A Simple Guide to Radio Controlled Flying

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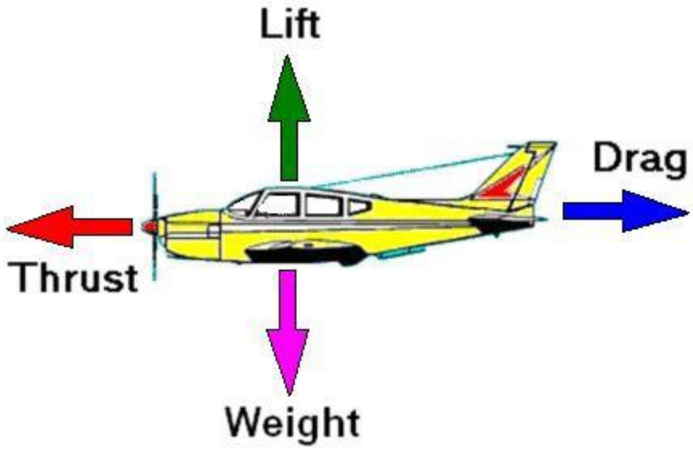
INTRODUCTION

This guide is primarily to explain some of the reasons that aircraft fly. In particular we are looking at radio controlled, fixed wing model aircraft, but the principles are very similar for real aircraft. If you have a clear understanding of the basic physics of flight and why an aircraft behaves the way it does in response to movement of the control surfaces, changes to engine speed and external influences, you will become a better pilot.

We start with the basic effects of the aircraft controls, followed by some secondary effects and finish with some tips to achieve a safe takeoff, circuit and landing. You will find some specific references to the Holdfast Model Flying Field layout and there is also reference to the AS3X™ SAFE™ stabilized E-Flite Apprentice. The basic techniques may be applied to all types of model aircraft.

The radio transmitter can be Mode 1 or Mode 2 and the Instructor will guide you in what is best for you. Most HMAC members fly Mode 1. Always remember that the terms right and left apply to movement of the sticks on the transmitter and that this will relate to movement of the controls in the aircraft, as if you were sitting in the cockpit. It will take some practice to become accustomed to the problem of orientation when the aircraft is coming towards you. Keep practicing and it will become second nature!

FORCES ACTING ON AN AIRCRAFT IN STABLE FLIGHT

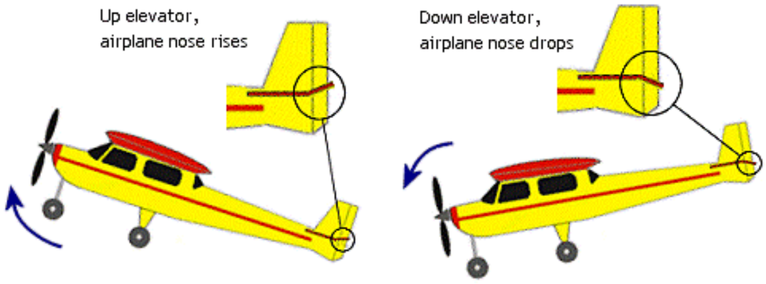


Lift is provided by the wing and it balances **Weight.**
Thrust is provided by the engine and it balances **Drag** incurred by the airframe.
There are many variations on this diagram in various stages of flight. For example, if the engine is not developing power, a component of the Lift vector will replace the Thrust to overcome Drag, but Gravity (weight) always wins! Without Thrust, the plane will descend.

PRIMARY FUNCTION OF CONTROLS

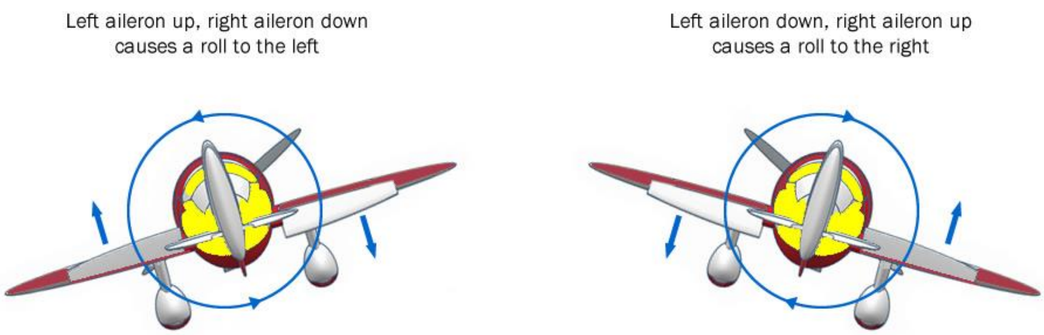
ELEVATOR

The elevator is the movable control surface attached to the horizontal tailplane. Both sides of the elevator move up or down together. When you pull the elevator stick back, towards your stomach, the surface moves upwards, forcing the tail to move down. We use the elevator to control attitude (pitch up or pitch down). If we raise the nose, the airspeed decreases. If we lower the nose, the airspeed increases. The airspeed changes with every change of attitude. Therefore, the function of the elevator is to control the airspeed and the attitude of the nose.



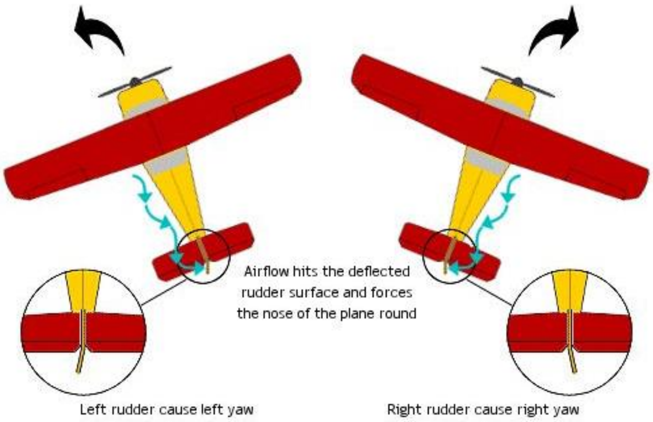
AILERONS

The ailerons are the movable control surfaces on the trailing edge of the wings, usually on the outer part of the wing, towards the tip. The surfaces are linked so that when the left aileron goes up, the right one goes down resulting in less lift on the left wing and more lift on the right wing and a roll to the left will start. Obviously, the opposite applies when the left aileron goes down, the right one goes up and a roll to the right will start. If we move the control stick left or right just a little, the ailerons move just a little and the left or right roll is gentle. If we move the stick more, the ailerons move more and the rate of roll is faster. If you hold the aileron stick over to one side, the plane will continue its rolling movement. So once the desired Angle of Bank has been achieved, you can relax the pressure on the ailerons, back to neutral. The plane should stay in that banked attitude, at least for a short while. It will be necessary to apply aileron in the opposite direction to regain level flight. Thus the function of the ailerons is to control the rate of roll and the angle of bank. This is how we initiate a turn.



RUDDER

The rudder is the single moveable control surface attached to the rear of the vertical fin. It is used to control sideways or "yawing" movement of the plane. The nose will move left or right. However, unlike a boat, the rudder is not the main control for turning the plane. It is used to "balance" the turn. For a perfect, coordinated turn we can use the aileron and rudder together - left aileron and left rudder or right aileron and right rudder. However modern RC training aircraft usually do not need any rudder input for simple turns. In fact, it is easy to demonstrate that a much sharper turn can be made by initiating the angle of bank and then pulling back gently on the elevator. The harder you pull on the elevator, the tighter the turn will become. However, there are limits! Too much elevator can force the wing to "stall" (see later). The rudder is extremely useful in some phases of aerobatic flight and sometimes for crosswind landings.



THROTTLE

The throttle stick controls the engine power. It is used to control height. Full power is found at the fully forward position. Idle power is fully back. There is no neutral position but a ratchet or a friction setting will hold the stick where you want it to be. On our approach for a landing, we control airspeed with the elevator and our rate of descent with the throttle. An increase in throttle setting increases propeller revs and will result in the nose of the aircraft rising because of different forces. Airspeed will increase but to a definite limit. A decrease in throttle will result in the nose dropping and a loss of height. The aircraft can be readily controlled in a stable glide, with no power at the engine. Think about gliders. They manage to fly quite well without an engine! The glider does, however, need a tow from an aircraft or a winch or even a small onboard engine to get up to an operating height. So, basically, for a conventional powered aircraft, the throttle, or propellor revolutions (RPM), will control the rate of climb or descent.

FURTHER EFFECT OF CONTROLS

We have seen that the primary effect of the controls is that the ailerons cause rolling, the rudder causes yawing, and the elevator causes pitching movements. However, there are also some further Effects of Controls which might be rather surprising.

FURTHER EFFECTS OF AILERON

When you move the aileron stick, say, to the left, the left wing goes down and the right wing goes up. If you hold that aileron position, the aircraft would continue to roll. So the aileron command is only used to establish the angle of bank, then pressure on the stick can be relaxed back to neutral. The aircraft will now be flying with one wing higher than the other. However, the aircraft then sideslips to the left and begins to lose height in a spiral. The reason for this is that the lift produced by the wing is far less when it is banked over compared with lift in level flight. If the wing was tilted over to absolute vertical, it could not support the weight of the aircraft. In a moderate turn we can negate the loss of lift by pulling back on the elevator. This increases the angle of attack (see below) thus producing more lift. And this is what you will do almost every time that you make a turn with your model.

A slight amount of rudder in the same direction as the turn might also be required for a perfectly coordinated or balanced turn. The aim is to not lose any height in the turn unless you intend to lose height! A properly coordinated and balanced turn can involve all three of the primary controls in unison.

Remember also that when you have completed the turn and you apply opposite aileron in order to regain straight and level flight, you must cease holding the "up elevator" or the nose will rise up. This transition from turns to straight and level will require some practice to learn but eventually, it will become second nature.

Notes for the HMAC LIFT Apprentice.

HMAC uses the E-Flite Apprentice fitted with the excellent AS3X™ stability system. You will notice that when using the Beginner Mode, it is necessary to use quite large movements on the aileron and elevator controls AND it will be necessary to hold the aileron control over in the direction of turn. The stability system will automatically add elevator to compensate for loss of height in a turn. In due course, the Instructor will introduce you to the Intermediate Mode. This will require MUCH smaller movements on the sticks and it WILL require you to centralize the aileron position once the angle of bank has been established and it will also require you to add elevator as described in the previous section.

The Beginner Mode and the Intermediate Mode also limit the pitch and roll angles so that the aircraft cannot be forced into an extreme attitude. The Experienced Mode has no limits. All three modes have a degree of automatic stability, making the aircraft easier to fly in turbulent conditions.

FURTHER EFFECTS OF RUDDER

The rudder's primary job is to yaw the aircraft. However, a quick jab of the rudder will speed up the outer wing and slow down the inner wing. This will result in a slight roll in the direction of the turn. This is not a problem in normal flight and can be very useful in crosswind landings and in some aerobatic maneuvers. Rudder only turns are sometimes used in very basic RC planes. The wings of those planes are fixed in a pronounced "V" configuration, known as dihedral. It is possible to steer some model aircraft using only rudder and elevator.

AILERON DRAG (Information for Advanced Scale Operations)

Remember that "down going" aileron on the opposite wing to the "up going" one? Well, the bad news is that it creates more drag on the lowered aileron than the raised aileron. This induces yaw towards the lowered aileron. For example, if a left bank is commanded, the left aileron goes up and the right aileron goes down, causing a roll to the left, but it also induces some yaw to the right. This is called "Adverse Yaw" because it will try to turn the aircraft in the opposite direction to that induced by the aileron deflection! The instinctive reaction is to add more aileron in the direction of turn but, of course, this just adds to the problem. The proper reaction is to apply a small amount of rudder in the desired turn direction until the bank angle is achieved and the ailerons returned to neutral. This rudder deflection offsets the adverse yaw.

Some aircraft are affected by this more than others. There are easy fixes for the problem in scale models (and in real aircraft). But you can rest assured that your RC trainer will turn quite nicely. A common fix for scale high wing models like the Piper Cub is to use "Differential Aileron Movement." This is usually set on most models via the Transmitter. The up-going aileron can be unrestricted while at the same time, the down-going aileron can be limited to just a few millimetres of movement. This will minimise the adverse yaw.

Some General Notes on Aerodynamics

Lift keeps our aircraft in the air. You do not need an engine to keep flying (but you will come down eventually). Lift is the vertical force generated by the shape of the wing and the angle at which it approaches the oncoming air. The amount of lift must be sufficient to overcome the weight of the aircraft or it will sink to the ground. More lift is generated as the airspeed of the aircraft increases. Reducing airspeed results in less lift. The angle at which the oncoming air hits the wing is critical. This is called the "**Angle of Attack**". If the nose of the aircraft is lifted and held up by holding the elevator stick back, the airflow over the wing becomes turbulent, and lift is suddenly lost. The wing stops working and is said to "stall". This is not like a car engine stalling. An aerodynamic stall can occur with the engine running at high revs. The aerodynamic stall is a sudden loss of lift caused by exceeding a certain critical Angle of Attack (about 12-15 degrees to the oncoming airflow).

Excessive up elevator in a high Angle of Attack to the surrounding air, at any speed, can result in a stall. A stall is recognized by the sudden drop of the nose and potential loss of height. Application of down elevator on your transmitter, or even just releasing the backward pressure, will allow the aircraft to accelerate and the wing to produce useful lift once again. A stall can be induced at any phase of flight. Power on or power off. High speed or low speed. The high angle of attack induced by application of the elevator will cause the wing to stall with possible serious consequences. The training syllabus requires you to practice deliberately stalling and recovering the aircraft at a safe height.

Most aircraft give their best performance with an angle of attack of about 4 degrees. As the Angle of Attack increases up to about 15 degrees, lift increases, but falls off rapidly beyond that angle. We say that 12-15 degrees is not only the angle of maximum Lift but is also the **Stalling Angle**. A wing stalls when the stalling angle is exceeded.

THE EFFECT OF SLIPSTREAM AND AIRSPEED ON CONTROL

All control surfaces are more effective with greater airspeed. In fact, their effectiveness as controls depends upon there being sufficient speed of airflow over them. The airflow over the wings and ailerons may also include the faster moving rearward slipstream from the propeller.

In a climb, the airspeed (and hence the airflow) is less than in level flight. If we try the effect of each control, in turn, we find that they are less effective even with the engine developing normal power. This is because the airspeed is less and the total pressure around the control surfaces is less.

If we close the throttle and set the aircraft in a stable glide, all controls will become less effective. If the glide speed is allowed to build up, the controls become more effective again. Remember that the Elevator controls airspeed. When the aircraft is gliding, with no engine power, it is essential to have the nose pointing slightly downwards. The aircraft will continue to lose height safely.

INERTIA

There is a natural tendency for all things to continue doing what they are already doing. A body that is at rest tends to remain at rest. A body that is moving tends to continue moving - at the same speed and in the same direction.
Like all bodies, an aircraft also possesses inertia. That is, it tries to continue on its original path even when forces are introduced to change that path. This can be useful or not, depending on the intended flight path. A good deal of energy can be built up by allowing the aircraft to accelerate in a shallow dive, but remember that you will have to wash off that speed somehow to bring the aircraft back to level flight. Conversely, when the aircraft is flying slowly and close to the stall speed, it will take time to accelerate to a safe flying speed. The aircraft could cover considerable distance and lose considerable height during these types of maneuvers. A model aircraft must be kept within the confines of an approved area, so this is an important matter for us at the HMAC Field.

SOME FURTHER NOTES ON STALLING

Ailerons can become Ineffective:

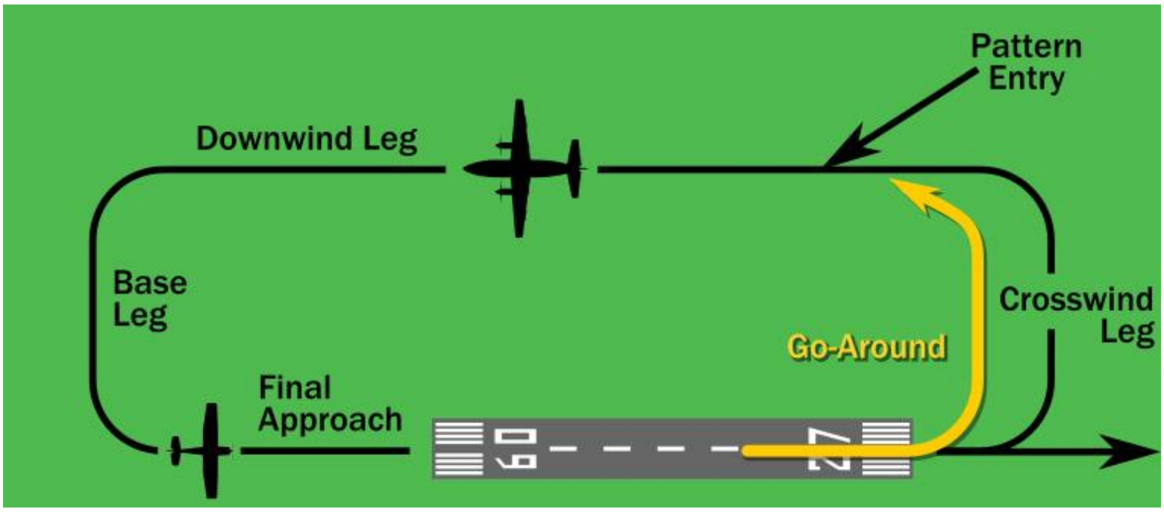
Any attempt to pick up a dropped wing by the use of aileron when the wings are near the stalling angle could be disastrous. In normal flight, if the left wing drops, we can pick it up with aileron by moving the stick gently to the right. However, in some model planes and many full-size ones, this could be just the action to initiate a spin. Try and keep the wings level by use of the rudder, gently and of course get some airspeed by quickly lowering the nose. When the speed returns you can resume use of ailerons.

Spinning

While spinning can be an impressive aerobatic maneuver, a spin can be deadly if entered unintentionally. If a rotation occurs and you have the height to recover, immediately ease off from holding the up elevator pressure or even apply down elevator. Centre the ailerons (In RC aircraft, the spring will return you to the neutral position). The rudder will still be effective and can be used to stop any rotation. When control is recovered, pull out of the dive gently but positively.

INTRODUCTION TO A SUCCESSFUL FLIGHT

THE CIRCUIT PATTERN



You should become familiar with the names of the four legs of the circuit.

Upwind is the first leg immediately after takeoff. It is not often referred to by name. It is the upwind leg when flying a circuit. Takeoffs are usually made into the wind and it is recommended to use the maximum available runway length.

Crosswind is the next leg. It is a short leg. On this leg you will reach cruising height after takeoff.

Downwind is the next leg. It is a long leg, cruising with a tailwind. Check your height and position parallel to the runway.

Base is a short crosswind leg prior to lining up a final approach for landing. ..

Final is the short leg aligned with the runway as you set up for landing., but don't cut the corner and don't make it too short! Accurate positioning is required. HMAC has runway centre line markers to help you judge your position.

TAKING OFF, TURNING, CLIMBING, GLIDING, AND LANDING.

TAKING OFF

A critical phase of flight is the takeoff. Apply full power steadily but not slowly. Steer with the rudder while on the ground. As the propeller rotates it produces a twisting vortex of air that comes back and strikes the side of the aircraft, including the vertical fin. This can cause the aircraft to wander off to the left of the runway. You must be ready for this and add some right rudder to keep the aircraft straight. The control for steering on the ground is the rudder (which is connected to the nosewheel or steerable tail wheel in the case of a tail dragger). Once airborne, the adverse turning effect will be less noticeable thanks to previous trimming flights and the rudder pressure can be eased. The aircraft is required to gain enough speed to generate sufficient lift to leave the ground. This will happen at a relatively low speed compared with the cruising speed. A safe climbing speed should be well above the stalling speed. Do not hold too much elevator soon after takeoff because airspeed will drop off and the critical angle of attack could be exceeded, resulting in a stall. Allow the aircraft to accelerate in speed and maintain a steady climb. Ensure that the aircraft tracks out in the same direction as the runway. Don't allow it to diverge left or right. Keep the wings level. Don't allow the nose to rise up too high. Don't reduce the throttle until you have reached a safe height. Once clear of the runway you may commence a gentle turn onto the crosswind leg.

TURNING

Turning is the next most basic maneuver in flying training after straight and level. An accurately balanced turn is a change of direction at a constant rate of turn and at a constant airspeed without any slip or skid and no loss of height. Try to make all of your turns gentle, with only a moderate angle of bank. (About 30 degrees is good).

Naturally, if we steepen a turn, we apply more bank and, as we require much more lift with the greater bank, we need a much larger Angle of Attack. This is provided by an appreciable backward movement of the elevator stick. But beware of the STALL.

USE OF POWER

Greater Angles of Attack mean more Drag. And more Drag results in a slower airspeed.

In steep turns, we not only move the stick back quite a bit, for more Lift, but we also need more power. Power is increased to provide additional Thrust to counteract the extra Drag and to prevent the airspeed falling too low. If, however, the turn is tightened even more and the bank further increased, a point will be reached when the extra Lift required will call for the angle of attack to be at or near the maximum Lift position. i.e., just below the stalling angle. This is the limit of the aircraft's turning capacity for that given power setting, because, if we pull the stick back, even more, the Angle of Attack will exceed the stalling angle and the wing will stall with possibly disastrous results. Full size aircraft have warning systems to alert the pilot when he is approaching the deadly stall. We must watch our models carefully and be aware of the speed and angle of attack at all times.

CLIMBING TURNS

A climbing turn must not be anything other than gentle. In order to climb, more thrust or power is needed, and most of the available power of the engine is used to provide it. If the nose is too high and power is insufficient, with speed dropping off, you are heading for a stall and possibly a spin.

LANDINGS - A FEW FUNDAMENTALS

A wise Instructor once said, "Take-offs are voluntary, Landings are Compulsory!" If you chose to get up in the air, now you have to get it down again.

We control our nose attitude and speed with the elevator stick back and forth, and our rate of descent with the throttle.

On the landing approach, The aircraft must not be flown too fast, which would result in a misjudged, long landing. The aircraft must not be permitted to develop an excessively high rate of descent. It must be "Just Right" or "In the Groove" with a controlled speed and rate of descent. A good clue is to keep the "body angle " of the aircraft either slightly nose down or flat compared with the horizon.

The best landings will result from a carefully flown rectangular circuit. Do not try and cut corners. Reduce power slightly on the downwind leg. Reduce power further after turning onto the Base leg.

Turning Base
Fly nice straight legs with a square turn at the Base position. Call “Landing” in a loud voice for the benefit of other flyers and reduce the power further as required. Be patient and look for the runway centre marker on the fence.

Turning Final
On reaching the centre marker, make a positive but not steep turn onto final. Keep the nose flat or slightly down. Do not speed up and do not fly too slowly. Look forwards from the aircraft to check your position in relation to the runway. Adjust your rate of descent with the throttle. Add power if undershooting, reduce power if overshooting.

Short Final.

The nose might come up as the headwind starts to take effect. Speed may wash off. If it does, add a slight amount of power to reduce the sink. Do not allow the nose to rise because you are now very close to the stall speed. Ideally, as the ground approaches, and when you are about half a metre above the grass, aim to fly parallel to the ground and hold only a slight amount of up elevator to do so.

Touch Down or Go Around

By now you should have virtually no power on. Concentrate on keeping the wings level. Adjustment of height may be required, using the throttle. Do not make sudden turns on final. If you have a problem, initiate a “Go Around”.
The main wheels should touch first and the nosewheel is held off until last. If you are not happy with the position and speed of the aircraft, do not persist with the approach. In any landing, an excessive Angle of Attack with the nose too high and not enough speed could result in a stall from an excessive height. Control problems while at minimum speed could result in a high rate of descent and difficulty in arresting it. A very hard landing will almost certainly be the result. Your safety procedure is to execute a “Go Around”. This requires the application of full power while keeping the wings level and nose relatively flat. Gradually climb the aircraft in a straight line<u>. Do NOT try to climb AND turn at the same time when close to the ground at a low airspeed.</u> I am sure, by now, you know the reason! When at a safe height, reduce power, enter a cruise and set up for another landing attempt.

THE GOLDEN RULES

Fly a good DOWN-WIND leg to start with, being in the right position at the right height at the time you turn onto Base Leg. On Base, lose no time in positioning yourself correctly, getting your aircraft on descent at the correct speed and rate of descent, and watching that your height is not washing off too fast for the approaching turn. Don’t be impatient. Don’t “cut the corner” onto final. When on Final, leave yourself with as little to do as possible except to keep the aircraft lined up with the middle of the runway or landing area and have it positioned nicely for a smooth round-out. Good landings START with a good Down-wind leg and a nice position when turning onto Base and Final.