ON TOP OF THE WORLD FLYERS
STUDENT TRAINING MANUAL

A TUTORIAL TO ACQUAINT THOSE WITH A DESIRE TO UNDERSTAND AIRCRAFT AND TO FLY RADIO CONTROL MODEL AIRCRAFT

November 2017
Rev 2

INTRODUCTION TO RC AVIATION

The On Top of the World RC Flyers Club wants to help you enjoy the pleasures of building and flying radio controlled aircraft. As a chartered club of the Academy of Model Aeronautics (AMA), one of our main goals to is foster interest in the hobby/sport and to promote the joy of people coming together with a common interest.

The material in this manual has been obtained from similar clubs around the country and from the expertise of those who have been participating in the hobby/sport for many years. The technical advancements made in radio control equipment (airplanes, engines and radios) have been amazing. There literally is something for everyone – from those who only want to fly to those who painstakingly design and craft their model aircraft. Similarly, the breadth of interests is wide as witnessed by the many types of aircraft seen at flying fields around the country and world.

The Flyers Club has a group of well qualified instructors who happily train people to fly. Your instructor will help you through all the steps – from choosing equipment to getting you qualified to fly safely. After obtaining membership and insurance coverage from the AMA and your FAA registration, there are only four basic rules that will lead to this goal:

1. **Safety is paramount. There are significant hazards associated with operating R/C aircraft. These hazards can (and have) resulted in major injuries and even death.**
2. **Read and understand the instructions for all of your equipment. The equipment manufacturers are quite good at telling you how to get the best service from their product.**
3. **You cannot teach yourself to fly at the OTOW RC Flying club. Even with the outstanding computer-based simulators, learning to fly safely is a process. That is why the Flyers Club has a flight training program – take advantage of it.**
4. **Have fun! You can expect to be nervous – it never completely goes away. Like any activity requiring hand/eye coordination skills are developed over time. Don’t get discouraged as everyone has their own learning pace. Meanwhile don’t fail to seize the enjoyment that this sport/hobby provides.**

We would like to extend special thanks to the DC Radio Control Club (District of Columbia) and the Oswego Valley Modelers (New York) for contributing their training materials.

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1. Principles of Flight

There are four fundamental forces acting on an airplane in flight (Fig. 1). They are lift, weight, thrust and drag. When these forces are in balance, the plane is in straight and level flight at a constant speed. Changing anyone of these forces causes a change in the flight path: if lift is reduced the plane descends.

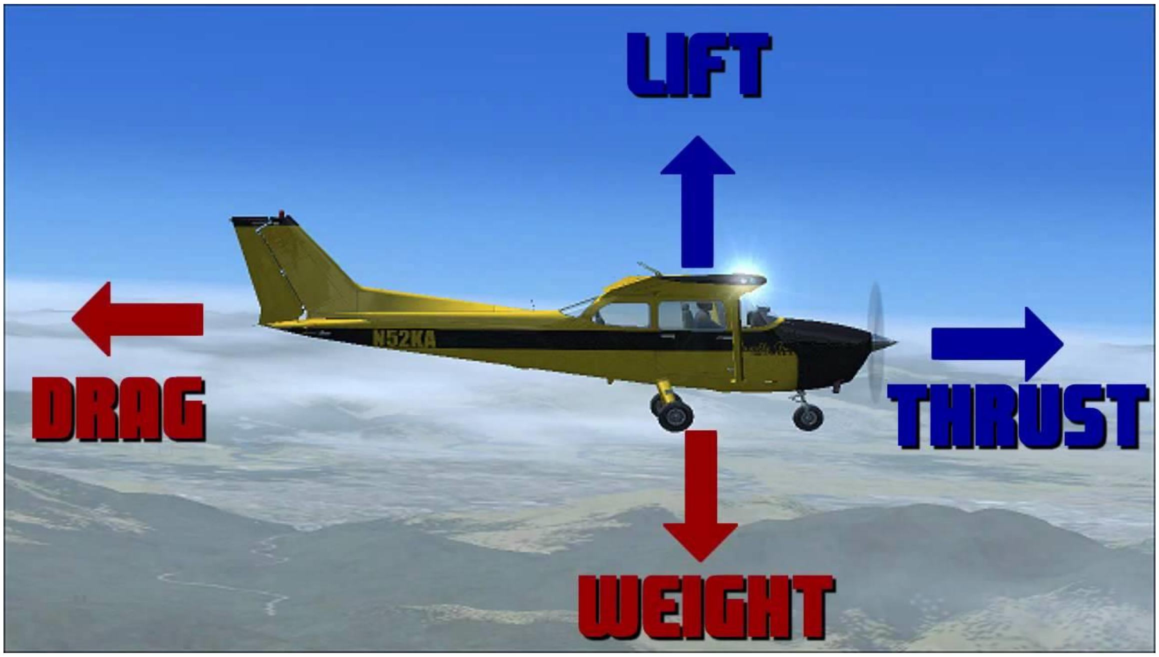


Figure 1
Forces in flight

To fly there must be some way to exert a lifting force on the flying object. So, our first order of business is to examine "lift".

Bernoulli's principle states, “In a fluid (liquid or gas), pressure and velocity are inversely proportional if there is no change in temperature.” In other words he found that the pressure of a fluid decreases at points where the speed of the fluid increases (Fig. 2).

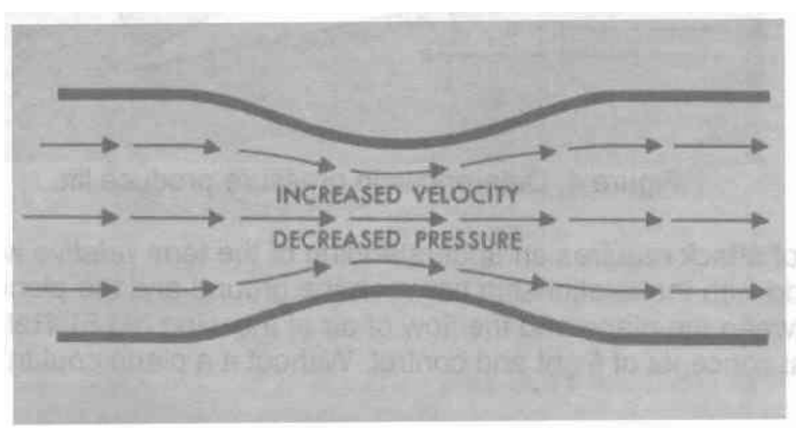


Figure 2
Flow of air through a Venturi tube

Compare the Venturi to the shape of the airfoil (wing cross section shape Fig. 3), and the reduced pressure on the top of the wing is apparent. For many years it was taught that this is what provided enough lift for flight. If Bernoulli's principle is what makes planes fly, how does an aerobatic plane having a symmetrical airfoil fly?

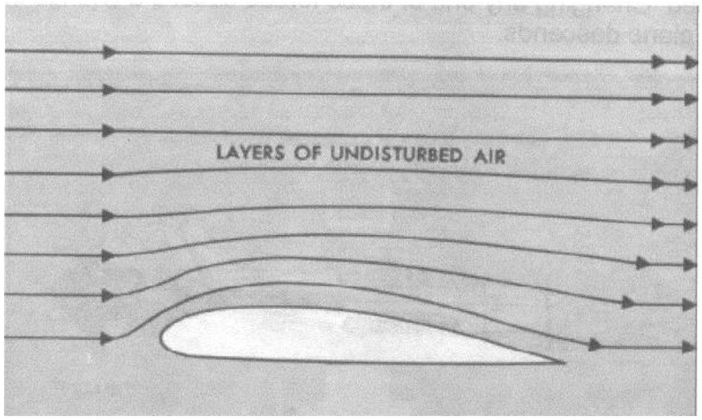


Figure 3
Airfoil showing Venturi effect

The answer? An angle of attack is also needed to produce sufficient lift for sustained flight (Fig. 4).

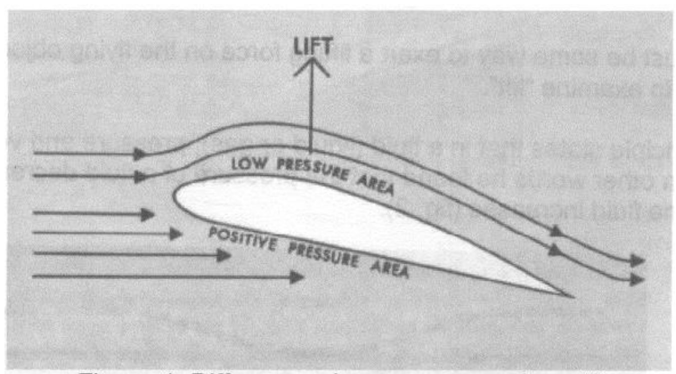


Figure 4. Differences in pressure produce lift.

Next on the agenda of our fundamentals is the *angle of attack.* In figure 5 the wing is always going almost straight into the relative wind in level flight. However, to initiate a climb or descent it is necessary to change the relationship of the wing to the relative wind.

The angle between the wing and the relative wind is the angle of attack.
Defining angle of attack requires an understanding of the term *relative wind.* Relative wind has nothing to do with the relationship between the ground and the plane. It is the relationship between the plane and the flow of air at the wing (fig 5). Relative wind is one of the fundamental concepts of flight and control. Without it a plane couldn't pullout of a dive.

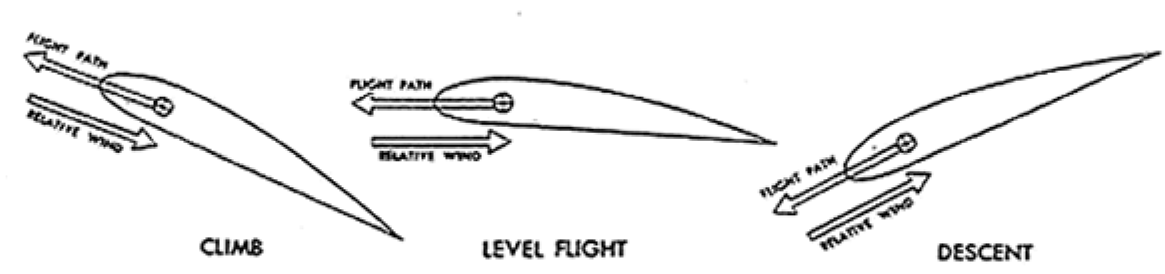


Figure 5

Figure 6, (top line) shows a wing operating at a constant angle of attack while climbing, in level flight and descending. Fig 6 (bottom line) shows a wing at various angles of attack while operating in level flight at various speeds. Angle of attack then is not the angle of the wing chord in relation to a horizontal line. It is, rather, the angle of the wing chord in relation to the relative wind.

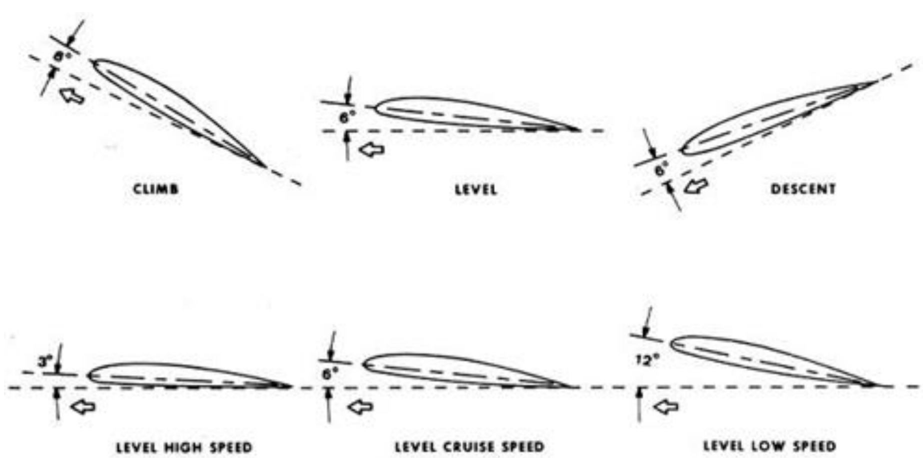


Figure 6

High angles of attack can result in a loss of lift or a "stalled" resulting from the airflow becoming turbulent over the lifting surface of the wing. A stall can be generated at any attitude or airspeed, even when going straight up or straight down if the angle of attack becomes great enough to cause this turbulent airflow (see Fig. 7 below depicting turbulent airflow progression due to increasing higher angles of attack, ultimately ending in a full wing stall.)

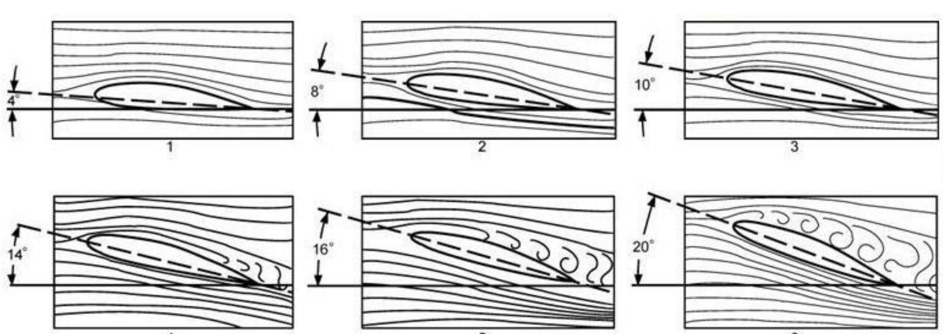


Figure 7
Angles of attack

So we can answer the previous question about our friend Bernoulli and his venturi principle. Lift is a force caused by both differential pressures (high pressure on lower surface of the wing, lower pressure on top of the wing) **and** the effect of accelerating airflow downward from both the top and bottom surface of the wing. Huh? Who said anything about accelerating airflow? Our old friend Isaac Newton had some laws, one of which is that “For every action there is an equal and opposite reaction” (his third law). With angle of attack, regardless of the airfoil shape, there are three independent lift forces. First, the static pressure differential from the Venturi effect (Bernoulli). Second, the dynamic pressure effect from air impacting the lower surface of the wing (Newton), and third from the fact that the air mass passing over and under the wing is accelerated downward (Newton). The force that accelerates the air mass downward produces an equal and opposite force upward. It takes several text books to fully understand the fluid dynamics laws and equations used to calculate lift. Suffice it to say we are only providing a rudimentary explanation here.

So how does an airplane fly inverted? Think about the three lift forces and note how each airfoil design actually performs. With a symmetrical airfoil, angle of attack is nearly the same whether upright or inverted. With a flat bottomed airfoil, considerable angle of attack is required when inverted. This increased angle of attack results in the dynamic pressures and “downward” flow that exceed the benefits of the lost Venturi or static pressure force. Obviously a flat bottom airfoil is not optimized for inverted flight. One aerodynamicist opined that with enough thrust, you can make a barn door fly. He was correct – it just takes a high angle of attack and a lot of thrust to overcome the high drag associated with this angle of attack. If you don’t believe it, stick your flattened hand out the car window and experiment with positive and negative angle of attack.

With an understanding of lift, relative wind and angle of attack, we know why a plane can fly. Flying is fine but it is necessary to be able to control the plane's direction and altitude. This is done with "control surfaces". The ailerons on the wing and the elevator and rudder on the tail (Fig. 8).

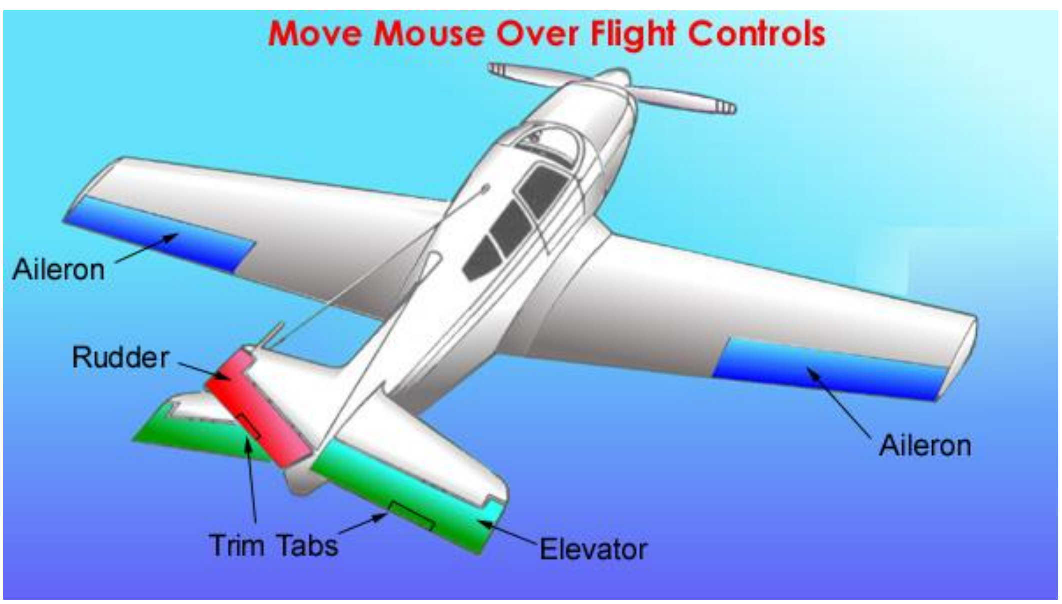


Figure 8
Control surfaces

These control surfaces when deflected cause the plane to rotate about the three axes of the aircraft which are pitch, roll and yaw. (Fig. 9)

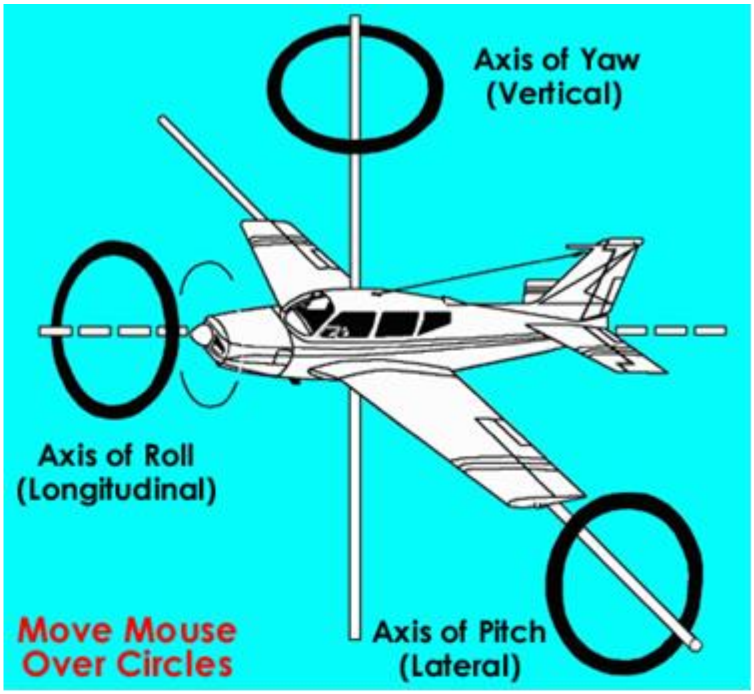


Figure 9
Axes of rotation

Looking at the control surfaces and the axes of rotation, can you tell which control surfaces affect which axes of rotation?

Remember, lift is perpendicular to the wing, not to the ground. Look at figure 10. In order to turn and at the same time maintain a constant altitude it is necessary to do something to correct for the loss of lift while in a bank.

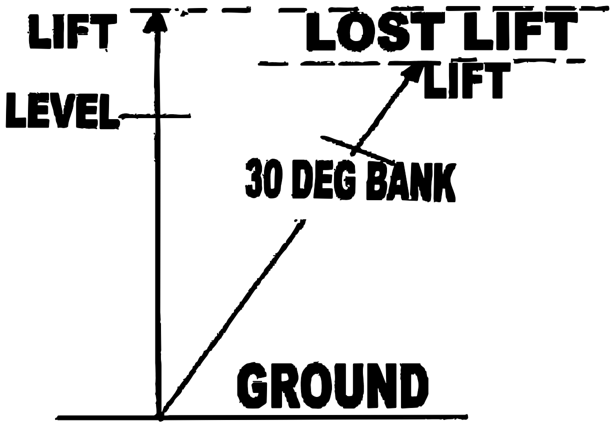


Figure 10. Lift in a banked turn.

This correction is made by pulling back on the elevator stick which increases the amount of up elevator thereby increasing the angle of attack and generating additional lift.

While the subject of different airfoils is complex and fills many a book, some idea of the basic types commonly used with R/C aircraft is worthwhile knowledge. (Figure 11)

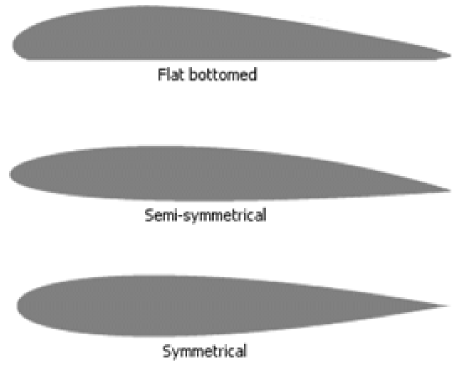


Figure 11

2. Anatomy of R/C Aircraft

2.1 The Airplane

As with full size airplanes, a trainer is used when learning to fly. Flying skills need to be developed and practiced before one becomes an "RC pilot". Once you are an RC pilot, you can advance into any airplane you desire. But at the beginning you start with a trainer to learn the fundamentals of flying. We will talk about learning to fly later, but for now let's look at types of trainers, materials, electronics and engines.

A recommended minimum wingspan for a trainer is about three to four feet. Smaller sizes are available but they are less stable and therefore more difficult to fly.

There are a number of different trainers and methods of construction. Until the 1980's the only way to have a new trainer was to build it from a kit. A kit contained most of the parts and materials to build a trainer yourself (Fig. 12). Usually glues and covering are separate and sometimes wheels aren't included. There are a number of good trainer kits on the market. To build a trainer from a kit is going to take many hours for the beginner (80 to 100 hours of building time isn't uncommon).

Figure 12
Typical kit parts

In contrast to this type kit is the Almost Ready to Fly (ARF) model which has the basic construction and covering completed. The assembly takes about 12 hours, which is spent on the wing and tail assembly and installing radio and control equipment. These are available from Great Planes, SIG Manufacturing and Hangar 9 among others. Some ARFs are virtually identical to the kit aircraft.

Extending the ARF trend are new “Ready to Fly" (RTF) kits that come with radio, servos and engine assembled (fig 13). Some of these can be ready to fly within one hour of opening the box except for charging the batteries. The RTF’s are available from the same sources as the ARFs and in many cases the same model can be purchased as an ARF or RTF.

Each experienced flyer probably has a bias toward one or another trainer, so talk to several people and especially your instructor before making a decision. It is hard to make a bad choice with the models available today, but some choices are better than others. A modern day example of a trainer that has built in stability control, three flight limiting modes and comes in either an ARF or RTF version is the Apprentice S trainer. It costs approximately $200-$300 at the time of this writing depending on the version you purchase.

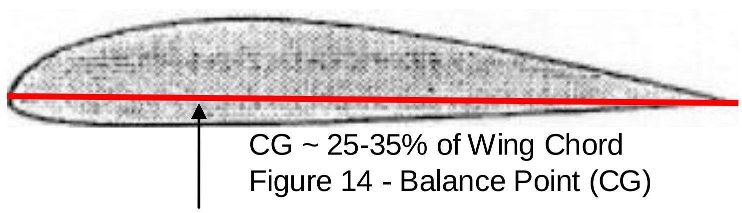
Figure 13
Typical ARF or RTF

The important characteristics of a good trainer are a flat bottom wing which provides a little more lift and stability, the wing on the top of the fuselage for stability, some dihedral in the wing (the tips are higher than the center) for stability, and has all three control surfaces as opposed to no ailerons (banked by rudder only). Finally a good trainer airplane needs sufficient power. Whether you build your airplane from scratch or buy an ARF or RTF version is totally up to you and the time and skills you have available. Most flyers select an ARF or RTF version for their first trainer plane so they can begin their training more quickly.

2.2 Balance.
One of the most critical aircraft design aspects is balance. Balance is closely related to stability, so let’s discuss stability first. A stable aircraft tends to remain in a constant line of flight once trimmed out. This is what permits hands-off flight. Stability is created primarily though aircraft design. The wing does the lifting, but the horizontal and vertical stabilizers render the aircraft controllable. The stabilizers act like the feathers on an arrow. They provide directional stability in the pitch and yaw axes. The elevators and rudder provide control in the pitch and yaw axis, but in their neutral position help stabilize the model. Wing design provides stability in the roll axis by providing equal lift components in both the right and left wings. The overwhelming majority of aircraft

designs are said to be "inherently stable" and these are the conventional designs we are most familiar with. However, some modern high performance aircraft (F-22, F-16, F-18 and B-2 are "inherently unstable" and require active computerized flight control systems to create stable and controllable flight. Here, sensors and computers react with lightning speed to stabilize the aircraft through minute deflection of the control surfaces. Absent these flight controls system, these aircraft would tumble like leaves off a tree. At the design extremes, unstable aircraft have no tail (i.e. no vertical or horizontal stabilizers.) This is the unique feature of the B-2 "Spirit" stealth bomber.

With this basic understanding of stability, the concept of balance is more easily understood. Aircraft must be "balanced" in the pitch and roll axes. The most important of these is what we refer to as the "Center of Gravity" or "CG". The CG is a point along the wing chord where the aircraft balances perfectly nose to tail. Typically this is about 25-35% of the wing chord dimension aft of the leading edge (see Figure 14 below.) This is a "static" balance point that optimizes the "dynamic" (or in flight) balance point relative to the center of lift. A complicated subject simply stated an aircraft has to be properly balanced on the ground or it will not fly properly. A nose heavy aircraft will be sluggish on the controls and a tail heavy aircraft will be overly sensitive to the pitch (elevator) controls. A tail heavy aircraft is said to be "less stable" than a nose heavy aircraft. The proper CG is always noted in the aircraft instructions. Don't ignore this step or you will repeat the process of building another airplane! Simply shift internal items or add weight where it is needed to obtain the proper CG balance point. The other aspect, of less consequence, is lateral balance. That is, if the aircraft is held by the propeller shaft and vertical stabilizer, the wings should remain level. Weight should be added to the light wing tip to achieve proper lateral balance.



CG ~ 25-35% of Wing Chord
Figure 14 - Balance Point (CG)

2.3 Materials

Most models are constructed with a combination of balsa (a soft lightwood), plywood (different thickness and quality), hardwoods (spruce and pine), and now various types of foam. If building from a kit, you will find these materials in the box, but with ARFs, they are already in the constructed plane.

Whether a kit or ARF, you will need different glues. Epoxy comes with different working times (5, 15, 30 minute for example). Generally the longer the working time the stronger the bond. CA (cyanoacrylate) is like crazy glue, very fast curing and very strong. CA comes in several thicknesses for different applications. Whatever type plane you select, you will need both epoxy and CA, if not for building, for repair. Foam type models require Foam Safe CA. So when working on these types of models be sure you use the proper adhesives or you may just end up with a melted mess of foam on your hands.   It is also a good idea to have debonder around when using CA to remove excess CA or to unglue your fingers.

Other than foam models, trainers will be covered with some kind of film, and with ARFs this can be important. The most common coverings are MonoKoteTM and Ultracoat TM. These are Mylar materials with a heat sensitive adhesive on the back and a special iron may be used to attach the material. Both are also heat shrinkable that is the material will shrink, eliminating wrinkles when a heat iron or heat gun is used.

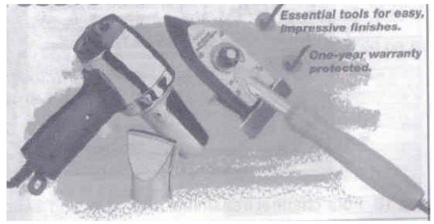


Figure 15
Covering tools

About the coverings for ARFs, some use a material that neither MonoKoteTM nor UltracoatTM will adhere to. Consequently, if the covering tears it can only be patched with clear tape, or worse, stripped and recovered.

Some more advanced planes may be sheeted with balsa, and then covered or painted. There are also aircraft made from foam which has the color built in and decals applied.

We are not going to discuss construction of the model. All kits, whether you assemble everything or purchase as an ARF or RTF, generally come with excellent instructions. Crafting a model “from scratch” is a subject unto itself. If you are into that type of building, talk to other modelers in our club for information as many have exceptional abilities along these lines.

Recognizing that the state of the art is rapidly changing, it is strongly suggested that talks with the RC Flyers training staff would be helpful before choosing a model. The people in the hobby shops can also be helpful. Just bear in mind sales associates want to sell what they have in stock at times.

It is difficult if not impossible to learn to fly with a glider as your first model and is not recommended as your first trainer airplane for a variety of reasons. Talk to your instructor if you need more information about gliders.

2.4 POWER - Engines and Propellers
Internal combustion and electric engine sizes are designated by their cubic inch displacement, 0.40, 0.60 etc. or wattage and KV capabilities for electric motors. Trainers are usually designated by the same size parameters or have the power requirements included in the kit. There is nothing wrong with going slightly oversize on the engine. For example a 0.46 engine could be used in a 0.40 size plane with some advantage. There are both two-stroke and four-stroke glow fueled engines. Both are excellent for a trainer, but the four stroke is more expensive. Most modern trainers are now powered by an electric brushless motor, ESC and battery. Again, each experienced person usually has a bias toward a brand or type of engine. Luckily there are very few bad choices available.

2.4.1 Engines
There are several factors to consider in selecting a power plant. For training aircraft, the most commonly used engines today are electric. Second to an electric motor are the 2-Stroke glow engines due to its simplicity and lower cost. The 2-Stroke Cycle (Figure 16)

and the 4-Stroke Cycle (Figure 17) glow ignition engines are depicted as options. As these names imply, the 2-stroke engine fires once every revolution and usually has no valve system for the intake or exhaust. The 4-stroke engine fires every other revolution and uses "poppet valves" for both intake and exhaust routing. The size of all engines determines power output and is expressed in either wattage for electric motors or cubic inches (CI) or in cubic centimeters (CC) for glow engines. Cylinder materials for most 2 stroke engines are ABC (aluminum, brass and chrome). The piston is aluminum and the cylinder sleeve is chrome-plated brass. These engines don't have rings and break in faster, plus they are usually a bit more powerful. Many ABC engines have ball bearings (BB) rather than sleeve or bushing bearings. As usual, better costs a bit more. These engines use a "glow plug" for ignition as we will discuss later. Fuel for glow engines is a mixture of methanol, nitro-methane and oil. Most commonly used glow fuel is a mixture of 10% to 15% nitro methane, plus 16% to 18% lubricant (synthetic oil and/or castor oil), with the balance being methanol. Both 2-stroke and 4-stroke engines use the "lost oil" method of lubrication. The oil is mixed with the fuel and is lost in the exhaust stream as fuel is burned. Thus they can be a bit messy. Some of the newer engines have the high-speed needle valve located toward the rear of the engine, which keeps the fingers out of the propeller during carburetor adjustments. Several brands are available including the most popular OS, Saito, Super Tiger, and Evolution. Other choices are available and soliciting comments from flyers can't hurt in making a selection. But remember everyone has a bias, so talk to more than one person.

Figure 16
Two Stroke Engine

Figure 17
Four Stroke Engine

a. Glow Plug. A separate discussion is warranted for glow plugs which are unfamiliar to most people.

1. Glow Plug and coil check

Glow plugs are like small sparkplugs but instead of a spark the plugs coil will glow red hot when you hook it up to the igniter. It stays hot by the fuel and compression of the running engine. The coil of wire is located inside the plug. This coil breaks often and when this happens, the engine will no longer run and the plug must be replaced. Hook up the glow plug igniter, to the glow plug, then check the plug meter on the control panel. If the meter moves the plug is ok. If the meter shows no movement even after turning the meter knob, the plug is dead.

2. Coil check

Let's take a look at a plug. Take the existing plug out of the engine or use a new plug. Take the plug and push it in to the battery powered glow igniter. Look at the coil - is it glowing red/orange? Assuming the battery in the igniter is charged the coil should be visibly glowing. If not, either the coil is "burned out" or the igniter battery is dead. Substitute one or the other to determine which. Failed glow plugs are the most common cause for glow engines that won't start. Worn plugs can cause the engine to run poorly, so replacing the plug is one of the first trouble shooting steps to take.

3. Remove/Replace the glow plug as follows:

(a). Put the washer on the glow plug and set the plug in the hole.

CAUTION!
Costly engine head damage can occur by accidental cross threading when putting the plug back in. The plug should screw in easily. IF the plug starts to bind while tightening, THEN STOP and fix it before you damage the motor head.

(b). Use ONLY your fingers to screw the plug in. (or use a nut driver, again turning it with ONLY your finger tips). Use a nut drive or plug wrench to tighten the plug.

b. Choking an engine prior to starting

Choke the engine by opening carburetor full bore, place left thumb over carburetor opening. Carefully use your fingers or better yet use a "chicken stick" to flip the propeller counter clockwise a few times, generally until a wet sound is heard. Do not use the starter for this because too much fuel will sucked in. Take your thumb off the carburetor, grab the prop in your right fist and rotate it once or twice to be sure the engine is not hydraulically locked up. If you can not turn the prop through a revolution then there is too much fuel in the engine. Tilt the engine so that the extra fuel can run out of the muffler. While the engine is on its side rock the prop back and forth to drain the cylinder.

c. After Run Oil

We use "after run oil" in our engines mainly to prevent rusting, especially rusting of the bearings. You can buy actual "after run oil" or you could also use "Marvel Mystery Oil' or automatic transmission fluid. Whenever you are done running an engine you should liberally coat the engine's insides with after run oil. The best way to do this is to:

- After defueling the aircraft, run the engine to eliminate residual fuel
- Remove the glow plug and washer.
- Fill the carburetor with oil.
- Rotate the prop by hand CCW to suck up the oil.
- Fill the carburetor a second time and rotate the prop again.
- Use the starter momentarily until oil comes out the glow plug hole.
- Replace the glow plug using the instructions above. Close carburetor completely and turn off your radio.

2.4.2. Electric Power

Electric power has become even more popular as the motor and battery technology has improved. New Lithium Polymer (LiPo) battery technology has improved electric flight time. Repeated flights require more than one set of batteries. It is even possible to fly on one set while the other is charging from the car battery.

2.4.3. Propellers

a. Propellers come in all shapes and sizes; two blades, three blades, four blades. Materials include plastic, wood, carbon fiber and other composites. Colors vary from material and brand.

b. Safety:

1. The tips of all Props should be painted a bright color for visibility.
2. Throw away any props that have any nicks or cracks in them.
3. Before using a plastic prop sand or scrape off any flashing. Flashing causes the prop to be very sharp along the edges.
4. If you're holding a plane that has it's engine running. Look behind the plane to make sure you're prop blast is not blowing dust and dirt towards somebody else.

c. Sizes: Props basically come in two types and have two numbers that identify them. The different types made are for electric motors and for glow or gas motors. A 10X4.7E is an example of a prop for a small electric motor. The "E" designates this pro is designed for and electric motor. (CAUTION: Never use a prop designed for an electric motor on anything but an electric motor.) The first of the numbers in the designation is the "DIAMETER" or its length in inches. In this example the prop has a 10" diameter. The second set of numbers is the props' "PITCH" and in this example it has a pitch of 4.7". Pitch is how much the blade of the prop is curved or twisted and means in one revolution, in a solid, how far it would move forward. A small number means less twisting and a higher number means more of a twist. The prop uses the inside curved part (the side facing the back) to do all it's work. Some props are designed to rotate clockwise and others counter-clockwise so make sure you select a prop specific to your model's need.

d. RPM: Each internal combustion engine has a certain Revolutions per Minute (RPM) range where it runs the best. If you put a small prop on these engines the engine might spin too fast and be damaged. Put a large prop on the same engine and it might not spin fast enough for the plane to take off. Each change in diameter or pitch of a prop changes the engines RPM and the way the plane flies. The trick is finding the right combination of diameter and pitch to make the plane fly the way you want it to. Most manufacturers identify a range of propellers appropriate for that engines operation.

Brushless electric motor RPM's behave quite differently from internal combustion motor RPM's. Their RPM's are driven by the KV rating of the motor and the battery voltage used, regardless of prop size. The prop size selected is to derive the amount of load placed on these motors and thus the thrust created. The designed load or amount of energy consumed for these motors is in specified in watts and has limits for that motor/ESC/battery combination for a given model. Select too large or a too high of a pitched prop and the current flow from the battery/ESC thru the motor will exceed the internal components design capabilities resulting in burned out motors, overheated and damaged ESC's or batteries that puff up and won't last an adequate amount of time nor the number of recharge cycles they are designed to last. Worst case you may experience a fire caused by the excessive heat generated. Use too small of a prop and the same RPM will be achieved but the thrust generated will be below what is needed for adequate take-off and flight performance. To measure the proper loading and propeller size, you will need a watt meter (cost under $20) that plugs in between your battery and ESC. It will show you the battery voltage and current (in amps) at various power settings and also show you the wattage (current x voltage) that is being consumed at those power settings. Experiment with different prop sizes and stay at or below the specifications of your selected components.

e. Vibration: Besides using the correct prop for your plane, taking care of the propeller is also very important. Vibration of any kind is bad for the plane and a major source of vibration is the propeller. A prop out of balance sends vibrations everywhere. This vibration can loosen screws, crack joints, wheels could fall off, covering could tear, and in rare cases cause damage to the circuit board in the receiver. You can't stop all vibration especially in glow or gas models. That is the main reason for those models that servos have rubber grommets that the mounting screws go through and why we wrap the radio receiver in foam padding. It is also the reason their propellers are much more substantial. Although prop vibration can't be eliminated, it can be minimized by balancing in all prop types. Electric powered motors do not produce the same kind of vibrations that internal combustion motors do. Electric motors run relatively vibration free except for the propeller itself, As such, balancing electric props is just as important, if not more important than internal combustion models. Electric model airframe components are not designed to dampen vibrations to the same extent as their counterparts.

f. Prop Balance: In the ideal world each blade of the prop would be of equal weight but we don't live in the ideal world. One tip will always be slightly heavier than the other. Mount the prop on any "Prop Balancer" and you will find that one tip of the propeller always hangs down. This is the heavier of the two. Generally the difference in the weight of the tips will be small. So, for a wooden or plastic prop we sand or scrape some material off the heavy end to make that tip lighter. This should only be done on the outside curved surface. That's the side facing forward. You should never sand the inside curved surface or any of the edges.

Figure 18
Prop Balancer

g. Mounting: Props should always be mounted on internal combustion motors so they are horizontal when the engine is going counter clockwise and starting its compression. We do this so that if the engine quits in flight, the tip of the prop will not be pointing down when we land. A tip that's pointing down is bound to break sooner or later on landing. (Note - Mounting position is of no consideration on an electric motor.)

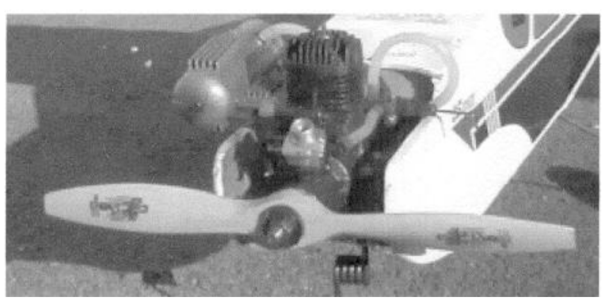


Figure 19
Prop Mounted Correctly

2.5 Control Systems
The radio control system consists of a transmitter (Fig. 20), receiver, batteries, servos, switch and possibly a charging jack. The transmitter sends a signal to the receiver which interprets the signal and sends inputs to the servos (servomotors) that cause the controls to move. Power to operate the receiver and servos comes from a battery pack that is carried in the plane. The receiver's right hand stick controls the aileron and elevator while the left hand stick controls the rudder and throttle (commonly referred to as a Mode 2 transmitter configuration). There are also trim adjustments next to each of the sticks to make slight adjustments to those controls.

Transmitters come in various capabilities but all currently manufactured transmitters operate in the 2.4GHz range and use digital signals. Older model transmitters operate in the 72MHz range and typically share their operating frequency with other modelers using the same type of transmitter. This potential duplication of frequencies in use for these types of radios creates the need for frequency management controls at flying fields for obvious reasons. Conversely, a 2.4GHz transmitter can be operated independent of all transmitters and without concern for frequency degradation to any other 2.4GHz transmitters in use. This is why they are now the only choice available when purchasing a new transmitter.

An entry level 2.4GHz aircraft transmitter has five or six channels and is not computer driven. At the higher end, transmitters are available with up to 18 computer driven channels. At current market pricing, it is recommended that the student start with a computer driven five or six channel transmitter. The cost differential is miniscule between the two with competition driving the costs down seemingly daily. The receiver has to match the transmitter manufacturer's transmission modulation type and the number of channels needed. (Note - Futaba receivers don't work with Spektrum or other 2.4GHz transmitters and vice versa).

Figure 20
Six channel computer driven 2.4GHz transmitter

For a beginner, a most important selection factor is the need for your radio transmitter to be compatible with the instructor's "buddy box". A buddy box provides for a dual control system that enables the instructor to take control and avert an impending crash. Here again, it is necessary to talk to instruction personnel to get up to date information.

The second major component is the receiver. Receivers are designated by the number of channels; i.e. 4, 6, 8, etc. Obviously, the receiver must be compatible with the 2.4GHz transmitter manufacturer. As mentioned earlier, not all receivers are compatible with all transmitters.

Another major component are the servos used to actuate each channel of the flight controls plus the engine throttle. Generally, one brand of servo is compatible with most brands of receivers. However, some minor differences exist in the connectors that may affect your choice of brand names. In recent years digital vs analog receivers were introduced to the hobby. The main difference being the rate at which they update their positions. Digital servos are roughly six times faster in updates yet consume a bit more power for that capability. For entry level trainer airplanes however, this update rate is negligible. If cost is comparable, digital servos would be the recommended choice.

Yet another important component is the aircraft radio "On/Off" switch or Safety Plug in electric models. Do not use inexpensive switches designed for other purposes – they are likely to not be designed for the vibration environment of an R/C aircraft. Stick with those commonly used by experienced flyers. Obviously the onboard battery is being used up while in flight. It is a good practice to check the battery voltage between flights.

A minimum of four channels are required to control aileron, elevator, rudder and throttle. Additional channels are now being used for stabilization and flight modes. Talk to your instructor or other flyers when considering requirements for your particular model.

Battery technologies seem to be changing by the passing of months. Where NiCads (nickel cadmium) and a charger were used as a main stay, they have been replaced by NiMh, LiPo, Lithium Ion, and LIFE battery technologies in receivers as well as on board aircraft power supplies. Of course the batteries must be fully charged when you set out to fly. This is achieved by using a charger that came with the transmitter radio system. For other battery pack locations, a smart charger applicable to that specific battery technology should be used. Batteries are labeled in technology type, voltage, milliampere hours (mAh) capacity and a current deliverance rating known as a "C" rating. The separate onboard trainer battery (if not derived from the main battery as is typically found in an electric model) has a typical capacity of 1500 to 2000 mAh at either 4.8 or 6 volts (1.2 volts per cell for NiCads). Nickel Metal Hydride (NiMh) batteries are also commonly used and are perfectly acceptable as a stand-alone battery for receiver and servo operation however there are even more reliable technology batteries available today. Compared to NiCad, a NiMh battery has a higher energy density so you can get more capacity in an equal size battery pack. Generally, NiCad and NiMh batteries can be charged with the same type charger. Never attempt to charge any battery with a charger that is not compatible with its design. Again, consult an experienced flyer for advice.

With proper care you can expect long battery life. The charger that came with radio will charge NiCad and NiMH batteries at a rate of C/10. At this rate the battery wont be overcharged even if left on overnight. Other chargers using rates in the area of C/4 will charge in a few hours, but can't be left on for more than what it takes to reach full charge. These chargers should have the capability of detecting peak charge and then switching automatically to trickle. Brand new batteries of this technology usually won't reach full charge until they have been cycled two or three times. There are chargers on the market that cycle the batteries by draining to about 1.1 volts per cell and then switch to charge mode. LiPo and various other Lithium based batteries require special chargers with settings to accommodate a variety of configuarations, voltages and charging rates. These batteries also pose risks of fires when mis-handled, stored improperly, charged improperly or damaged. Familiarize yourself with your battery type and all requirements for safe operating practices.

A typical on board radio control system is shown below in Fig. 21. Like everything else, there are choices to be made. The most popular radio control systems are made by Futaba and JR. Next are the Hitec and Airtronics brands. The main advantage of the newer 2.4 GHz radios and receivers is that you are neither tied to a single frequency nor is there risk of inadvertently operating on the same frequency as another flyer.

The various parts of the radio system are tied together with connectors, male and female, that may be keyed so that you won't make improper connections (Figure 21-21a). These connections are critical, especially when mixing brands of servos and extension wires. The receiver antenna can be pulled from the receiver if too much pull is exerted, and the antenna on the transmitter can be easily bent. (Never modify the length of a receiver antenna, especially a 2.4GHz receiver which has a very short antenna.) If redundancy is needed, many of these 2.4GHz receivers have satellite receivers that work with your main receiver. They plug into your main receiver and are placed elsewhere in your model to ensure adequate signal reception is maintained in all attitudes of flight.

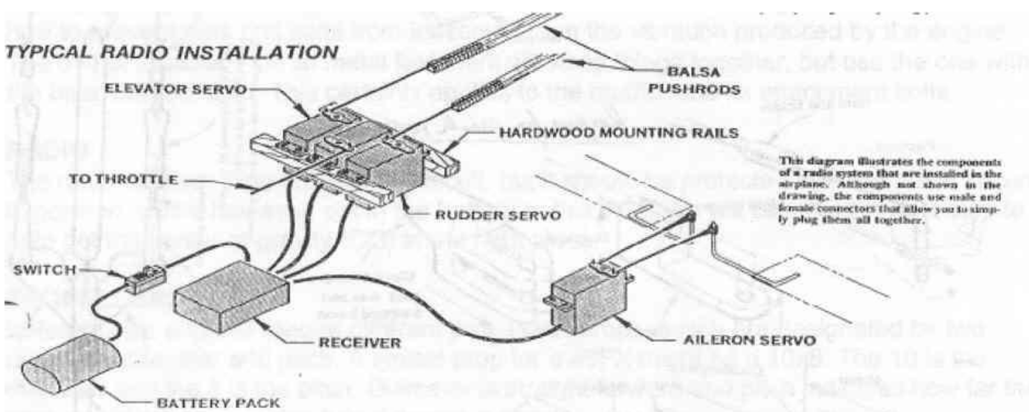


Figure 21
Onboard Radio Control System (Non-electric model)

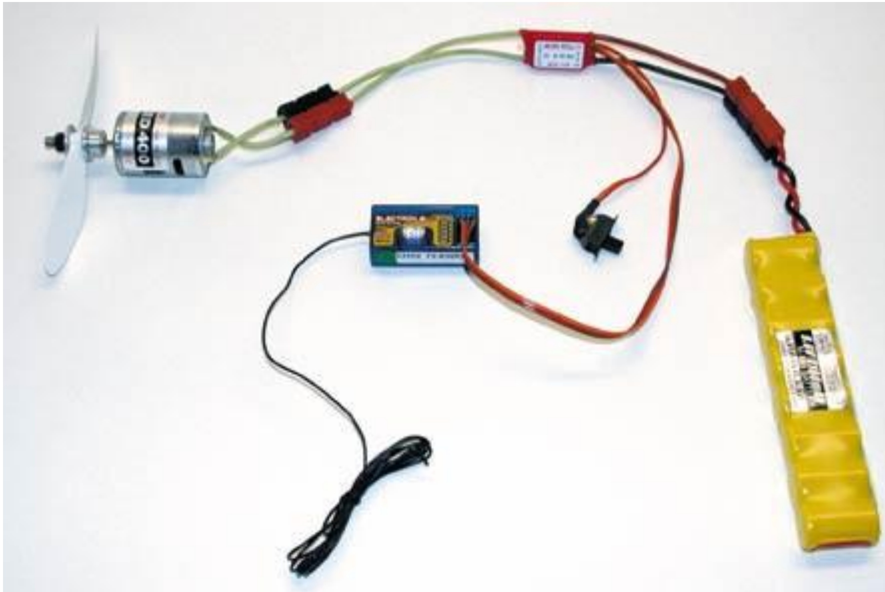


Figure 21a
Onboard Radio Control System (Electric model)

Take care of your radio equipment. It lets you keep the plane in the air!

3. Field Equipment

The equipment required to get a trainer off the ground can be very inexpensive. There are a few basic items that will suffice to get a beginner into the air and learning to fly but there are other items that can be added to make the job a lot easier.

MINIMUM EQUIPMENT FOR ELECTRIC POWERED AIRCRAFT
Batteries
Battery testing meter

MINIMUM EQUIPMENT FOR GLOW POWERED AIRCRAFT
Glow Plug Driver Clip on battery for supplying power to glow plug
Chicken Stick used for flipping the prop to start the engine
Fuel recommended by engine manufacturer
Fuel Bulb - Rubber bulb or manual pump used to transfer fuel to the model fuel tank
4 - Way Wrench Combination wrench with sizes to fit glow plug, prop nut, etc.
Tool Box Any box suitable for carrying the other equipment
Liquid cleaner and paper towels

These items should cost about $70. This can vary depending on the brand of the items and the place from which the items are purchased. An assortment of screwdrivers, pliers, and allen wrenches may also be needed to perform field maintenance.

OPTIMUM EQUIPMENT FOR GLOW POWERED AIRCRAFT
NAME DESCRIPTION
Starter Battery powered motor for starting model engine
Glow Plugs
Connector Clip on battery connector for supplying power to glow plug
Power Panel - Power distribution panel for distributing power from a field battery to starter, glow plug connector, etc.
Field Battery Small 12 volt wet or gel cell battery
Fuel mixture recommended by engine manufacturer
Fuel Pump Electric pump used to transfer fuel to model tank
4 - Way Wrench Combination wrench with sizes to fit glow plug, prop nut, etc.
Field Box Tool box specifically designed for carrying model field equipment
These items will cost about $200. The cost will vary depending on the brand of the items and the place from which the items are purchased. Field box kits are available for a wide range of prices but can be built from readily available materials. An assortment of screwdrivers, pliers, nut drivers, and allen wrenches is also desirable to perform field maintenance.

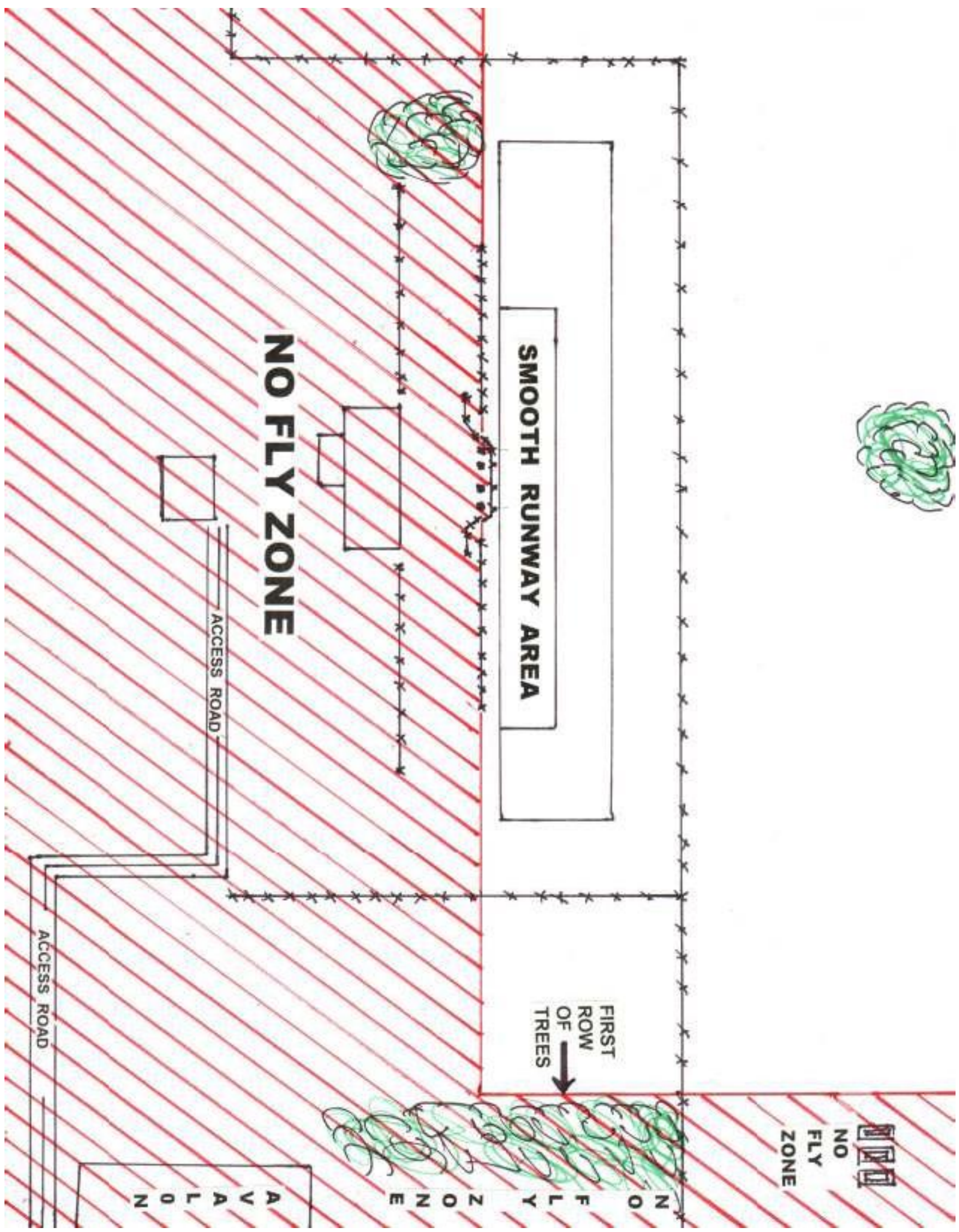
4. Basic Ground Training

The following is a progressive tutorial for ground training geared toward the student. Instructors use differing methods and techniques and may vary the sequence in which the training is conducted. However, the material provided in this section is intended to help the student learn the basic ground and safety practices leading to solo and unsupervised flying.

4.1 Safety

a. Field layout.

See the diagram below for the no fly zones. Also view the disgram in the shelter showing the spectator area, spectator fence, pit area, runway and flight line. The flight line and pilot stations for our field is the fencing near the edge of the runway.



b. Safe area

Remain on the Spectator side of the fence when you're not flying. Don't wander around, stay in the shelter area and be ready when it's your turn. Do not go on or near the runway without permission.

c. Listen for warnings from others taking off, landing, or in trouble

Be generally aware of what's going on around you at all times. All pilots should call out when they are turning on a 72 MHz transmitter, taking off, landing or are in some kind of trouble. The call out is a warning for you. So be alert and pay attention to what's going on. As you start to fly it is an expectation of everyone that you will call out your intentions as a courtesy to everyone else. Get used to making those calls early on in your training.

d. Close Contact

1 Most propellers are very sharp, be careful when handling them.
2 Engines are very HOT while running and for several minutes after being shut off. Treat all engines as hot.
3 If you get glow fuel or exhaust oil on your skin wipe it off with a paper towel, not on your clothes.

e. Propeller space, prop circles, and kick back

Prop space is the physical space used by the prop while it is rotating or spinning. This is where cuts and lacerations happen. A spinning prop or even an armed engine on an electric model is the number one safety issue at any *RIC* flying field.

"DO NOT GO ANYWHERE NEAR AN ARMED ELECTRIC MOTOR OR RUNNING ENGINE UNLESS YOU ARE UNDER THE DIRECT SUPERVISION OF AN INSTRUCTOR."

(Definition of "near" - If you can stretch out your hand and touch the prop you're too close)

Students in the flying program are only permitted near an armed electric motor or spinning propeller when they are carrying a plane out to the runway for takeoff, under direct supervision of an instructor for demonstration purposes, or when they have their own plane and are being trained to operate their own model.

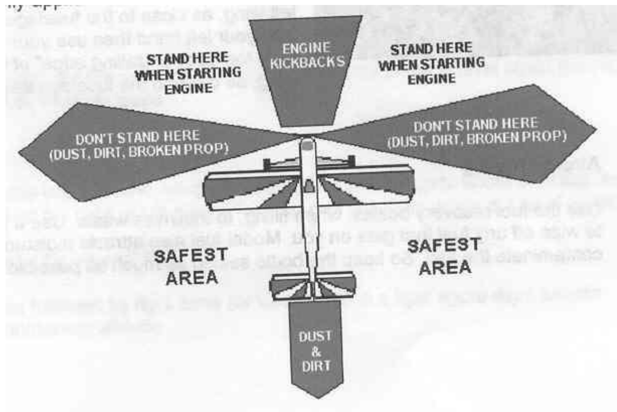
For safety reasons your prop tips should be painted white or other bright colors for better visibility. Unpainted prop especially black ones are almost invisible.

Prop circles - Imagine a kid standing next to you spinning a Yo-Yo around by the end of the string He's spinning it around really fast in a big circle. If you're smart you won't stand beside him just in case the string breaks. A spinning propeller is like that Yo-Yo. Any sand, stones, dust particles that get picked up by the air around the prop will fly off the tip of the prop in whatever direction the prop is pointing. If you are standing to the side of the prop you are in the line of fire. Also if a propeller blade breaks off while it's spinning, the blade will take off in the direction the propeller is pointing.

"DO NOT STAND IN FRONT OF OR TO THE SIDE OF A SPINNING PROPELLER!"

The safest place to stand is in back of the prop. The next safest place to stand is in front of the prop not directly in front but off center. Ask your Instructor where you should be standing if you're not sure.

Kick backs - This is when an internal combustion engine kicks backward, for whatever reason, during startup and generally the spinner, nuts, and prop come loose and fall off. This diagram applies to someone who is starting this type of engine but you should be aware of it.



4.2 Basic ground school Instruction

a. AMA Safety Code and Field Rules

We are required by our AMA Charter to abide by the AMA Safety Code. The field rules included later are specific expectations for our club.

b. Frequency Board (for non-2.4 GHz transmitters)

There are 50 Radio Frequencies or channels available. No two people can use the same channel at the same time. The "Frequency Board" is our way of controlling the channels in use.

c. Transmitter Impound (for non-2.4 GHz transmitters)

Transmitters are placed in the "Impound" for your safety and the safety of others.

Go over and understand all the equipment in the flight box including how to hook everything up correctly and how to use them.

d. Picking up the aircraft

These aircraft are basically very fragile. Grabbing it at the wrong place can easily break something. Some places on the plane are stronger than others. We hold on to the stronger points. When moving a plane around or retrieving one that has landed, pick it up from the left side by grabbing the leading edge of the wing with your left hand and the fuselage behind the wing with your right hand. This technique is the safest and avoids the dreaded “spinning prop”

Aircraft refueling can be done on the assembly tables or on the ground in the pit area. To minimize the waste and mess from overflows, it is recommended to use a fuel recovery container. Use a paper towel to wipe off any fuel that gets on you or the assembly tables. Model fuel also attracts moisture which will contaminate the fuel. So keep the fuel jug sealed as much as possible.

4.3 Pre-Flight

a. Transmitter sticks, trainer cords, and trim levers

The transmitters we use are predominantly set up in the "MODE 2" configuration. This setup has the Aileron and Elevator on the right transmitter stick and Rudder and Throttle on the left transmitter stick. A trainer cord or wireless trainer master transmitter is used to connect two transmitters together for training purposes. It allows an Instructor to instantly correct a situation without the student and the Instructor having to pass a single transmitter back and forth. Trim levers are used to make small adjustments to a particular control function.

b. Instructor - Student verbal signals

When the Instructor says, "Left or Right" it is always the aircrafts left or right, not the students left or right. When the Instructor asks for some "up" as in "give the plane some up," he is not asking for you to push the elevator stick UP but to pull the stick back towards yourself which causes the plane to go up. Students should NEVER push the elevator stick forward (down elevator) unless told to do so.

c. Battery charging (Student's own plane)

1. With “wall trickle chargers”- Flight packs require (16 to 20 hrs) and Transmitter (16 to 20 hrs). If your plane or transmitter has other than NiCd or NiMH batteries please follow the instruction manual that came with that equipment for charging.
2. After the 16 to 20 hour charge the NiCd and NiMH transmitter and flight pack batteries can be kept fully charged by plugging them into a 24 hour timer set to go on for 1 hour a day.
3. Flight box battery (per manufacturer) Ni-Starter (per manufacturer)

d. Pre-flight aircraft check

This is a check for areas of the plane and not just a particular item. Example checking the "Motor and Prop" would involve checking the motor bolts, the prop mounting bolts, spinner, muffler, etc.

"SKETCH"

S - Servos and screws
K - Keepers on all clevises
E - Engine and prop
T - Tail feathers
C - Control rods and collars
H – Hinges

e. Mount Wing

Connect Aileron servo wire and align the wing in saddle area. Be sure aileron wire is not pinched between the wing and the saddle area. Lead the charge wire connector out the left side of the fuselage to check voltage between flights if so equipped. If desired, a small notch can be cut in the wing saddle to provide relief for the wire.

f. Rubber bands

Use appropriate rubber bands every time wing is put on. Buy a box from the hobby shop. They get really nasty from residual oil and fuel or weak from normal use and heat, so throw the used ones away frequently.

g. Transmitter retrieval (PIN IT OR POUND IT - for non 2.4 GHz transmitters)

1. Make sure YOUR frequency or channel is available.
2. Use your AMA/club card in the frequency stand to Identify the channel you're using. One card - one channel at a time!
3. Put the frequency pin on your transmitter.
4. Notify others BEFORE you turn the transmitter on.

IMPORTANT! - (For non-2.4 GHz transmitters)
A TRANSMITTER THAT IS NOT IN THE TRANSMITTER IMPOUND RACK MUST HAVE A FREQUENCY PIN ON IT!

Note 1: *Many flyers will not fly when someone is on an adjacent channel.* ***DO NOT*** *turn on* a *transmitter when there is another card in the slot. If you find a transmitter in the impound area with the frequency pin you need attached, find the person before taking the pin or turning on your transmitter.*

Note 2: *During cleanup is the time when most frequency related accidents happen. Turn on your transmitter to close the carburetor, to set your control sut1aces to neutral, to check your batteries, etc. only with the frequency pin attached to the transmitter.*

h. Pre - Flight Range check

With the transmitter antenna completely collapsed or for more modern radios place the transmitter in the reduced output power mode or range check mode and walk at least 100 feet away from the plane. Look for the control surfaces to move as you move the transmitter sticks. They should move smoothly without any jitters. It is helpful for a second person to observe the aircraft during your range check as it is difficult to see the surfaces from this distance.

i.Transmitter check

"**CATS"**

C = Control surface check, be sure to check both directions. (See below)
A = Antenna fully extended
T = Trim Tabs centered
S = Switches in the correct position

Fully move control stick hold in full deflection and check each of the following.

SURFACE	Transmitter Stick	RESULT
Aileron	Move to the right	Right Aileron up, left aileron down
Aileron	Move to the left	Left Aileron up, right aileron down
Elevator	Pull towards you	Elevator up
Elevator	Push away from you	Elevator down
Rudder	Move to the right	Rudder moves to right
Rudder	Move to the left	Rudder moves to left
Throttle	Pull towards you	Carburetor completely closed
Throttle	Push away from you	Carburetor fully open

5. Basic Operation & Flight Training

Before First Flight

Engine Break-In (does not apply to electric models): Engines shall be broken in at the designated engine test area under the oak tree at the west (left) end of the pit area. Follow the engine manufacturer's instructions. Do not attempt to fly an aircraft until the engine is completely reliable at all throttle settings. An experienced person can help you understand the dynamics of carburetor adjustment. Make sure that the throttle servo and linkage are adjusted to "kill" the engine when the throttle trim is all the way down.

Restraining aircraft The aircraft must be restrained before starting or running the motor. This can be done using one of the starting stands or using physical restraint on the ground. Before starting make sure the aircraft cannot move forward.

Aircraft Inspection Before flying the aircraft for the first time, an instructor will thoroughly inspect the aircraft using a club furnished checklist. Know and understand each inspection step for future reference.

Flight Training Requirements:

The matrix below will provide you with the various maneuvers and requirements that you will be trained in. Each instructor has his/her own approach to the sequence to be performed, but the objective is to not make a training session monotonous by doing just one thing. Each session should have some "fun" things mixed in. No attempt will be made to explain each maneuver here, your instructor will do that for you.

Flyer Training Matrix

Student Name																								
Date:																								
Maneuver:																								
Fly left pattern																								
Fly right pattern																								
Loop																								
Roll																								
Fly figure 8																								
Taxi																								
Slow Flight																								
Land																								
Rudder control																								
Out of trim flight																								
Dead stick landing																								
Number of Flights																								
Comments																								
Instructor																								
P= Pass W=Working																								

The rate of progression will vary with each student. Some will pick up the skills very quickly while others will find it more difficult. Do not try to compare yourself with anyone else, we are all different. Each student will be expected to demonstrate competency in each of the maneuvers on the matrix. The final "solo" flight will include those elements that demonstrate your skill, confidence and safe operation of the aircraft. Even after you have been "signed off" for solo flight, you may wish to have some assistance during your continued flying as a spotter. Most experienced flyers are more than willing to assist. Instructors are almost always at the field if you prefer this level of experience. A word of advice to those who have full scale flight experience. The aerodynamics in full scale aircraft is exactly the same in RC aircraft. However, the "in cockpit" sensory inputs are completely absent. Development of RC skill and techniques is hand/eye coordination and learning experience. Don't get discouraged – we all struggled at some point in time!

Student/Instructor Relationship

It is a fact of human nature that any given combination of two people may not produce the most conducive relationship for learning. While we must all be sensitive and tolerant of our differences, if you have difficulty with your instructor contact the Training Coordinator. We will make every attempt to assign compatible instructors. Also, there is something to be said about having more than one instructor during the training process. Differing techniques may be advantageous.

Simulators

There are several commercially available RC Flight Simulators. If you have a computer, these simulators will greatly help you to gain the skill and confidence you are pursuing. A simulator is not a requirement but its use can certainly help you gain experience faster and is highly encouraged.

6. OTOW Flyer's Field Rules

*****Members are responsible to inform their guests of these rules*****

1. Current AMA membership is required.

2. Comply with AMA rules for Safe Operation of Model Aircraft. AMA approved frequencies only. Display your frequency on your transmitter. We recommend the numbers be a minimum of 1½-inch. All aircraft must have expansion type mufflers.

3. Flying permitted 8:00 am Monday through Saturday and 9:30 am Sunday to dusk. Quiet electric planes are permitted to fly from dawn to dusk. For your safety, it is recommended you never fly alone.

4. For non-2.4GHz systems - Impound your transmitter on arrival at the field. When you are ready to fly, place your AMA or Club card in the frequency slot provided and take the pin. After each flight replace the pin, take your card and again impound your transmitter. Do not leave transmitters in the pit area or on the starting stations. Never turn on your transmitter without the proper frequency pin in your possession, if you (member and/or guest) do and cause damage to another person's airplane or any property, you will be held financially responsible for the full cost of repair or replacement.

5. Current members who require instructions to learn to fly must never fly alone. The member must fly with an instructor until soloed.

6. New members must demonstrate their flying ability to the Safety Officer, a member of the safety committee or a listed instructor. If additional training is required; a club instructor will provide that training.

7. Club member's guests, who are AMA members, can fly at the field a maximum of 5 days in a 365-day period. The guest must demonstrate their flying ability to a member of the safety committee or a listed instructor and be accompanied by their club member host at all times who is responsible for their guests actions. Prospective home buyers brought to the field by OTOW sales representatives to fly must be AMA members and also demonstrate their flying ability to a member of the safety committee or a listed instructor before flying solo.

8. Please be considerate of other members waiting to fly. Do not assemble, fuel, or leave your aircraft or support equipment on the starting tables or large aircraft, starting stations. Do not: assemble fuel, change batteries, display or leave your aircraft under the pavilion at any time.

9. All aircraft must be positively restrained while starting and running engines and electric motors. Engines and electric motors will only be started and ran on or beside the starting tables and in the large aircraft, starting stations or the engine break in and adjustment station. Engines may run for only 1 minute at the flight line start up stations.

After 1 minute move your aircraft to the engine break in and adjustment station. Electric powered aircraft must have their batteries disconnected when in the pit area. Tables in the pit assembly area are for assembly, fueling or minor repair of aircraft only. Please stage your aircraft and support equipment on the ground between flights.

10. Preflight/range check your aircraft. Pilots will fly from a pilot's station. Take offs and hand launches will be from the runway. After hand launching from the runway, the pilot will move to a pilot's station as quickly as possible. Number of aircraft in the air is established at four and can be changed during club Invitational Fly Ins.

11. **Observe the NO FLY ZONES**, see map on back of the field rules. Do not fly over golf carts, vehicles or people retrieving aircraft or working in the pasture. No vehicles (cars, trucks or golf carts) allowed in pit area or on the runway.

12. Do not taxi in the pits. Walk or carry your plane to and from the flight line. Aircraft with engines running are not allowed directly behind the pilots flight stations at any time. Fly a pattern as determined by the wind direction and other flyers operating in the air. Crosswinds may dictate different takeoff and landing patterns. Above all - Fly safely.

13. Announce your intentions to land, including touch & go and dead stick. Other pilots at the flight stations must acknowledge they have heard and understand the announced intentions. Low level high speed passes will be at least 100 feet from the flight line.

14. Spectators will remain outside the pit area behind the spectator fence unless escorted by a club member. The club member is responsible for that person/people at all times. Children are not allowed in the pit area when engines are running or airplanes are in the air. They may be brought into the pit area at other times when accompanied by a club member.

15. Smoking is not permitted in the pit area under the pavilion or on the flight line. Please be considerate of other members when smoking in other areas and take all cigarettes butts and other smoking material home with you.

Appendix A
Glossary of R/C Terms

ABC / Non-Ringed - These letters stand for aluminum, brass and chrome or a composite such as nickel. These engines have an aluminum piston and a chrome or composite coated brass cylinder sleeve which allows them to be more efficient for higher performance. They have no piston ring and rely on a very tight piston/cylinder fit to obtain a piston/cylinder seal. New ABC engines are normally hard to turn over by hand. Because of the tight fit, it is very important that the engine is broken in properly.

Adjustable Travel Volume (ATV) - ATV allows you to preset the maximum travel of a servo to either side from its neutral position. Such settings help tailor control action to suit your flying or driving style.

Adverse Yaw - The tendency of an airplane to yaw in the opposite direction of the roll. For instance, when right aileron is applied, the airplane yaws to the left, thus opposing the turn. Adverse yaw is common in trainer type airplanes having flat bottom wings. It is most noticeable at slow speeds and high angles of attack, such as during takeoffs and when stretching a landing approach. Caused by the unequal drag of the upward and downward deflection of the ailerons, this undesirable trait can be minimized by setting up the ailerons with Differential Throw or by coordinating the turns, using the aileron and rudder controls simultaneously. (See Differential Throw.)

Ailerons - Hinged control surfaces located on the trailing edge of the wing, one on each side, which provide control of the airplane about the roll axis. The control direction is often confusing to first time modelers. For a right roll or turn, the right hand aileron is moved upward and the left hand aileron downward, and vice versa for a left roll or turn.

AMA - The Academy Of Model Aeronautics. The official national body for model aviation in the United States. AMA sanctions more than a thousand model competitions throughout the country each year, and certifies official model flying records on a national and international level.

Angle of Attack - The angle that the wing penetrates the air. As the angle of attack increases so does lift and drag, up to a point.

ARF - A prefabricated model - Almost Ready to Fly.

Battery Eliminator Circuitry (BEC) - A circuit that eliminates the need for a receiver battery, usually in electric R/C airplanes.

BB - These letters usually designate a ball-bearing supported crankshaft in an R/C engine. This makes the engine run smoother and last longer.

Buddy Box - Two similar transmitters that are connected wirelessly or with a "trainer cord." This is most useful when learning to fly -- it's the same as having dual controls. The instructor can take control by using the "trainer switch" on his transmitter.

Boring Holes in the Sky - Having fun flying an R/C airplane, without any predetermined flight pattern.

CA (Abbreviation for "Cyanoacrylate") - An instant type glue that is available in various viscosity (Thin, Medium, Thick, and Gel). These glues are ideal for the assembly of wood airplanes and other materials. Note: Styrofoam requires a foam safe CA as other forms of CA will melt or destroy Styrofoam.

Carburetor - The part of the engine which controls the speed or throttle setting and lean/rich mixture via setting of the needle valve.

CG ("Center of Gravity") - For modeling purposes, this is usually considered -- the point at which the airplane balances fore to aft. This point is critical in regards to how the airplane reacts in the air. A tail-heavy plane will be snappy, generally very unstable and susceptible to more frequent stalls. If the airplane is nose heavy, it will tend to track better and be less sensitive to control inputs, but, will generally drop its nose when the throttle is reduced to idle. This makes the plane more difficult to land since it takes more effort to hold the nose up. A nose heavy airplane will have to come in faster to land safely.

Charge Jack - The plug receptacle of the switch harness into which the charger is plugged to charge the airborne battery. An expanded scale voltmeter (ESV) can also be plugged into it to check battery voltage between flights. It is advisable to mount the charge jack in an accessible area of the fuselage so an ESV can be used without removing the wing.

Charger - Device used to recharge batteries, usually supplied with the radio if NiCd batteries are included. LiPo batteries require chargers specifically used to charge these types of batteries.

Chicken Stick - A hand-held stick used to "flip start" a model airplane engine.

Clunk - A weighted fuel pick-up used in a fuel tank to assure the intake line is always in fuel.

Dead Stick - A term used to describe unpowered flight (glide) when the engine quits running.

Differential Throw - Ailerons that are set up to deflect more in the upward direction than downward are said to have Differential Throw. The purpose is to counteract Adverse Yaw.

Dihedral - The V-shaped bend in the wing. Typically, more dihedral causes more aerodynamic stability in an airplane, and causes the rudder to control both the roll and yaw axis. This is why some trainers and sailplanes require only 3 channels of radio control--i.e. having no ailerons.

Direct Servo Control (DSC) - This radio feature permits you to check servo operation without broadcasting a radio signal. A cable connects the transmitter to the receiver. Direct servo control is very useful for on-the-ground control checks.

Ding - Minor dent or damage to the structure. Also, a nick in a prop. Dinged props must be replaced.

Down Thrust - Downward angle of the engine relative to the centerline of the airplane. Down thrust helps overcome the normal climbing tendency of flat bottom wings.

Electric Starter - A hand-held electric motor used for starting a model airplane engine. Usually powered by a 12-volt battery.

Electronic Speed Control (ESC) - Electronic speed controls replace the mechanical speed control and servo providing enhanced power efficiency and precision in an electric R/C airplane. In addition, they are lighter which improves the performance of some electric models.

Elevator - Hinged control surface located at the trailing edge of the horizontal stabilizer, which provides control of the airplane about the pitch axis and causes the airplane to climb or dive. The correct direction of control is to pull the transmitter elevator control stick back, toward the bottom of the transmitter to move the elevator upward, which causes the airplane to climb, and vice versa to dive.

Endpoint Adjustment - This radio feature adjusts the length of servo travel in one direction (a single channel will have adjustments for two endpoints). If your plane rolls faster one way than the other, endpoint adjustments can correct the problem.

Epoxy - A two-part resin/hardener glue that is extremely strong. It is generally available in 6, 15 and 30 minute or greater curing time formulas. Used for critical points in the aircraft where high strength is necessary.

Expanded Scale Voltmeter (ESV) - Device used to read the battery voltage of the on-board battery pack or transmitter battery pack.

Field Charger - A fast battery charger designed to work from a 12-volt power source, such as a car battery.

Flaps - Hinged control surface located at the trailing edge of the wing inboard of the ailerons. The flaps are lowered to produce more aerodynamic lift from the wing, allowing a slower takeoff and landing speed. Flaps are often found on scale models, but usually not on basic trainers.

Flare - The point during the landing approach in which the pilot gives an increased amount of up elevator to smooth the touchdown of the airplane.

Flight Box - A special box used to hold and transport all equipment used at the flying field.

Flight Pack (or Airborne pack) - All of the radio equipment installed in the airplane, i.e., Receiver, Servos, Battery, and Switch Harness.

Flutter - A phenomenon whereby the elevator or aileron control surface begins to oscillate violently in flight. This can sometimes cause the surface to break away from the aircraft and cause a crash. There are many reasons for this, but the most common are excessive hinge gap or excessive "slop" in the pushrod connections and control horns. If you ever hear a low-pitched buzzing sound, reduce throttle and land immediately.

Four Stroke (Four Cycle) - Although a 4-stroke engine has less power than a 2-stroke engine of comparable size, there are advantages to 4-stroke engines. They do not require a muffler and are often quieter than most 2-strokes are with a muffler. They can swing a bigger prop than the same size 2 stroke engine. This is an asset in the large, slow flying aerobatic and scale models where 4-stroke engines are usually mounted. Lastly, the fuel economy is better.

Frequency Control - The FCC has allowed the use of 2.4GHz and 72MHz band to be used for R/C aircraft operations. This latter band is divided up into many different channels in which you can choose a radio system. You should be aware that certain areas have frequencies in which there is frequency interference. This is why it is always a wise move to check with your local hobby shop to find out any channels that may be troublesome in the area you wish to fly. Or simply avoid these issues and use a 2.4GHz transmitter/receiver system.

Frequency Module - A frequency module plugs into ~~the~~ a 72MHz transmitter and enables you to change the channel number your radio broadcasts on.

Fuel Overflow Line (Vent) - The fuel line is either open to atmospheric pressure or attaches to the muffler pressure nipple to pressurize the fuel tank for better fuel flow to the engine. This is the line through which the fuel will overflow when the tank is full.

Fuel Pick Up-Line - The fuel line in the fuel tank through which fuel travels to the carburetor. Typically a flexible tube with a weight or "Clunk" on the end which allows it to follow the fuel with changes in aircraft attitude. This is the line through which the tank is filled.

Fuselage - The body of an airplane.

Glitch - Momentary radio problem that never happens unless you are over trees or a swamp.

Glow Plug - The heat source for igniting the fuel/air mixture in the engine. When starting the engine a battery is used to heat the filament. After the engine is running, the battery can be removed. The wire filament inside the plug is kept hot by the "explosions" in the engine's cylinder. (See next heading and "Idle Bar" Plug.)

Glow Plug Clip/Battery - A 1.2-volt battery, which is connected to the glow plug on a model airplane engine for starting. The battery is removed once the engine is running steadily.

Grease-In - A very smooth, gentle landing without a hint of a bounce.

Hit (or to be hit) - Sudden radio interference which causes your model to fly in an erratic manner. Most often caused by someone turning on a radio that is on your frequency, but can be caused by other radio sources miles away.

Horizontal Stabilizer - The horizontal tail surface at the back of the fuselage which provides aerodynamic pitch stability to the airplane.

Idle Bar Plug - This type of glow plug has a "bar" across the tip to help prevent raw fuel from being splashed onto the glow element. Too much raw fuel will cool the plug and prevent it from igniting the fuel/air mixture. An idle bar is a help in obtaining a low idle speed.

Lateral Balance - The left-right or side-to-side balance of an airplane. An airplane that is laterally balanced will track better through loops and other maneuvers.

Leading Edge (LE) - The very front edge of the wing or stabilizer. This is the edge that hits the air first.

Mixing (Coupling) - Two radio control channels can be coupled together so that they move together when only one control channel is activated. Many 1/4 scale models require a combination of aileron and rudder to turn. Mixing does this electronically at the transmitter. V-tailed models, where the two halves of the V-tail must move not only together but independently, are another use of control mixing.

Muffler - A device attached to the exhaust stack of the engine to reduce noise and increase back pressure which helps low speed performance. Note: Most R/C Clubs require the use of mufflers.

Muffler Baffle - A restrictor plate inside the muffler which reduces engine noise. This plate can be removed to increase power, but only if there are no noise restrictions where you fly.

Needle Valve - Adjustment on a carburetor used to set proper fuel/air mixture. Some carburetors have separate needle adjustments for low and high throttle. Typically, turning the needle clockwise (screwing in) leans the mixture (less fuel), and vice versa. However, there are a few exceptions--refer to the engine manufacturer's instructions.

NiCd - Nickel Cadmium battery. Rechargeable batteries which are typically used as power for radio transmitters and receivers.

Nitro - Nitromethane, a fuel additive that increases a model engine's ability to idle low and improves high-speed performance. Ideal nitro content varies from engine to engine. Refer to the engine manufacturer's instructions for best results. Nitro content in fuel is indicated by the percent of the fuel.

Ni-Starter - A self-contained battery and glow plug clip, used when starting the engine. (See Glow Plug Clip.)

One-Point Landing (or a figure 9) - Synonymous with "stuffing it in." Something we hope you never do.

Peak Charger - A peak charger automatically shuts off when your battery is fully charged. This means longer run times for your vehicle. Peak chargers are nearly foolproof, if you forget to turn it off, the charger does it for you. No more overcharged batteries.

Pitch Axis - The airplane axis controlled by the elevator. Pitch is illustrated by holding the airplane at each wingtip. Raising or lowering the nose is the pitch movement. This is how the climb or dive is controlled.

Power Panel - 12-volt distribution panel that provides correct voltage for accessories like glow-plug clips, fuel pumps and electric starters. Usually mounted on a field box and connected to a 12-volt battery.

Programmable or Computer Radios - These high-tech radios are not inexpensive but allow a full set of programmable transmitter features like multiple plane memory, preprogrammed maneuvers (rolls, loops, etc. at the touch of one button) and much more..

Prop Pitch - Props are designated by these two numbers, for instance 10 - 6. The first number is the prop's length, 10". The second number is the pitch or angle of the blades.

The 6 represents the distance the propeller will move forward in one revolution, in this case 6".

Re-Kitting Your Airplane - Changing your finished model back into a kit, as a result of "stuffing it in."

Receiver (Rx) - The radio unit in the airplane which receives the transmitter signal and relays the control to the servos. This is somewhat similar to the radio you may have in your family automobile, except the radio in the airplane perceives commands from the transmitter, while the radio in your car receives music from the radio station.

Roll Axis - The airplane axis controlled by the ailerons. Roll is illustrated by holding the airplane by the nose and tail. Dropping either wingtip is the roll movement. This is used to bank or turn the airplane. Many aircraft are not equipped with ailerons and the Roll and Yaw motions are controlled by the rudder. This is one reason why most trainer aircraft have a larger amount of dihedral.

Rudder - Hinged control surface located at the trailing edge of the vertical stabilizer, which provides control of the airplane about the Yaw axis and causes the airplane to Yaw left or right. Left rudder movement causes the airplane to Yaw left, and right rudder movement causes it to Yaw right.

Servo - The electro-mechanical device which moves the control surfaces or throttle of the airplane according to commands from the receiver. The radio device which does the physical work inside the airplane.

Servo Output Arm - The removable arm or wheel which bolts to the output shaft of a servo and connects to the pushrod.

Servo Reversing - This radio feature allows you to install the servos where they can give the best pushrod routing without concern about the direction of servo rotation. When your installation is complete, turn on your radio and check each channel. If a channel operates opposite of its intended direction a simple flick of a switch corrects the problem.

Shot Down - A "hit" that results in a crash landing. Sometimes caused by radios miles away.

Slop - Unwanted, excessive free movement in a control system. Often caused by a hole in a servo arm or control horn that is too big for the pushrod wire or clevis pin. This condition allows the control surface to move without transmitter stick movement. (See Flutter.)

Solo - Your first totally unassisted flight that results in a controlled landing.

Spinner - The nose cone which covers the hub of the propeller.

Sport Airplane - A model which possesses some attributes of many of the specialty airplanes and are best for general flying as they are the most versatile and durable.

Stall - What happens when the angle of attack is too great to generate lift regardless of airspeed.
(Every airfoil has an angle of attack at which it generates maximum lift -- the airfoil will stall beyond this angle).

Tachometer - An optical sensor designed specifically to count light impulses through a turning propeller and read out the engine RPM.

Tip Stall - The outboard end of one wing (the tip) stops developing lift, causing the plane to roll suddenly in the direction of the stalled wing. This situation is not fun when you are only a few feet off the runway trying to land.

Trainer Airplane - A model designed to be inherently stable and fly at low speeds, to give first-time modelers time to think and react as they learn to fly.

Trainer System - This effective method of training allows two transmitters to be connected by means of a trainer cord or wireless connection. The instructor can pass control over to the student's transmitter so that he can fly. If the student gets into trouble, the instructor can regain control instantly.

Trailing Edge (TE) - The rearmost edge of the wing or stabilizer.

Transmitter (Tx) - The hand-held radio controller. This is the unit that sends out the commands that you input.

Touch-And-Go - Landing and taking off without a pause. Often confused with a good bounce.

Vertical Fin - The non-moving surface that is perpendicular to the horizontal stabilizer and provides yaw stability. This is the surface to which the rudder attaches.

Washout - An intentional twist in the wing, causing the wing tips to have a lower angle of attack than the wing root. In other words, the trailing edge is higher than the leading edge at the wing tips. Washout helps prevent tip stalls.

Wheel Collar - A small, round retaining device used to keep wheels from sliding off an axle.

Wing - The main lifting surface of an airplane.

Wing Loading - This is the amount of weight per square foot that has to be overcome to provide lift. It is normally expressed in ounces per square foot. This specification can be easily calculated as follows: If you know the square inches of the wing, simply divide by 144 to obtain square feet. Divide the total weight (in ounces) of the airplane by the wing area (in square feet). This information is valuable when deciding on which airplane to build next. Planes with high wing loading numbers must fly faster to stay in the air. These are generally "performance" airplanes. Conversely, planes with lower numbers do not need as much air flowing around the wing to keep it flying. Gliders and trainer airplanes fall into this category because slow, efficient flight is desirable.

Wing Root - The centerline of the wing, where the left and right wing panels are joined.

Y-Harness - Two servos can be plugged into one channel with a Y-harness. The two servos will then operate simultaneously. It is most often used in areas where the strength of one servo is not adequate.

Yaw Axis - The airplane axis controlled by the rudder. Yaw is illustrated by hanging the airplane level by a wire located at the center of gravity. Left or right movement of the nose is the Yaw movement.

Z-Bend - A simple Z-shaped bend in the wire end of a pushrod, which is used to attach the pushrod to a servo output arm.

Z-Bend Pliers - An inexpensive plier type tool used for easily making perfect Z-bends.

Appendix B

OTOW Multi-Rotor Pilot Practice Instructions

1. Take Off and Land:

Main goal: Practice throttle/altitude control.
Sub goal: Control drifting using roll and pitch.

Description:

1. Take off and stay at 3 to 6 feet for a few seconds, then slowly come down to ground and land.
2. Make sure the take-off and landing is soft and gradual.
3. Don't cut your throttle too rapidly, hard landing may cause damage to your quadcopter.

2. Flying forth and back:

Goal: Practice forward flying, yaw turns, speed control, altitude control.

Description:

1. Take off and stay at about at 3 to 6 feet high.
2. Fly forward by pushing pitch stick, for maybe 60 feet. Keep your height constant at all times by adjusting throttle.
3. Start to slow down by pulling the pitch stick towards you, and come to a stop.
4. Turn around left or right using Yaw, accelerate again (pitch forward) to fly back to where you took off, slow down and turn around.
5. Repeat!
6. You can increase speed and distance as you progress. Feel free to use roll as well to level your craft while making yaw turns.

3. Square pattern turns:

Goal: Some more turn practice and making corrections to path after turns while getting used to flying in a bigger area.

Setup: Square off an area about 100 x 100 feet marked with a white ribbon or any other thing you think is right.

Description: Fly along the sides of the square while trying to keep a constant altitude and pace. Switch between CW and CCW direction.

4. Circle a flag while constantly facing it:

Goal: Practicing yaw, roll and throttle control combined.

Description: Circle a flag while constantly making roll, yaw and throttle adjustments to keep a constant distance from the flag and altitude.

5. Make a 8 figure around 2 poles:

Goal: Much better coordination between both hands, you should be able to control all 4 axis better at the same time: throttle, yaw, pitch and roll.

Description:

1. It's easier to have the 2 poles further away.
2. Try to turn around as smooth as you can.
3. Fly in an 8 figure while trying to maintain constant altitude

6. Sharp turns:

Goal: Able to make a accurate sharp turns, enables you to avoid some crashes. Sharp turns are also an effective way of braking.

Description:
Fly towards to the side of a pole or with some speed, and turn 180 in yaw axis in a fast manner. You will need to use roll and pitch to help leveling the aircraft, and fight some of the momentum.

7. Fly through an Air Gate:

Goal: Practice fast flying combined with fine stick control.
Setup: a long field with one air gate in the middle. Start with a big gate.

Description: Starting at one end of the field, above the height of the gate, fly towards the gate and descend slowly to the height of the gate. Increase altitude once you passed through the gate. Perform a sharp turn and repeat.