Learn to Fly RC Airplanes

A Field Handbook

Table of Contents

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1) Introduction

These pages will help you face the exciting challenge of learning to fly radio controlled (rc) airplanes. You will be led through the essential pre-flight preparations, how to perform you first flight even if you have no instructor, and given a taste of rc airplane aerobatics.

This will be one of the most rewarding things you have ever done. Flying rc airplanes is unlike any other hobby. Stick with us here, the fun is just beginning!

Where to fly

Consider joining up if there is a club near you. You will meet fellow pilots, have access to their flying facility, as well as be able to find a good instructor. It may be worth it to drive some distance to a flying field to get these benefits.

Visit the club or clubs in your area before joining up. Talk to several of the members, and see how welcoming they are to the idea of new members. Most rc pilots are happy to talk about their airplanes. If the chief instructor is around, talk to that person to get an idea of what your flight lessons might be like. Don't underestimate the people factor, as you will probably start spending a lot of time at the club ☺

The club will most likely have membership dues, as well as requiring you to join the Academy of Model Aeronautics, AMA. The AMA membership gets you insurance, which we'll talk about in the next section. Consider these annual dues when preparing your hobby budget.

If a club is not available nearby, or is somehow not right for you, there are now slow-flying electric rc airplanes that can be flown in a large park. Please be aware of local rules and posted sign in the parks. Observe the rules! Most importantly, remember that parks and other public spaces have to be shared with other users. Be courteous, and above all, be safe. If there are other people around, consider postponing your flight to another less-busy time.

On the subject of safety in parks, if you have to choose between crashing your plane on purpose, or colliding with another park-goer, chose the crash! Airplanes can be rebuilt….. Never fly a fast or otherwise hazardous aircraft in a park. Also, do NOT fly in a park that is close to an RC club! You will not know who is on your frequency and it's only a matter of time before a crash results.

Insurance

When learning to fly RC airplanes, accidents can and do happen. Even world champion flyers crash occasionally, that is part of the fun! It's recommended that you not fly without purchasing liability insurance. This helps cover costs in the event that persons are hurt or property is damaged as a result of your rc airplane activities. While personal injury from rc aircraft seems less common than in most physically demanding sports, it's still a good idea to protect yourself from the possibility of payments to an injured party.

An easy way to get such insurance is to join the Academy of Model Aeronautics, AMA. The insurance coverage is meant to be secondary to your homeowner's insurance, up to $1,000,000. As long as you follow the AMA's safety guidelines while learning to fly RC, the coverage is applicable.

In addition to the insurance, the AMA lobbies on behalf of our interests, provides assistance with obtaining and keeping flying fields, plus other matters. There is also a free monthly magazine highlighting all aspects of the model aviation hobby.

As mentioned previously, most clubs require membership in AMA. It's also a requirement for many contests, and in my opinion, just a good idea.

2) Instructors

Get a live Instructor

A live instructor can greatly cut down on the time it takes for you to learn to fly. Your expenses will be cut down too, as you will crash less often.

Despite your best efforts to build or assemble your plane, there will be slight imperfections in it. This causes it to not fly perfectly smooth or "hands-off". Instructors can flight test your airplane, and perform trim adjustments. This ensures that your plane is stable as it can be, before you, the newbie pilot, take over the controls.

If an instructor has a Tx that is compatible with yours, the two units can be connected with a cable. This arrangement is known as "buddy-boxing". This allows the instructor to take the plane to a safe altitude, then release control to the student using a switch on his Tx. If the student gets into trouble, the instructor can take over the controls easily, just by releasing the switch.

Even without the buddy-box, having an instructor by your side is still priceless. In addition to the test flight, the instructor is there with advice and calming words of encouragement. And if all else fails, in an emergency you can hand the Tx to your teacher! Just do that before the plane is really close to the ground…

So, what if you cannot get an instructor? Many people have taught themselves to fly, including yours truly. The key is knowing what to expect. Read on….

If you cannot get an Instructor

So you live on an isolated farm in the middle of large continent? No other rc pilots within driving distance? How do you do it?

1) Choose the Right Airplane
Choose a plane that will be really easy to fly. You want something that is relatively large, as it will be easy to see at distance or altitude. You also want something slow-moving, as this give you lots of time to react to changes in the airplane. You will also need an airplane that tends to be "self-righting", meaning if it's disturbed

from straight and level flight, it will want to return to straight and level, on its own.

Generally large (72 inch wingspan) rc gliders or powered gliders will fit this description. The designs with “polyhedral” (bent) wings will be stable and self-righting.

Weight is also a factor. Considering building from a balsa wood kit, as these will generally be lighter than most of the ARF airplanes on the market.

Some rc airplanes for the self-teaching pilot to consider

Some options for beginners’ gliders are the Thunder Tiger “Whisper” and “Windstar”, the Great Planes “Spirit” and the Goldberg “Gentle Lady”. These will require a launching system (winch or high-start) or a shallow slope.

If you prefer a powered electric glider, consider Thunder Tiger “Windstar Mk2” and “Whisper”, the Great Planes “Spectra” and the Goldberg “Electra”. You’ll need batteries for the electric motor, as well as a battery charger.

If you prefer a model that has wheels and takes off from the ground, consider the GWS “E-starter” or “SlowStick”. Wheels add a whole other dimension of fun to the sport!

These gliders and electric planes are perhaps a better choice for the self-taught rc pilot, when compared to nitro-powered airplanes. Nitro engines require a somewhat fine touch to start and operate, and will increase the complexity of trying to learn on your own.

All of the above airplanes are readily available from major hobby retailers.

Whatever you do, do NOT get a model that is advertised as capable of aerobatics! Or a scale model, one that looks a lot like the real thing. These categories of model may look nice, but will cause you nothing but grief when learning to fly. You can always get one after learning. Stay away from flat, straight wings, as these do not have built-in stability.

3) Use a Flight Simulator
A great tool for learning to fly is the flight simulator. This is common practice among military and commercial aviation pilots, and is now becoming more common for learning to fly rc airplanes.

If you've not seem a computer flight simulator, it's like a computer game where you control the airplane with a device that looks like a transmitter, or in some cases, using your actual transmitter.

The neat thing is that you can crash over and over while learning to fly on the simulator! This can save you a lot of time and money. Even advanced pilots use the simulator to practice new moves. It's also great when the weather outside is just too cold or windy to fly.

A bit later, we'll review some popular flight simulators.

4) File a Flight plan
Many beginner rc flights end as out-of-control crashes. The joy of flight is so great that new (unassisted) pilots tend to stay up as long as possible (which for them is not very long). That is, until control is lost and an unplanned arrival happens.

To reduce this risk, you need to have a plan before every flight. The idea is to plan to land while you still have control. Then savor the moment, think about what went well and what you might do differently next time. Make another plan, then fly again.

For example, if you're teaching yourself to fly an rc glider, don't stay up in the air until you run out of upward rising air. First slope glider flights could be a straight line, smooth, controlled glide to the bottom of the hill. First thermal glider flights could be simply a straight ahead toss on a flat field. Follow-up flights could be launched off the high-start, then circle back downwind and prepare for landing.

If you're flying a powered plane, a first flight might just be a fast taxi on the field, a short hop of a few feet, then let the plane settle back down and land. All in a line straight ahead. Or the same with a throw straight ahead if your aircraft doesn't have wheels. The next flights may involve take-off, turn and do a couple passes over the runway, then a final landing approach.

The idea here is that since you are doing this by yourself, take it slow and easy in baby steps. Keep the "control" in your radio control.

RC Flight Simulators Reviewed

Here is some info about common RC flight simulators:

FMS
Realflight G2 and G3
Reflex XTR
Aerofly Pro

FMS

FMS is a real bargain. The software is available for free! You can download the latest version here:

http://n.ethz.ch/student/mmoeller/fms/index_e.html

The program can be operated using your computer keyboard, if you do not yet have a transmitter. This is OK to get the initial taste but you will want/need to have a proper controller before long.

You can get cables to attach your transmitter to your keyboard for about $50 from HeliHobby (this comes with the program already on a CD).

If you are good with DIY electronics, you can try building your own cable using the information here:
http://www.heliguy.com/nexus/fmsinterface.html
I did not have much luck with the DIY method (using a Tx that was not specified), but many others have. Personally, I prefer building planes to building electronics ☺

Another possibility is to get a USB game controller. I've used a Logitech AxisPad dual stick controller (about $20). If you go this method you may want to remove the spring on the throttle stick to make it more like an RC transmitter. This involves opening the case and drilling into the box holding the left stick. If you are mechanically inclined, it's not too hard.

Is the program realistic? I've found that the flight physics are way too simple. It's easier to fly the planes or helicopters in the program than in real life. However, the program is very valuable in that it will help the beginner:

a) understand the required Tx stick movements, and
b) overcome the orientation challenge (left/right controls get reversed when the rc plane flies towards the pilot)

So is this program worth the (almost) free price? In my opinion, get this if you are a beginner *and* on a tight budget. However, for a few dollars more, the other rc flight simulators listed here will take your skills a lot further in the long run.

Realflight G2 and G3

Realflight G2 is perhaps the most popular of the paid rc flight simulators out there.

While I have no personal experience with this sim, there is a review here that helps explain its popularity:

http://www.rcuniverse.com/magazine/article_display.cfm?article_id=73&CFID=3080807&CFTOKEN=32800498

There is now a new and improved version G3, which boasts improved physics. Be aware that helicopters will not be available for this version until Spring 2005 (as a free download).

Reflex XTR

Reflex XTR is one of the newest generation simulators. The graphics are excellent and the flight physics good. I've played with a demo version and been very impressed with the flight qualities of the helicopter in the demo. Screenshots from the full version are photo realistic and stunning.

The one criticism that I've heard of this program is that is somewhat helicopter centered, that the airplanes don't fly as well as they could.

Click here for a thorough review of Reflex XTR:

http://www.modelairplanenews.com/reviews/mrcreflex_1.asp

Aerofly Pro

Aerofly Pro is one of my favorite simulators. It saved me many thousands of dollars in crash costs while learning to fly RC helicopters ☺ This program has very realistic flight physics and decent graphics. There's a dedicated cable to connect your own Tx to your computer. This allows you to get used to flying with your own transmitter. There is also a version that comes with a controller, but I would recommend getting comfortable with the Tx that you will use at the field.

The standard program comes with both planes and helicopters. An expansion pack is now included for free. There is also "Deluxe" version available with lifelike photo realistic sceneries.
You can read more about the features of this program, check system requirements, and view some neat videos of the program in action, at:

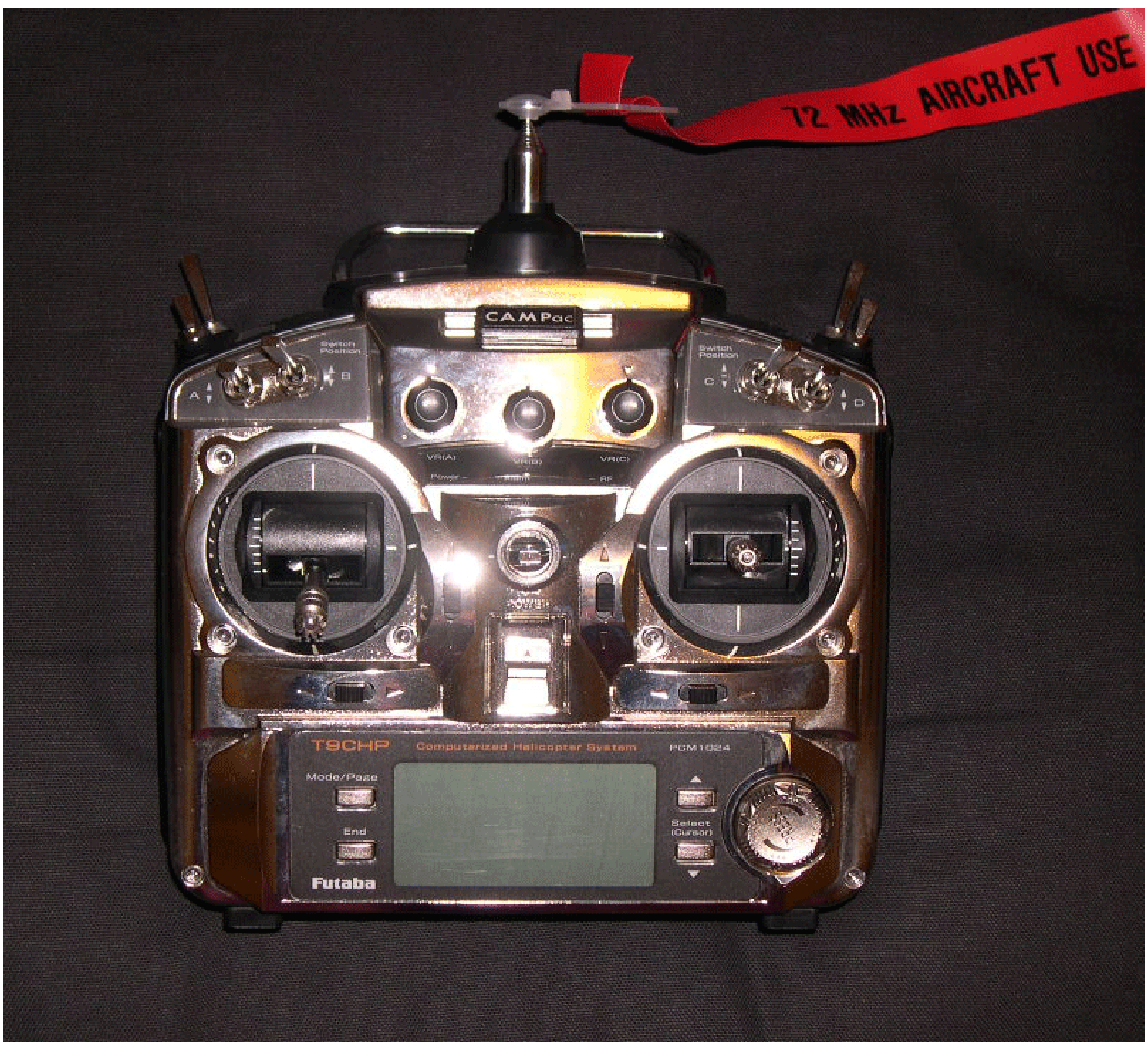
http://www.aeroflypro.com

Be aware that the cable comes with a serial connector, and many newer computers no longer have serial ports, as USB is becoming the standard. You can purchase a serial to USB converter for less than $20 at www.sfcable.com . The "deluxe" program version has USB connectivity built in.

3) Radio Control Systems

The radio control system is the heart of the RC airplane. Many people use these wonderful systems with hardly a thought as to how they work. Here is some info that could prove useful.

Every radio control system contains a **transmitter** (Tx) and **receiver** Rx). There are also actuators, or **servo** motors. The pilot uses the transmitter to send a radio command to the receiver. The Rx then relays this command to the servo, which moves and also creates movement of the airplane surface to which it is connected. Most modern rc systems feature proportional control, i.e. the amount of joystick movement at the Tx determines the amount of movement of the airplane's control surface.



The FCC (Federal Communications Commission) has designated certain portions of the frequency band for radio control use. For example, **72MHz designates the frequency band most often used for RC aircraft** (50MHz is another, but requires an amateur “ham” radio license). 75 MHz is used for rc cars and boats. Note that the permitted frequencies vary from country to country.

That 72MHz is really not a single number, but designates a “band” of frequencies that can be used. For example, one of the sub-frequencies is 72.030 MHz, also known as Channel 12. ***It’s vitally important that you know what channel your radio uses!*** Why? Because switching on your Tx while someone else is flying on your channel will create radio interference for that person’s aircraft, very likely resulting in a crash. This unfortunate event is called a “shoot-down”, and is a generally unpleasant event (not to mention unsafe). The model could have cost thousand of dollars or man-hours. So, the first order of business when you go flying should always be to check that no else is on your channel. Look at the back of your radio for a frequency sticker, or check the box that it came in.

Also note that *radio control systems for planes should not be used interchangeably with those for cars and boats.* The reason is that surface models and airborne models inhabit different regions of space. Someone running a model boat in a pond near your flying field is likely to be unaware of your airplane (and you will be unaware of his or her boat.) Using separate frequency bands helps reduce unnecessary incidents.

When buying your system, you will probably see the terms FM (frequency modulation) and AM (amplitude modulation). These are simply different ways of transmitting a radio signal. FM tends to be less prone to interference, and is generally a better choice for flying models where the cost of a radio error (glitch) could be high. AM is still a fine choice for surface models.

You will probably buy a complete radio control system, either included with a ready-to-fly plane, or as a separate package. If you do buy radio components separately to save cost, be aware that a given transmitter is not compatible with all receivers. Both Tx and Rx need to be on the same channel. They also need to be both FM, or both AM. There is another distinction that makes different manufacturers systems incompatible with each other. This is the concept of “shift”, which is one feature of the radio wave. Positive shift (JR, Airtronics) is not compatible with Negative shift (Hitec, Futaba). Just something to look out for if you are mixing and matching.

You will also see the terms 4-channel, 6-channel, etc. What is a channel and how many do you need? In this case, channel is not referring to your radio frequency, but is referring to the number of separate radio functions that the system can handle at the same time. The most basic radios available are two channel. These can work fine for gliders, or some very basic powered aircraft.

My recommendation for beginners is to get at least a four channel radio. These may be more expensive than 2 or 3-channel, but they have more potential for your growth in the hobby. Even if your trainer airplane only needs three functions (throttle, rudder, elevator), you will someday want the more advanced flying performance of a 4-channel airplane. If you are thinking that you are just trying the hobby, a 4-channel radio generally has a higher resale value.

If you are already convinced that you will be staying with the hobby, and perhaps someday build scale planes or fly helicopters, get the best radio you can afford. A good 7- or 9-channel radio can stay with your for many years. These have not only more channels, but many other useful features. These include mixing of channels, as well as the ability to store model configurations (memory). You will not believe me when I tell you that you will use these features someday, but it's likely to happen. Again, these more complex systems have good resale value.

Once you have decided on number of channels, you still have a large number of manufacturers to choose from. Any of the major brands will work: Futaba, JR, Hitec, Airtronics. I generally like Futaba systems, for their ease of use and quality. Supporters of JR equipment will say the same thing. Hitec offers really good value at lower prices; I especially like their components (receivers and servos).

Whichever system you get, read the instructions carefully. Your typical 4 channel radio system will be setup as in the diagram below, depending on your aircraft needs (3 function or 4 function).

Now install your system and go fly!

What do all the controls *really* do?

Some definitions:

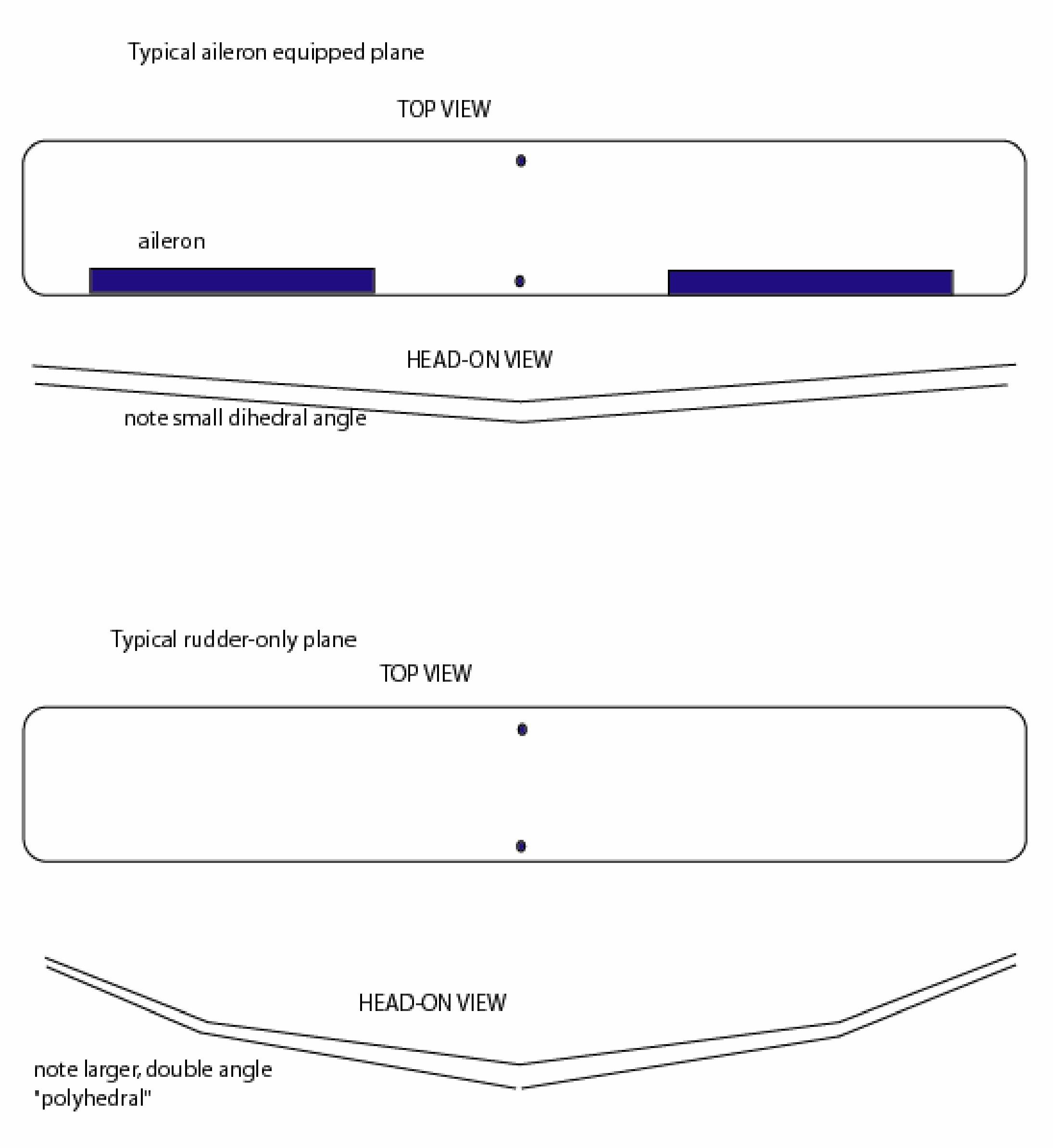
Rudder – The movable part at the back of the vertical fin. Causes the airplane to rotate left or right (yaw) about a vertical axis.

Elevator – The movable part at the back of the horizontal stab. Causes the airplane to rotate up or down (pitch) about a horizontal axis.

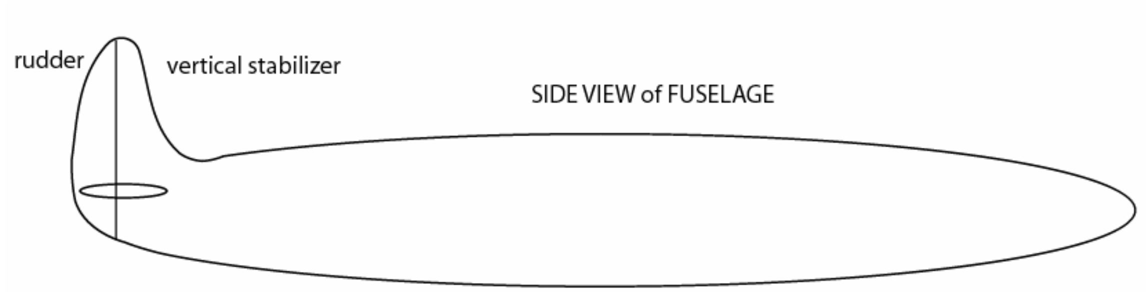
Aileron – The movable part at the back of the wing. Causes the airplane to roll left or right.

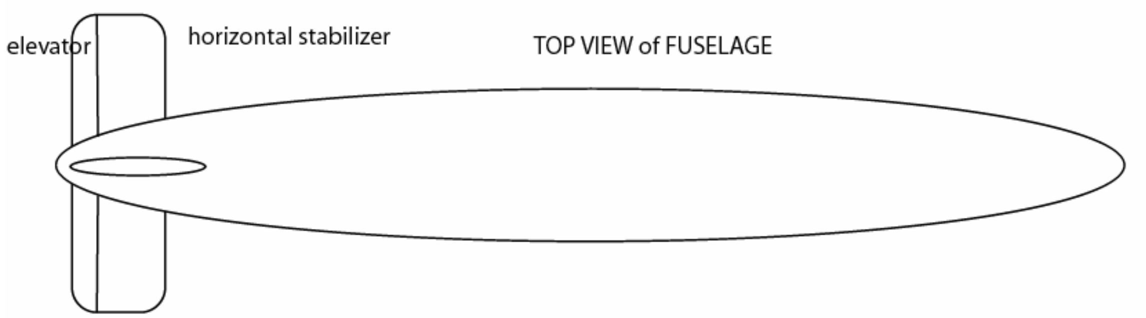
Throttle – The device (mechanical or electronic) that cause the airplane's engine or motor to speed up.

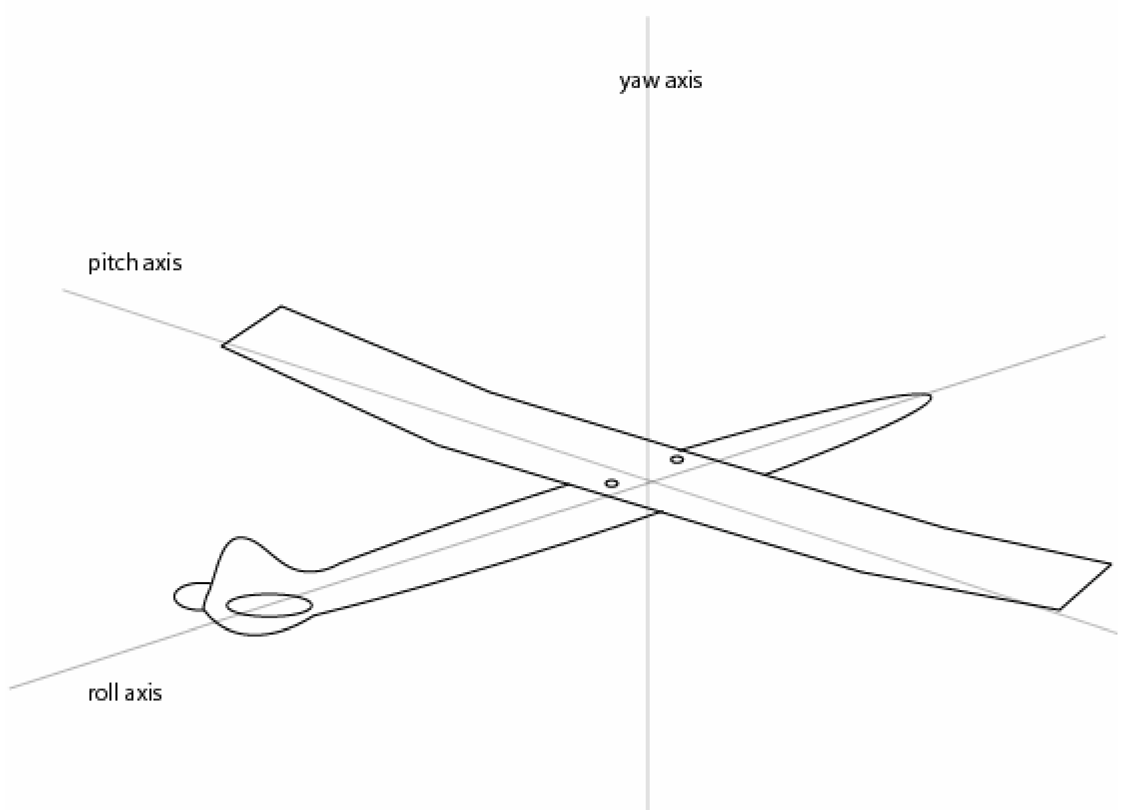
See the diagrams below for sketches of your typical radio control airplane. In particular, note the different wing configurations and the location of the control surfaces.



Wing Diagrams

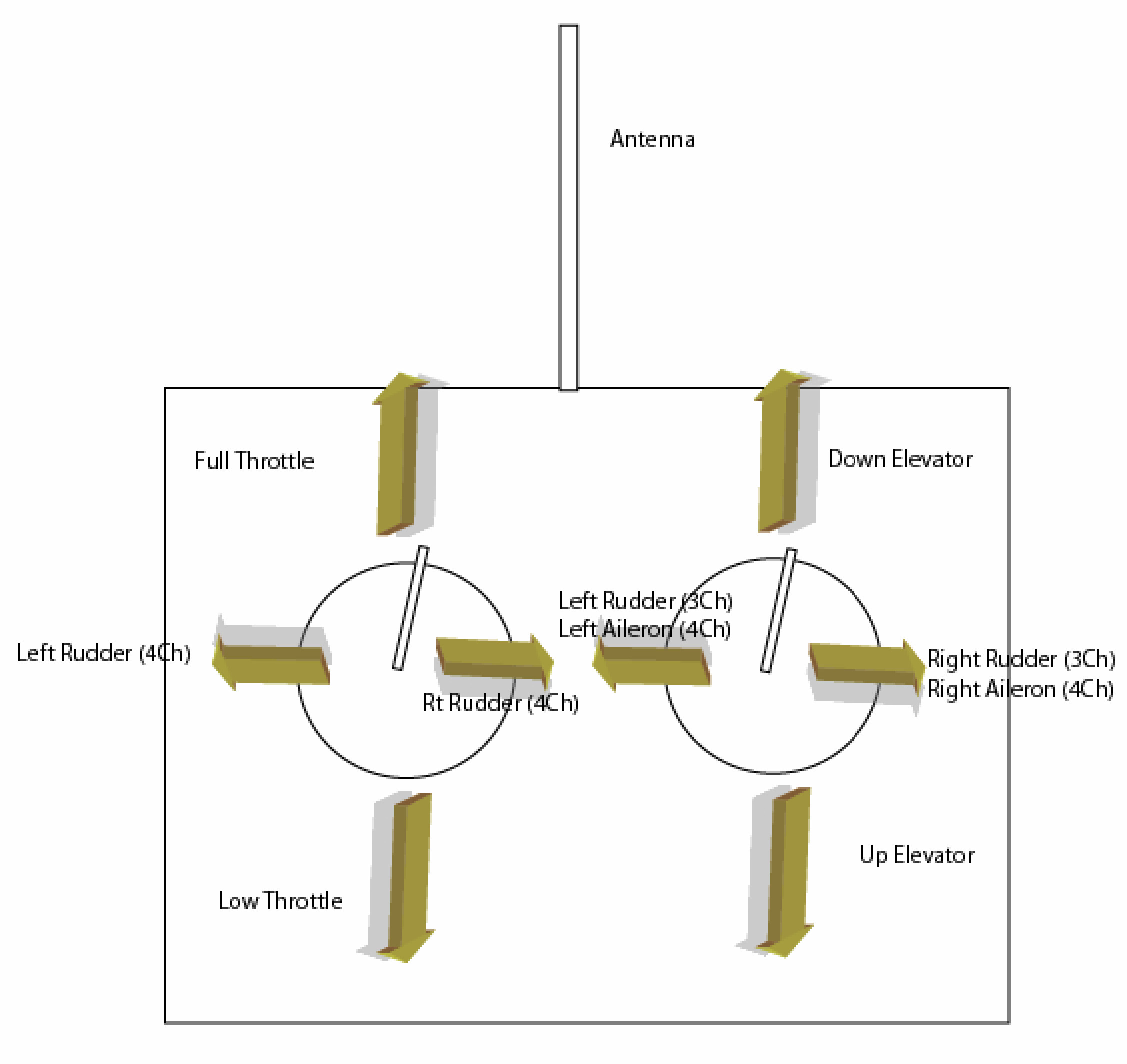

rudder
vertical stabilizer
SIDE VIEW of FUSELAGE


elevator
horizontal stabilizer
TOP VIEW of FUSELAGE


yaw axis
pitch axis
roll axis

Now see the diagram below for sketch of your typical 4 channel radio. Note that there are two sticks that can move back and forth or side to side. The setup shown is the typical "Mode 2" arrangement. These pages assume that you have a Mode 2 setup. (There is also a Mode 1 setup, less commonly seen in North America).

Note that if you're airplane only has three channels, the rudder control will be on the right stick. This will be the turning control.
For a 4 channel airplane, ailerons will be on the right stick (main turning control) and rudder on the left (used for turning assist, ground steering, and aerobatics).



The elevator control is also on the right stick. Forward is down elevator and back is up elevator. The throttle is on the left stick.

Let's look in greater detail at what these controls do:

Turning

Consider first the 4 channel airplane with ailerons. To initiate a left turn, left aileron is applied by moving the right control stick to the left. This in turn causes the left aileron on the wing to move upwards, while the right aileron moves downwards. Increased air pressure on the left aileron will cause the left wing to roll downwards, and presto, the airplane has rolled left.

Now if a bit of up elevator is applied while the airplane is banked over, the nose of the plane will tend to rotate around.   So aileron to roll plus elevator results in a turn. Some planes also benefit from the application of a little rudder in the turns, but many fliers skip that fine detail (this comes back to haunt people when they learn to fly helicopters ☺).

Now consider the 3 channel rudder only plane. The rudder actually causes the plane to pivot about the vertical yaw axis, not the roll axis (see previous diagram). So how is it possible that the rudder can roll / turn the airplane?

Well, let's say that left rudder is applied. The plan yaws to the left. Now, the angle of attack of the right wing has increased, i.e. the angle of the wing relative to the air stream has increased. (Another way to look at this is that the right wing has rotated partially forward, exposing more of its underside to the air stream). This has the effect of increasing the lifting force on that wing. So the right wing goes up higher, and left wing goes downward, creating a roll!

This effect is known as yaw-roll coupling, and allows us to build 3 channel airplanes with rudder-only control. This reduces complexity and expense. An added benefit is that the increased dihedral which is necessary to make rudder-only turns effective, also makes the plane more stable (great for you, the beginning flyer). The disadvantages are that the plane becomes too stable for the advanced flyer, and inverted flying performance is poor.

Going up or down

So now that we understand turning, what makes the aircraft go up or down? If you said giving it up or down elevator, that's a common answer.   But an incorrect one!

The elevator really controls the aircraft's airspeed. Let's say the aircraft is cruising along in straight and level flight. When up elevator is applied, it is true that the nose of the elevator goes up, pulling the rest of the plane with it. But as the plane goes up, the aircraft starts to slow down. Eventually the speed of the plane is slow enough that there is not enough air over the wing to maintain lift, and the aircraft stalls. The nose then falls until airspeed is regained. If the aircraft is near the ground, there many not be room to regain airspeed and continue flying, so CRUNCH!

In some cases, a stall may cause the airplane to enter a spin, which can be tricky to recover from. [Most polyhedral type trainers are designed to have good spiral stability (i.e. be spin resistant)].

If the airplane is given down elevator, the nose of the airplane points down. It also picks up airspeed. So a good way to think about the *elevator control* is that it *is your airspeed control*. The elevator stick is also your *stall stick*!

All of the preceding discussion assumed that as you applied elevator, no throttle control was applied.

Going faster or slower

So, if you want your RC airplane to go slower or faster, you add or reduce throttle, right? Well, you're not going to fall for a second trick question.

The throttle stick really controls your altitude. Applying more throttle does increase the engine or motor speed, pulling it through the air faster. But this increases the lift produced by the wing, causing the whole airplane to gain altitude. Similarly, throttling back causes the plane to lose altitude.

But, you say, if you're flying in a straight line and want to go faster (in the same line) don't you just increase the throttle. Well no, the airplane will want to climb, so you will have to compensate with down elevator to keep it from climbing.
If you understand the functions of the elevator and throttle, you now understand why many people crash their plane close to the ground. Someone sets up for landing by reducing throttle, bring the plane close to the ground. The angle of descent is too steep, and the pilot adjusts

by instinctively “nosing up” with the elevator. This kills the airspeed and the plane stalls onto the runway.

If you learn only one thing from the preceding paragraphs, it should be that you need to have a healthy respect for the elevator stick.

4) Model Airplane Engines

Model airplane engines provide the power for most rc airplanes. These engines are usually piston and cylinder internal combustion engines, although other types are available. These engines are often referred to as “glow” or “nitro” engines.

RC engines work by burning a fuel. The burnt gases expand and move a piston, which moves a rotating crankshaft, which in turn drives the airplane’s propeller.

The fuel for most model airplane engines is something called “glow” fuel. It is actually mostly a type of alcohol (methanol, please do *not* drink), plus nitromethane to help burning, plus some oil to help keep the metal parts lubricated.

It’s called “glow” because the engine uses a glow plug instead of the spark plug found in regular gasoline engines. In the glow plug, a heated element causes the fuel to burn. The plug has a steady glow instead of an intermittent spark. To start the engine, a battery is used to create the initial glow; after that, the heat of burning keeps the plug glowing, and the battery is removed (saving weight).

The typical glow model airplane engine is a “two-stroke”. The engine burns fuel (produces power) on every second stroke of the piston. “Four-stroke” engines are also available, that produce power on every fourth stroke of the piston. The four strokes are more complex and expensive, but quieter as well as more fuel efficient.

There is an ongoing debate about the merits of nitro engines versus electric power. The electric systems are quiet, clean, low-vibration. The drawbacks are generally lower power to weight ratio than a comparable glow-power engine. Newer technology lithium polymer batteries are beginning to remove this disadvantage, although currently at a price premium. Many modelers now fly both types of power systems.

It is something of an art to operate a glow-powered model airplane engine. The next sections are designed to help you with that. Note that these are general recommendations; if possible you should follow your engine manufacturer’s advice. If such advice is not available or falls short, these pages should prove helpful:

How to start the engine

1) Make sure that glow plug and propeller are firmly attached, using the correct wrench.
2) Fill the fuel tank of the airplane. This is commonly done by disconnecting the fuel line from the carb, and connecting it to the supply line from the fuel jug. Do not forget to reconnect the line to the carb!   Another filling option is a three-way valve, so you will not need to disconnect the carb line.
3) Set the needle valve of the engine as recommended in the instructions. E.g. from the needle valve fully closed (counter clockwise), open the valve two complete turns counter clockwise. This starting position varies from engine type to another, so please check your instructions.
4) Turn the radio on but do not connect the glow igniter yet.
5) Open the throttle to full using the Tx throttle stick.
6) Place your finger on top of the carb opening. Now rotate the propeller and watch the fuel being drawn up the fuel line to the carb position. Turn a couple more times to get the fuel into the engine. This procedure is known as "priming" it gets the fuel into the engine so that it is easier to start.
7) Remove your finger from the carb and flip the propeller a few more times.
8) Reduce the throttle setting to partially open, say one-third of the full travel of the carb throttle arm.
9) Have an assistant hold the plane from behind, so that it will not move when started. Or use a mechanical hold-down restraint.
10) Only now, attach the glow plug igniter to the engine.
11) You should be in front of the engine but clear of the propeller's turning arc.

12) Using a “chicken stick”, flip the prop vigorously past the compression point of the engine (i.e. past the point at which you feel the most resistance).

13) The engine should start after a few flips, so be mentally ready for it to come to life. Stay clear of the propeller!

14) Move behind the aircraft while your assistant is still holding it.

15) Check that the aircraft is secured, then advance the throttle to full.

16) Now reach in carefully, and close the needle valve slowly. Listen to the engine sound as you do this. When the exhaust note changes to a higher-pitched sound, stop.

17) Throttle back and disconnect the battery leads.

Check the troubleshooting chart in Section 7 for what to do if the engine stops during this procedure.

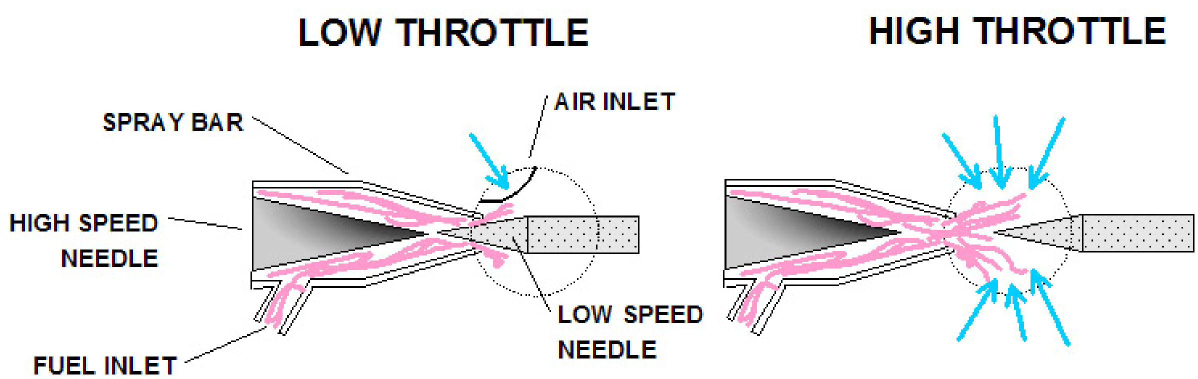
How to Tune Your Engine

What is **tuning** and why would you want to do it? Tuning is simply adjusting your engine for best performance. The settings that it comes with from the factory may be a good starting point. However, these engines are somewhat sensitive to the environment. You may need to adjust for higher altitude operation, or for temperature variations throughout the year. Changes in fuel type, or in wear as the engine breaks in, may also call for re-tuning.

To understand how to tune your engine for best performance, it helps to first understand the function of the **carburetor**. This is a modified tube on the front of the engine. It functions as the **air inlet**, pulls fuel from the tank, allows you to **throttle** the engine, as well as set the correct fuel-air mixture for best performance. There are many variations on carburetor (carb) designs; we will discuss the popular

twin needle design. This has a "high speed" as well as "low speed needle", which we'll discuss below.

The engine itself acts like a pump and creates its own air suction. When the engine is running, the flow of air through the carb actually pulls fuel into the carb. This is accomplished by the **Venturi** effect. When a fluid like air speeds up, its pressure decreases. The inside of the carb opening gets narrower over its length, causing the air flow to speed up, and the pressure to decrease. Another smaller tube called the **spray bar** is connected to the fuel inlet. The opening of the spray bar is positioned in the low pressure area, causing the fuel to be pulled into the engine's crankcase.



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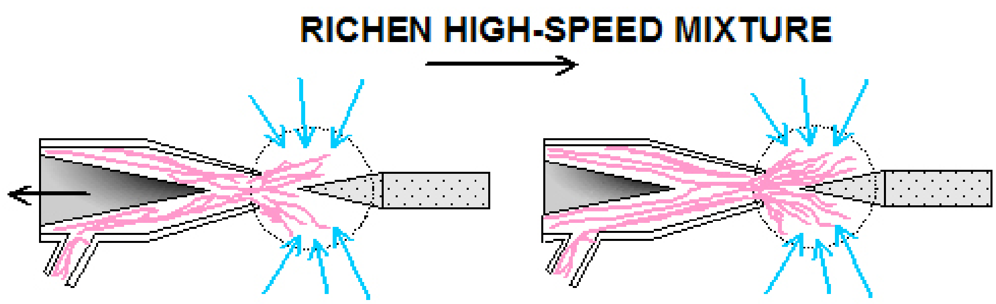
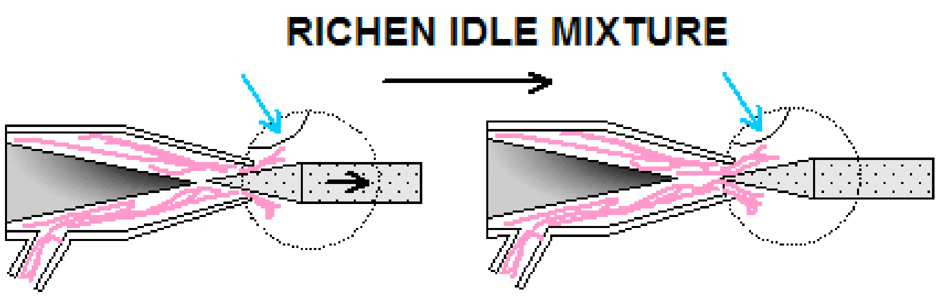
Inside the typical carburetor body is a **rotating barrel** with a hole. The barrel has an arm that is connected to the throttle servo. Moving the throttle stick on the transmitter causes the barrel to (1) rotate, *and* (2) move inwards or outwards. At low throttle stick, the barrel mostly blocks the hole that allows air into the engine. At high throttle, the barrel opens up fully, allowing maximum air in. In addition, the rotating barrel *at the same time* moves a low speed needle to partially block or unblock the spray bar, controlling the amount of fuel released into the engine.

So now you understand what happens when you throttle up or down. Low throttle = less air *and* less fuel. High throttle = more air *and* more fuel. To run properly, the engine needs the right ratio of fuel to air. This ratio is known as the **mixture**. The carburetor needles (or screws) allow us to set the correct mixture, both at low and high throttle, for best operation of the engine.

Relatively more fuel to air is known as a "**rich**" mixture, whereas relatively less fuel to air is known as a "**lean**" mixture. A lean mixture generates more power, but also generates more heat. Running the engine past its optimum lean point can result in damage to the metal parts, and should always be avoided. A rich mixture generates less power and less heat. Too rich and the engine might quit while you're flying, and just generally be harder to keep running.

Both the low and high speed needles can be richened, or leaned out. Richening is usually turning them counter-clockwise, which pulls the needle away from the spray bar opening. The high speed needle often has a thumb screw for manual operation, while the low speed is adjusted with a small screwdriver. The high speed needle controls the total fuel flow into the engine, and affects the engine's behavior from half to full throttle. The low speed needle tends to have more of an effect from half throttle down to idle. So the high speed mixture is set with the engine at full throttle; the low speed is set after throttling back to idle. See detailed procedure below.





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Tuning Procedure

1) Start with the factory recommended needle settings. If you have no idea what these settings should be, use the Needle Starting Point procedure in the next section (below).

2) Start the engine. If you don't know how, see the tutorial in the previous section on How to Start the Engine.

3) With the engine or aircraft secured, open the throttle to full.

4) Lean the high speed needle slowly and watch and listen:

Too rich: lots of smoke, low pitched sound

Leaner: reduced smoke, sound starts changing to higher pitch

Leaner still: little smoke, max rpm reached

Too lean: very little smoke, max rpm can be heard falling off. Open the needle valve up 20 or 30 degrees from this point. If you have a tachometer, open the needle about 300 rpm less than max.

5) Still at high throttle, perform the **pinch test**. Briefly pinch then release the fuel tube going into the carb. If the engine momentarily speeds up, then slows back down, you're done. If the engine does not speed up, or quits, then it is too lean; richen the needle some more.

6) Now throttle back to idle; let the engine idle for a couple minutes.

7) Now perform another pinch test. This time pinch and hold the line. The engine will want to speed up and die (since you are effectively leaning it out). If it speeds up immediately, it's too lean, richen the low speed needle. It should take 4-6 seconds to speed up and begin to die. Any longer and it's too rich.

8) Also check the throttle transition. With the aircraft secured and engine idling for a couple minutes, advance the throttle quickly to fully open. If the engine hesitates, the low speed mixture is too rich.

Frequency: The low speed needle will seldom need adjusting. Do the pinch test for the high speed mixture before every flying session.

Needle Starting Point Procedure

Use this procedure if you don't know where to set your needle valves for initial operation.

1) Open the high speed needle 4-5 turns from the closed position.

2) Fully close the low speed needle valve.

3) Place a clean piece of fuel tubing on the carb inlet. (It needs to be clean because you're going to blow into it!)

4) Open the carb barrel from the closed position, about 20% of the full range.

5) Now blow into the fuel tubing while opening (richening) the low speed needle.

6) Stop turning the needle as soon as you feel or hear the air blowing into the carb. This will be a small flow of air. Remember that you want a small flow of fuel at low throttle, so this is a good starting point.

7) Fully close the high speed needle.

8) Open the carb barrel to the full throttle position.

9) Now blow into the fuel tubing while opening (richening) the high speed needle.

10) Turn until the air flows freely into the carb. This will be a large flow of air (compared to the low end needle setting). Remember that you want a large flow of fuel at full throttle, so this is a good starting point.

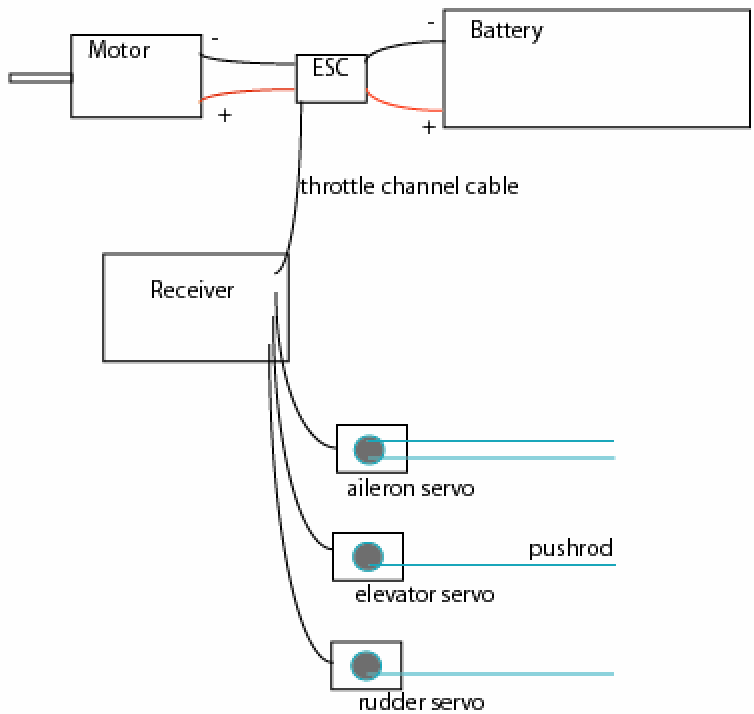
5) The Electric RC Airplane

The electric rc airplane is becoming more and more common, especially in models targeted at the beginning pilot. The advantages of electric power include reliability, low noise, low vibration, and lack of fuel residue (clean). The disadvantage of early systems was low power. However recent electric airplane motors, combined with advanced batteries, have increased the performance of electric rc airplanes dramatically. This type of power system is now a common sight at RC flying fields.

[Warning: physics ahead ☺] Electric motors work by converting chemical energy stored in batteries, into motion or mechanical energy. Electrical current from the batteries flows into electromagnet coils. These are repelled by permanent magnets in the motors, causing rotational motion. By repeatedly switching the polarities of the electromagnets, the magnets continually repel, causing smooth rotational motion. [Whew! End of physics alert.]

In the more common Brushed motors, current switching is accomplished mechanically, by means of sliding contacts known as brushes. The contacts generate heat and can wear down over time. In Brushless motors, the switching happens electronically using a special voltage regulator (speed controller). This second type of motor and its controller are more expensive to make. Its advantage is no heat due to brushes, and no worn-out brushes. Brushless performance is generally higher for similar size motors, when compared to brushed.

A typical electric rc airplane motor system would look like this:



What do ESC, BEC, and LVC mean?

ESC = electronic speed control
This device controls the battery voltage that your motor sees. Zero voltage (Tx stick at zero) means no power, full voltage (Tx stick all the way forward) means max power, etc.

BEC = battery eliminator circuit
This circuit in your ESC allows the receiver (and servos) and the motor to run from the same battery. This saves the weight of second battery. Most modern ESCs have this BEC feature. Be careful to read the manufacturers specs, as BECs have limitations on number of battery cells and servos that can be safely used.

LVC = low voltage cutoff
In a system using BEC, the power to the motor is cut off when the battery voltage drops below a certain value. Power to the receiver is maintained, enough to allow several minutes of control. The airplane is glided to a safe landing with the radio fully functional.

What Battery should I use?

When in doubt, use your airplane manufacturer's recommended battery. This is generally a good starting point, although with experience you will probably have your own ideas about the best battery to use.

There are three main types of batteries currently (no pun intended) in use for electric airplane motors. These are Nickel Cadmium (NiCad), Nickel Metal Hydride (NiMH) and Lithium Polymer (LiPo).

NiCads are the oldest generation of these batteries. They pack more power but are heavier than the NiMH. The NiMH voltage (power) tends to fall off fairly fast during the flight. The wonder batteries LiPos have great power for little weight and hold that power well throughout the flight. However, they tend to be much more expensive than NiCad or NiMH. Again, go with the recommended battery, you will have time to experiment after you learn to fly.

Note that more cells in the battery means more voltage, which means more power.

Power (Watts) = Current (Amps) x Voltage (Volts)

Again, go with recommended number of cells for now.

6) RC Gliders

RC gliders represent a really fun, challenging and rewarding aspect of the radio control hobby. Someone who has only seen a foam glider toy from a discount store might be wondering, "how much fun can that be?" The foam toy glides for a few seconds and then must be thrown again.

However, someone who has experienced a real or rc glider (or "sailplane") knows the difference. These aircraft can stay up for hours, powered only by natural forces! They fly silently and majestically, as a sailboat rides the waves. I've taken a ride in sailplane over the island of Oahu, and there's nothing quite like enjoying a quiet aerial view!

How does an rc glider get into the air, and how does it stay there? There are several methods of launching these airplanes. The **slope glider** is actually tossed over the side of hill! This sounds scary, but when thrown into a rising current of air, the airplane will take flight immediately. Winches or "hi-starts" are generally used to launch large **thermal gliders**, from a flat field, and flown into rising currents of warm air ("thermals"). **Handlaunch** airplanes are thrown by hand from a flat field, and also flown into thermals.

Whichever method of launch is chosen, all gliders rely on relative upward movement of air to stay aloft. It's an acquired skill to read these invisible air currents and get a long flight, which is what makes rc gliders so rewarding!

Thermal Gliders

Dedicated thermal gliders are usually launched from a flat field, using a winch or a "high-start". The goal is generally to stay in the area as long as possible, by riding invisible bubbles of air known as thermals. You have most likely seen hawks or other larger birds circling over areas while hunting, not flapping their wings but somehow staying aloft. They are riding on thermals.

Photo: An advanced thermal rc glider using four channels and six servos.

Thermals are created by uneven heating of the ground. The air over the warmer portions of ground gets heated up more than neighboring air. The hot air rises over the warm spot, and cooler air moves in from nearby to take its place. The bubble of warm air sometimes breaks free and drifts skyward. If a bird or thermal glider catches a ride, the fun begins! The bird or rc pilot circles with the area of the bubble. The art form comes in knowing how big a circle to turn. The wind is also pushing the bubble across the field, adding to the challenge. Find out how to “see” these invisible thermals in the section below.

The high-start is like a gentle slingshot. A length of latex rubber tubing is tied to a length of nylon line, which is attached to a ring. The ring goes over a hook on the bottom of the sailplane. The other end of the line is attached to a peg driven firmly into the ground. When ready to launch, the pilot stretches the line downwind, away from the peg, then releases with a gentle, slightly upward through. The glider carves out a curving path upward, while the pilot steers with the transmitter. At the top of the flight path, the pilot noses down the aircraft slightly, and the ring slides off the hook on the glider, which can then be flown around the field in search of thermals.

A winch is slightly more complicated and expensive launch system. (Thermal glider clubs generally have one or more of these for club members). The winch is powerful motor run by a 12V battery. The motor pulls on the launch line, as the pilot increases or decreases motor speed with a foot switch. Winch launches are generally more powerful than a high-start, yet with more control.

Some options for beginners’ thermal gliders are the Thunder Tiger “Whisper” and “Windstar”, the Great Planes “Spirit” and the Goldberg “Gentle Lady”. All of these are readily available from major hobby retailers.

How to find those invisible and elusive thermals

One of the most fun aspects of rc airplane flying is finding a thermal and staying in the air for a long flight, while your flying friends are struggling at low altitude or are stuck on the ground. Talk about bragging rights! Entire contests are built around this simple idea, and the top pilots have legendary status world-wide.

Well, how do find something that’s invisible? You look *very* closely. Searching for thermals actually begins before you launch the airplane.

First, **observe the layout of the field**. Do you see dark areas (trees, asphalt) and light areas (dirt, light colored buildings)? These different colored areas tend to absorb heat at different rates, creating thermals. NOTE: thermals can be created during the winter. It's the difference between heated areas that matters. The thermals do tend to be stronger in the summer-time.

Now, **observe what's over the field**. Do you see hunting birds circling? That's a dead giveaway, but not always present. How about swarms of bugs? Another sure sign.

Next, **observe the wind**. Look at any flags, and remembering the wind will push the thermals downwind, so you will need to adjust your circling pattern to stay centered in any thermals. As be aware of changes in the wind speed and direction. Check the direction by throwing a few blades of grass into the air and watching what happens.

Now face into the wind. Say the wind is smoothly from the North at about 8 mph, then suddenly there is no wind for a few seconds, then it starts backs from North at about 8 mph. What just happened? A thermal just passed over your location, heading South! Remember that the thermal sucks air into its center; this causes the prevailing (dominant) wind to change for a little while.

By **paying attention to the changes in the wind**, you can get to the point where you launch into a thermal, or very nearly so. Then turn downwind and keep circling to stay in the thermal. Your skills will also develop to the level where you can sense the changes even while paying attention to your aircraft in the air.

Now assuming you are in the air, and **need to find a thermal in a hurry**. The airplane is descending as gliders do, but you want to keep flying. First of all don't panic! These things are designed as thermal gliders, remember? If it's starts coming down fairly close to the ground, steer it towards you and prepare for landing. But say you're fairly high up after launch, and they are no birds or obvious wind changes, what now?

Well, you need to fly to areas where you think there might be thermals. Fly to the boundaries of warm/cold areas, e.g. where dark asphalt meets light baseball field. If the plane starts going up, begin to circle in the thermal. If not, fly to another area.

If you're out of "obvious" thermal generating areas, try flying long paths back and forth across the field. If you fly *through* a thermal, the glider will react to it. In general, one wing will suddenly rise without any input to the transmitter, if that happens, turn back and try to circle and center in the thermal.

It's a good idea before you launch to have a "decision height" in mind. This is the point at which you setup for a landing and bring the plane in, e.g.: when the glider gets below 50 ft. As you get more experienced, this height might decrease. The height will also depend on how far away the thermal glider is from you. For example, you might not worry about 50ft directly overhead, but 50 ft of altitude a half-mile away could be asking for trouble. The idea is, try to respect your current skill level and limitations, and land a little sooner rather than a little too late….

Slope Gliders

Slope Gliders, also known as **slope soarers**, are a subject near and dear to my heart. The reason is that I learned to fly with these machines. In retrospect, maybe not the best way to learn: throwing an airplane over the side of a hill! I was by myself (no instructor), had saved up for this thing, and spent weeks building it. Note: I do NOT recommend that you do it alone! You can also learn to fly on the slope, but an instructor will save you a lot of time and money….

How do these gliders work? You've probably seen seagulls flying by the beach, without flapping their wings, for long periods of time. How is that possible? Well, if there is an upward sloping piece of ground (e.g. a hill or cliff) or even a wall or building, the conditions may be right. Just add a steady breeze that is more or less perpendicular to this rising feature. When the wind hits the cliff/wall/building, the air is forced to rise upwards. It is this rising air that seagulls, and slope gliders, use as their "free ride".

By flying back and forth along the cliff/wall/building, the savvy pilot can stay in the air indefinitely (well, as long as the wind keeps its speed and direction). In fact, pilots can gain height, and start doing fast passes, and even aerobatics! And all without an engine / fuel tank, or an electric motor.

For a first rc slope glider pilot, I would recommend as must-haves: a) an instructor, (b) a gentle, low slope with a large grassy landing area in front of it, and a steady breeze blowing into it, and (c) a slow and stable "polyhedral" glider. If you HAVE to, choose two out of these three must-haves. You can also do your first short gliding flights on a large flat field, it that is what you have available.

Some options for beginners' slope gliders are the Thunder Tiger "Whisper" and "Windstar", the Great Planes "Spirit" and the Goldberg "Gentle Lady". All of these are readily available from major hobby retailers.

Your first slope flight

-If at all possible, have an instructor check out the plane, and perform the first flight.

-If no instructor, check and double check that the control surfaces move in the direction and amount specified in the plane's instructions. Also check that the center of gravity is correct. Otherwise stop and fix, do not fly!

-Face toward the slope, into the wind. Ideally, the wind will be about 5 to 10 mph (check your weather forecast ☺), in a direction close the perpendicular to the slope.

-Remind yourself that your goal here is not sustained flight until you crash. It's a short controlled hop (think "Wright Brothers").

-Throw the plane smoothly and gently forward into the wind. Aim and release the plane at the horizon. Bring your throwing hand back to the transmitter.

-If setup correctly, the plane will continue forward in a straight line. Make small corrections to the rudder (left and right) if necessary, to keep it going straight. The keyword here is "small" corrections.

-Allow the plane to lose altitude slowly and then let it land at the bottom of your small hill. You may need to give a small amount of "up" (back) elevator, right before touchdown.

You've just completed your first flight! You will probably be shaking with excitement. Walk down the hill, retrieve the airplane, go back up and throw again! Start making gentle S-curves with the rudder while the plane is on the way down.

When you are ready for sustained flight, launch into a stronger wing or over a larger or steeper hill. If you have an instructor, they may do this with you on the first flight, using a "buddy-box".

7) Flight Training

Flying in Small Steps

Here is a summary description of a nice, simple training flight of a powered rc airplane, followed by detailed steps to do this:

Pilot checks the flight-worthiness of the aircraft, and range of the radio. Engine is started and placed on the runway, pointing into the wind. Throttle is slowly advanced and pilot steers the plane straight ahead. When the plane has enough speed to fly, the pilot gently pulls back on the elevator and smiles as his rc airplane goes airborne!

At 20 to 30 ft of altitude the pilot initiates a gentle turn and heads back roughly parallel to the runway. The plane is still climbing gently. At 50 to 100 ft the pilot levels off, and performs gentle circuits of the field.

Preparing to land the pilot reduces throttle and flies downwind, past the end of the runway. Then, a turn is made onto final approach. The descent is adjusted for a nice shallow angle approach to the runway. At 6 to 12 inches before touchdown, the pilot applies slight up elevator to help the plane "flare" onto the runway right at touchdown. The plane then rolls straight ahead, and is steered back to the start point. The pilot is all smiles!

Sounds simple enough, eh? Well here are twenty-eight (28) steps to make it happen:

1) Verify that the plane is balanced (center of gravity set per the instructions).
2) Pull on the control surfaces, verify that nothing is loose
3) Check that servo arm screws are installed
4) Check that pushrods are connected properly
5) Check that no other pilot is on your radio frequency

6) Turn on your transmitter, then your receiver

7) Move the transmitter sticks and check the control surface direction. Left rudder stick = rudder moves left. Back elevator stick = elevator moves up. If you have ailerons, left aileron stick = aileron on left wing moves up

8) Do a radio range check. (Best to weigh down your electric aircraft in case the motor turns on suddenly.) Collapse the Tx antenna and walk about 30 paces away from your aircraft. Point the collapsed antenna at the plane and move the sticks. You should still have full control.

9) Return to the plane, prepare to start the engine. If electric, hold the plane and gently advance the throttle trim to check that power is available.

10) Carefully place the airplane on the field or runway, pointing into the wind.

11) Advance the throttle and steer the plane as it moves forward on the ground. It might be good to practice this a few times before your first take-off. For a 3-channel plane you will be steering with your right-hand; for a 4-channel plane, ground-steering (rudder) is with your left hand, switch to right-hand (ailerons) after the plane leaves the ground.

12) Keep the plane going in a straight line on the ground as it picks up speed. If it starts to wander too far left or right of the centerline and you sense that you are losing control, simple return the throttle to zero, pick up the plane and return it to the start point.

13) A nice stable trainer may want to take off by itself when it reaches flying speed. If not, you will notice that the plane looks a little "light on its feet". At that point, give it a SMALL amount of up elevator (more is not better), this should get the plane flying. If you give too much elevator, or so it before the plane reaches flying speed, the plane could go into a stall. Stall on takeoff = crash.

14) After takeoff, return the elevator to neutral and allow the plane to climb on its own. Resist the temptation to give it more up elevator: remember, that's the stall stick! Watch it climb and steer it straight ahead with the rudder stick (or keep the wings level with the ailerons if so equipped).

15) OK, so far so good. But as some point you have to turn the airplane. First, give a little forward elevator to make the climb angle more shallow. Why? Because the aircraft already has a low airspeed due to the climb. Turning will reduce the airspeed

further, which could lead to a stall. Nosing forward a bit before turning increases the airspeed and gives you a safety margin.

16) Now move the right Tx stick (left or right) to turn the airplane in the desired direction. Note that to maintain the angle of turn (bank), you may need to hold or move the stick back in the opposite direction just a bit.

17) Before the turn is complete start moving the stick back to its original position. This will straighten the aircraft out.

18) You may have to apply a little bit of up elevator (back stick) during the turn as well, to help keep the aircraft nose up.

19) Now you should be flying more or less downwind. You will need to reduce throttle a bit, and ease the elevator stick forward, to level out the aircraft.

20) Continue making gentle turns near the ends of flying area, and flying long straight passes to get from end to end. Be careful to maintain your control input orientation relative to the airplane (see Section 8 for more info on orientation).

21) After making a few circuits of the field, setup for landing.

22) After a downwind turn at altitude, start reducing throttle. You want to adjust your descent rate with the throttle so that your get fairly close to the ground (20-30 ft).

23) Turn onto the “base” leg, then onto the final approach to the runway. Reduce throttle some more, but keep your speed above the stall speed of the aircraft. Ideally, you will be approaching the runway at a vertical angle of 10 to 20 ft.

24) If you feel that you are descending too fast or uncontrollably, add throttle and a little bit of elevator, very smoothly. Resist the temptation to simply pull hard back on the elevator: at stall at low altitude will probably result in more damage than a slightly hard controlled landing. If you must abort the landing, keep adding power and fly over the runway, then turn and setup for landing again.

25) Be advised that there is no shame in aborting a poor landing approach.

26) When the aircraft is 6-18 inches above the runway, start adding a small amount of back stick (up elevator). This can be as little as a couple millimeters of stick movement, depending on your plane and radio setup. This will do two things: 1) slow the aircraft even more, and (2) bring the airplane parallel to the runway. If the timing of this “flare” is correct, the airplane touches the runway just as it levels out. Whatever you do, do NOT pull back hard on the elevator. This can cause the airplane to “zoom” upwards for a few feet, then run out of speed and

come crashing down (i.e. stall). It's better to flare too little than to stall the aircraft so close to the ground.

27) Now that the aircraft is down, reduce the throttle some more so that it's moving at a comfortable speed on the ground. Don't forget to steer it more or less straight ahead. For a 4 channel plane, this will mean using your left thumb.

28) When the speed has slowed enough, steer the aircraft back to your position, being carefully to not accidentally bump the throttle forward.

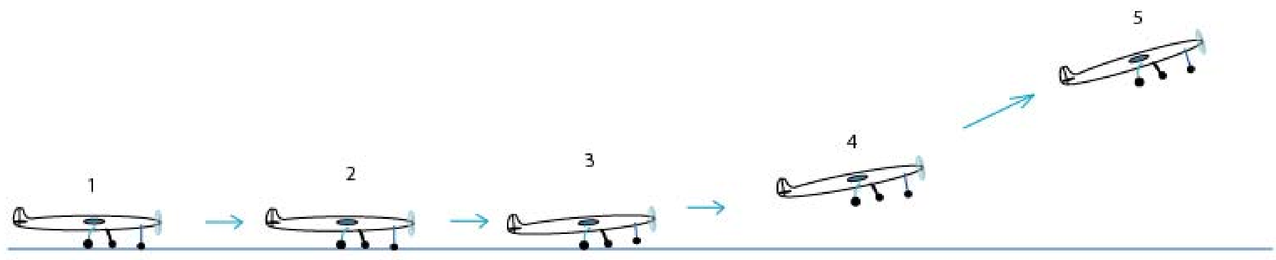
Congratulations! You've just soloed! You're well on the way to your goal of learning to fly rc airplanes. Before you know it, you'll be doing aerobatics.

Note 1: If the plane is not equipped with wheels, throw gently forward at the horizon (also into the wind).

Note 2: If you are learning on your own and have a large enough field, make your first test flight short, straight-ahead hops or glides. (You'll have enough going on without trying to turn the plane.)

In the next three sub-sections, we look in much greater detail at how to takeoff, fly circuits, and land:

Detailed Takeoff Procedure



The traditional trainer aircraft has a “Tricycle” landing gear configuration (i.e. there’s a nose wheel up front). This type typically has good handling on the ground. The numbered takeoff sequence in the above diagram is as follows:

1) Advance the throttle and steer the plane as it moves forward on the ground. It might be good to practice this a few times before your first take-off. For a 3-channel plane you will be steering with your right-hand; for a 4-channel plane, ground-steering (rudder) is with your left hand, switch to right-hand (ailerons) after the plane leaves the ground.

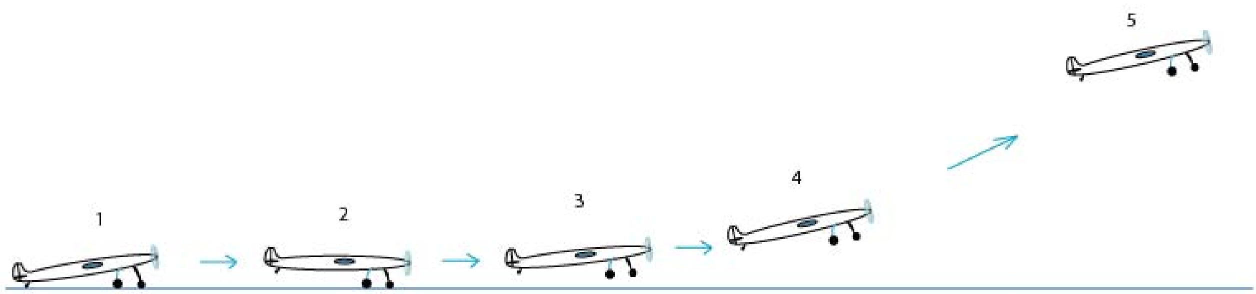
2) Keep the plane going in a straight line on the ground as it picks up speed. If it starts to wander too far left or right of the centerline and you sense that you are losing control, simple return the throttle to zero, pick up the plane and return it to the start point.

3) A nice stable trainer may want to take off by itself when it reaches flying speed. If not, you will notice that the plane looks a little “light on its feet”. At that point, give it a SMALL amount of up elevator (more is not better), this should get the plane flying. If you give too much elevator, or so it before the plane reaches flying speed, the plane could go into a stall. Stall on takeoff = crash.

4) After takeoff, return the elevator to neutral and allow the plane to climb on its own. Resist the temptation to give it more up elevator: remember, that’s the stall stick! Watch it climb and steer it straight ahead with the rudder stick (or keep the wings level with the ailerons if so equipped).

5) OK, so far so good. But as some point you have to turn the airplane. First, give a little forward elevator to make the climb angle more shallow. Why? Because the aircraft already has a low airspeed due to the climb. Turning will reduce the airspeed further, which could lead to a stall. Nosing forward a bit before turning increases the airspeed and gives you a safety margin.

The other common landing gear configuration is “Taildragger” i.e. there’s a tailwheel at the back of the airplane. This type is considered less stable than the Tricycle, as the tail can sometimes wander left or right during takeoff. The takeoff procedure is modified per the diagram below:



1) Apply throttle gradually. Use some up elevator to keep the tail firmly on the ground and controllable. Once the tail lifts off the ground, neutralize the elevator! The plane does not yet have enough flying speed, and you want to avoid a stall. Be prepared to steer the aircraft on the ground. If you find the nose swinging around (“ground-loop”) abort the takeoff.

2) The tail will lift off, let the aircraft build up to flying speed.

3) Apply a touch of up elevator to help the aircraft rotate off the ground.

4) Continue climb out at moderate angle.

5) Prepare for your first turn.

Detailed Circuit Flying Procedure

a) OK, so far so good. But as some point you have to turn the airplane. First, give a little forward elevator to make the climb angle more shallow. Why? Because the aircraft already has a low airspeed due to the climb. Turning will reduce the airspeed further, which could lead to a stall. Nosing forward a bit before turning increases the airspeed and gives you a safety margin.

b) Now move the right Tx stick (left or right) to turn the airplane in the desired direction. Note that to maintain the angle of turn (bank), you may need to hold or move the stick back in the opposite direction just a bit.

c) Before the turn is complete start moving the stick back to its original position. This will straighten the aircraft out.

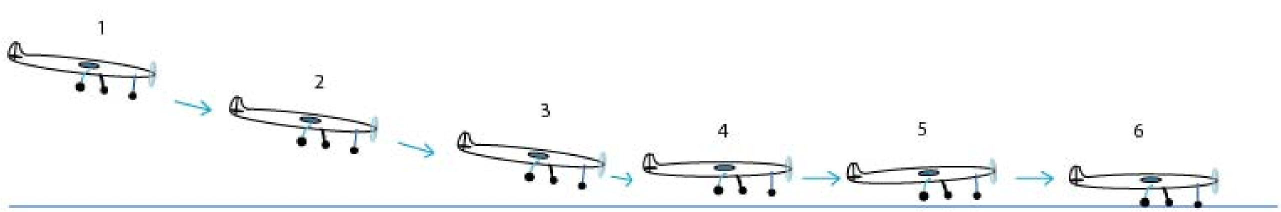
d) You may have to apply a little bit of up elevator (back stick) during the turn as well, to help keep the aircraft nose up.

e) Now you should be flying more or less downwind. You will need to reduce throttle a bit, and ease the elevator stick forward, to level out the aircraft.

f) Continue making gentle turns near the ends of flying area, and flying long straight passes to get from end to end. Be careful to maintain your control input orientation relative to the airplane.

g) After making a few circuits of the field, setup for landing.

Detailed Landing Procedure



The numbered landing sequence in the above diagram is as follows:

1) Turn onto the "base" leg, then onto the final approach to the runway. Reduce throttle some more, but keep your speed above the stall speed of the aircraft. Ideally, you will be approaching the runway at a vertical angle of 10 to 20 degrees. The pitch "attitude" of the aircraft should be flat or slightly angled downwards.

2) If you feel that you are descending too fast or uncontrollably, add throttle and a little bit of elevator, very smoothly. Resist the temptation to simply pull hard back on the elevator: at stall at low altitude will probably result in more damage than a slightly hard controlled landing. If you must abort the landing, keep adding power and fly over the runway, then turn and setup for landing again.

3) Be advised that there is no shame in aborting a poor landing approach.

4) When the aircraft is 6-18 inches above the runway, start adding a small amount of back stick (up elevator). This can be as little as a couple millimeters of stick movement, depending on your plane and radio setup. This will do two things: 1) slow the

aircraft even more, and (2) bring the airplane parallel to the runway. If the timing of this “flare” is correct, the airplane touches the runway just as it levels out or noses up a tiny bit. Whatever you do, do NOT pull back hard on the elevator. This can cause the airplane to “zoom” upwards for a few feet, then run out of speed and come crashing down (i.e. stall). It’s better to flare too little than to stall the aircraft so close to the ground.

5) Here you can see the aircraft angled up just a tiny bit before the moment of touchdown.

6) Now that the aircraft is down, reduce the throttle some more so that it’s moving at a comfortable speed on the ground. Don’t forget to steer it more or less straight ahead. For a 4 channel plane, this will mean using your left thumb. When the speed has slowed enough, steer the aircraft back to your position, being carefully to not accidentally bump the throttle forward.

8) Troubleshooting

What if the engine or motor quits?

Many people think that all bets are off if you have an engine or motor failure. The truth is that all airplanes can glide (even a Boeing 747!), just by differing amounts. Even helicopters have a limited glide (autorotation).

If you're flying a glider you are never worried about your motor or engine quitting, because you don't have a motor or engine! People who fly both gliders and power planes are generally very comfortable with the idea of motor failure. Those who have only ever flown power planes may not have had enough practice at landing with power, to feel comfortable with such an event.

If the engine or motor quits, first of all DON'T PANIC. Remember that your plane is now a glider. You can convert kinetic energy (motion) to potential energy (altitude), and vice versa. If you try to zoom up with the elevator stick, you will slow down and stall.

So, let the plane descend at its preferred rate. Concentrate on steering the plane back to landing area. Do not apply lots of up elevator during the turns. If you see the aircraft getting very slow, apply some *down* (forward) elevator.

You may think that down is not the direction you want to go, but the truth is that down is the direction that you're heading anyway! No engine means gravity has taken over (exception would be if you are in a thermal or other updraft).

You should also realize by now (you have been paying attention, right?) that down elevator will actually increase the plane's airspeed and prevent a stall. Of course, do not overdo it and point your aircraft straight down into terra firma.

So, keep the airspeed up, steer the plane to the landing area, and land as normal. What if you seem to be falling short of the runway? Do NOT try to keep the airplane in the air longer by applying some up elevator. First, this may cause a stall. Second, a gliding plane actually covers LESS ground when it is flying near to stall speed. The best speed for glide ratio (ratio of distance covered to altitude lost) is higher than the speed that causes the glider to come down (vertically) the slowest (sink rate). So, keep the airspeed up, and hope that you make the runway.

If you don't make the runway, so what? Most slow-flying beginner planes will land just fine in the "rough" around your chosen landing spot. No shame in walking a bit to pick up your intact airplane.

What if the radio glitches?

A radio glitch is simply a temporary loss of control. This is generally due to a stray radio signal, either from the surrounding environment or from noise generated by your own power system.

Again, don't panic. If control is lost, chances are good that you will regain it a second later. Try again. If still nothing and a crash seems imminent, alert others in the vicinity by calling out in a loud voice (Lookout, Heads-up, Lost Control, I don't have it).

Orientation issues, and how to overcome them

A few words on orientation. When you sit in the pilot seat of a full-size airplane, you are always moving in the same direction as the airplane. With an rc airplane, you stand still, and the aircraft moves relative to your position. This is fine when the airplane is moving away from, but when it turns and comes towards you, some of the controls get reversed! This is a very common cause of new rc pilot crashes.

One simple way to get around this, is to always picture yourself in the cockpit of airplane, moving forward in the direction of the airplane. So if the airplane is headed away from you, turning the airplane left means moving the control stick to the left of the radio (i.e. your left).

Now, when the plane turns around and faces you, rotate your body slightly away from the plane, and look back at it over your shoulder. You are looking at the plane, but point the radio and Tx antenna in the direction that the airplane is moving. Now if you want the airplane that's coming at you to turn left again, *you also move the control stick to the left of the radio.* This will be second nature, as the plane is turning in the same direction as the stick movement. (If you had faced the airplane head on, it would have seemed as if the stick and the airplane are suddenly moving in opposite directions. It's this sudden change that creates the confusion.)

With practice, the body rotation will become very slight. Just moving the hands to orient the radio at a slight angle to the oncoming plane should be sufficient.

Note that the elevator and throttle controls remain the same when the plane is coming at you. It's the rudder (and ailerons, if so equipped) that get reversed.

Another method that works well is to face the oncoming plane directly, and watch for the angle of the wing. If the wing is flat (parallel to the ground), do not give a turning input. *If a wing dips downwards, then move the control stick towards the low wing.* This may sound awkward, but again with practice becomes second nature and you will do it by instinct.

Whichever method you chose, the important thing is to be aware that this control reversal will occur, and prepare mentally for it to happen.

How to Troubleshoot your rc airplane flight

Symptom	Diagnosis	Fix
Plane will not take off	Too little power	Use more powerful motor, or higher voltage battery
	Not enough airspeed to fly	Wait a bit longer before trying to take-off
	Not enough up-elevator	Apply a bit more up elevator, as a last resort.
	Nose gear too short	Airplane is pointed down, so does not want to rotate. Increase nose gear length/
Plane is very twitchy	Too much control throw (range of movement)	Reduce control throws
Aircraft zooms up, drops the nose, then repeats	Aircraft is tail-heavy	Move components (especially battery) further forward in airplane
Airplane will not roll straight down the runway	Wheels misaligned	Twist landing gear wire to correct alignment
I try to turn, and the plane rolls over right into the ground	Plane stalled	Keep airspeed up in the turns, or use less elevator
Airplane will not fly straight and level hands-off for a couple seconds	Plane is too advanced for a beginner	Get a lightweight, polyhedral trainer!
	Plane needs trim adjustments	Have an experienced flyer do a trim flight.

How to Troubleshoot your model airplane engine

Symptom	Diagnosis	Fix
Engine Does not Fire	Prop flipped too weakly	Flip prop vigorously
	Battery low	Charge battery
	Glow plug burned out	Replace plug
	Battery wires faulty	Replace wires
	Engine flooded	Remove plug, rotate prop to remove fuel
	Engine not primed	See how to start.
Engine fires intermittently	Battery voltage problem	Check recommended voltage
	Too much priming	Disconnect battery and wait a few minutes. If still unsuccessful, Remove plug, rotate prop to remove fuel
	Prop flipped too weakly	Flip prop vigorously
Engine starts, then rpm decreases till engine cuts out	Fuel mixture too rich (too much fuel)	Close needle valve half a turn, then restart.
Engine starts, then rpm increases till engine cuts out	Fuel not reaching engine	Check for: a) fuel in tank b) fuel tubing not cut or

		kinked c) carburetor not clogged with dirt
Engine starts, then stops as soon as battery wires are disconnected	Fuel mixture too rich (too much fuel)	Close the needle valve a small amount
	Glow plug incompatible with fuel used	Change plug type or fuel type

How to Troubleshoot your electric rc airplane

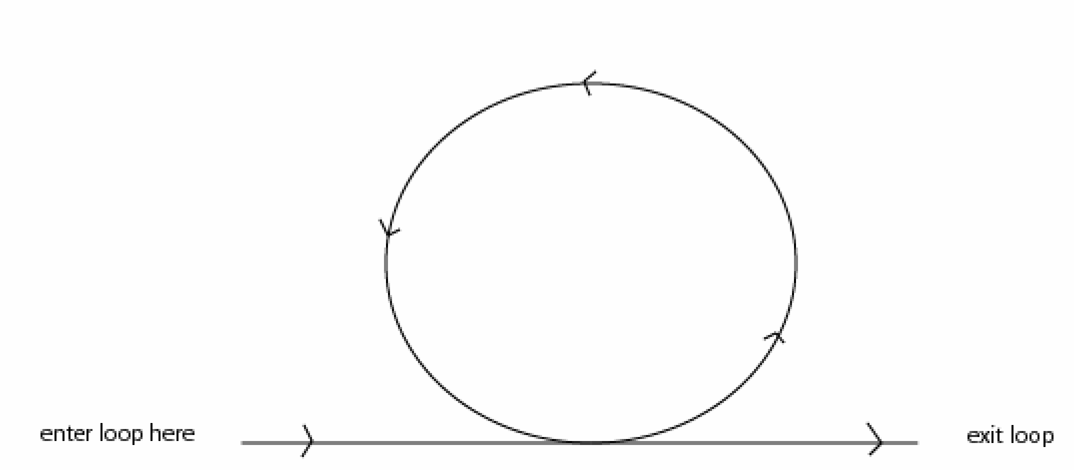
Symptom	**Diagnosis**	**Fix**
Nothing seems to work	Throttle cable not plugged into Rx (BEC system)	Plug lead from ESC into throttle channel
	Loose connection	Check connections and resolder if necessary
Servos work, but throttle doesn't	Motor not plugged into ESC	Plug in motor
	Low Voltage Cutoff reached	Charge batteries
ESC hot, burned, smoking	Too much current through ESC	Reduce prop size
	Plane crashed, stalling prop and drawing too large a current	Throttle back after crash. Better yet, don't crash.
When plane Rx glitches, motor cuts out	ESC may have glitch SW cut back throttle to prevent accident	Move throttle stick on Tx to zero, try to power up again
Plane works fine but wire connectors melted	Cheap connectors not capable of high current performance	Replace connectors with Sermos, Deans, Astroflight
System glitches excessively	May be noise generated by the ESC	Increase the distance between ESC and Rx

9) Aerobatics

Here are some common aerobatic moves and how to perform them.

Loop

The Inside Loop is one of the best-known maneuvers, and the easiest to describe (make a circle in the sky!). It's also generally the first maneuver that is attempted after take-off, landing, and straight and level flight are mastered.



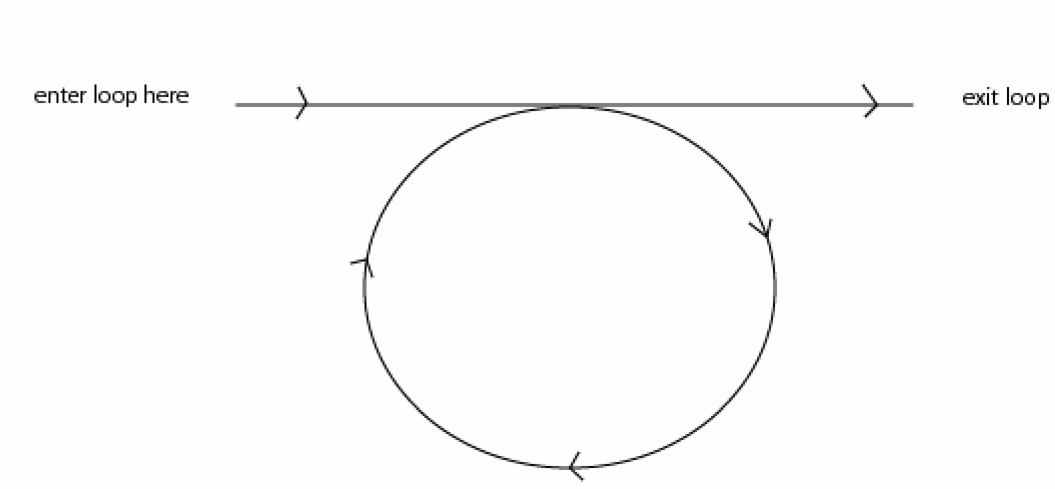
From straight and level flight, start feeding in up elevator so that aircraft noses up. Add throttle to maintain airspeed. Keep adding up elevator until the aircraft is flat on its back, and then throttle back a bit. Add more up elevator to keep the aircraft going around the circle; throttle back some more when the aircraft is pointed straight down. As the plane levels out onto its initial heading, add throttle again.

The loop is in theory really simple, but hard to make perfect. It takes skill to modulate the throttle correctly to make a circle at constant airspeed, entering and exiting at the same point. Corrections for wind may need to be made with rudder or ailerons.

For a beginner, any similarity to an oval shape is going to very exciting! For lower-powered trainers or gliders, you may need to dive down at bit before entering the loop, to have enough airspeed to make it around. Make sure that you try your first loops (and other aerobatics) at a high altitude.

Outside Loop

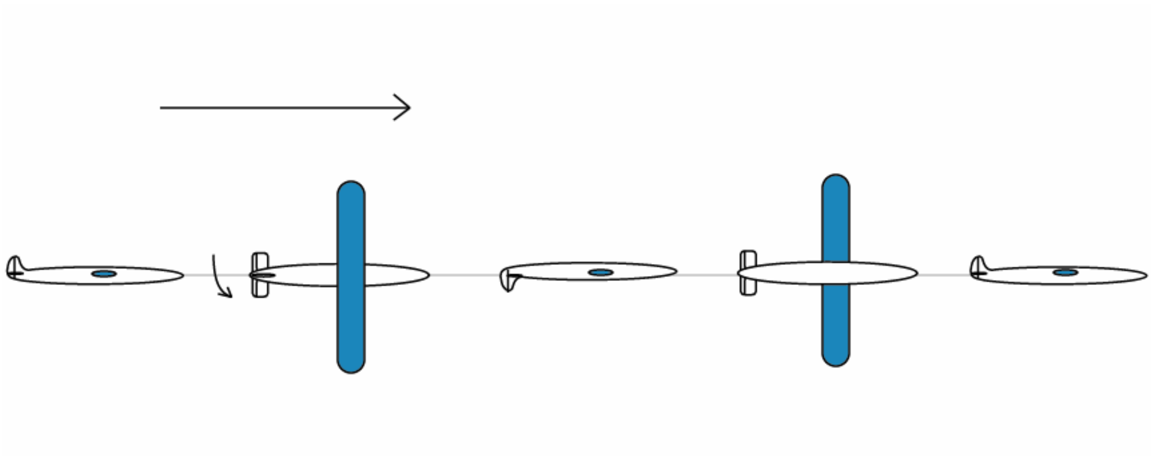
On paper the outside loop looks similar to the inside loop, except it uses down elevator to go around the circle. However, it is a lot more demanding on the airframe, and many beginner aircraft will not handle the stress. Consider this an advanced maneuver and save it for later.



Roll

The roll is perhaps the second maneuver that people attempt after mastering the loop. As the name indicates, the airplane is rotated about the roll axis.

From straight and level flight at good speed, apply full left or right aileron. As the aircraft rolls to inverted, you many need to apply a bit of down elevator. Keep the aileron stick deflected, and remove the down elevator as the aircraft rolls upright. Then release the aileron stick.



Barrel roll

This is similar to the “axial” roll above, but the plane rotates in a spiral instead of about a straight line. Generally happens when trying to roll a 3 channel rudder-only airplane. Note that some 3 ch trainers will be too stable to roll easily.

Snap roll

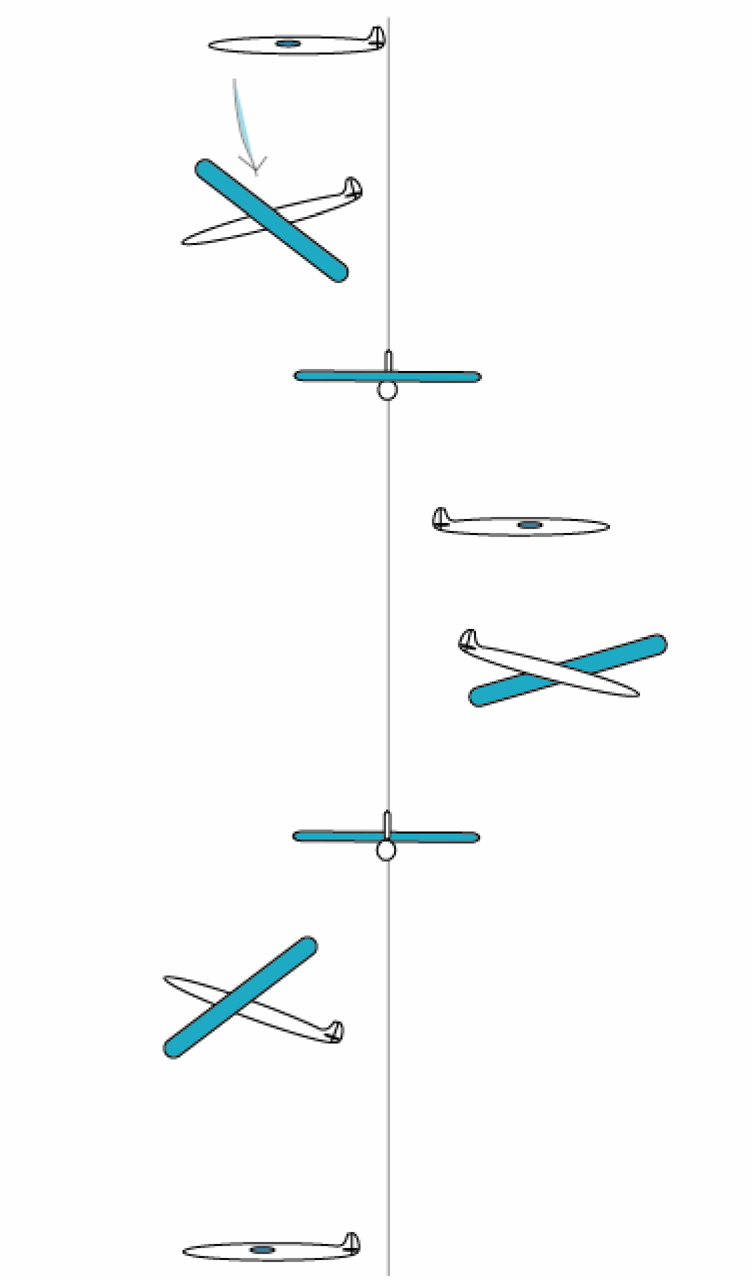
This is a very fast and sudden roll. It’s done by stalling the wing right before rolling. The stall causes a wing to drop, which accelerates the roll.

To perform, reduce the plane’s airspeed, then apply full rudder and a bit of up elevator. You should see the plane stall and drop a wingtip. Add full aileron in the same direction as rudder. As the roll is completed, neutralize the controls. This completes your basic inside snap roll.

The snap roll is stressful on the airframe, and can lead to a spin. Consider this an advanced maneuver, and initially perform “3 mistakes high”.

Spin

In a spin the aircraft is rotating about a vertical axis, with the wing in a stalled condition. One of the easiest ways to enter this is by doing a snap roll, and holding the control deflections. You can flatten the spin out (slow the descent rate) by gradually decreasing the aileron deflection. Make sure you start off at high altitude!



Inverted Spin

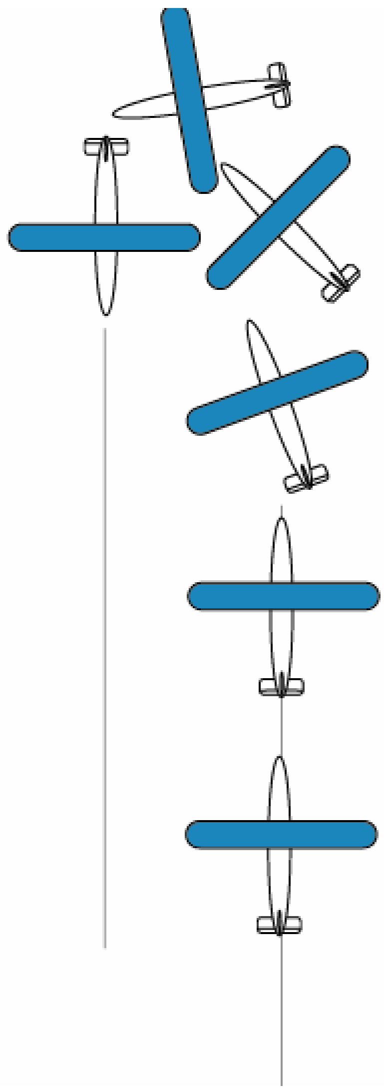
Like a regular spin but performed inverted. From inverted flight, push down elevator and give full rudder and full aileron. Hold the controls to maintain the spin. Reduce as aileron as desired to flatten the spin.

Stall turns and Hammerheads

These are easy and fun to do, and good maneuvers for turning around at the ends of the flying field.

From straight and level, apply up elevator and throttle as necessary to fly vertically. As you run out of airspeed (reduce throttle if necessary), the airplane will stall and rotate around into a turn.

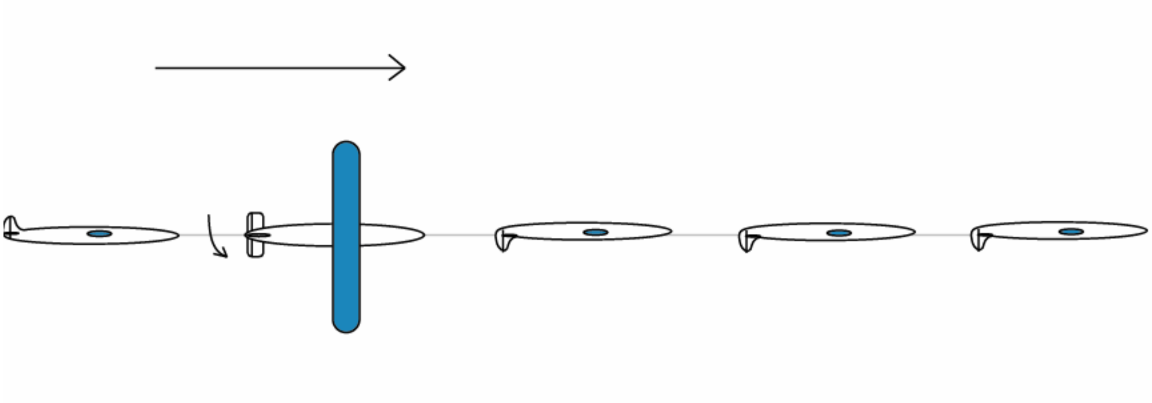
To make it into a hammerhead, apply full rudder and full throttle at the moment of the stall. This will cause the airplane to rotate sharply about its yaw axis, and come back down on the same vertical line.



Inverted Flying

Flying upside down is fun, and with the right plane is easier than it looks. Please note that some trainers, especially polyhedral planes, will fly poorly upside down.

Enter a loop (or roll). When inverted, neutralize your elevator (or aileron) and continue flying. Note that you will probably need to apply a bit of down elevator to maintain inverted flight. Your pitch axis is reversed while inverted (down elevator moves the nose up), so pay attention!



Pattern flight

Pattern flight is also known as precision aerobatics. It consists of very smooth, precisely controlled maneuvers, done in a well-defined space.

3D flight

3D flight is somewhat of a misnomer, as all flight takes place in three dimensions! However, it's commonly used to refer to a style of aerobatics that appears more extreme and less smooth than precision aerobatics. The plane is put into a series of high-angle of attack moves. One of the most popular moves is hovering, where the plane is essentially pointing straight up but held in one place just like a helicopter. Lots of fun to watch and do!

If you'd like to know more about rc airplane aerobatics, check out the International Miniature Aerobatic Club (IMAC):
http://www.mini-iac.com/DesktopDefault.aspx

Or the National Society of Radio Control Aerobatics:

http://www.nsrca.org/

-The End-

Learn to Fly RC Airplanes

A Field Handbook

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