<u>FLIGHT</u>

<u>By M Papadakis JD ©</u>

Some of the older generation still believes flight is accomplished through smoke and mirrors .Look at the white knuckles on an airliner at takeoff, and it is obvious that there are some who still don't believe it can work. Even after thirty years of flying these things, I'm still in awe of the ability of a 747 to get airborne. Here's how it works.

In order to lift the weight of an airplane we have to create a force slightly greater than the weight. The forces are created by air moving around and over the airplane. Just as you can put your arm out the window of a high-speed car and have the wind, try to force your arm up or down and always back, the same forces and laws act on an airplane.

The resistance and wind friction force that act opposite the direction of movement, is **Drag**. The force that is created by the wings is called **Lift**. This lift is always perpendicular to the wind. (Relative wind actually)

It is the rounded shape of the upper surface of the wing that is instrumental in creating the lift. When wind streams over the top of the wing, its shape forces the wind to increase velocity over the rounded portion (called chambre). A law of physics says the faster the velocity the lower the pressure. Thus the wind over the top of a wing is at lower pressure than that moving under the wing.

The pressure exerted on the bottom of the wing exceeds that on the top. If you multiply the pressure difference by the wing area you derive the lift produced by that wing. Sometimes designers mold fuselage backs to mimic wing surface, so even the body of the airplane may contribute a little lift.

The aerodynamic forces exerted by a moving wind stream increase or decrease with the square of the velocity change. Thus doubling the speed will multiply the aerodynamic forces by four (drag and lift) this is true until we get to the high-speed range where compressibility factor comes into play (low subsonic). All General aviation airplanes operate in the area where the rules of compressibility are not a substantial consideration. A P.H.D. in aerodynamics might disagree.

Whenever a wing produces lift it also produces a rearward drag force. This force is actually called induced drag. An airplane in its entirety produces a drag that is the summation of three varieties of drag. There is a skin friction, a cross sectional area drag and the induced drag created with the creation of lift. The summation of these drag forces creates the total **DRAG** of the airplane.

In order to fly we must then create lift greater than the weight of the machine. In order to accomplish the lift we have to have a propulsion unit capable of accelerating the airplane to velocities high enough that the wings will produce the lift force required. Additionally the propulsive unit must overcome the wind friction or drag forces or total **DRAG.** This is accomplished by single or multiple engines.

When an airplane is airborne and flying at constant speed and constant altitude there is a balancing act going on. The propulsive force called thrust will equal all the **DRAG** force. The lift force will equal the weight.

To climb (at constant speed) the lift must exceed the weight .To descend the weight must exceed the lift forces. To accelerate (at constant altitude) the thrust must exceed the drag. To decelerate the drag exceeds the thrust.

On the ground and in slow flight regimes you may have noticed devices on the back of the wings and sometimes on the leading edge that extend and droop down. These devices are called **Flaps** and leading edge flaps or slats. The function of these devices is to change the geometry of the wing (increase it is chambre) and sometimes increase the wing area. When the wing is in the flap down configuration the wing produces both more lift and more drag. The purpose of flaps is to allow the airplane to takeoff and land at slower airspeeds. The flaps are only used in the slow flight regime. In high speed flight they are retracted.

The purpose of the tail of an airplane is two fold. To an extent it acts like the feathers on a dart or arrow. This provides directional dynamic stability. Additionally an airplane is usually nose heavy in most regimes of flight. The center of gravity of the airplane (the imaginary point where the weight is centered) is usually forward of the center of lift (the imaginary point where the wings lift is centered) the center of lift of a wing will change locations slightly (fore or aft) based on its attitude and the relative wind. The tail must counteract any unbalanced forces to keep the nose from pitching up or down.

Imagine the center of lift as a teeter-totter with the weight at the center of gravity in front; The center of gravity must be balance equally by force created at the tail to remain in balanced flight. To accomplish this the tail must almost always create either some positive or negative lift. Any body creating lift will also create drag, drag is resistance. Thus any drag is costing thrust to overcome it. Drag requires engine power and fuel expenditures. Thus a designer will attempt to design the tail so that it is producing little lift and drag at the cruise speed regimes. To control the flight direction of the airplane, designers have incorporated flight controls.

Ailerons are hinged to the trailing edges of the outboard section of the wing. These are attached to the pilots control yoke or stick. These devices control airplane roll or bank. If a pilot rolls left, the left wing device will elevate and the right will simultaneously lower, the left wingtip losses some lift while the right gains some and the airplane will tilt to the left.

The elevator is hinged to the trailing edge of the horizontal tail. It moves up when the pilot pulls back on the controls and wants to pull the nose up. This creates negative (downward lift) on the horizontal tail. This in turn lowers the tail and raises the nose initiating a climb (nose up) attitude. The opposite is true for nose down.

The vertical tail has a device hinged to the trailing edge called the rudder. The rudder is utilized to overcome some torque induced directional stability problems and to compensate for asymmetric thrust from loss of engine power on engines not mounted centerline. It is also used to counteract yaw and balance turns.

Additional devices known as trim are provided to remove control forces by adjusting the movable flight controls to a new balanced condition .These are provided so the pilot would not have to always apply muscle power to hold each flight control position.

The more critical phases of flight are takeoff and landing. Both of these are due to the close proximity of the ground and the potential for sudden stop. The takeoff phase is the most critical because of the heaviest weights and large amounts of fuel. For Airline type flying every takeoff is planned with a certain sense of urgent responsibility.

Every airliners weight will be computed to insure it does not exceed aircraft structural weights. It is computed also to see that the weight is distributed properly for center of gravity conditions. Once these conditions are satisfied certain numbers are computed that are for speeds required by regulation to fly.

They are V1, Vr and V2 speeds. V1 speed is a refusal speed that determines if the airplane should continue takeoff or abort based on a loss of a critical engine.

Vr is a speed determined to be optimum for rotating the nose off the ground. The attaining of the V2 speed insures a minimum safe climb gradient first segment.

V1 or commit speed may vary with runway conditions. They all vary with airplane weight and configuration of flaps.

After the weights and numbers have been determined the pilots compute the runway allowable takeoff weights by consulting an airport book with numbers computed for runway length and temperature conditions as well as airport altitude above sea level. It is quite common that some airports will have multiple runways some long enough and others not. Determination which runway is adequate is factored upon accelerate stop distances sufficient for an airliner to get to V1 and then abort. Wind direction and velocity play a part in the runway allowable takeoff weight computations.

To make it even more complex there are a set of conditions that if met allow the pilot to select less than maximum power for takeoff. This in turn creates the need for a separate set of takeoff numbers. Utilization of anti- ice during takeoff changes power settings. Wet runways, icy runways and standing slush effect takeoff weights and speeds,

HELICOPTERS

If you marvel at how airplanes fly, then the helicopter is a miracle of complexity. The same laws of physics and aerodynamics apply, they're simply utilized differently. Lift still overcomes weight, and thrust still overcomes drag. The major difference is that the huge rotating propeller on the top of a helicopter provides both the thrust and the lift required.

The way this is accomplished is through the rotor blades. Consider each rotor blade to be a rotating wing, as the blade rotates its velocity creates lift on the surface (rotor). When the rotation speed is sufficient there will be enough lift created on all the blades to overcome the weight of the airplane. Now it will levitate or climb.

The way forward flight is accomplished is that the rotational plane created by the rotating rotor blades is tilted slightly forward. Now some of the wind force created by the rotors is being utilized as thrust. It is the tilt of the plane of the rotors that determines the percent of thrust being used for thrust and the percent used for lift.

Now some of us know that whenever there is a force applied there is an equal and opposite force required. Armed with this knowledge it is hard to understand why the helicopters body doesn't rotate opposite the direction of the rotor blades as torque is applied. It would be one heck of a mess if this did occur and the designers figured out a way to counteract this tendency.

Most all helicopters are equipped with a tail rotor in back this tail rotor is designed to counteract torque forces created by the main rotors rotation (acceleration -deceleration). The purpose of the tail rotor is to counteract torque and provide directional control. Some helicopters have fuselage designs that contribute to directional stability once forward flight is achieved.

Power to achieve flight is through a motor or motors geared through a complex set of clutches and transmissions to the main rotor. The tail rotor is powered by the same engine through transmissions and a complex set of U joints and at least one 90 degree gear box.

Since these rotating parts are moving, so fast it is very, very critical that they be exactly balanced. Even a slight difference or change in weight of the main or tail rotors can set up destructive vibrations. Most helicopter accident investigators are well versed in looking for rotor problems or power transmission problems to the rotating main and tail rotors.