTAH

How Do Airplanes Fly?

There are four physical forces that work on an airplane in flight. **LIFT** is the aerodynamic force that keeps the airplane aloft. **GRAVITY** is the force that pulls the airplane down toward the Earth's surface. **THRUST** is the force created by the engine and propeller (or jet engine, depending on the airplane) that pushes the plane forward. **DRAG** is the force that holds the airplane back due to air resistance, or friction, against the surfaces of the airplane.





The balance and interplay of these four forces determine if and how the airplane flies. Lift must be greater than gravity and thrust must be greater than drag in order for the airplane to take off and fly. In level flight at constant speed, thrust exactly equals drag and lift exactly equals the pull of gravity. To land, an aircraft's thrust must be reduced safely below its drag, as its lift is reduced to levels less than its weight.

Lift is the aerodynamic force that counteracts gravity and holds an airplane in the air. Most of the lift required by an airplane is created by its wings, but a certain portion is also generated by other parts of the aircraft, such as the fuselage. But what actually causes the creation of lift?

First, understand that air is a fluid, just like water, and that all fluids adhere to the same physical and mathematical principles. Next, realize that lift can only be generated when a fluid is in motion. For example, a wing must be passing through the air or the air must be moving around a stationary wing, one or the other. (The way it usually happens is that the wing is doing most of the moving, although the air may be moving too, at the same time.)

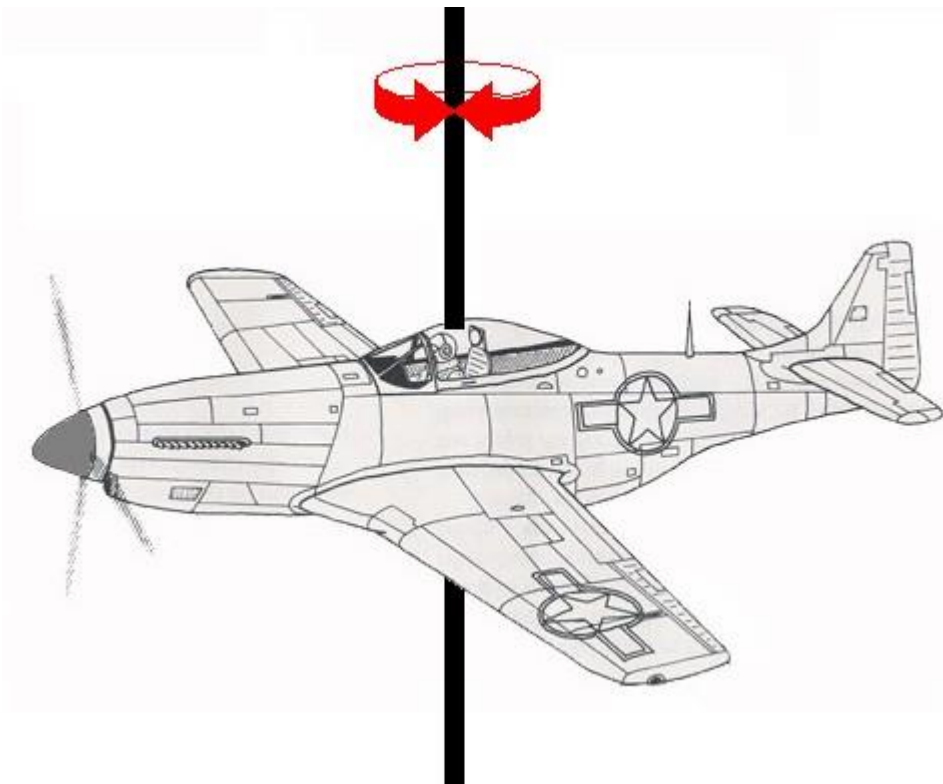
Airplane wings have a special, basic shape as viewed edge-on: their upper surfaces are curved and their lower surfaces are flatter. This shape is what works with the fluid motion of the air to create lift. As air moves around a wing, some goes over the top and some goes underneath. The air that goes over the curved upper surface undergoes two important changes: it is reduced in pressure (by the centrifugal force of flowing across the curved surface) and it is accelerated downward as it leaves the trailing edge of the wing. The wing is forced into the region of reduced air pressure above the upper surface of the wing by the higher air pressure beneath the wing. Also, the downward acceleration of the air ("downwash") at the trailing edge forces the wing upward.

Since lift is dependent on the motion of the air, it increases as the speed of the air increases. Lift also increases (to a point) as the angle that the wing makes with the airflow (known as the *angle of attack*) increases. Past a certain point, however, increased angle of attack will cause the wing to suddenly lose its lifting ability, or *stall*.

A pilot guides an airplane in flight by moving the aircraft in three basic ways, using the plane's *control surfaces*:

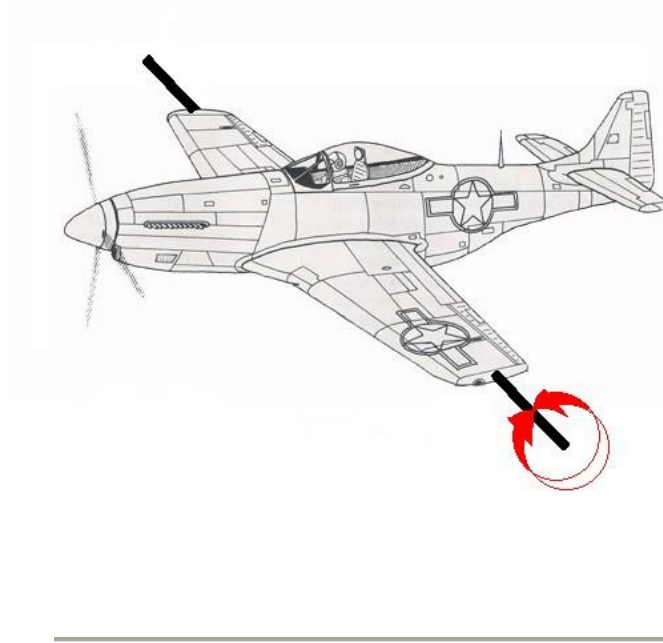
YAW is movement around the vertical axis (right and left). The rudder on the rear edge of the vertical stabilizer on the airplane's tail controls yaw. It is connected to the pedals at the pilot's feet. Pushing the right pedal causes the rudder to deflect to the right. This makes the tail of the airplane move toward the left, causing the nose to move to the right. Pushing the left pedal makes the rudder deflect left, the tail move to the right, and the nose point to the left.

Although the rudder pedals and control wheel in the cockpit are not linked together, they must be used simultaneously to control the airplane. The pilot guides the airplane by careful and precise movements of the control wheel and rudder pedals, as well as adjusting the thrust of the aircraft.



PITCH is movement around the lateral axis (up and down). The elevators on the rear of the horizontal stabilizer of the tail of an airplane control pitch. They are tied to the control wheel in the cockpit. When the wheel is pulled back, the elevators move upward, causing the tail to move downward and the nose to pitch upward. When the wheel is pushed forward, the elevators move downward, causing the tail of the plane to rise and the nose to pitch downward.

The elevators work by causing changes in the lift generated by the tail surfaces of the airplane. Also, the elevators of most airplanes work together, simultaneously. Both go up when the control wheel is pulled back and both go down when the wheel is pushed forward.



ROLL is movement around the longitudinal axis (banking left or right). This motion is controlled by the *ailerons* on the outer trailing edges of both wings. The ailerons are tied to the control wheel in front of the pilot and work together, simultaneously, but in opposition to each other. When the control wheel is turned left, the aileron on the left wing goes up and the one on the right wing goes down. The opposite occurs when the wheel is turned right.

The ailerons alter the lifting ability of the wings slightly. When an aileron is lowered, the lift on the outer portion of that wing increases, causing that wing to rise a little. When an aileron is raised, the lift on the outer portion of that wing is decreased slightly, causing the wing to drop a little. Since the ailerons work together, their action causes the airplane to roll around its longitudinal axis.

