FSEA
STUDENT HANDOUT

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THE MODEL AIRPLANE
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This section explains how to adjust rubber band powered model airplanes so they will fly nicely. The process goes in three sequential steps, with trial and error adjustments made in each step. The first step is "low powered flight" adjustment, the second is "high powered flight" adjustment, and the third step is “fine tuning”.

The objective of the adjustment procedure is to make the model fly in a continuing smooth turn for as long as possible. To accomplish this, models should be trimmed to fly circles tight enough to avoid walls, and should fly as slowly as possible to conserve energy.

Low Power Adjustments:

This is the first step in flight adjustment. Low powered means that the airplane is gliding or the motor is not wound up much. For small airplanes like the STARVED PUSSYCAT, this means 200 to 300 turns of the propeller. When the low power adjustments have been made correctly, the airplane should fly level or climb a little and then descend in a turn of reasonable and constant size.

The adjustments used to control low powered flight trim are:
1. wing and rudder warps to fix circle and roll problems (called roll and yaw trim).
2. center of gravity changes to fix stall and dive problems (called pitch trim).

TERMS

Roll and Yaw Trim

Washout means the wing is twisted so the leading edge is lower than the trailing edge at the wing tip. Washout makes the airplane tend to roll so the “washed out” wing tip drops.

Washin means the wing is twisted so the leading edge is higher than the trailing edge at the wing tip. Washin tends to roll the airplane so the “washed in” wing tip rises.

Rudder Warps
Left rudder means the rudder is twisted so the trailing edge is off center toward the left side of the airplane. This tends to make the airplane turn left.

Right rudder means the opposite, a twist so the trailing edge of the rudder is off center toward the right. This makes the airplane tend to turn right.

Since the Starved Pussycat has twin rudders, either or both rudders may be used to control circling. Do not confuse the desired circle direction with the side of the airplane where the rudder is located. To recognize which side of the airplane is the left or right, hold the plane with wings level, pointing away from you. The left side of the plane is now on your left and the right side is on your right.

The rudder into the turn is the left rudder for a left turn, the right rudder for a right turn.

The rudder out of the turn is the opposite right rudder for a left turn, and so on.

Moving or changing non-moveable parts on the Starved Pussycat requires breaking the joint and re-gluing.   Active participation and guidance from the mentor is required in this process.

Pitch trim

Center of Gravity (CG) is the location along the airplane body where you can “balance” the airplane on your finger so the body will be parallel to the floor. CG shift means to add ballast to the nose of the airplane or the tail to move the "CG" towards the nose or the tail. CG shifts are used to fix stall and dive problems. An airplane that dives (more or less straight ahead) is said to be nose heavy, and an airplane that stalls is tail heavy. Tail heavy model airplanes are common. Nose heavy ones are fairly rare. The center of gravity can also be moved by moving a part of the airplane. The STARVED PUSSYCAT design uses CL (center of lift) shifts caused by moving the wing back and forth along the motor stick. The CG does not move with the wing, but it does “follow” it slowly. Thus, moving the wing forward moves the CL forward of the center of gravity and makes the airplane fly more tail heavy. Moving the wing rearward moves the CL closer to the CG and makes the airplane fly more nose heavy.

Moving the wing changes the pitch trim, but also affects the stability of the airplane. Moving the wing back makes the airplane less stable, so you cannot go too far with this or the airplane will become unstable and won't fly at all. If an airplane is so tail heavy that it is unstable, you have to add ballast to the nose (move the CG forward) to make it stable enough to trim. If this happens, you cannot change the ballast you added for stability, and must use incidence changes to fix pitch trim problems.

INCIDENCE ANGLE
Moving the CG with ballast or wing position shift is easy. But ballast makes the airplane heavy, so if you need too much ballast or move the wing too far forward so the airplane becomes unstable, you must change the incidence angle to fix the situation. Incidence is the angle between the wing chord plane and the tail chord plane. Positive incidence means that the leading edge of the wing is higher than the trailing edge (measured from a line through the stabilizer’s leading and trailing edges). An airplane must have some positive incidence to trim for normal flight. That means that the wing has a higher angle of attack than the tail or rear surface. If this condition is not met, the airplane will dive at all stable CG positions. Increasing the angle of incidence will correct diving tendencies and decreasing the angle will correct stalling problems

PREFLIGHT CHECKS.

Do the Preflight checks prior to any flight, and repeat between flights, especially if a hard landing ended the previous flight.

1. Check for loose or broken parts. The airframe must be dimensionally stable, or it cannot be properly adjusted. Broken or loose parts will result in constantly changing flight characteristics, which will in turn make accurate diagnosis of any problems impossible.
2. Don't forget to check thrustline and incidence shims.
3. Check for (unintentional) warps in wing, elevator and rudder.
4. Make sure the wing is in the proper position on the motor stick.
5. If you must fly outside, check the wind direction.
6. Go ahead and try a flight. Launch the model more of less into the wind and more or less level. Don't throw it hard, but launch it forward at about normal flight speed. It takes a little practice to learn to do this. If you launch the airplane too hard, it will probably zoom up and stall, even if correctly trimmed. If you don't launch it hard enough, it will fall, and may or may not recover before it hits the ground.

It is important to learn the difference between a bad launch and bad trim. You cannot fix a bad launch by changing trim. Nor can you fix bad trim by launching the airplane in incorrect ways.

If the airplane dives more or less straight ahead, move the wing forward, add ballast to the tail or increase the incidence in the wing. If the dive is a spiral dive, you do something else described later.

If the airplane stalls, move the wing back, add ballast to the nose, or decrease the wing incidence. A stall is sometimes mistaken for a dive because the airplane invariably dives after the stall occurs, and observers remember the last action, not the initiating maneuver. A dive is a continuing decent at a steep angle sometimes getting steeper until the airplane hits the ground. A stall occurs when the airplane nose pitches up (rises to higher angles) and then drops when the wing loses lift at the stalling angle of attack. The rise may be fairly slow and the drop abrupt. The airplane dives a little after the nose drops, but the pattern will repeat if there is enough altitude to do more stalls.

Spiral dives. The airplane descends and turns, usually more and more sharply as the flight progresses. A spiral dive is usually fixed by adding washout on the wing on the outside of the turn to make the airplane try to roll away from the turn. It is sometimes fixed by adding rudder out of the turn, but that usually works only if the turn is unreasonably small in the first place. In a spiral dive the airplane is really rolling more and more into the turn.

Spiral dives sometimes are combined with nose heavy conditions, and then you have to twist the wing or rudder and fix the pitch trim as well. Try fixing the roll trim (spiral dive) first.

When you have the pitch trim and roll trim under some kind of control, then adjust the turn size to suit yourself. If the airplane flies too straight, add rudder into the turn. If it turns too tightly, add rudder out of the turn. When you do this, you may have to make small changes to the pitch and roll trim as well. It takes 10 or 20 flights to get the low power trim straightened out if you are good at it, beginners shouldn't be surprised if it takes longer.

When making any kind of trim change, easy does it. If you overshoot, you just confuse yourself.

HIGH POWER ADJUSTMENTS

(Note high power trim techniques are not applicable to a STARVED PUSSYCAT because it isn't practical to change the thrust line. The high power trim and subsequent fine tuning sections are included here for possible use with models employing removable propeller ("Nose blocks") bearings which you may want to build as an independent follow on action.)

IF DOING THE STARVED PUSSYCAT, SKIP THIS AND GO TO "FINE TUNING"

The adjustments you make to control high power trim are all tilts of the propeller shaft axis and are called Up, Down, Right, and Left thrust.

(Do not forget preflight checks.)

After getting the low power trim in shape, high power trim is usually fairly easy (but it may be hazardous to the airplane if not carefully executed). Increase the turns in the motor approximately 200 times for each subsequent test. Fix loops, stalls, dives, spiral dives and turn pattern changes with thrust adjustments only. The low power trim settings must be left alone, or you will ruin the low power trim to fix the high power trim. The thrust adjustments are only effective at high power, so they won't bother the low power trim settings.

TERMS

Prop Disk is an imaginary circle swept by the propeller as it rotates. Diameter is the same as the prop diameter and the disk is perpendicular to the propeller shaft. You should imagine it replaces the propeller.

Down thrust - The prop disk is tilted forward at the top and back at the bottom. This is usually done by putting shims between the nose block and the fuselage to get the desired tilt. Down thrust is used to fix power stalls or loops. Power stalls are stalls that occur when the motor is wound up a lot, but flies OK at low power. Sometimes a power stall looks like a low power flight stall (the airplane pitches up almost vertically, and hangs on the prop, but is unable to climb vertically). In its final stages, this kind of power stall usually leads to a tumbling maneuver followed by a steep dive. As with a low powered flight stall, if the airplane has enough altitude, the pattern may repeat, but usually a crash occurs before this happens.

Up thrust. The prop disk is tilted so the bottom of the disk is forward and the top of the disk is back. Up thrust usually doesn't fix anything. Sometimes, up thrust will cure a power dive, but when this is the case, the airplane had too much down thrust in the first place, and adding up-thrust simply brought the trim back to where it should have been.

Right thrust and ***Left thrust***. The prop disk is tilted so the right side is forward and the left side back for right thrust, and the opposite for left thrust. These are the two kinds of side thrust.

Side thrust is used to cure a spiral dive under power by adding side thrust out of the turn. For a spiral dive to the right, add left thrust, etc. Side thrust is also used to fine tune the power turn pattern. If your airplane flies larger circles under high power than it does under low power, add side thrust into the turn. If it flies tighter circles at high power than at low, add thrust out of the turn. If you only fly outside, this may not matter, but if you fly indoors, too large a power turn may lead to a collision with the wall. When you change side thrust, you will probably have to change downthrust as well. Most airplanes that turn to the left require some right thrust and some down thrust. Airplanes that fly to the right need left thrust and down thrust. In rare cases side thrust out of the turn does not fix a spiral dive. If this happens, add washout to the outboard wing tip (a change in low power trim) and start the high power trim cycle again.

FINE TUNING

For maximum performance, go back and try small changes in low power trim. This takes a lot of time, but continued testing will probably result in a set of low power trim conditions (close to, but different from your original settings) which result in longer flights than were originally acheived.

MOTOR CROSS-SECTION SELECTION

An important step in fine turning is selection of the best number of strands and rubber band cross-section for long flight.

If the airplane does not climb well, increase the motor cross-section, which means either more strands, or larger size strands, or both. If the airplane is too hard to trim at high power, then decrease the motor cross-section. The right cross-section motor will result in a good climb followed by a glide or power decent as the motor runs down. During indoor flight, the airplane will usually fly under power all the way to the floor. Outdoor models are usually trimmed (with larger cross-section motors) to climb until the motor runs down almost completely, and then glide to the ground.

MOTOR LENGTH SELECTION

After the right motor cross-section has been selected, the length can be optimized. The longer the motor, the longer the flight will be (until trouble develops with knots and CG shifts).

Motor length will be limited by knots jamming inside a small cross section fuselage or by knots bunching at the front or back end of the motor as it unwinds. The uneven bunching causes a CG shift that defeats low power trim. The knots jamming inside a small fuselage mechanically interfere with the unwinding of the motor. Practical motors range from a minimum of the spacing between the fixed and rotating rubber hooks up to about 2.5 times this length. The short length is forced by very small inside fuselage dimensions and the long limit by rubber bunching.

Stretch Winding

To wind up an airplane motor the required number of turns, it is necessary to “stretch wind” the motor. Just spinning the propeller without stretching the motor will break the motor prematurely.

To stretch wind, a partner is required. The partner holds the airplane while the motor is wound, and may get stung by the breaking rubber band if the winder is not careful. The partner holds the airplane in a precise way and does not move until the winding is complete and the motor has been hooked to the tail hook (or propeller hook, if the winding is done from the front end). The way the partner holds the airplane is with the wing straight up and down and the motor stick or body horizontal, and with the rubber band on the side of the airplane away from the partner’s body. The rubber band is then about parallel to the floor and the rubber band and prop and tail hooks are easily accessible. The partner must hold the rubber band just behind the propeller hook by pinching the rubber between two fingers to take the stretching loads away from the model while the winder is winding.

When the partner is holding the model properly, unhook the rubber band from the tail hook and stretch the rubber 3 or 4 times its un-stretched length. Do this in a direction about 30 or 40 degrees away from the model body so that if the rubber breaks, the model is somewhat protected from the rubber. Begin to wind the motor with the winder. Wind it up about 1/2 way to the expected final number of turns without changing the motor stretch (don't move). At this point, the winder continues to put in the second half of the motor turns while slowly approaching the model (relaxing the stretch) a little at a time. When the winder is done winding, the rubber length should just matche the distance between the front and rear hooks. The winding is now done, but the wound up motor must be transferred from the winder hook to the prop hook. The partner is still standing like a statue waiting for this to happen.

To get the rubber off the winder hook, the winder pinches the rubber 1/2 inch or so away from the winder hook and lets go of the winder so it can spin and release the turns in the short loop of rubber between the winder's fingers and the end of the motor. If done correctly, this results in a small loop (say ¼" long) at the end of the motor. The winder slips this loop over the tail hook and then holds onto the propeller and takes the model from the partner for launching. Don't drop the winder on the floor when the motor is unhooked from it, the winder will break! Put it down gently or hand it to the partner.

Proper stretch winding will allow nearly twice as many turns in a motor as could ba accomplished without the stretch technique. That usually means almost twice as long a flight!

ROLL: Roll tends to rotate the plane around its long axis. If looking at the aircraft from the front, a right roll would force the right wing tip down (or up) and the left wing tip up (or down) around an axis which runs from the propeller to the center rear of the fuselage.

YAW: Yaw tends to rotate the plane around a vertical axis going through the center of gravity. If looking at the aircraft from above, a yaw would force the front of the aircraft to move to the right (or left), and the tail of the aircraft to move to the left (or right).

PITCH: Pitch tends to rotate the plane around an axis which generally runs parallel to the wings through the center of gravity of the aircraft. If looking at the aircraft from the side, pitch would force the front of the aircraft up (or down) and the tail of the aircraft down (or up).