PART 3 OF THE NMAS FLIGHT INSTRUCTION MANUAL

NMAS - GROUND SCHOOL

CONTENTS

This document is based on information available at rc-airplane-world.com and has been modified for NMAS requirements. The RC Airplane World website is recommended viewing for beginners in RC model planes.

1 - HOW PLANES FLY

1.2 - The basic principles of flight

The basic principles of why and how planes fly apply to *all* planes, from the Wright Brothers' first machine to a modern Stealth Bomber, and it's actually not difficult to understand how planes get, and stay, airborne.

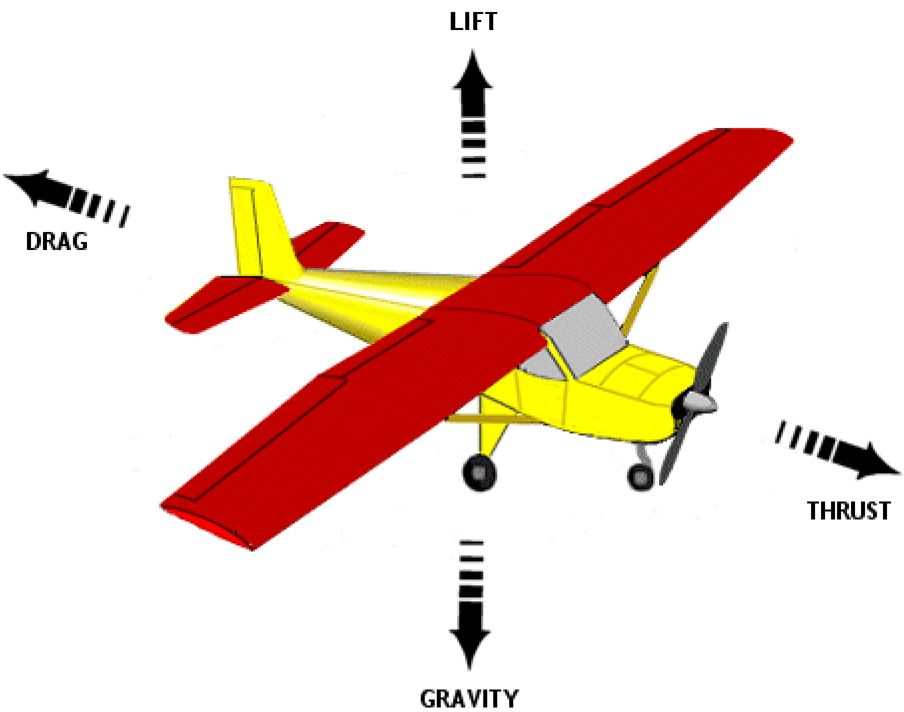
1.3 - Aerodynamic forces

Essentially there are 4 aerodynamic forces that act on a plane in flight; these are **lift**, **drag**, **thrust** and **gravity** (or weight).

In simple terms, drag is the resistance of air (the *backward* force), thrust is the power of the plane's engine (the *forward* force), lift is the *upward* force and gravity is the *downward* force. So for planes to fly, the thrust must be greater than the drag and the lift must be greater than the gravity *(so as you can see, drag opposes thrust and lift opposes gravity).*

This is certainly the case when a plane takes off or climbs. However, when it is in straight and level flight the opposing forces of lift and gravity are balanced. During a descent, gravity exceeds lift and to slow a plane drag has to overcome thrust.

The picture below shows how these 4 forces act on a plane in flight:

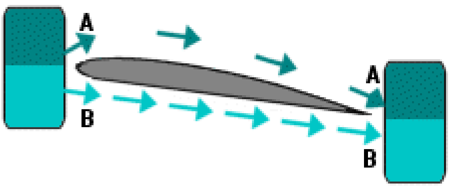


The thrust is generated by the plane's engine (propeller or jet), gravity is natural force acting upon the plane and drag comes from friction as the plane moves through air molecules. Drag is also a *reaction* to lift, and this lift must be generated *by* the plane in flight. This is done by the **wing** of the plane...

1.4 - How wings generate lift

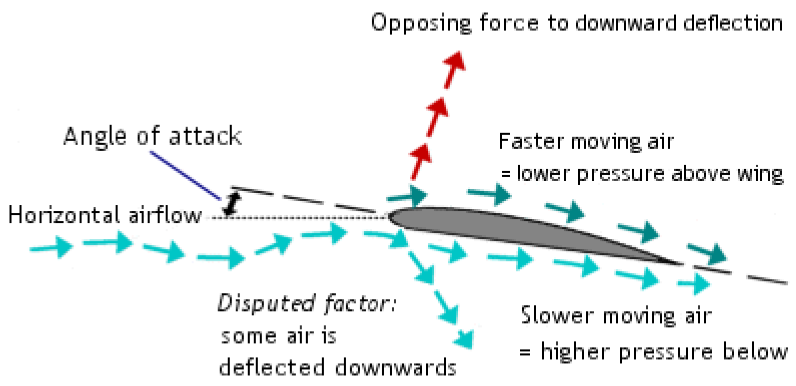
The generation of lift is a widely discussed and sometimes disputed theory, but there are some key factors that nobody argues. A cross section of a typical plane wing will show the top surface to be more curved than the bottom surface. This shaped profile is called an '**airfoil**' (or 'aerofoil').

During flight air naturally flows over and beneath the wing. Any given 'parcel' of air gets split in two as it hits the leading edge of the wing, and both halves of that parcel actually meet up again at the same moment as they come off the trailing edge of the wing. So because the air moving over the top of the wing has more distance to cover (because of the curvature it is forced to follow) in the same amount of time as the air passing below the wing, it has to move faster.
If you're having trouble following that, look at the picture below showing a parcel of air hitting a wing. Arrows A and B is air getting split at the same moment, and meeting up again at the same moment.



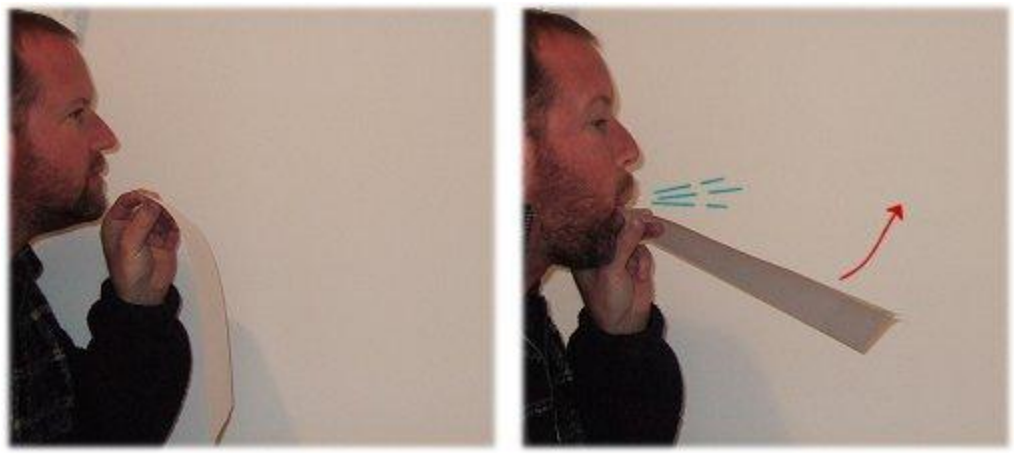
Faster moving air is less dense than slower moving air, so this speed difference results in a **lower air pressure** on top of the wing, and a higher air pressure below the wing. The result of this pressure gradient is that the wing, and hence the plane, is pushed upwards by the higher pressure.

One of the argued theories of lift generation is that some of the air that passes beneath the wing is deflected downwards. This causes an opposite upward force in accordance with *Newton's 3rd Law of Action & Reaction* that acts upon the underside of the wing, effectively pushing it upwards. It's widely agreed that this upward force also occurs because the air that comes over the top surface of the wing moves downwards as it flows off the trailing edge, hence forcing the upwards reaction.



Above, the movement of air over an airfoil

If you want to generate some lift yourself, try holding a sheet of paper in front of your face and blowing hard over its top surface. Your breath moves the air molecules above the sheet, thus reducing the pressure while the pressure below the sheet remains the same, and so becomes relatively higher pushing the paper upwards...



Above, have a go at generating some lift yourself!

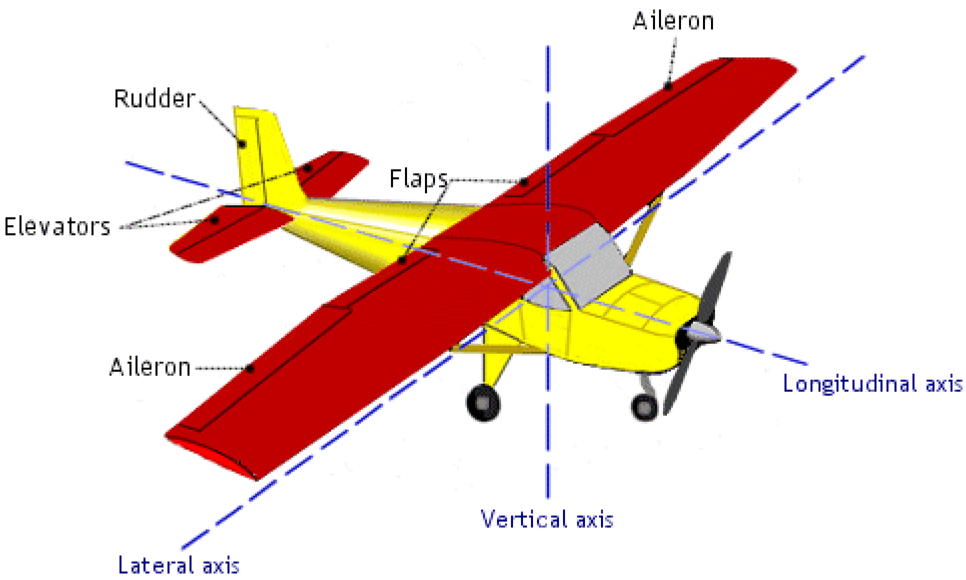
The faster a wing moves through the air, so the actions are exaggerated and more lift is generated.

However, a direct *reaction* to lift is drag and this too increases with airspeed. So airfoils need to be designed in a way that maximizes lift but minimizes drag, in order to be efficient.

A crucial factor of lift generation is the **Angle of Attack -** this is the angle at which the wing sits in relation to the horizontal airflow over it. As the angle of attack increases, so more lift is generated - but only up to a point until the smooth airflow over the wing is broken up and so the generation of lift cannot be sustained. When this happens, the sudden loss of lift will result in the plane entering into a **stall**, where the weight of the plane cannot be supported any longer.

2 – RC PLANE CONTROL SURFACES

For a plane to be controllable, **control surfaces** are necessary. The 4 main surfaces are **ailerons**, **elevator**, **rudder** and **flaps** as shown below:



To understand how each works upon the plane, imagine 3 lines (***axis** - the blue dashed lines in the picture above*) running through the plane. One runs through the centre of the fuselage from nose to tail (*longitudinal axis*), one runs from side to side (*lateral axis*) and the other runs vertically (*vertical axis*). All 3 axis pass through the **Center of Gravity** (CG), the plane's crucial point of balance.

When the plane is in forward flight, it will rotate around each axis when movement to any control surface is made by the pilot. The table below shows the appropriate actions...

Action:	Axis:	Controlled by:
Roll	Longitudinal	Ailerons
Pitch	Lateral	Elevators
Yaw	Vertical	Rudder

3 - TRANSMITTER MODES FOR RC PLANES

When talking about RC transmitter **modes** we are referring to how the transmitter is set up to control the plane *ie;* which sticks operate which controls on the model.

There are four different modes available, but only modes **1** and **2** are commonly used by the majority of radio control pilots.

NMAS recommends that new students fly **mode 1** as the majority of club members are mode 1 flyers. Incidentally, RC transmitter modes only apply to radio gear with **4 or more channels**, where each stick has both vertical *and* horizontal movement.

The four different RC transmitter modes for RC planes are illustrated below:

Mode 1 Stick controls are:
left stick operates elevator & rudder, right stick operates throttle & ailerons.

Mode 2 Stick controls are:
left stick operates throttle & rudder, right stick operates elevator & ailerons.

4 - WHICH CONTROLS DO WHAT?

4.1 - Throttle

Throttle controls the speed of the motor.
In a nitro, or glow plug, engine (*shown right*) the throttle works the same as any internal combustion engine throttle, by changing the amount of fuel and air that enters the combustion chamber of the engine. In an electric RC plane the throttle is usually referred to as **an electronic speed control (ESC)**.

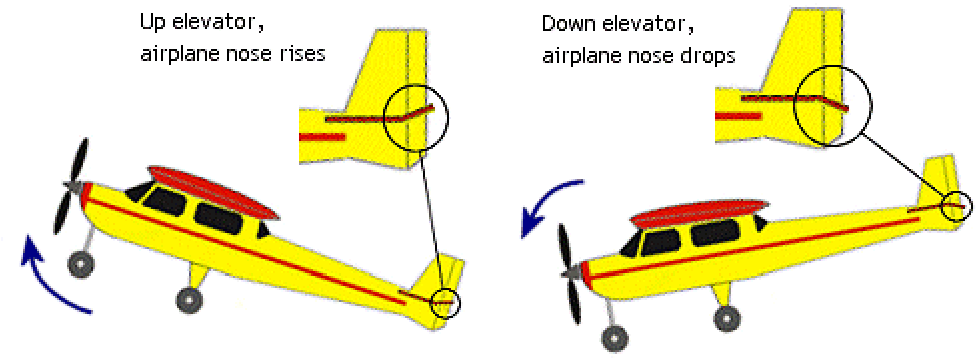
In the air, throttle not only controls the speed of the plane but also the rate of climb and descent, because different amounts of **lift** are generated at different airspeeds. For example, if your landing approach path is too low you can make the plane rise slightly without changing speed, simply by opening the throttle instead of using up elevator. Conversely, closing the throttle will cause the plane to sink *before* the speed reduces.

4.2 - Elevators

The elevators are the hinged section of the tailplane, or horizontal stabilizer, at the very rear of the plane.

Elevators control the **pitch attitude** of the plane, in other words the angle of the plane in relation to the horizontal.

Moving the elevator up (pulling *back* on the transmitter elevator stick) will cause the plane to pitch its nose up and climb, while moving them down (pushing *forward* on the yoke) will cause the plane to pitch the nose down and dive. Elevators are linked directly to each other, so work in unison unlike ailerons.

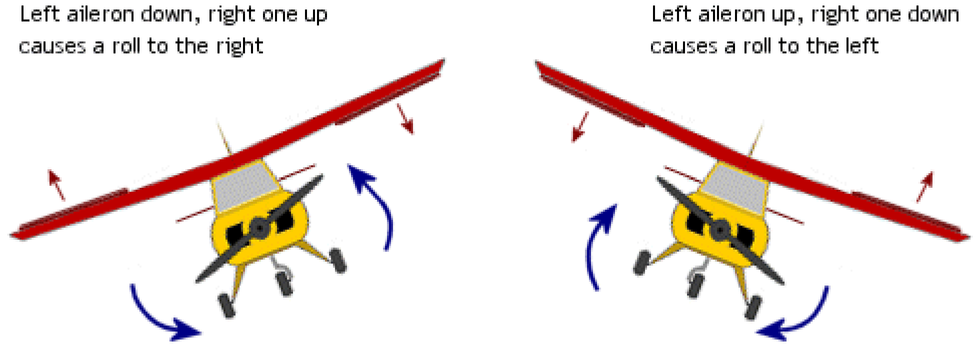


Elevators are always used in conjunction with rudder and/or ailerons when making a turn.

4.3 - Ailerons

Not all RC planes have aileron control, in fact the majority of 3 channel planes use rudder instead. But, where fitted, ailerons control the **roll** of the plane about its longitudinal axis (*imagine a straight line running from nose to tail*).

Ailerons come in pairs and are found on the trailing (rear) edge of the wing, and they work opposite to each other *ie;* when one aileron moves up, the other one moves down and vice versa.



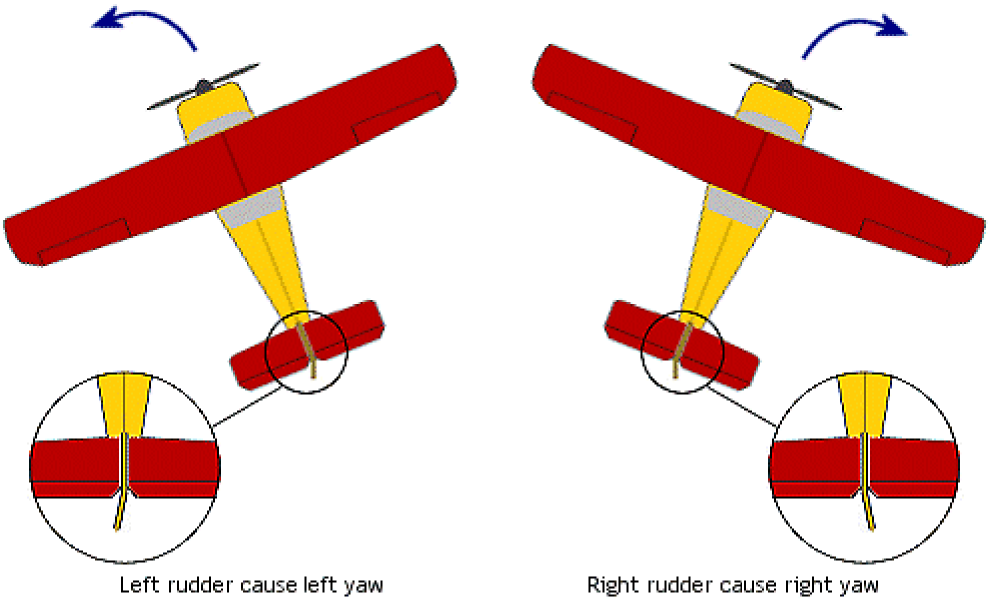
This movement causes a slight decrease in lift on the wingtip with the upward moving aileron, while the opposite wingtip experiences a slight increase in lift. Because of this subtle change in lift, the plane is forced to roll in the appropriate direction *ie;;* when the pilot moves the transmitter stick left, the left aileron will rise and the plane will roll left in response to the change in lift on each wing.

The ailerons are controlled by a left/right movement of the control stick, or 'yoke'.

When used in conjunction with elevators, ailerons cause the plane to turn and are also used in all aerobatic manoeuvres that require the plane to roll.

4.4 - Rudder

The rudder is the hinged section of the fin, or vertical stabilizer, at the rear of the plane. It's used for directional control by changing the **yaw** of the plane, and works in the correct sense *ie;* moving the rudder to the left causes the plane to turn left and vice versa.



Yaw is different to roll because when a plane yaws to the left or right because of rudder it remains more or less level. Only the combined use of rudder *and* elevator causes a plane to bank in the same way as ailerons cause it to.

When the pilot moves the transmitter stick left, the rudder moves to the left. The air flowing over the fin now pushes harder against the left side of the rudder, forcing the nose of the plane to yaw round to the left.

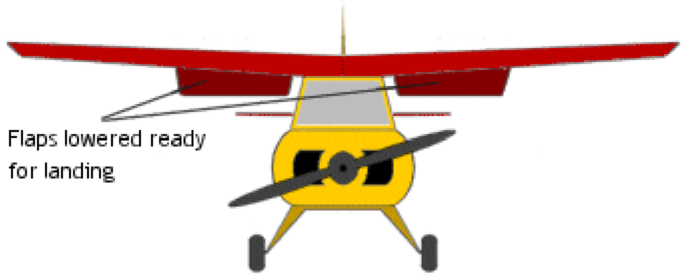
4.5 - Other RC plane controls

Other controls found on more complex RC planes include **flaps** and **retractable landing gear**, or 'retracts'.

Flaps are located on the trailing edge of each wing, between the aileron and fuselage.

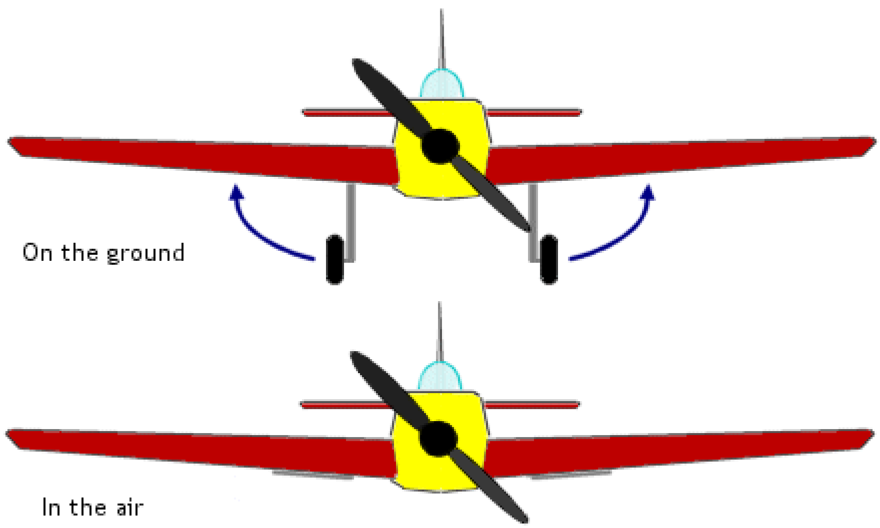
The purpose of the flaps is to generate more lift at slower airspeed, which enables the plane to fly at a greatly reduced speed with a lower risk of stalling. When extended further flaps also generate more drag which slows the plane down much faster than just reducing throttle power, this will slow the plane down close to landing.
They're used to generate more lift at slower flying speeds, and to slow the plane down close to landing. Unlike ailerons, flaps are connected in such a way that they both drop exactly the same amount together.

The flaps are operated with toggle switch or dial on the transmitter.



Retractable landing gear (undercarriage) is landing gear that folds away into the plane's wings or fuselage, once the plane has taken off.

Retracts are often used on larger RC planes, particularly scale models where the real plane has retractable undercarriage - war birds, for example. Larger non-scale planes can also have retracts, particularly competition aerobatic planes where it's necessary to reduce the amount of drag on the plane in the air. Obviously a plane with no landing gear hanging below it experiences a lot less drag than one with.



Retracts can be operated mechanically by a servo or driven by compressed air. The retraction of the landing gear is operated by the flicking of a single switch on the transmitter, either on the 5th or 6th channel.

4.6 - Control surface mixing

Some RC planes are designed in such a way that they cannot have separate ailerons and elevators - delta-wing jets, for example.
When this is the case, control surface 'mixing' is necessary and this is only possible on computerized RC systems that offer a mixing capability.

When elevators and ailerons are combined together, or mixed, they become **elevons**. They look just like elevators but move together, as elevators do, *and* individually, as ailerons do. In short, one pair of elevons does the job of elevators *and* ailerons.
Flaperons are control surfaces that mix the actions of ailerons with flaps. In other words, one pair of control surfaces along the trailing edge of the wing take on the job of aileron control *and* flap control, when needed.
Spoilerons are, in effect, the inverted version of flaperons. Spoilers are often found on large RC gliders and operate by the control surface moving *upwards* as opposed to flaps that drop down.

4.6 - Proportional RC plane controls

You'll often see the word *proportional* when looking at RC systems.
By proportional control, we mean that the control surfaces respond directly to how much you move the stick of the transmitter. In other words, if you only move the stick a small amount, then that channel will only respond a small amount. Moving the stick to the maximum position will move that channel to its maximum.

Understanding your RC plane controls, or indeed the controls of *any* RC model, is of paramount importance if you want to enjoy your model to its fullest.
Always take a bit of time to understand how your new RC plane is operating; you'll get much more out of the hobby than just moving the transmitter sticks and watching the model change direction!

5 - FLYING THE MODEL (BASICS)

5.1 - The take off

Without doubt the easiest part of the flight, taking off your rc airplane is a simple process that lasts just a few seconds, hopefully!

With all your pre-flight checks and range check complete, and the transmitter antenna *fully* extended, face the plane directly into wind (<u>and of course you must comply with circuit rules at the NMAS field</u>). It's important that you take off into wind, because this maximizes the airflow over the wing and the plane will get airborne sooner.

Smoothly increase motor power to **full** and let the airplane accelerate along the ground. It's probable that you'll need to use rudder to keep the plane going in a straight line, don't let it veer off to the left or right.

In a very short time, the plane will rise off the ground. If it seems to be struggling, help it along by applying a *small* amount of up elevator; this will lift the nose and help it get airborne.

Don't apply full up elevator as soon as the plane starts rolling, you won't gain anything and the plane will likely take off, climb too steeply and just stall - *crash!*
The idea is to just smoothly accelerate along the ground and let the plane take off itself, with just a tiny amount of up elevator if it needs it.

Once the plane is airborne, maintain full power and continue a smooth climb out, and commence a turn before the plane gets too far away.

5.2 - Co-ordinated turn

Before the airplane gets too far away from you after take off, you need to turn it, the direction you turn will depend on the circuit direction you are flying at the NMAS field.

As you turn after the climb out, **reduce power** to somewhere around half / three-quarter throttle; once you've taken off, there's no need to keep the motor going flat out, the plane doesn't need this amount of power for general flying.

Keep the turn gentle. As you apply rudder/aileron also apply a small amount of up elevator; this prevents any altitude loss during the turn, and with ailerons is essential to pull the airplane round in a turn and not just roll in a straight line.

When you've turned (to keep within the NMAS rectangular circuit), get the airplane flying straight and level for a few seconds and then, turn again to maintain a rectangular circuit.

5.3 - Landing

Fly your airplane downwind until it passes you by, say, 50 meters or so (keeping within the NMAS rectangular circuit), smoothly turn onto base leg (cross wind) and then turn back into the wind (final approach). As you turn onto final approach, slowly reduce motor power at the same time but be ready to increase it again quickly if the plane drops too much, too soon.

Use rudder to keep the plane in a straight line, and use motor power to control its rate of descent. You can use elevator also, but the proper control for rate of descent is in fact motor power; while elevator will certainly make the plane go up and down, it also directly effects the airspeed of the plane and ideally you want to keep this as constant as possible.

As the airplane nears the ground, reduce the motor power completely and gently apply up elevator to slow the plane's speed and reduce the rate of descent further, until the plane touches down. The timing of this '**flaring**', as it's known, is crucial to a good landing - flare too soon and your airplane will stall and crash, flare too late and it will touch down too hard and fast, and more than likely bounce all over the place!
Getting the timing of the flare is something that only comes with practice, and the more landings you do, the better you'll get at it as you get to know your plane's flight characteristics.

6 - GLOSSARY OF TERMS

- **Angle of Attack -** the angle of the wing (when viewed from the end) in relation to the horizontal airflow when the airplane is flying. Nothing to do with your incoming trajectory when trying to cut the tail off your friend's model in aerial combat games.
- **Attitude -** *not* the obvious meaning, but in the flying world 'attitude' refers to the angle of the plane in relation to the horizontal eg *"My plane had a very nose-down attitude, from which it would not recover..."*
  Well, in this case you could say that your plane had a 'very bad attitude'!
- **Buddy Box -** one of the best training aids, where the student's transmitter is attached via cable to the instructor's. The student has complete control over the model, but at the flick of a switch the instructor can take control if the student gets into difficulties. Or just to be mean, funny or annoying.
- **Center of Gravity / CG -** the airplane's point of fore-aft balance. As a very general rule of thumb it's found approximately 1/4 to 1/3 of the way back from the leading edge of the wing and is built in during the design stage.
- **Crosswind -** when the wind is blowing at, or approximately, 90 degrees to your line of flight, take off or landing.
- **Dead stick -** when your airplane's motor cuts out unexpectedly in mid-air. With any luck you'll have enough altitude to glide safely in for a nice landing, otherwise you may need to use your plastic bag.
- **Differential** (aileron) **-** when the ailerons are set up to move upwards more than downwards, to counteract any adverse yaw during a turn caused by extra drag on the outer wing from the down aileron.
- **Dihedral -** the upward angle of the wings when viewed from the front. An airplane with dihedral is more stable in the air than one without.
- **Disorientation -** when you lose sight of which way up your rc airplane is and what it's doing, either because it's too far away to see properly or because you've just flown it directly over your head and momentarily lost all visual reference to everything. Not much fun when it gets you.
- **Dual rates -** a feature of many rc systems, whereby the control surface deflection can be reduced while still maintaining full movement of the transmitter sticks. With dual rates enabled, the airplane is less sensitive to control inputs.
- **Flare -** the action taken in the last few seconds of the landing approach, to reduce the approach angle and slow the rate of descent. Forgetting this crucial action may result in you needing your plastic bag.
- **Leading edge -** the front edge of the wing, tailplane or rudder.

- **"Oh nooo" -** hearing this term from an rc pilot usually indicates that his/her airplane isn't doing what he/she wants it to do. '*Oh nooo*' soon changes into mixed swear words if the airplane's situation deteriorates.

- **Plastic bag -** the thing used to take home the pieces that was once your beloved model aircraft, before you failed to keep it airborne at the wrong moment, or didn't manage to pull off the best of landings, or tried to perform an aerobatic maneuver too close to the ground...

- **Range check -** an essential pre-flight check to test the operation of your rc gear.

- **RC flight simulator -** a home computer based training aid that lets you practice flying radio control from the safety and comfort of your house. Excellent for novice rc pilots, particularly those looking at flying rc helicopters.

- **Receiver -** part of the radio control gear that lives inside the model and picks up the radio signals sent out by the transmitter.

- **Rx** - abbreviation for receiver.

- **Servo -** the part of the radio control gear that converts the radio signal into movement.

- **Stall** - any flying model will stall when the flying speed gets too low and the necessary amount of lift needed to hold the model in the air is lost. Getting to know your model's stalling speed by reducing throttle and applying up elevator at the same time is a very good idea, but don't practice too close to the ground if you want to avoid using the plastic bag.

- **Straight and level -** when your rc airplane is flying in a straight line, with no fluctuation in altitude. A well trimmed airplane should fly straight and level with the tx sticks in their central positions.

- **Tail wind** - when the wind is blowing in the same direction as your plane is flying, taking off or landing. Flying with a tail wind not only increases the plane's airspeed, but also its stalling speed, and that's never good.

- **Thrust** - the force that is generated by the spinning propeller or fan/turbine of the airplane, and pushes/pulls the model through the air.

- **Trailing edge -** the rear edge of the wing, tailplane or rudder.

- **Trimming** - the action of getting your model to fly straight and level, with the transmitter sticks in their neutral positions and no input from you.

- **Tx -** abbreviation for transmitter.

- **Yaw -** the rotational movement of an aircraft about its vertical axis, controlled by the rudder.