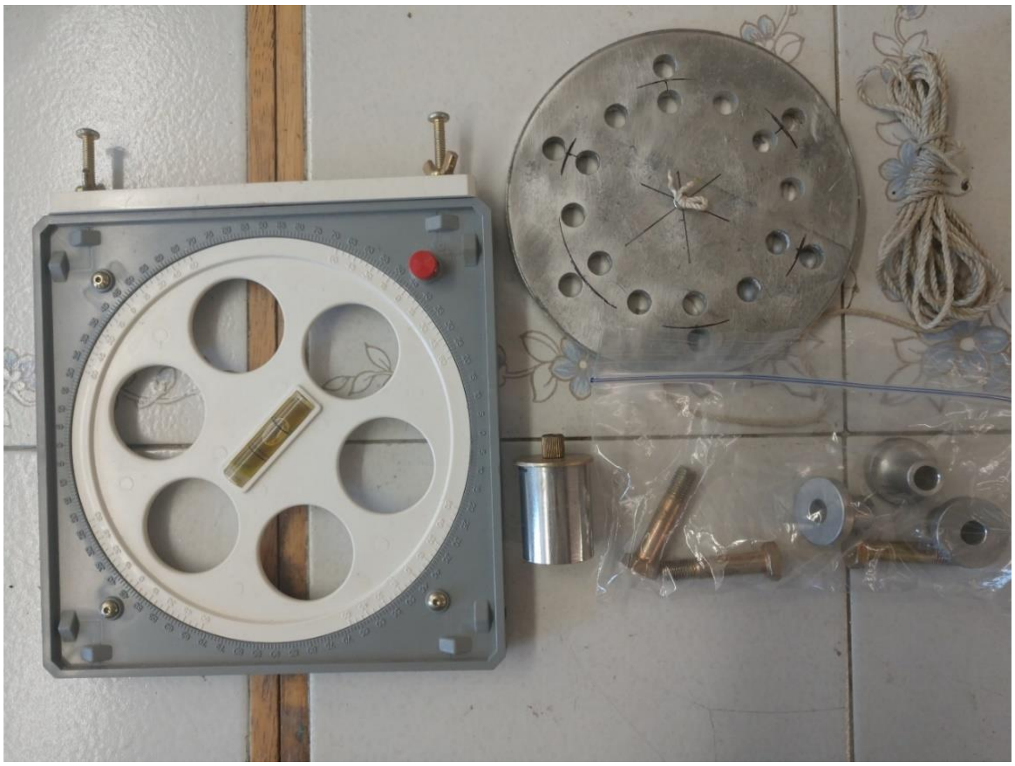
Custom Flight Prop Static Balance Kit

Parts:
Propeller Protractor.
Propeller 4 inch center six bolt prop hangar disk (looks like a propeller squash plate).
Common Propeller centering tool for wood and Warp Drive propeller hubs.
String, 50 pound tensile.
Spacers and 5/16 Airmaster propeller mounting bolts.



Instructions to check static balance (especially important on a repaired or used propeller).

Do this first: Assemble the propeller IAW the manufacturer's instructions. Install the propeller backplate and bulkheads as supplied by the prop manufacturer. Check the propeller spinner is centered and properly fastened and indexed in its final state for running. Spinner bulkheads must be in contact with the spinner front as well. Check the blades are all at exactly the same length and blade angle using the propeller protractor mounted at exactly the same point (typically at the tip, or more precisely at the 2/3rds span position) to assure uniformity.

Note

Fiberglass spinners nearly always have a glass overlap on one side and often times are not perfectly true. To check, set the spinner on a flat, smooth surface and see which side is heaviest. If the propeller hub and blades have a heavy side place the spinner if possible so that the heaviest side of the spinner is opposite to the heavy blade.

Performing the static balance
Updated Apr 2020

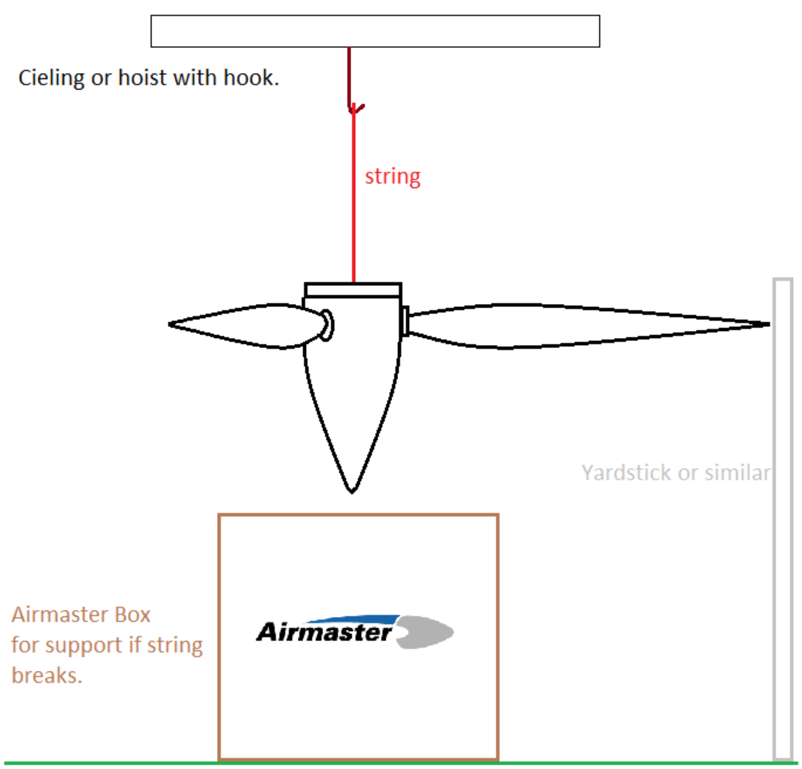
Airmaster Propeller:
Install the propeller to the propeller hangar disk. Use the bolts supplied. Always use the same length and type bolts.

Warp Drive:
Install the round centering plug with washer into the center of the hub and run the string through the center hole.

Use a box or padded device to prevent the propeller from falling to the floor should the string break or lifting attachment device fail.

Hang the propeller from the ceiling on a firm hook or use an engine hoist to securely affix the prop to the ceiling or hanging device. The propeller arc should not allow any obstruction to contact the prop when hung. See drawing of a typical setup.

Static Balance Setup Used by CFC, Inc.



Shorten the propeller string to elevate the propeller above the protective box/device used to prevent the prop from being damaged should the string break.

Allow the string, which is now under full tension, to spin the propeller to unload its twist. Don't allow a rapid spin.

While the propeller is spinning on its string, it may wobble. Try to get it to spin centered.

Observe the spinner is running fairly true and note if the propeller has a heavy side or is wobbling rather than a nice smooth spin. Slow the spin to a very slow rotation.

Set a yardstick or similar on the ground and measure and mark each blade as it advances toward your seated position next to the prop arc. Normally I use a felt tip to number each blade then mark on the measuring tool (yardstick) the height of each blade.

Install a weight opposite to the lowest blade using a nut/bolt and washers as required on the propeller flange until all blades are the same distance measurement from the floor. The Airmaster has holes in the propeller flange to assist in this mounting, use them.

Bolt on the weights where they are on the spinner flange. This may require spinner removal. If the propeller spinner backplate does not have holes, carefully mark the areas where the hub does not interfere with the weight position and the bolts and tools to install are all clear of propeller blade and hub components. Then when weights are placed, drill and mount the weights.

Note

The installation of multiple weights evens out the center of mass rather than one large weight. This will make dynamic balancing a bit easier later.

Recheck the propeller static balance after all balancing bolts are installed.

The propeller can be untied and lowered safely to the protective box/device.

Remove the balancing tools.

Prior to installation of the propeller on the aircraft, the airframe, engine and propeller mounting must be accomplished properly IAW manufacturer’s guidance.

Preparation for Engine run and engine/propeller/vibration checks.

Airframe:
Check the aircraft engine has been properly installed IAW the manual and secure.
Ensure the aircraft is properly fueled.
Ensure the aircraft is properly tied down.

Engine:
Ensure the propeller flange is undamaged.
Ensure the proper drive lugs for the propeller chosen are installed into the hub using manufacturers installation procedures.
Never beat or pry on a propeller flange. Use a press to insert and remove drive lugs.
Ensure the engine ignition is off and inadvertent actuation of the starter is assured.

Propeller:
Install the propeller IAW the propeller and airframe manufacturer's directions.

Ensure the propeller is fully pulled down on its lugs, torqued and lock wired as required.
Pull a plug from each cylinder and rotate the propeller by hand.
Ensure the propeller and its components are well clear of any engine component, hose, wire or duct or cowl.

Using a prop protractor or similar, determine if the blades are exactly at the same angle. (See instructions at the end of this document.) Set the prop horizontal. Cut a stick or board to set the blade horizontal elevation and measure each blade at that same angle at the same point on the same side of the aircraft when using a propeller protractor. For a ground adjustable propeller, reset blade angle until all blades are equal. If the Airmaster blade angle is off at the tip, continue to the next step.

For all propellers, check the blade angle at a point 2/3rds span from the hub centerline. (This is the aerodynamic center of the prop and is more important than the tip). It is not uncommon that the tip and 2/3rd point may vary a small amount. If the difference is more than .1 degree adjust the 2/3rd point blade angle to get all three the same. Contact Airmaster if the difference is significant.

Place a stand or a tripod directly under the propeller that is very close to the propeller tip as it passes a marked point on the stand (camera tripods or jack stands can work) and mark each blade position as it passes. The track should be withing 1/16-1/8 inch after all adjustments are made to assure good tracking. Recheck the bolt torque.

Remove the tripod/stand.

Prepare to run the engine. (Install the plugs and ensure the area is clear and the aircraft is well tied down.)

After engine start adjust the engine IAW the engine manufacturers installation and initial run checklist.

Observe the spinner and propeller for tracking and unusual movement during the engine pre-run and warm up.

Any wobble of the spinner should be corrected immediately. I prefer to do a static balance and adjust the spinner for center at that time. However, in the field some technicians will check the spinner with the prop on the aircraft. This is normally done on a tricycle gear and well clear of the prop blades. How they do this is they safe the engine and turn the engine with the starter. Standing in front of the aircraft and well clear of the blades. They set the engine ignition off, and the plugs removed, then crank a couple of turns with the starter and use a grease pencil to mark the high spot on the spinner tip while the starter is cranking the engine slowly with no compression. The tech will stand in front of the prop, while an assistant is spinning the starter, and with a steady hand mark the spinner for a high spot. Then remove the spinner, and adjust the tracking and repeat. This is a technique that is risky and should never be done unless the engine is properly safed up, the starter limits are not exceeded and all safety precautions observed.

After the spinner is tracking straight (er), start the engine and sight the propeller tip tracking from a safe distance and note if there is any blade blur that may indicate a tracking or blade problem under rotation. (Some so called flexible propellers are flexible enough they will not track or maintain an even angle while rotating and, in my opinion, should not be used. Any blade tracking errors must be corrected if noticed.

Shut down and inspect the propeller and retorque if not safety wired. Check all spinner screws and do a post run inspection on the engine.

Preparing for Dynamic Balance

Once the engine is running properly and safely within limits, in a near zero wind or direct headwind environment, run up to full power IAW the engine manufacturers documentation and check for smoothness and operation. Engine overheating may be a problem with the cowl removed.

If engine limits can be maintained and the engine and propeller are running relatively smooth, do a dynamic balancing.

Dynamic balancing should be done at climb power or at a cruise power setting IAW the dynamic balancing manufacturers instruction. Allow the engine to cool before attaching the dynamic balancing optical and vibration sensors.

The vibration sensor must be attached as near to the centerline of the engine and as near the prop as possible. It must be oriented in the vertical position for most balancing equipment manufacturers. Use of an extension or bracket that is home made is preferred to a poorly fit supplied bracket. Attach the optical sensor so as to illuminate the tape positioned on the backplate or a blade and make sure both are attached rigidly and the wires to these devices are secure so as not to become entangled in the prop/exhaust.

The optical sensor must be protected from reflective light sources from the other propeller or engine components such as polished leading-edge tape, polished prop hub components in line of sight with the sensor, a polished engine block or component or any outside source like light from a window/windshield nearby reflecting light into the sensors path. Keep a can of cheap flat lacquer paint to dull surfaces if necessary. Then use lacquer thinner and take it off when done.

Note:
If the propeller has been statically balanced, do not allow the dynamic balance tech to remove the static balance weights. A propeller that is not statically balanced will not dynamically balance.

Accomplish the dynamic balance IAW the manufacturer's instructions.

At high power settings the aircraft will jump around and the propeller air blast will impart many vibrations on an un-cowled engine, its plenums, ducting, tail planes, open doors and pilots. These vibrations will be picked up by the dynamic balance sensors and will most likely affect the balance and may even preclude a successful balance attempt. Run the engine at the highest power that does not excessively shake the aircraft from prop blast and give consistent results. Always make engine runs in calm or no wind conditions for best results.

Install weights as indicated. If the weights cannot be placed exactly where the unit calls out, most manufacturers allow you to input your weight and its position and the program will adjust as required during the next test run.

The basic dynamic balance procedure is to make the initial run at the desired RPM, then a weight is attached at the O'Clock position indicated by the computer. This is an initial coarse estimate which will determine the effect of the initial run with this new weight. After the first run, the initial balance weight is removed and replaced. This second run is made to refine how the weight affects the IPS and its O'clock position and should be somewhat smoother than the initial run. Then subsequent runs are made to fine tune this weight and position slightly to achieve an acceptable balance.

Attempt to balance until IPS can be decreased to a minimum of .07 (considered fine) and lower if possible. I prefer to be .04 or lower.

If the static balance was fine, and the dynamic balance is moving weights about with no significant improvement, you have other problems.

Example:
If your dynamic balance suggested 30 grams at 125 degrees. On the next run it is 35 grams at 230 degrees, then a third run is 40 at 360 degrees, you are what I call, chasing your tail.

In the example above either the engine has out of balance components or there are loose or damaged components and the dynamic balance is picking these up or a very light aircraft can be so prop blasted that the airframe is hopping about.

If the aircraft is vibrating excessively on the ground, the dynamic balance may need to be accomplished in flight to get a true balance solution. The installation of the equipment in a tight fitting cowl can be a real problem for in flight operations. The optical sensor is normally fastened to the top of the cowl. Since owners do not like to drill mounting holes in their cowl, tape is used to secure the sensor. Another issue is securing the wires for flight operations and setting the equipment in the cockpit. A second person is essential to collect the data and operate the equipment while the pilot flies the aircraft. Consult with your dynamic balancer manufacturer.

Problems associated with poor dynamic balance results

Mechanical Problems:
If you are sure you have done everything right, and you can't improve the vibration level at the propeller RPM chosen or even a reduced RPM -- YOU MAY HAVE A MECHANICAL PROBLEM.

A variety of mechanical problems can show up at propeller turning speed. These include:

Prop:
Propeller out of track.
Blade angle different between blades.
Blade broken or damaged and is bending/moving at high RPM.

Engine:
Crankshaft unbalance.
Bearing problems.
Loose or worn components in the engine.
One or more cylinder has poor compression.
One or more cylinders may be misfiring due to ignition/carburation problems.
Defective crankshaft counterweights.
Loose or worn components in the propeller hub.
Loose airframe components such as turbo mounts, and engine mounts.
Excessively soft engine mounts.

If the static balance is OK, the aircraft is secure during engine runs and it won’t dynamically balance then it has to be a mechanical problem.

The result of a mechanical problem is always the same; “IT JUST WON'T BALANCE.” The natural reaction to this situation is to suspect that the balancing equipment is defective, the odds don't favor that conclusion. Trust the equipment, it has worked before and there's no reason to suspect it now. One simple test you can do to confirm that there is a mechanical problem is to remove any weights the dynamic balance recommended be installed and run the engine again. If you don't have the same readings as the very first run, the vibration is caused by something other than propeller unbalance.

In my experience (which is limited as I have only dynamically balanced about 20 props) I have had many problems. As far as technique, normally the rpm optical sensor and its reflective tape are not working properly initially and were easily found as one sees the RPM unsteady. However, I have also found a dead cylinder, a mis-wired ignition system with the engine firing out of order, a prop that was not installed straight (bolts were tight but the prop was actually angled due to an inattentive install of a spacer on the Subaru engine (it was cocked), badly warped spinner, and a broken engine mount. Of the five that were mechanical problems, the A&Ps had no idea they had a problem, they just knew that they paid $300 and the prop was still very rough. All the mechanical problems were found after a prop removal and static balance was made and verified that the static balance was very close. When the dynamic balance did not cure the roughness, it had to be something else. Since I had the same problems trying to balance out the prop as the other guys, we left it to the mechanics to find the issue. Once the mechanics looked harder at the engine/airframe, and the mechanical problems were solved, a successful dynamic balance was accomplished.

Setting Blade Pitch Using
The Warp Drive Professional Protractor
Courtesy of Warp Drive Propellers

SET PROPELLER PITCH WITH THE PROTRACTOR ATTACHED AT THE PROPELLER TIP.

The Warp Drive Protractor was designed after the professional prop protractors used by A&P mechanics. When used properly, this protractor can help you set the pitch of your blades to within a 1/4 of a degree. It can also be used for a variety of applications such as wing surfaces, flaps, tail surfaces or anything needing to be measured in degrees.

The outer scale on the protractor is marked out in one degree increments. The only number you will use on the inner scale is the zero on the white wheel. The white bar on the side of the protractor is for clamping to the blade using the two wing nuts. The red knurled knob is for locking the white wheel in place. This will prevent the wheel from moving as you are changing from blade to blade.

1. Determine the Starting Point. There are two ways of determining your initial starting point. One is to position the aircraft so that the hub of the prop is vertical or perpendicular to the ground. For example, if you have a tail-dragger aircraft, raise the tail until the hub is vertical. The other way is to simply take a reading at the prop hub to determine how many degrees from vertical the aircraft is sitting. Either way is fine.

On a tractor aircraft you would hold the white bar side of the protractor in your hand and place the opposite side of the protractor against the hub and rotate the wheel until the bubble is centered. On a pusher you would place the white bar itself against the hub. You may also remove the top bolt with the wing nut to let the white bar swing down, then place the protractor itself against the hub.

2. Setting Blade Pitch. Determine how many degrees of pitch you want in your propeller, then rotate the center wheel that many degrees from your initial staring point. For example, if your aircraft is sitting level and you want ten degrees of pitch in the prop, rotate the center wheel until the white 0 lines up with the 10 on the outside scale. Likewise, if your aircraft is not sitting level, take your reading at the hub then rotate the center wheel 10 marks from this reading. This will give you the ten degrees difference from the hub to the tip of the blade. After rotating the center wheel for your pitch, attach the protractor to the tip of the blade. The body of the protractor should be against the back, flat side of the blade while the white bar should be on the front side.

Next, simply rotate the blade until the bubble is centered. You will also want to pull out on the blade as you are setting the pitch so you make sure the collar is fully seated in the hub. After you have rotated the blade and centered the bubble, tighten the clamping bolts slightly. Do not take to full torque yet.   You will want to leave the protractor clamped to the tip of the blade while you are torquing the bolts to make sure the pitch is not changing while you tighten. If it does, simply move in a criss-cross pattern while you torque to keep the bubble centered.   When you have the first blade set and partially torqued, lock the center wheel with the red knurled knob, remove the protractor, rotate the next blade into the same position, mount the protractor and follow the same setting instructions. The position of the blade while setting the pitch does not need to be perfectly horizontal with the ground, as long as when you bring the next blade around, it is in the same position as the first.   Once you have set all blades for pitch, then go back around and tighten the clamping bolts to full torque value, again watching the bubble as you tighten.

Warp Drive Propeller Bolt Torque Values--All Standard, HP and HPL hubs that use 1/4" bolts to clamp the blades in the hub should be tightened to 120 inch pounds. All Rotax bolt patterns that use 8 mm bolts to mount the prop to the gear box flange should be tightened to 175 inch pounds. All Standard, HP and HPL hubs that use 3/8" bolts to mount the prop should be tightened to 35 foot pounds. Warp Drive propeller installations on direct-drive aircraft engines and other engines used on airboats must tighten the 5/16" clamping bolts to 200 inch pounds and tighten the 1/2" flange mounting bolts to 60 foot pounds. Adherence to these torque values is imperative for reasons of safety.