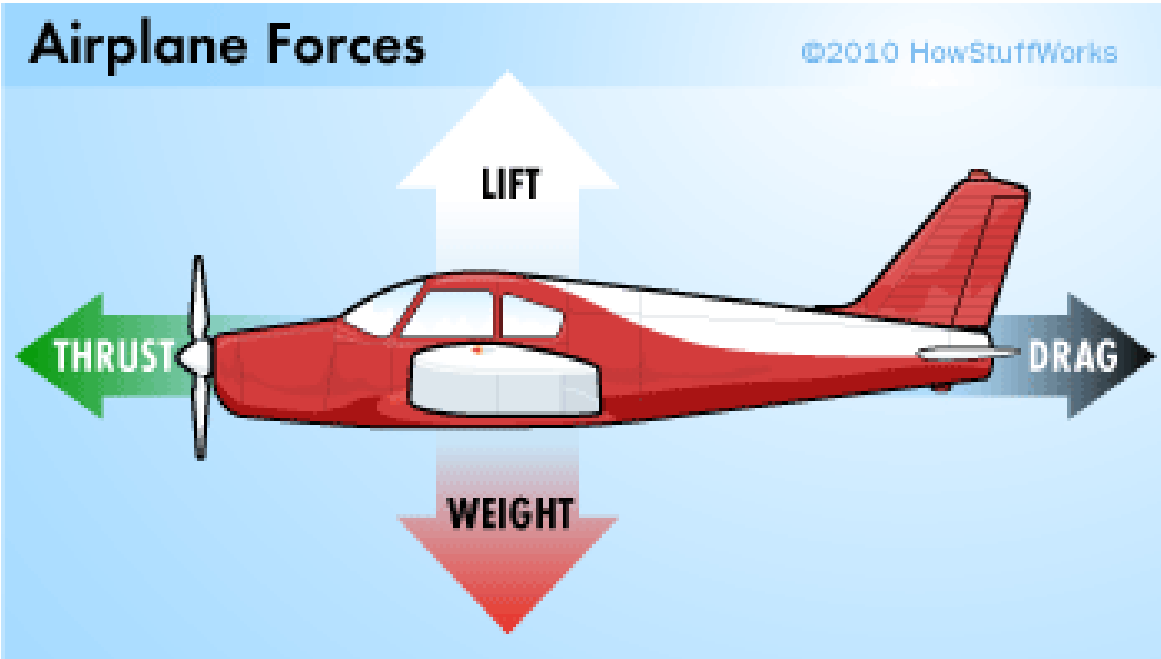
How Do Planes Fly: Thrust and Drag



Airplanes take advantage of four forces.

Drop a stone into the ocean and it will sink into the deep. Chuck a stone off the side of a mountain and it will plummet as well. Sure, steel ships can float and even very heavy airplanes can fly, but to achieve flight, you have to exploit the four basic aerodynamic forces: lift, weight, thrust and drag. You can think of them as four arms holding the plane in the air, each pushing from a different direction.

First, let's examine thrust and drag. **Thrust**, whether caused by a propeller or a jet engine, is the aerodynamic force that pushes or pulls the airplane forward through space. The opposing aerodynamic force is **drag**, or the friction that resists the motion of an object moving through a fluid (or immobile in a moving fluid, as occurs when you fly a kite).

If you stick your hand out of a car window while moving, you'll experience a very simple demonstration of drag at work. The amount of drag that your hand creates depends on a few factors, such as the size of your hand, the speed of the car and the density of the air. If you were to slow down, you would notice that the drag on your hand would decrease.

We see another example of drag reduction when we watch downhill skiers in the Olympics. Whenever they get the chance, they'll squeeze down into a tight crouch. By making themselves "smaller," they decrease the drag they create, which allows them to zip faster down the hill.

A passenger jet always retracts its landing gear after takeoff for a similar reason: to reduce drag. Just like the downhill skier, the pilot wants to make the aircraft as small as possible. The amount of drag produced by the landing gear of a jet is so great that, at cruising speeds, the gear would be ripped right off the plane.

For flight to take place, thrust must be equal to or greater than the drag. If, for any reason, the amount of drag becomes larger than the amount of thrust, the plane will slow down. If the thrust is increased so that it's greater than the drag, the plane will speed up.

Every object on Earth has **weight**, a product of both gravity and mass. A Boeing 747-8 passenger airliner, for instance, has a maximum takeoff weight of 487.5 tons (442 metric tons), the force with which the weighty plane is drawn toward the Earth.

Weight's opposing force is **lift**, which holds an airplane in the air. This feat is accomplished through the use of a **wing**, also known as an **airfoil**. Like drag, lift can exist only in the presence of a moving fluid. It doesn't matter if the object is stationary and the fluid is moving (as with a kite on a windy day), or if the fluid is still and the object is moving through it (as with a soaring jet on a windless day). What really matters is the relative difference in speeds between the object and the fluid.

As for the actual mechanics of lift, the force occurs when a moving fluid is deflected by a solid object. The wing splits the airflow in two directions: up and over the wing and down along the underside of the wing.

The wing is shaped and tilted so that the air moving over it travels faster than the air moving underneath. When moving air flows over an object and encounters an obstacle (such as a bump or a sudden increase in wing angle), its path narrows and the flow speeds up as all the molecules rush though. Once past the obstacle, the path widens and the flow slows down again. If you've ever pinched a water hose, you've observed this very principle in action. By pinching the hose, you narrow the path of the fluid flow, which speeds up the molecules. Remove the pressure and the water flow returns to its previous state.

As air speeds up, its pressure drops. So the faster-moving air moving over the wing exerts less pressure on it than the slower air moving underneath the wing. The result is an upward push of lift. In the field of fluid dynamics, this is known as **Bernoulli's principle**.

How does gravity work?

Gravity keeps the moon where it's supposed to be -- in orbit.

Every time you jump, you experience gravity. It pulls you back down to the ground. Without gravity, you'd float off into the atmosphere -- along with all of the other matter on Earth.

You see gravity at work any time you drop a book, step on a scale or toss a ball up into the air. It's such a constant presence in our lives, we seldom marvel at the mystery of it -- but even with several well-received theories out there attempting to explain why a book falls to the ground (and at the same rate as a pebble or a couch, at that), they're still just theories. The mystery of gravity's pull is pretty much intact.

So what do we know about gravity? We know that it causes any two objects in the universe to be drawn to one another. We know that gravity assisted in forming the universe, that it keeps the moon in orbit around the Earth, and that it can be harnessed for more mundane applications like gravity-powered motors or gravity-powered lamps.

As for the science behind the action, we know that Isaac Newton defined gravity as a force -- one that attracts all objects to all other objects.