How do I fly my airplane? What do I do to get better flight times?

By Brian Turnbull for NFFS

Initial Airplane Trimming

1) Verify that the following measurements are exactly per plan or kit instructions. **<u>This is a very important step. Do not proceed to flight testing till these measurements are correct.</u>** Make necessary adjustments even if it means slightly cracking a glue joint, repositioning the part and regluing (or adding clay/putty ballast in case of CG).
    a. Center of gravity (CG) (fig.1)– Move the wing back to shift the CG forward or visa versa. If wing needs to be moved more than ¼" back from kit/plan recommended position, add small amounts of clay/putty ballast to the nose to correct CG instead of moving wing back.
    b. Left wing washin (fig.2)
    c. Wing and stabilizer incidence (fig.3 and fig.4)
    d. Tailboom offset and stabilizer tilt (fig.5 and fig.6)
    e. No unplanned warps

Figure 1: CG measurement. Usually expressed as distance from rear wing post.

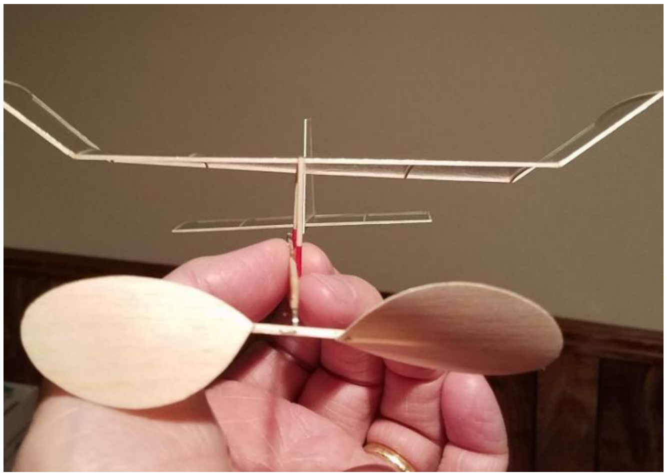


Figure 2: Left wing washin measurement. Can be done by "eyeballing". This wing washin is about ¼".

Figure 3: Measuring wing incidence relative to motorstick. Measure distance from motorstick bottom edge to wing TE and also motor stick bottom edge to wing LE and take difference; calculate in degrees by doing the Trig.

Figure 4: Stabilizer incidence in most airplanes is the tailboom vertical angle relative to the motor stick, which is set and measured as tailboom is attached. In this case, the tailboom tip is shimmed with two 1/16" thick wood scraps, so the incidence is 1/8", or 0.9 degrees for this 8" long tailboom (do the Trig yourself). Often tailbooms are tapered (ex. ¼" tall tapered to 1/8" tall at tip). Angling the tip of this tapered tailboom by 1/8" would essentially make the top side 0.0 degrees incidence (it would be level with the motor stick top line).

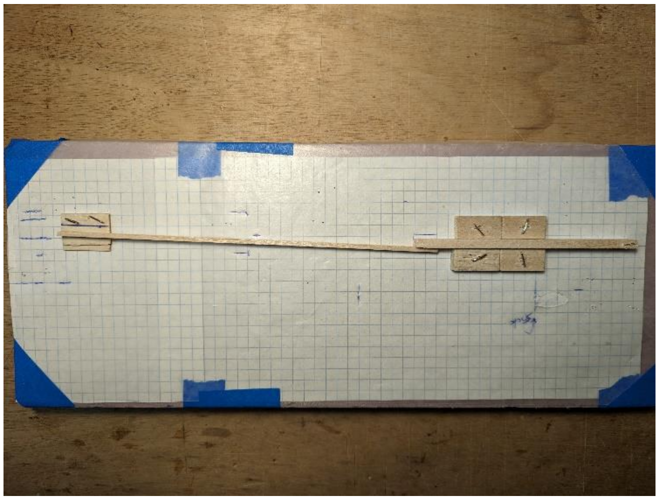


Figure 5: Tailboom offset is the horizontal angle relative to the motor stick, which is set and measured as tailboom is attached. In this case, the tailboom tip is angled 3/16" relative to the fuselage. So, for this 8” tailboom, this is 1.34 degrees. 2 to 3.5 degrees would be a more typical measure.

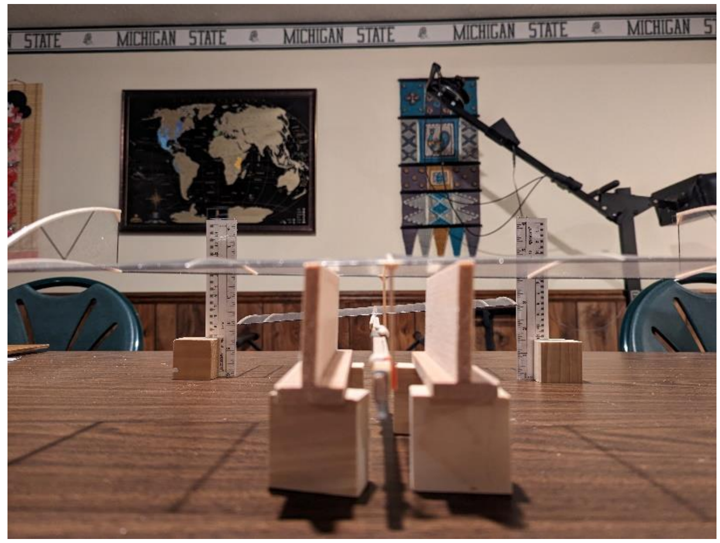


Figure 6: Stabilizer tilt. Block the wing LE so that it is level to the table. Measure from table surface to each stabilizer tip leading edge. Difference is the tilt amount. Calculate in degrees by doing the Trig. Tilt shown of 7/8" (or 4.56 degrees for this 11" span stabilizer) is more than typical. Typical would be 2 to 3.5 degrees.

Initial Flight Testing

1) Start with "mid-range" rubber density per kit or plan; log all flight data

2) First flights at 30-40% max turns, no backoff. Inspect flight character. Here is a maximum turns calculator (see figure 7 below): https://docs.google.com/spreadsheets/d/1f6ImQiyC75cJG7yd9hIGlB2ptOzFty_I/edit?usp=drive_link

    a. Calculator uses this equation: https://drive.google.com/file/d/1plUa9ZNc2Z7jTuT8bzKIk4nLxCu7IrQH/view?usp=sharing

3) If diving and rolling left – add 1/16" to 1/8" left wing washin

4) If stalling - reduce wing incidence 1 degree. If still stalling, move CG forward 1/8" at a time. Best flight performance is typically achieved by trimming to slightly stall and then moving CG very slightly forward to remove stall. Do not control climb rate and climb height with wing incidence. Propeller pitch and launch torque are the primary controllers of climb rate and climb height (respectively).

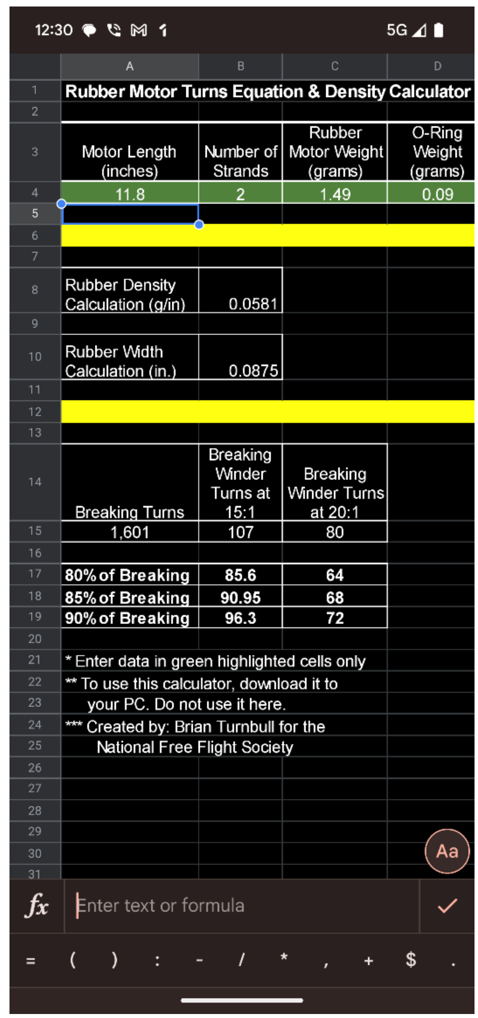
5) If turn is too tight (<20 ft dia circle) and airplane appears to want to climb, reduce rudder offset by 50%.

6) If turn is too large (>35 ft dia circle) and climb is good, reduce left wing washin by 50%. If washin reduction reduces climb rate too much, put washin back in and tighten circle instead with 1 degree more rudder offset. If circle is still large after washin reduction and climb rate is good, increase rudder offset another 1 degree.

7) Once circle size is about 20-25 ft dia and climb rate is gradual and gentle, all flights should now be wound to 80% max turns or more and to 1.2-1.4 inch ounces torque. We'll call these flight "full winds". First "full winds" flight should have backoff turns to very low launch torque, like 0.25-0.35 in oz.; should produce climb of 10-15 ft.

8) Subsequent flights; always wind to 85%+ max turns (and 1.2-1.4 in oz maximum torque) and gradually reduce backoff turns flight by flight and increase launch torque 0.02 in oz for each flight (ex. Launch at 0.32, 0.34, 0.36, etc.). Each flight in this series will climb a little higher. Continue till you identify the launch torque that produces a climb to just below the ceiling or rafters. You will see that, for a particular airplane trim and propeller/propeller setup, climb height is a linear relationship to launch torque.

9) **<u>Here is an NFFS Video demonstration of proper rubber winding technique to get full power and maximum flight duration</u>**: https://youtu.be/_MCNDiLF06I



Rubber Motor Turns Equation & Density Calculator			
Motor Length (inches)	Number of Strands	Rubber Motor Weight (grams)	O-Ring Weight (grams)
11.8	2	1.49	0.09
Rubber Density Calculation (g/in)	0.0581		
Rubber Width Calculation (in.)	0.0875		
Breaking Turns	Breaking Winder Turns at 15:1	Breaking Winder Turns at 20:1	
1,601	107	80	
80% of Breaking	85.6	64	
85% of Breaking	90.95	68	
90% of Breaking	96.3	72	

* Enter data in green highlighted cells only
** To use this calculator, download it to your PC. Do not use it here.
*** Created by: Brian Turnbull for the National Free Flight Society

Figure 7: Maximum Turns, Density and Rubber "Width" calculator.

Advanced Flight Testing

1) Once initial flight testing with mid-range rubber density is completed, move on to flights with slightly higher density motors and slightly lower density motor. Continue this to "extremes" to determine best density for this particular airplane trim and propeller type and propeller blade pitch angle.
    a. "Best motor" for the current trim and propeller is highest flight time. See 2.a. and 2.b. also.
2) Follow same procedure as initial testing. First flights with low launch torque, reducing backoff turns and increasing launch torque slightly on each subsequent flight till close to the ceiling
    a. If motor density is too low, high launch torque will be required to get sufficient climb and descent will be too rapid and there will be lots of turns remaining on the motor at flight completion. Measure turns remaining by picking up airplane at flight completion without allowing propeller to spin. Load the motor back on torque meter and winder and wind backwards counting turns remaining.
    b. If motor density is too high, lots of backoff turns (and low launch torque) will be required to keep climb low enough and there will be very few (or zero) turns remaining on the motor at flight completion.
3) Once the best motor density has been determined for the current airplane trim and propeller type and pitch, the next step to improve flight times is to try different propeller pitches; maybe 2 degrees more pitch (or 2 less) for each change and fly again with several densities of rubber.
    a. Increasing propeller pitch will slow climb rate, and might increase duration. Increasing propeller pitch may also hurt the duration during descent. Test logical extremes.

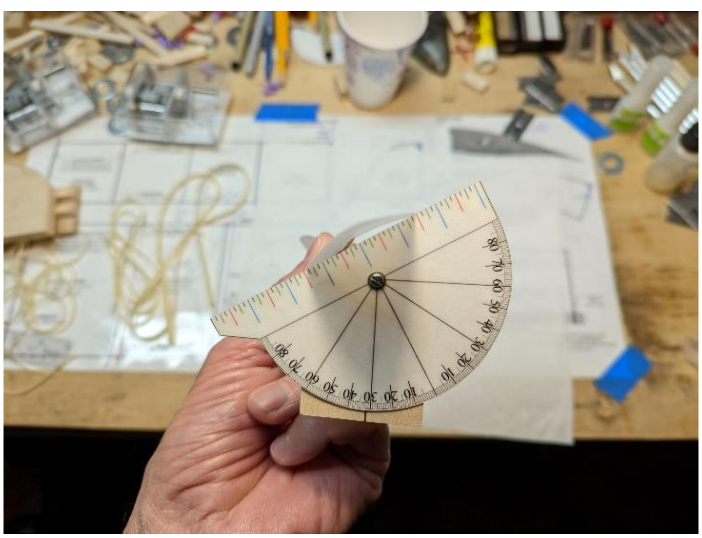


Figure 8: Propeller blade pitch measurement. 32 degrees, measured at the 3" diameter radius is 11.77" pitch (tangent of 32 degrees times circumference of a 3" radius circle) and is a pitch/diameter (P/D) ratio of 1.25 for this 9.4" diameter propeller. Typical P/D to test would be 1.4 to 1.8

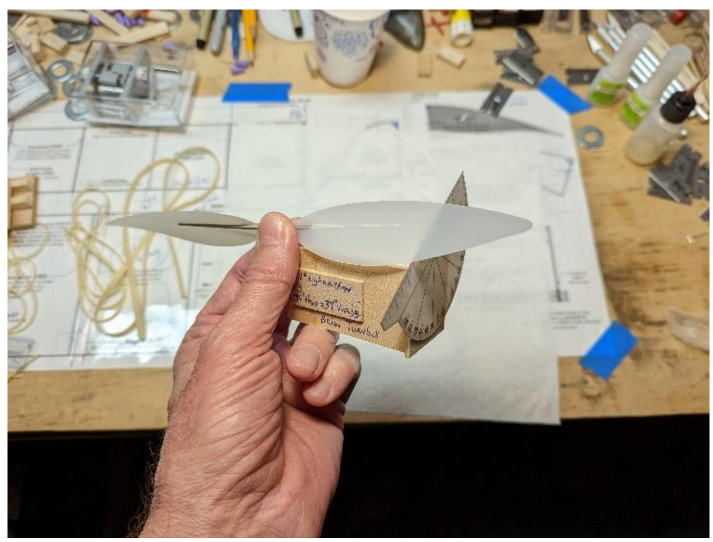


Figure 9: Propeller blade pitch measurement

4) Once the propeller pitch and rubber density are determined for maximum duration for this trim/propeller setup, consider slight changes in CG; maybe moving CG back 1/8" at a time (or less) to try to slow down the airplane. After moving CG, retest the logical range of propeller pitches and rubber densities. Improving flight time is the key indicator of correct testing direction.
5) A good indicator of efficient climb is a low propeller revolutions per second. Calculate this and log flights with significant trim/power system changes. RPS = launch turns minus turns remaining divided by flight time in seconds.