Trimming for F3A Aerobatics (Version 2)

The following guidelines work best if your aircraft has been built with a straight fuselage and wings and the manufacturer's weight recommendation has not been exceeded. There are many other trimming techniques but this one can be used on Club aircraft as well. Centre of Gravity (CG) should also start as close to the manufacturer's specification as possible. CG position is the single most powerful trimming tool you have and after any change in CG you need to re-do all the other trimming steps. These guidelines will benefit any aircraft. Conduct tests in reasonably calm weather and make small changes between flights. After any change, re-do all the trimming steps.

The most usual setting for incidence is with the tail plane at 0 deg and the wing at between +0.7 and 1.0 deg.

The primary aim of trimming your aircraft is to have one that has "pure inputs," where control inputs result in singular movements without unintended pitching, rolling or yawing. It is also so the aircraft continues along the last line flown, without any deviation in roll, pitch or yaw. The objective is to reduce the workload on the pilot to allow them to focus on flying the schedule.

The Basics			
1	Trim your model for straight and level flight, hands off, with the engine set at just over half throttle. Aircraft smaller than two metres may need a slightly higher throttle setting. If you have tailplane incidence adjusters, it is assumed that you have trimmed out the inaccuracies to leave the tailplane and elevators level. Adjust the elevator clevis till the servo arm is back to its central neutral position. Check that all servo throws are matched to recommended settings and there is no play in the control linkages.		
Balance - Centre of Gravity			
2	Fly straight and level, increase the throttle to full and pull to a 45° climb. Hold the 45° line then roll to inverted and release the stick. Aim for a **gentle** pitch towards the canopy.	Model pitches quickly **towards** the canopy	Move the flight pack aft **or** add weight to tail **or** remove nose weight.
		Model pitches **away from** the canopy	Move the flight pack forward **or** add weight to nose **or** remove tail weight.
3	If any adjustments made, go back to 1		
Engine/Motor Side and Up Thrust Adjustment			
4	Hold straight and level flight at just over half throttle then smoothly increase the throttle to full.	Model climbs immediately	Increase engine down thrust.
		Model dives immediately.	Decrease engine down thrust.
5	Climb to height, push to a vertical dive in the centre of the field while closing the throttle and perform a ¼ roll so you can see the model in plan form	Model yaws to the left. Model yaws to the right	Add right rudder trim till dive is vertical Add left rudder trim till dive is vertical
6	Fly straight and level and then pull to vertical.	Model pulls to the left.	Add more engine right thrust.
		Model pulls to the right.	Decrease engine right thrust.
7	If any adjustments made, go back to 1		

Wing Incidence			
Wing incidence should be related to the datum line (fuselage reference line given by the manufacturer) of the model. The wing incidence can also be related to the centre line of the tailplane aerofoil. The two reference lines may be different.			
Most stable aircraft will tend to pitch to the canopy on a vertical downline as a result of using the incidence setup referred to at the beginning of this document i.e. tail plane at 0 deg and the wing at between +0.7 and 1.0 deg.			
8	Vertical Downline. Start high and reduce throttle to tick over and dive on centre in a straight line.	Model pulls to canopy.	Set Mix with Throttle as Master. With fully closed throttle mix a few clicks of down elevator till the dive is vertical.
		Model pulls to belly.	Increase wing incidence **OR** decrease tailplane incidence.
9	Vertical Upline. Start low and pull to a vertical climb on centre.	Model pulls to canopy	Increase downthrust **OR** increase wing incidence
		Model pulls to undercarriage	Decrease downthrust **OR** decrease wing incidence
10	If any incidence is changed go back to 1.		
Elevator Balance – equal throw from each elevator			
11	The objective is to ensure that both elevators are aligned with each other and, if there are 2 elevator servos, that both elevators deflect by the same amount throughout their range. Failure to ensure this will introduce unwanted rolling when using the elevator.	You can use a pair of new pencils for this task. Make sure that their points are at the same height when they are flat on a table. Then, use masking tape to attach them to each elevator half with the pencil ends close to each other but clear of the rudder when at each elevator extreme.	**For a single elevator servo**, mechanically adjust so both elevators are in the same position. **For twin elevators servos**, adjust the elevator servos using the Tx "Balance" controls to ensure that both elevators move exactly the same amount throughout their range.
Lateral balance			
12	Fly model towards you and pull a tight loop. Repeat for outside loop.	Wing drops at exit.	Add weight to high wing tip.
		OR	
	Roll model inverted at half throttle.	Wing that drops is the heavy wing.	Add weight to other wing.
Aileron differential - achieve axial rolls			
13	Fly model towards you and pull into a vertical climb, then half roll.	After half roll, model changes heading in the same direction as roll. (i.e. roll right and model heads to the right).	Increase aileron differential (up going aileron to move further than down going aileron).
	You may find that you do not need any differential movement.	Opposite direction to the roll.	Decrease aileron differential.

Knife Edge (KE)			
Roll to KE and note what happens i.e. roll increases past the vertical or roll decreases AND/OR aircraft pitches to canopy or to the undercarriage. CG position can sometimes have a marked effect on reducing cross coupling between the rudder and pitch and roll. Try moving the CG further aft first and if that doesn't cure the problem use an electronic mix to act against this tendency. What you are looking for is a pure Rudder action to hold the aircraft level in KE without any associated pitch or roll.			
14	**For Rolling Issues**: From straight and level flight, roll to knife edge and hold top rudder to maintain level flight.	Model starts to roll to inverted.	With Rudder as master, add a few clicks of aileron to act in the **same** direction as rudder i.e. with left rudder add left aileron
		Model starts to roll back to upright	With Rudder as master, add some aileron to act in the **opposite** direction as rudder i.e. with left rudder add right aileron
15	**For pitching problems**: From straight and level flight, roll to knife edge and hold top rudder to maintain level flight.	Model pitches to the canopy	With Rudder as master, add a few clicks of **down** elevator.
		Model pitches to the u/c	With Rudder as master, add a few clicks of **up** elevator.

Trimming should be a constant concern to make the most of your model and it is expected that you may have to revisit the above chart to improve your models flight characteristics.

Make one adjustment at a time and check the effect thoroughly before making any further adjustments.

Note that mixing might solve one problem while impacting on another. Using either a logical switch or a physical switch to bring the required effect into play without affecting other manoeuvres might be a good solution.

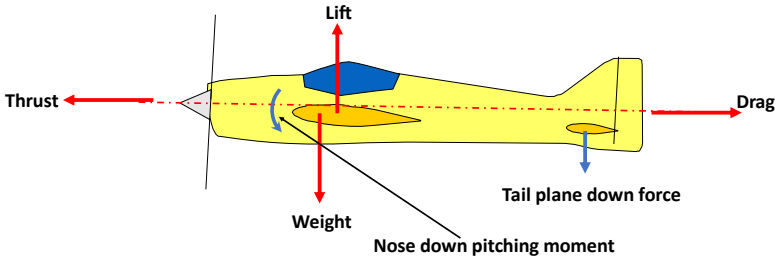
It is almost always better to fix the trim problem mechanically, but if you have exhausted that route then use electronic mixing. Trimming is an individual art which you will develop with time and experience. Indeed, no 2 pilots might agree on how to fix their trim issues or indeed how they like their aircraft to feel. This guide is the starting point.

For those wishing to correct a basic design fault, the first action is to decide on a fuselage datum line. This is the attitude of the fuselage in relation to the straight and level line being flown. All other incidences (wing, canalyser, tailplane and engine thrust line) are then set with reference to the fuselage datum line.
Rudder hinge line angle and proportions of the rudder can also affect rolling when rudder is applied, however these are not easily changed and a mix may have to be used.

For those who find it useful, there is a discussion of the forces acting on an aircraft in flight on the following page. This might help you to understand better how the trimming process alters the way these forces act on the aircraft.

IT'S ALL A MATTER OF FORCES

It helps to understand what is going on when you are trimming an aircraft. It all comes down to the balance of forces acting on your aircraft. The first diagram shows the situation when the aircraft is flying straight and level at the datum speed you have set. At that point, the Thrust and Drag are equal and opposite. However, unless the centre of drag is on the thrust line then there will be a resultant moment that will either pitch the nose up or down as the Thrust force is varied.



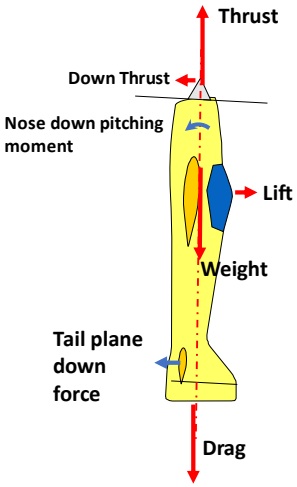
The wing lift force acts through the centre of pressure (CP) while the overall aircraft weight acts through the Centre of Gravity (CG). These two forces, shown in the position when the aircraft is stable i.e. the CG is in front of the CP. These two forces generate the largest nose down pitching moment that the Tail Plane is required to counteract. In this case, the Tail Plane needs to exert a down force to balance the nose down pitching moment generated by the other two. Also, our Lift force has to be equal not just to the aircraft weight but also to the tail plane down force.

INCIDENCE

The wing is set at an incidence to the fuselage datum line as is the tail plane. As mentioned earlier in this document, the usual set up is wing at 0.7 degrees with tail plane at 0 degrees. Remember though that the tail plane is operating in an area in which the wing has induced the airflow to change direction slightly and flow downwards. This is one of Newton's Laws of motion whereby forcing a mass (of air) downwards, results in an equal and opposite force upwards that when combined with the Bernoulli force generated by the difference of pressure between the two surfaces of the wing, we call Lift. The tail plane is now facing an airflow at a negative angle of attack (AoA) so generates a down force that we make use of the balance our aircraft.

When the aircraft is flying what matters is the AoA of the wing relative to the airflow. The greater the AoA the greater the lift and lift induced drag. So, if you increase the wing incidence, to fly level at the same speed will require the fuselage to be very slightly tipped nose down so that the AoA is the same as before and the lift equals the weight. We do this by using a bit of down trim and then, if the tail plane is adjustable, we adjust the tail plane incidence so that we can remove the down trim we added.

Before we deal with the vertical upline, we need to make sure that the aircraft will dive vertically without yawing or pitching away from the vertical. This is done with the engine at idle so no thrust so that the effect of any down/up thrust is now zero that we are looking at just the aircraft's aerodynamics without the influence of thrust. We trim the rudder to get the aircraft to be flying with no yaw. Now, the basic setup of the wing and tail plane is such that they are trying to get to a position of equilibrium but one of the basic forces is now missing i.e. effect of motor thrust, so we usually get a pitch to canopy on the downline. Hence, the need for a mix of a few clicks of down elevator when the throttle is fully closed.



If we consider the forces in a vertical upline, ideally, we don't want any lift from the wing so the wing must be at 0 degrees AoA. However, there are other forces that we identified above and they might also need to be neutralised if our desire for a vertical upline to be flown hands-off.

Any downthrust, or the slight mismatch between the Thrust and Drag forces will cause a small nose down (or up) force and even the small amount of lift force needed to balance this will cause more nose down pitching requiring the tail plane's compensating down force to balance things. By adjusting the wing's incidence, we are giving ourselves the opportunity to tune the fuselage position so that we can arrive at a balance of all the forces to achieve our aim of a hands-off vertical climb at our datum speed which should match the aircraft's level speed.