

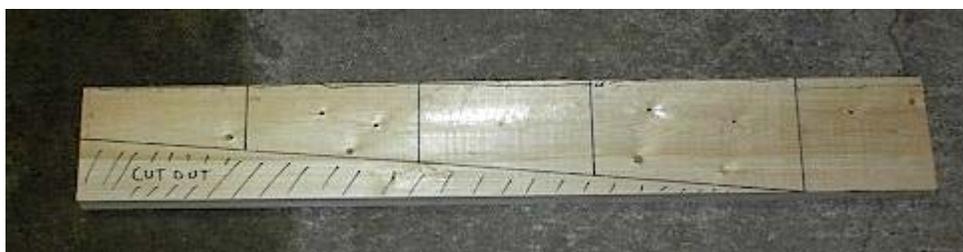
## Blade layout and carving

Starting out you'll need **2 x 6 lumber, 2 - 8ft pieces** should work fine with some to spare... just in case. You should look for some premium 2x6 standard pine studs with reasonably straight grain as well as no knots. Finding them with no knots is pretty much hard to do so look for some with no "big" knots and only real small ones. I use the standard lumber because it's inexpensive and so far they've worked out quite well for me. I wouldn't use hardwood, although it looks nice it's considerably more difficult to work with and its heavy. If you can carry a long board its best to make all 3 blades from the same cut of wood this way your more assured of consistency and density.

So you have your lumber and your ready to start. Begin by cutting the 3 boards 39 inches long. Below is a chart of the dimensions we will use to design the blades. All measurements in inches.

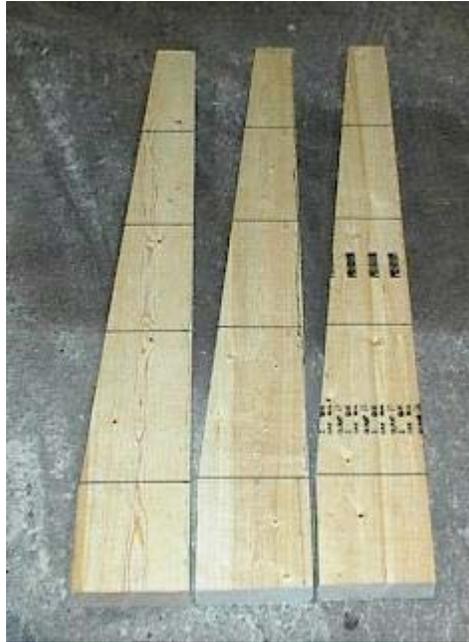
Station	Radius	Blade angle	Chord	Thickness	Drop
1	6	12	5 ½	1 ½	1 ½
2	15 ½	12	--	.88	1 ½
3	23 ½	6	--	.61	¾
4	31 ¼	4	--	.46	½
5	39	2	2 ½	.37	¼

Once the boards are cut to 39 inches find the edge that is in the best shape, one side or the other, this will be the Leading edge. You can mark it with a permanent marker along the edge so you remember which is which as we go. Standing in front of it the leading edge is at the top of the board the tip is to the left and the root is on the right. Measure from the root 6 inches toward the tip and make a mark. If you have a square draw a line across the board. At the tip, measure from the leading edge (top) toward the trailing edge (bottom) 2 ½ inches and make a mark. Take another board or a yard stick and draw a line from the tip at the 2 ½ inch mark to the trailing edge of the 6 inch root line. This will be your blade shape. Now mark the stations radius marks measuring from the root and using a square draw lines down to the angle line. When you're done it should look something like the below picture...



**Now complete the other two the same way.**

**When the other two blades are done you can cut away that portion that isn't the blade shown in the above picture as "cut out". When your done it should look line the below picture...**



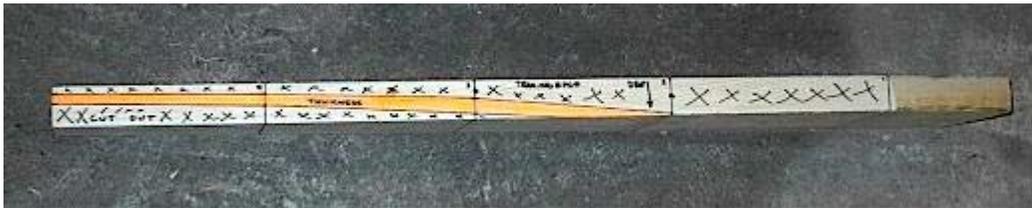
**When the un-needed section is cut off then use the square and draw the lines all the way around all 3 blades. Sometimes to make it easier you can number the stations starting from the first line to the root as 1 and the tip being 5. It helps to remove the confusion as we lay out the blade, especially if you've never carved a blade.**



Lay the blade on its edge with the Leading edge upright and mark the thickness at each station from the chart above then draw a line from one station to the next from each of the marks. I used a marker to hi-light the part of the blade that will remain and placed "X's" in the part that will eventually be cut away in the picture below...



Now flip the board over to lay out the trailing edge side in a similar fashion. The trailing edge is a bit different because we have not only the thickness of the blade but the amount of "drop" from the top of the board to form the angle of the blade. Start by marking the drop at each station and draw a line as you did before from station to station. Then measure the width from that line toward the bottom of the board. Once again connect the marks by drawing a line. Notice it looks like the root end will be cut away and the thickness of the area between 2 and 3 runs off the edge. It looks odd right now but it will come together shortly. When the trailing edge looks like the one below then complete the other two in the same process.



Below shows a picture of the tip with the lines drawn across. This gives you a better idea of what the piece your going to be cutting out looks like... notice I screwed up and drew the airfoil shape in the wrong direction... the darkened area is the correct direction...



I don't like whittling little pieces for a long time to make the blade start looking like a blade so lets make some big chips fly. If you have a band saw things will go quite a bit faster but you do have to watch what you're cutting. If you don't have a band saw you can use a regular hand saw or a hack

saw with a heavy tooth blade. A sawzall works well also, if you're careful. Power tools definitely make the process faster. The elbow grease works well too just takes a few minutes longer.

I should mention that I'm not a wood worker and there are probably other, better ways of doing this. This just happens to be the way I've worked out to make things a bit quicker and it works for me... you may know of better ways to accomplish the same task. I try to make big chunks as quickly as possible to form the blade. If you know of a better quicker way please share it with me...

I'm using a band saw through out these instructions, if you don't have a band saw, a jig saw – hand saw – hack saw will work just fine. Sometimes a little creativity goes along way using the tools and equipment you have.

I started by cutting a  $\frac{3}{4}$ " piece of plywood scrap to clamp in front of the blade so it doesn't cut the leading edge. Once its in place you can lay the blade up against the board and tilt the board in to make each cut. Tilt it out and move it down about an inch and make another cut until the entire blade is slotted. Only cut down to just above the line to leave some sanding room.

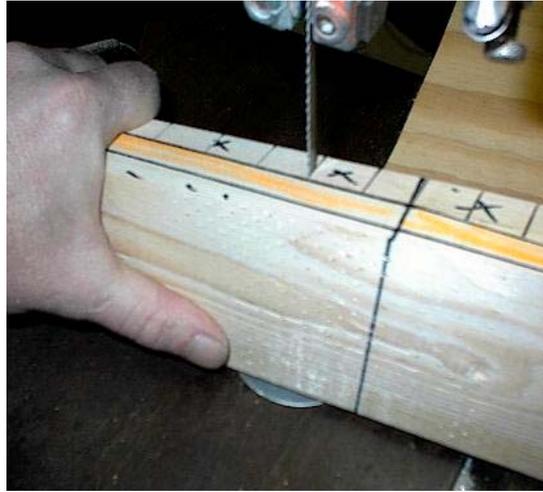
Below shows the board clamped to the band saw...



Below shows the start cuts ...



**Below shows the blade being tilted inward to make the slots...**



**This will cut the slot at the angle you want and leave the leading edge clean with no cuts. Once you're done with all 3 blades you can start on the other side of the blade.**

**The next cut will remove a lot of material fairly quickly. Since the drop and width are substantial on the trailing edge side of the blade you can remove a good portion of material in one cut as in the picture below...**



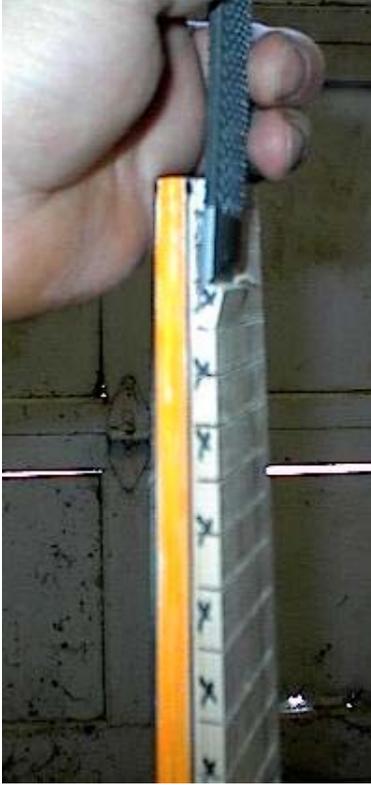
**Starting from the tip down to where it runs off the board. Be careful to cut on the outside of the line leaving a little material to work with in the end. Not critical but helpful.**

**All 3 boards can be cut at this time. Here again if you don't have a band saw you can cut slots and later remove the chunks with a chisel.**

**Once this cut is made, you'll need to put the angle cut  $\frac{3}{4}$ " plywood scrap back on the band saw to angle cut the side you just cut. As shown below...**



**Now grab a hammer and a wood chisel and start making chips... This goes fairly fast but you have to be careful and watch the grain of the wood. You don't want to split into the marked area. On the larger chunks where the cuts went deeper you should take them down a little at a time. I usually start from the tip and work my way down to the root as shown below...**



**Remember to leave a little material above the line for sanding and shaping later.**

**Once the chunks are out the blade starts to actually look like a blade...**



**You can do both sides the same way on all 3 blades.**

**Next we'll do some smoothing and shaping on the leading edge of the blade. I use a pocket plane for the shaping. I've used spoke shaves for doing this but be careful not to set the blade too deep. The little Stanley pocket planes are about 4 bucks at the local hardware or lumber store and work quite well. If you have a spoke shave and know how to use it then have at it. Set the pocket plane to only shave off a little at a time and start shaping...**

**Before you start shaping the blade you need to find and mark the thickest part of the blade section. This will be about 35% of the chord back from the leading edge. This will be 1.9 inch for station 1 and 2, 1.4 inch at station 3, 1 inch at station 4, and .75 inch at the tip. Connect the dots with a line and be sure not to cut the line off at this point. Below shows the blade marked...**



**The shaped leading edge should look something like the below picture when done...**



**For the trailing edge of the airfoil I used a full size plane to remove the material fairly quickly also shown in the above picture. That is the rough airfoil shape. You can use the pocket plane to shave down the lines and remaining chunks left before starting the sanding process.**

**Below shows the trailing edge cut down and what would be left before sanding...**



**You can see the blade starting to take shape at this point although it probably still looks like a hacked up mess.**

At this point if you have some power sanders it would be a good time to get them out. I like to put some sandpaper in that is really harsh like 20 or 40 grit. This will take the large surfaces down fairly quick, it'll make lots of dust quickly even with a hand powered sanding block. Do not use this on the leading edge, the heavy grit sandpaper will destroy the curved surface in a couple swipes. You'll want to go to 80 or even 100 when doing a final shape of the leading edge. The heavy grit is only for the large area faces on the trailing edge and the front face.

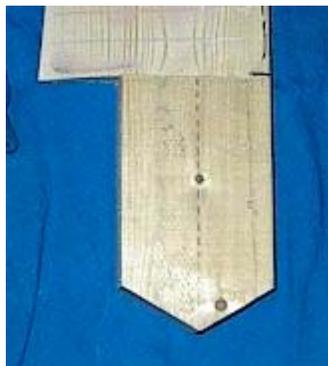
The airfoil shape doesn't have to be perfect, nor do the blades for that fact as long as their within a reasonable range of dimensions they will work fine. I highly doubt I've ever made a "perfect" set of blades and they have always worked quite well. Below shows a picture of the final airfoil shape next to two blades that have yet to be shaped...



Once everything is shaped then you can get out the lighter sandpaper. I start smoothing with 80 to 100 working up to around 220 grit. If you find a few areas where you chipped to deep you can use bondo to fill the areas. As well, if you knocked out a small knot this can be filled with bondo. Bondo works very well with wood, it's strong and bonds extremely well and is easy to sand. And yes I make a lot of mistakes while carving blades. One other note, the trailing edge should be no thicker than 1/8 inch when your done, typically I try to get them down to around 1/16 inch. The wider the trailing edge is the noisier the blades will be whipping through the air. At 1/16 inch they make less noise than the wind passing through the tree branches.

If the station marks have been sanded off you can remark them and check the thickness at each station as per the chart at the beginning. They should all be within the same range on all of the blades when you're done.

Once the blades are shaped and sanded, all the "boo boo's" filled with bondo you will measure the bottom stubs of the root from the leading edge toward the trailing edge 3 1/2 inches , as well mark the center of the stub at 1 3/4 inches. Cut out the block and it should look like the photo below...



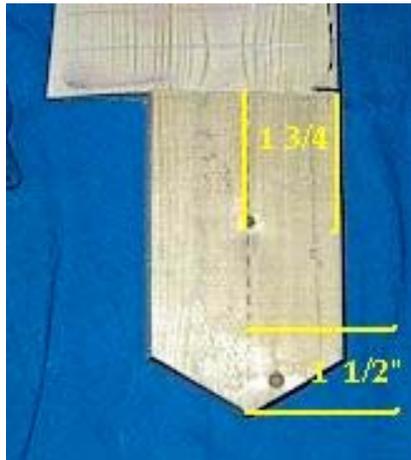
Once the root is cut to a width of 3 ½ inches mark and cut the angles at 120 degrees as shown above from the centerline. This will get them to fit snug in the center for mounting on the prop hub discussed later.

I typically weigh the blades on a postal scale to see how far apart they are. This set was 7 ½ ounces from the lightest to the heaviest. You can try to balance the blades by adding weight to them or balance them after mounting them to the hub. Most prefer the later and I usually add the weight and double check when it's assembled.

Once the blades are formed, shaped, and sanded you can choose the coating of your choice. I typically find the closest exterior latex and paint them up. Color is your choice. Also, after their painted I usually add a stainless steel tape to about 8 inches on the leading edge from the tip toward the root. Since the tips are running the fastest they are most susceptible to the rain, snow, sleet, dirt or what ever Mother Nature throws at it. The tape helps ward off erosion on the leading edge. The tape can be purchased from a local automotive store, it's used as a body patch for a temporary fix from rust holes. Another place to try is Wicks aircraft on the web or JC Whitney.

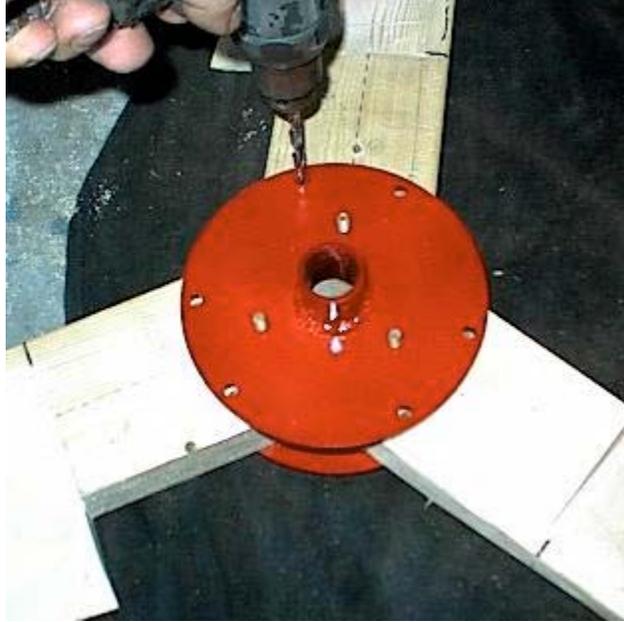
Next is mounting the blades to the hub and installing it on the machine...

Start by measuring the bottom of the blade to make the first mounting hole. This one must be centered and exactly 1 ½ inch from the bottom. Center should be measured from the leading edge side and should measure 1 ¾ inch. Below shows where to measure and mark the center of the blade at 1 ½ inches up from the bottom...



Once you have the blades marked its best to use a center punch. A center drill and a drill press are handy to make sure the drill doesn't wander and the hole is straight through. The hole should be drilled for a ¼ inch bolt to pass through. I recommend using the next size larger in a letter size or honing it out with sandpaper when you're done drilling. You want the bolt to fit nice but you don't want to have to force it in.

When all three blades are drilled for the locator holes you can slide 3 bolts ( you will need 9 – ¼ inch bolts 2 ½ inches long as well as 18 washers and 9 nylock nuts for the assembly ) through the plate and lay it on the floor with the bolts sticking upward. Slide the blades over the bolts one at a time until all 3 are in place then place the prop mounting hub over the 3 bolts as shown below...



Once it's all in place, measure the blades from tip to tip between each one. The measurement should all be the same or very close. If their not then you may need to tweek the 120 degree angles at the root of the blade to get them to move around where you need them. When their good to go then you can take a hand drill and mark the hole locations for the remaining holes. Don't drill through, drill just deep enough to disassemble them and finish drilling the holes with a drill press. If you don't have a drill press you can drill halfway on one side and finish from the other side keep it as straight as you can.

After all the holes are drilled, finish installing the bolts. No need to put nuts on them at this point. Next you'll need to remove the wood from the center of the hub by drilling the center 1 inch hole. As shown below... ( Note: the picture below is one from another set up which used a plywood backing instead of the steel which is used in this kit)



If you don't have a 1 inch drill you can mark the point on the root at  $\frac{1}{2}$  inch up toward the tip straight across and this will accomplish the same thing. No more than  $\frac{1}{2}$  inch though, it's best to allow the wood to sit on the shaft. You can hone the hole with a larger drill with some sandpaper

taped to the end of it to get the final fit. You want the prop to fit the shaft snug. not hard to put on but also not sloppy.

You'll need a ½ inch wide piece of PVC pipe for a spacer to fit over the bolts protruding from the magnet disc. You can simply butt the prop backing plate against the bolts without any problems but I prefer to use the plastic spacer. **In either case the prop plate must sit against the magnet plate or bolts.** The reason for this, the thrust against the prop will push against everything down to the bearing, if there is a gap then the thrust is against the shaft, in which case the shaft could move inward. If the plate is snug against the disc it will transfer all the forces to the bearing. Below shows a picture of the plastic spacer installed...



At this point you should bolt the prop assembly together with all nine bolts. They don't have to be torqued at this point but snug them up well. Slide the assembly on the shaft making sure its all the way back against the bolts or spacer and drill a ¼ inch hole through the shaft using the prop mount hub as a guide. Its best to drill ½ way through one side then finish from the other when using a hand drill unless your real good at lining them up.

When the blades are painted and the prop is going together for a final assembly you should mark the blades 1,2 and 3 and assemble them as such, this way they will go back together the same way they were assembled. The final tightening of the bolts should be torqued to no less than 100 inch lbs but no more than 130 in lbs. Use a cross-tightening pattern in increments of 40 inch lbs until all are tightened to 100 inch lbs. Let the assembly sit for an hour or so and double check it to make sure everything is seated properly. If it has loosened then re-torque them again and recheck later. After installing the prop on the machine for the final assembly and the locking bolt is installed on the prop hub through the shaft, take a hammer and tap the end of the shaft lightly to make sure its seated against the spacer or bolts and re-adjust the locking clamp on the back side of the machine. This will make sure everything is seated properly.

After the prop is installed you can balance the prop on the machine. The heavy blade will fall while the lighter blades will stay on top. Simply add weights on the lighter side until the blade will stay on one place no matter where it's turned. If you weighed the blades in the beginning and they were close or you added weight to the lighter blades they should be fine when installed although not always true. That completes the blades.

