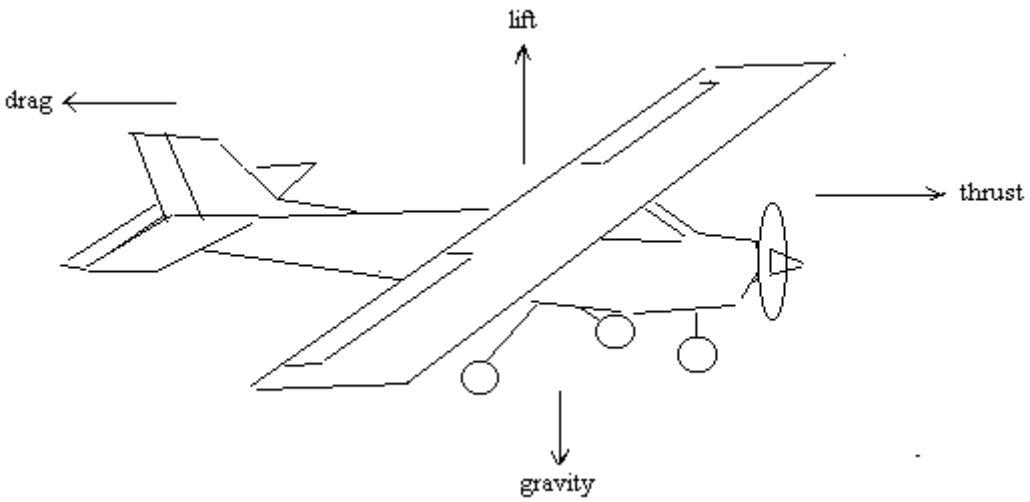
SWAP Modelers Club Ground School Instruction

This outline is designed to give newcomers to our club and to the hobby of R/C flying an overview of the basics of flight.

I. PRINCIPLES OF FLIGHT

The basic parameters of flight are the same for both full size aircraft and R/C models.



In order for an airplane to fly:

1) Thrust must overcome drag.
2) Lift must overcome gravity.

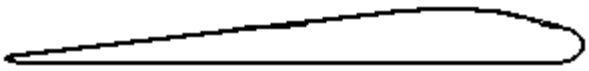
II. Lift

A) Basics of Lift on an Airfoil

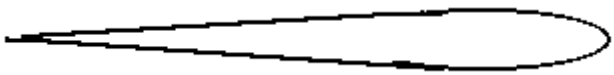
1) Air moving over the top surface of the wing creates a pressure difference between the top and bottom. (Less pressure on top of the wing allows it to lift up.)

B) Types of Airfoils

1) Flat bottom (This is the type of wing found on most trainers. It creates the most lift.)



2) Symmetrical (This type of wing is shaped the same on the top and bottom. It is typically found on acrobatic planes because it creates the same amount of lift upright or inverted.
This shape creates less lift, however.)



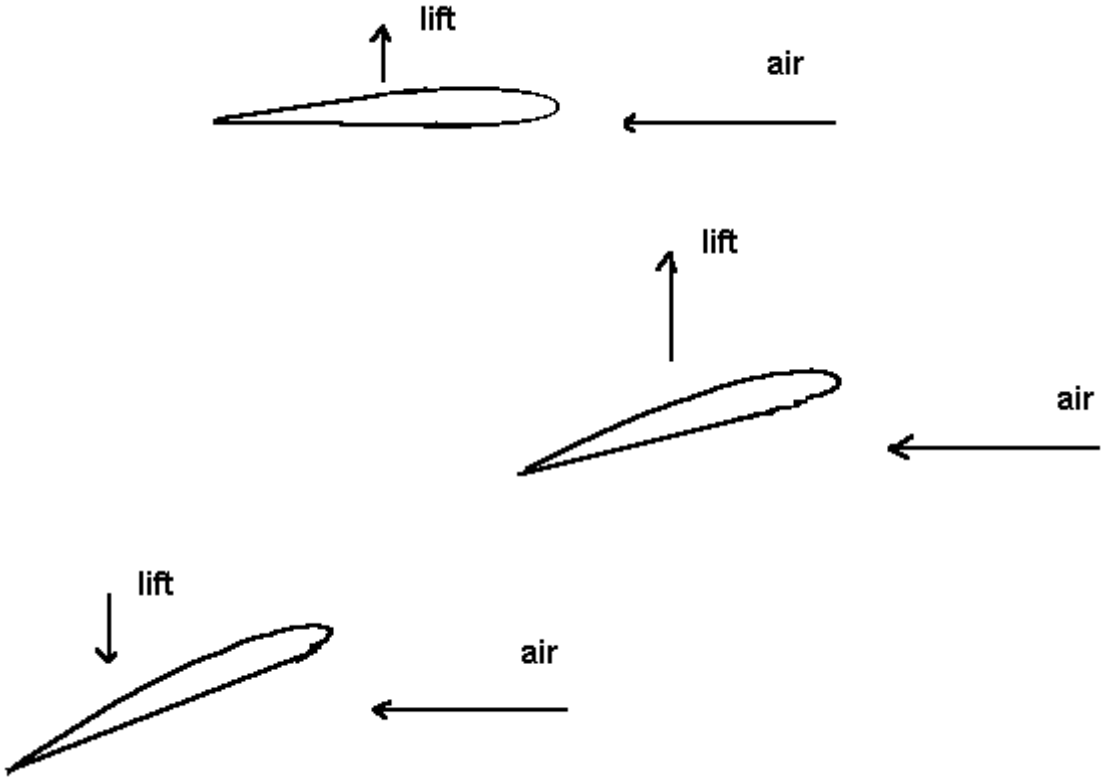
3) Semisymmetrical (Best of both worlds. This type of airfoil gets extra lift from the flat bottom portion, but because it is somewhat symmetrical it flies fairly well inverted.)

C) The faster the air moves across the wing, the more lift will be created. If you keep your speed up, you get more lift.

***If not enough air moves over the wing, it won't fly. This is called a stall.** (This becomes very important as you approach a landing. You are flying slowly close to the ground, so there is no room for recovering from a stall.)

D) Angle of Attack

1) The lifting ability of a wing is also affected by the angle of the wing with respect to the air approaching it. This angle is called the angle of attack. Up to a certain point, increasing the angle of attack will increase the lifting ability of the wing. However, this increase in lift does not come without a penalty. (As do all things on earth that obey Newton's Laws of Physics) This penalty comes in the form of increased drag. Therefore, when this added induced drag overcomes the thrust of the plane, you no longer get lift and the airplane stalls.



*** On landing approach, the most common problem is created by the following: The pilot realizes he is coming in too low, but instead of gently adding more throttle, he gives the plane more and more up elevator in an attempt to stretch out the landing until he gives so much up that the plane reaches the stall point and BOOM- down she comes!**

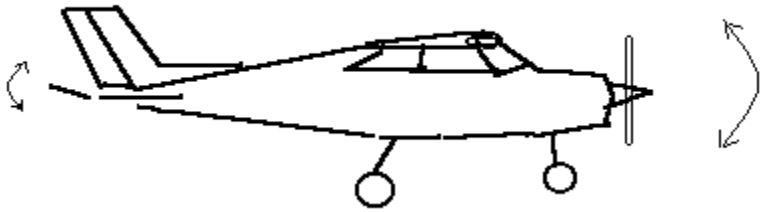
The rule of thumb is: If you need to stretch out a landing approach, do it by gently increasing the throttle, not by adding more up elevator.

III. Basics of Control

A) Control Surfaces

Control surfaces provide the movement of an airplane through the air. For conventional purposes, 3-dimensional space is represented by three axis'. Movements about these axis' are termed pitch, yaw, and roll.

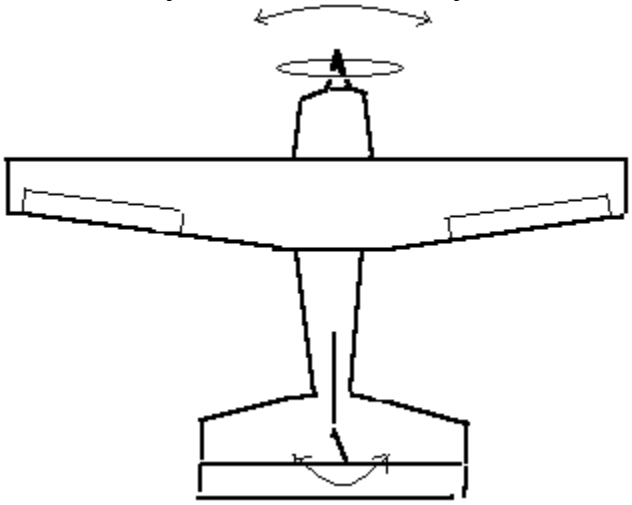
PITCH- Up and down movement is called pitch. It is controlled by the elevator.



Pulling back on the elevator stick deflects the elevator up, which pulls the nose of the plane up. This causes the plane to climb.

Pushing forward on the elevator stick deflects the elevator down, which pushes the nose down. This causes the plane to dive.

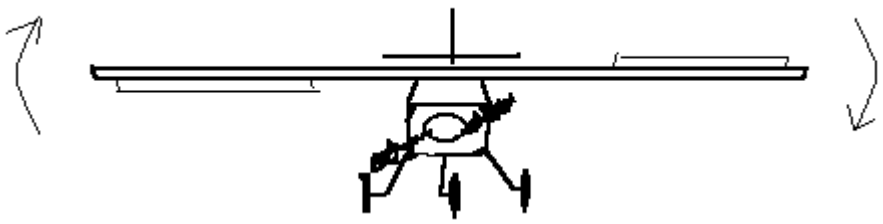
YAW- Left or right movement is called yaw. It is controlled by the rudder.



Pushing the rudder stick to the left causes the rudder to deflect left which causes the plane to yaw left.

Conversely, pushing the rudder stick to the right causes the rudder to deflect right causing the plane to yaw right.

ROLL-Rotation of the wings about the central axis of the plane to the right or left is termed roll. It is controlled by the ailerons. The ailerons are coupled together; downward deflection of one creates upward deflection of the other. Sometimes rolling is referred to as banking.



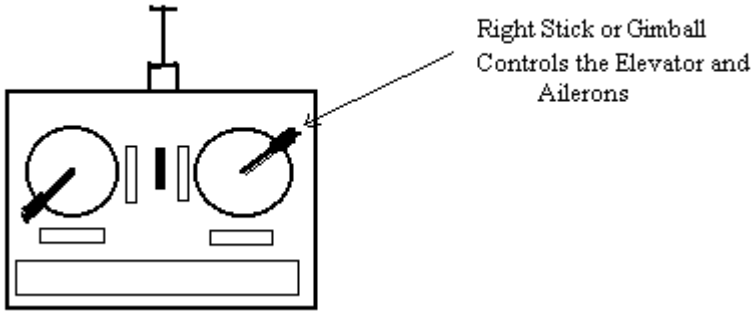
To control the ailerons, you move the aileron stick to the left or the right.

Movement of the aileron stick to the left causes upward deflection of the left aileron coupled with downward deflection of the right aileron which causes the plane to roll or bank left.

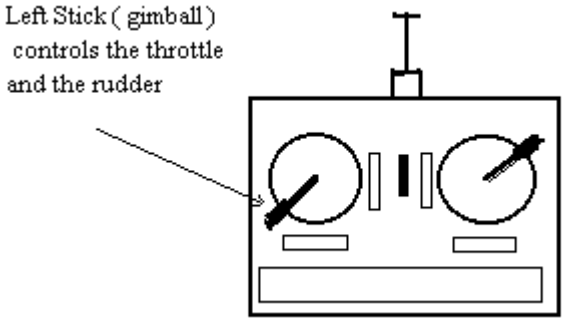
Movement of the aileron stick to the right causes the opposite deflections and the plane rolls or banks right.

All of these control surfaces are present on full scale aircraft and provide the same purposes. The major difference between R/C flying and full scale flying is that in a real plane, rudder control is by foot pedals and on an R/C transmitter, rudder control is the left stick. The aileron and elevator control on a full scale plane are done by either a single stick between the pilot's legs or by a steering wheel type arrangement called a yoke.

B) The controls on an R/C transmitter which correspond to these surfaces are as follows:



* Up/Down movement of the gimball moves the elevator.
* Left/Right movement of the gimball moves the ailerons.



*Up/Down movement of the left stick increases or decreases the throttle setting.

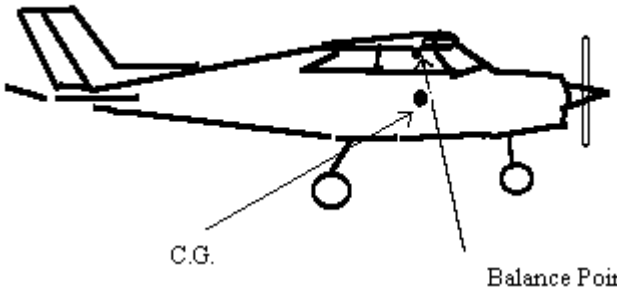
*Left/Right movement of the left stick deflects the rudder left or right.

You may notice that whenever the rudder is deflected, the nosewheel also moves. This is how you steer on the ground. Movement of the gimball to the left steers the plane left, and movement of the gimball to the right steers right.

IV. Miscellaneous Terminology

A) Balance Point/Center of Gravity (C.G.)

When you check the balance point of a plane, you are locating the center of gravity. The balance point is usually measured by holding a fingertip under each wing at the main spar approximately one foot away from the fuselage on each side. The plane should achieve a slightly nose down position when properly balanced. This is called being slightly "nose heavy". This makes a plane very stable; it has a tendency to right itself coming out of a turn, and the nose should fall forward in a stall. In reality, the center of gravity is actually a point somewhere in the middle of the fuselage, located beneath the balance point.



As you become a better flyer and move onto more acrobatic planes, you can take away some of the nose heaviness. This makes the plane more responsive with respect to your control surfaces, however, it also makes the plane less stable. In R/C terminology this lack of stability is called "squirrliness". You basically cannot relax while you are flying. You have to stay on the sticks.

B) Tricycle Landing Gear

With this arrangement the two main wheels are behind the C.G. and the nosewheel is forward of the C.G., usually just behind the engine. This arrangement is easiest to learn with, as it provides for good positive ground handling. You only need slight deflection of the nosewheel in order to change the direction of the plane. (Just like your car changing lanes on the Beltway; you only have to move the steering wheel slightly to move over to the other lane.) Too many times I've seen planes with too much response in the nosegear. This makes the plane track all over the runway while attempting to take off.

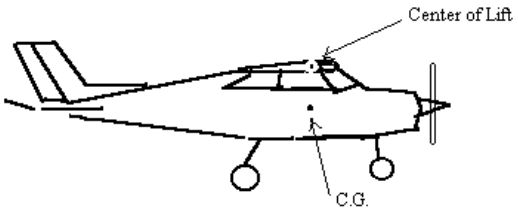
C) Taildragger

A plane with the two main wheels located forward of the C.G., and a smaller wheel attached to the rudder. Take offs with a taildragger are a bit more challenging, therefore this arrangement is not ideal for a new flyer.

D) High Wing Plane

This is where the wing is situated above the fuselage and cockpit. This is the most stable arrangement, so that's why you see it in trainer type planes. (This is what you see in a Cessna or a J-3 Cub) With this type of wing arrangement, the center of gravity is located below the center of lift.

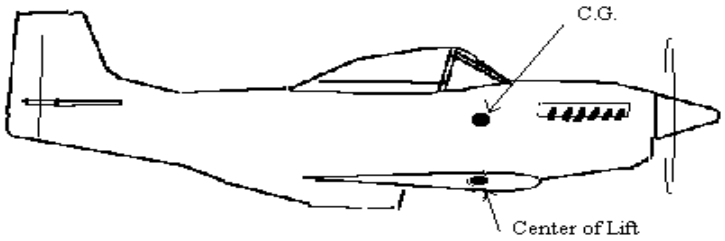
Note- The center of lift is created at the center of the wing when the plane is flying, usually right in between the two main spars.



With the center of gravity below the center of lift, the weight of the fuselage acts like a pendulum or plumb bob. This provides for some inherent stability, as the plane wants to level itself off coming out of a turn.

E) Low Wing Plane

This is where the wing is located below the fuselage. It allows for "snappier" maneuvers. (smoother rolls, tighter turns) This is what your classic WW II fighter looks like. (i.e. Mustang, P-40 Warhawk) In this arrangement, the center of lift is situated below the center of gravity. and the inherent stability of the plane is less than that of a high wing. As your wings approach 90^{0} of horizontal, there is a tendency for the plane to roll over



F) Midwing or Shoulder Wing Plane

In this arrangement, the wings come out if the sides of the fuselage. This is the best situation for a truly acrobatic plane. The C.G. and C.L. are located in the same place. This provides for smooth straight axial rolls and clean looking maneuvers. (Planes like the Extra 230/300 and the Lazer are midwings.)

G) Biplane

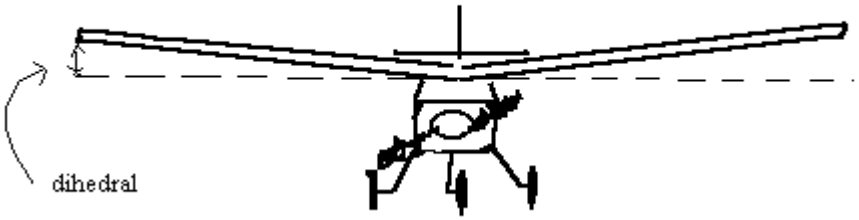
An airplane with two wings, usually one above the fuselage, and one below. This is what is found in your typical WW I bird. (i.e. Sopwith Camel, SE-5)

H) Wing Loading

This is the ratio between the weight of a plane and the surface area of the wing (i.e. oz./sq. ft.); the lower the value, the more lift you have. For example, my 8 $^{1}/_{2}$ lb. Goldberg Cub with the full-size wing (6'-4") has a lower wing loading than my 3 lb. Eaglet 20 with a 50" wingspan. The Cub floats or glides far better than the Eaglet. On high speed/high performance models, like a F-16 ducted fan, you may get wing loading figures of 25 oz./ sq. ft. or higher. A plane with a high wing loading must be flown at much higher speeds on landing approaches than a J-3 Cub which will basically fly around the entire field at idle. This high speed approach is termed as having to come in "hot" for a landing.

I) Dihedral

This is the angle of the wing from the horizontal plane when viewing from the front or back of the plane.



Without getting overly technical, let it suffice to say that the degree of dihedral in a wing affects the overall stability of the plane; the greater the dihedral, the greater the stability. Some acrobatic planes are setup with no dihedral at all. Because of this, these planes do not come out of a bank or turn on their own. (You must control them out.) On the other hand, a trainer with generous dihedral will correct itself out of a mild to moderate banked turn, provided you have enough altitude. This added stability detracts from a plane's ability to perform many maneuvers. It is almost impossible to make a trainer with dihedral do an axial roll, and many are very hard to put into a spin.

V. Basics of an R/C Flight

A) Preflight Check

This includes checking the C.G., proper setup and movement of control surfaces, smooth running engine, etc.. A complete checklist is included in our student packet, and is available to anyone that wants one.

B) Taxi and Take Off

1) Taxi out to the center of the runway and slowly advance the throttle. You need to gently apply right or left rudder to keep the plane straight in the middle of the runway. Many novices have the tendency to overcontrol the plane, both on the ground and in the air. Try and learn to make your movements gentle and deliberate, rather than hard and jerky. Note- Due to the rotational torque of the engine, you generally have to correct with slight right rudder on take-off.

2) Once you have reached full throttle and the plane is tracking straight, you can momentarily forget your left stick. As soon as the plane appears to become "light", you can apply gentle up (pull back on the right gimball), and the plane will lift off of the runway and start climbing skyward. (This "lightness" becomes apparent to you once you have flown several times.)

C) Climb Out and First Turn

1) Continue to gain altitude slowly by applying only a slight amount of up elevator. You will notice that it usually requires more up to lift off of the ground than it does to accomplish this slow gentle climb out, so almost as soon as you become airborne, you can release some of the up elevator. You don't want to start climbing too steeply right after take-off or you risk stalling the plane. This makes for a rather short and ugly flight!

2) After flying for about 5 seconds, you will notice that the plane has already travelled about 200 feet away from you, so you need to start to turn. I have found that left turns are the easiest to learn, so that's what we'll start with. To initiate a left turn, you must apply gentle left aileron, while simultaneously applying a slight amount of up elevator. If you forget to add some up in your turns, you will notice that you can lose altitude rather quickly.

3) When attempting a 90^{o} turn, you need to begin to come out of it when you have completed about $^{2}/_{3}$ of the turn. Simply neutralize your aileron and maintain only enough elevator to maintain altitude. Often, you may find it necessary to apply some very slight right aileron to come out of a turn level.

4) After reaching a comfortable altitude, (approximately 200 feet) you can throttle back half way or so. This will make the plane a little easier to control.

D) Flying a Pattern

1) The first flight pattern that you want to learn to fly is a large rectangle in front of you at an altitude of approximately 300 feet. By making repetitive gentle left turns, you should keep flying this pattern until you can perform it almost flawlessly. It isn't as easy as it may sound. This rectangular pattern is the setup to every good pilot's routine landing.

***The hardest things to accomplish when starting to fly R/C are:**

1) Learning not to over control the plane. You should try your best to make gentle deliberate movements with the gimballs, not quick, strong, jerky movements.

2) Learning to fly the plane while it's coming towards you. I have never met anyone who does this well, right from the start.

There are a few theories on how to learn to do this:

a) Move the stick to the same side as the low wing.

b) Imagine yourself in the cockpit at all times.

c) Try to face away from the plane, looking back over your shoulder while controlling it.

Although I guess any of these might work, what works best for me is:

a) Always fly with an instructor (preferably with a "buddy cord" arrangement) for your first flights.

b) Keep very clear in your mind which control input you entered your turn with. Keep telling yourself, "Left turn, right to come out. Left turn, right to come out."

Eventually this becomes second nature (like shaving or combing your hair in a mirror), but it takes lots of flights to accomplish it. I still have to concentrate while making right hand approaches, as I was trained with all left turns.

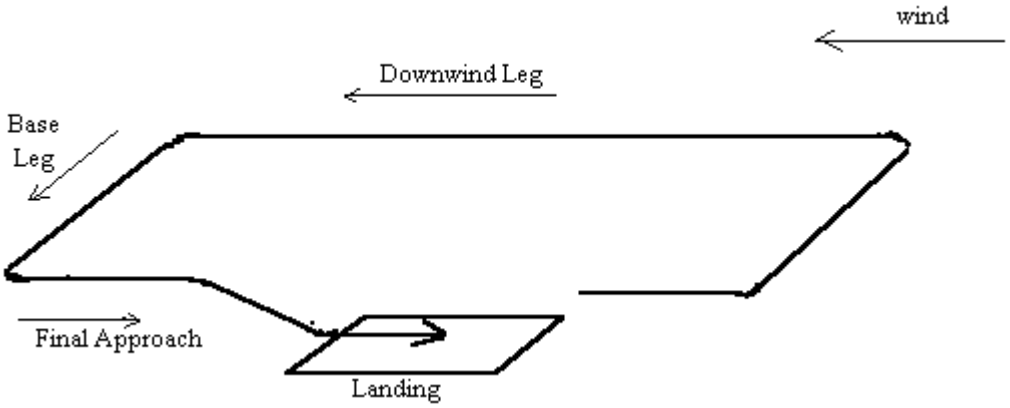
E) Approach and Landing

1) You can only fly this rectangular pattern for so long; the plane will run out of fuel, or the pilot will get

pretty tired. The sequence of events leading up to a successful landing are divided into two segments: approach and landing (the actual touch down of the plane on the field).

Approach:

a) Your approach is accomplished in three segments (the last 3 sides of the infamous rectangle):
   1) Downwind Leg
   2) Base Leg
   3) Final Approach



*You want to try your best to land into the wind (Just like you like to take off into the wind). This slows the plane down as well as increasing the lift due to the increased speed of the air passing over the wing.

Downwind Leg:You want to reduce your throttle setting to approximately one third. (You want to be well above stall speed, but not screaming thru the sky.) Your altitude should be about 30 feet.

Base Leg: As you turn into the base leg, you want to maintain your altitude or even be descending slightly. Note- After reducing your throttle to $^{1}/_{3}$, you should notice that the plane is sinking slowly. You should begin to feed in a slight amount of up elevator to keep the sink rate slow and steady.

Final Approach: As you come out of the base leg into final approach, you want to be lined up with the center of the runway. When you have accomplished this and your wings are level, chop your throttle to idle, and be ready to gently increase your up input.

*At this point you need to be going over a lot of things in your mind:

1) Am I lined up with the runway?
2) Am I coming in too "hot"? (fast)
3) Am I losing altitude too quickly?
4) Am I going to land short of the runway, or am I going to overshoot?

If anything doesn't seem right, gently increase the throttle, let the plane pick up speed, then gently climb out and repeat your landing approach.

It is important to keep your "nose down" during your approach. You want a near level attitude, while gently losing altitude. (Too many times crashes occur at this point; or at least rough landings, because the pilot pulls back too hard on the stick, trying to stretch out the approach- the plane stalls, and comes down rather quickly.)

Landing: When you are approximately 1-2 feet off of the runway, you want to gently increase the up elevator as the plane settles onto the runway. This is called "flaring". Flaring is actually a controlled stall done right at the instant of touch down.

Picture perfect landings don't occur by accident. You must practice and practice them time after time. There are still days at the field that all I do is practice landings and touch and go's. (A touch and go is a routine landing, except as soon as your wheels touch the ground, you throttle back up and take off again.

Tips on Successful Landings:

There was an article in Model Airplane News many years ago that talked about an imaginary window or keyhole that you need to establish in your mind in order to accomplish repeated successful landings. If you are not inside this imaginary window when you start your final approach, adjust the position of the plane, or throttle up slowly and go around again. Setting up a perfect final approach is over 90% of a perfect landing. Letting the plane settle onto the runway is the easy part. (In fact, I've let several 1st time students land on their first day of flight instruction, after I set up the entire approach.)

Checklist for Successful Landings

Problems	Solutions
1) Too high as you make your final approach.	Gently throttle up- go around- try again.
2) Correct altitude, but wrong heading (heading for the pits or the weeds)	If early enough in the approach, bank appropriately to correct. If unable to correct, throttle up- go around- try again.
3) Coming in too low- short of desired area	Increase throttle slightly without giving any up elevator. This will cause the plane to gain some altitude. When you've stretched things out enough, chop the throttle- continue decent and landing.

***Remember: Don't try to stretch out your approach with elevator only, or you risk a stall! Slowly add some throttle, then if you need a little elevator, gently pull back on the stick.**

F) Dead Stick Landings (without power)

All R/C aircraft will glide. it's just that some do it better than others. The most important thing to keep in mind in a dead stick situation is to keep your nose down. Once you lose power, you only have a limited amount of time to get on the ground safely. **(Altitude is precious. You don't want to lose too much in a hurry by stalling!)**

You want to set up your landing approach as soon as possible. If you have sufficient altitude, you want to maneuver the plane into the wind, and line up with the runway. If at this point you feel you are too high, DON'T ATTEMPT TO COME AROUND AGAIN! You want to bleed your speed and altitude by either wagging your wings (roll left/roll right), or wag your tail by applying alternate left/right rudder. I personally prefer wagging my wings. You'll be surprised how quickly this will slow you down. Once you have reached the "window", keep your nose down, then flare, just like during a powered landing. To the surprise of most novices, your first dead stick landing is usually your prettiest. The response of the control surfaces is slower, so you tend to find the plane more gentle to handle.

*Just remember: You get no second chances without power, so set up ASAP and then bleed your speed and altitude, if necessary.

GOOD LUCK AND MANY HAPPY FLIGHTS!!!!