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This instructable outlines the assembly process of my 2nd generation CNC machine which I designed to be simple to build and quiet enough to be apartment friendly. I have included example projects that I have made in the first two weeks of using the machine to demonstrate its capabilities. This is the second CNC machine that I have designed and built. My first machine was based off of oomlout’s instructable “How to make a Three Axis CNC Machine (Cheaply and Easily)” (by far my favorite instructable and the one that got me hooked on the site). It was moderately successful, cutting a number of parts from foam (a summary of parts made can be found on my abandoned blog here along with some build photos). The lack of overall stiffness and play in the linear mechanisms meant that plywood and plastics could not be cut effectively. The biggest downfall of the machine was the difficulty to setup and square the axes and lacked the ability to make fine adjustments once set up. The drive pulleys were sandwiched between the gantry sides and if a pulley loosened the entire gantry structure had to be disassembled and put back together and squared all over again (a couple evenings of work). In reviewing published designs for a 2nd generation machine I revisited Joe’s CNC, a popular design but I questioned my ability to produce so many duplicate parts with enough accuracy. I came across buildyourcnc.com and their blueChick design . What caught my attention was their use of V-groove bearings and how it simplified the design and the ease of aligning the axes. I had previously discounted V-groove bearings due to their cost ($150/ set vs. $12 for skate bearings) but after my first build I had enough experience to fully understand their benefits and to realize they were well worth the investment. The blueChick was simpler than the Joe’s CNC design but was still a bit too intricate for my tastes so I set out to design a new machine based off of the new bearings. I came up with a new design with three main design features that solved shortcomings of my first machine: 1) All of the drive mechanics are exposed. If anything requires adjustment or tightening you can walk up with an Allen key, screw driver or wrench and access everything allowing the machine to be up and running again in a matter of minutes. The axes are easy to setup with the V-groove bearings and can be micro adjusted once installed. 2) The design has a low number of fabricated components and allows for low build tolerances. The precision is based off of the flatness of the plywood and the straightness of the aluminum extrusions. All of the fabricated components can be roughly cut (except two edges detailed in Step 3) and all holes are oversized to allow for slight inaccuracies in drilling. This allows for any inaccuracies in the building stage to be taken up during assembly without loosing any precision. 3) Low operational noise. The machine had to be quiet enough to use in an apartment or I couldn't use it. The rotary tool I used on my last machine worked well but when running at 20k rpm, it screamed too loudly for me to use in my new home. A custom spindle was built as a low noise solution with negligible reduction in performance. The overall specs of the machine are as follows: Cutting volume 22 1/2" x 18 1/4" x 2 1/4" Axis drives: X&Y: MXL timing belts w/ 40 groove pulley (pitch dia 1.019") maximum resolution 0.004 inch at 1/4 micro stepping Z: 1/4" threaded rod. Theoretical resolution 0.00006 inches at 1/4 micro stepping All axes powered by 130 oz-in stepper motors. Cutting speed/depth are dependant on the material being cut and are limited by home made spindle power and router bit. The terminology for the different components as I will refer to them is shown in the picture. I have the X&Y axes oriented as shown so that when sitting in front of the machine, the axes match a 3D CAD drawing as seen in a top view (X axis horizontal, Y vertical and Z out of the page/screen). Attached is a breakdown of the components and the cost of the machine. The hardware and aluminium were purchased in batches from local home improvement stores as a matter of convenience as the design progressed and those prices are shown. With a complete bill of materials these could be sourced from dedicated metal and fastener suppliers at a significant discount. All prices are in Canadian dollars; these items will be much cheaper off of the same shelves for my neighbours down in the US. Even though Canada is a metric country, all stock sizes of lumber, metals and hardware are imperial with a hefty mark-up on metric components if they are even available. Because of this all components are imperial sizes other than the plywood (I'd never seen metric plywood in a home improvement store before, which is probably why it was half the price of imperial stock of similar thickness). The overall cost of the machine was above what I was expecting when I started my first machine but these costs have been spread out over the four years I have been working on the project. A comparison to entry level commercial products on the market shows that the DIY route is still a cheaper way to go. While these machines may have better performance than a home built wood framed design, there is no replacing the satisfaction of making a machine yourself. I am also unsure how flexible these are for running different driver software and overall flexibility on how you can use the machines.ShopBot Desktop $4995 + Taxes + S&H + spindleLaguana Swift $4900 + Taxes + S&HRockler CNC Shark Pro Plus $3800 + Taxes + S&H + spindleGeneral International i-Carver $2100 + Taxes Lumenlab's M3 kit looks like a nice product but at $999+ S&H + software + driver the overall price will be over $1500 to get it up and running. A note on designs titled CNC for less than $XXX dollars (usually under $200). There will always be a trade off between performance and price. Machines with very little forces on the tool can be made very cheaply (for drawing, cutting foam and 3d printing) but when cutting harder materials things have to be beefed up. These aren't bad machines but be clear with what you're building so you're not disappointed when the thing folds in half when it comes to cutting plywood. These prices also skip over several key parts, only including the major components in the price. Its amazing to see how quickly some 1/4" and 3/8" bolts add up and they certainly don't include software (or count trial versions as a permanent solution) and driver boards. Without these your $150 CNC is just an overkill paperweight. BOM Summary: Plywood & Metals: $158.25 Hardware: $107.77 Drive Line Components $261.46 Electronics $442.04 Software $522.26Miscellaneous $11.19 Grand Total $1502.96BOM.ods The list of fabricated parts required are as follows sorted by material. Attached at the bottom of the page are drawings for all the parts in pdf format.18mm Plywood -Base -Gantry Side Right -Gantry Side Left -Gantry Assembly -Trolley1" x 1/8" Aluminum Flat -2x Y rail -2x Y rail angle -Top X rail -Bottom X rail -2x Z-rail3/4"x 1/8" Steel Flat -4x Belt clampMDF -Bearing block -Stepper motor plate3/8" Ply -Spindle motor plate -2x Spindle bearing clamp -Z-axis bearing clamp1 1/2" x 1 1/2" x 1/8" Aluminum Angle -Stepper motor bracket -Top spindle bracket -Spindle motor bracket -Bottom spindle bracket The parts have been design to be as simple as possible to produce. I cut out everything using a jigsaw, drill press, disk sander and hacksaw. The disk sander greatly simplified the process as I was able to rough cut the parts using my jigsaw and sand to the line giving a very accurate and clean edge. As well as being as simple as possible the parts have been designed to allow for inaccuracies in manufacturing with all holes being oversized to take up any misalignment. The only part which needs to be made with a great amount of care is the Gantry Assembly. Once the pieces are cut and glued together the edges must be perfectly square to the front face or the machine will not be square. Using a disk sander made this easy to do as I held the front face flush against a miter gauge and sanded the edge until square. If you don't have a disk sander the edges will have to be squared using sandpaper or a block plane until true which will take longer but is feasible. Unfortunately I do not have any pictures of the parts being cut as I wasn't thinking of making an Instructable at the time. A keen eye will be able to see that these parts have already been assembled. Assembling the machine the first time I ran into some unexpected interference issues. For example the location of the V-groove bearings for the Z-axis as well as the location of the anti backlash nut had to be modified leading to the trolley looking a lot like swish cheese in the end. The drawings attached show the modified hole locations and won't have as many holes as the parts shown in the photos.Fabricated parts required: Plywood base 2x Y-Rail 2x Y-Rail Angle 4x Belt ClampsHardware required: 8x 8-32 x ½ machine screw 6x 8-32 x 1 ¼ machine screw 28x #8 washer 14x 8-32 nut 8x 1" ¼" dia hex bolt 8x ¼" cross nut 25x ¼" x 11mm threaded insert The base is the foundation of the machine and must provide a flat and stable support to mount the work piece and support the linear rails. 18mm birch ply was chosen to form the base as it was available at an affordable price, is easy to machine and can be expected to resist seasonal expansion and warping. Another benefit to using ply is that the overall dimensions aren’t limited by the material sizes available. I had an old children’s play table on hand that I used to support the base. The width of the machine (X axis) is such that the linear rails overhang the sides to have clearance on the underside. I do not have access to a table saw so the overhang was important as constructing a flat torsion box to provide adequate elevation would have been difficult. The length (Y axis) of the base was driven by the length of the timing belts I had purchased. The length of the base is determined to be the belt length plus the reach of the eye bolts less the length of the loop around the drive pulley (See Step 13). The dimensions of the machine are not optimum for standard lengths of aluminum extrusions found at home centers (36”, 48” and 72”). By using different timing belts the machine could be redesigned to have rail lengths of 24” or 36” to use these materials more efficiently. 4.1 The first step is to find an adequate support for the machine. If a similar set up like mine with an overhang is not used, the base will have to be built up to provide 2" of clearance underneath the rails, measured from the top surface of the base. The best way to do this would be with a torsion box construction to provide the most ridged surface possible (a simpler option would be to simply stack sheets of ply narrower than the base underneath. 4.2 Once the base is located on a suitable surface the Y rails can come together. Each Y rail and Y rail angle are attached using a 8-32 x ½” Machine screw, two washers and a nut in each of the 4 holes. The height of the rail was set by placing an offcut of the 1/8” aluminum flat bar on each end of the angle and bringing the flat flush with the top surface (photo #4) and then tightening the screws. These screws should be tightened securely to ensure the rail does not slip. The exact height of the rail isn't critical as long as it is greater than 1/16" to give the V-groove bearing clearance to sit on the edge of the flat bar and that the spacing is consistent down the length of the rail and between the two rails. The photo #5 shows the finished cross section of the rail and #6 shows the entire rail. 4.3 With the rails assembled they can be attached to the base. This is done using three 8-32 x 1 ¼” machine screws per rail and two washers and a nut per screw (photo #7). Only tighten the nuts loosely so that the rail remains free to move over the base, these will be tightened in step 6.5 when it comes to matching the rail separation with the width of the gantry. 4.4 The belt clamps are to be attached next. There’s nothing fancy about putting the supports on, two 2 ¼” x 1” hex bolts into two cross nuts per corner, see photos #8 and #9 for all the information you’ll need. Make sure the tops are flush or below the base top so that oversized stock can be mounted overhanging the base. The hex bolts only have to be put on finger tight as the tension of the belt will provide preload. (***NOTE I have included this step here as they are related to the base, but leave them off until you install the gantry sides, otherwise you’ll just have to take one off per side to get the v-groove bearings onto the rails in step 5.3)   4.5 The final step in assembling the base is installing the threaded inserts for clamping down the work piece. These were chosen as they are simple to install. A couple routed dados in the base with t-channels would provide more flexibility for clamping but would add build complexity which as mentioned previously was avoided in the design. Be careful installing these as they can pull up the surface of the plywood making the surface uneven. The chamfers on these holes go a long way to prevent this so don’t skip these. With the Y rails, belt supports and threaded inserts in place the base is complete and ready to support the gantry. Fabricated parts required: 1x Gantry Side Left 1x Gantry Side Right 8x modified 5/16” washersHardware required: 8x 3/8 V-groove bearings 8x 3/8” washers 8x 3/8” nut 3/8” x 2” hex bolt 4x 8mm skate bearings 4x 5/16” x 1 ¼” hex bolt 4x 5/16” washer 8x ¼” washer 4x 5/16” nut 2x ¼” cross nut 2x ¼” x 1 ½” hex bolt To build the gantry we will start with the sides that run along the Y rails. In this step we’ll see how amazing the v-groove bearings are and how easily they make the assembly process. The gantry sides are similar but with differences between left and right for the idler bearing counter bores and limit switch counter bores. The limit switch counter bores are on the outside of the ends when installed and the idler bearing counter bores are on the inside. The features for the stepper motor mount are repeated on both side so that the stepper is reversible should you want to install it on the other side for whatever reason. 5.1 The 3/8” V-groove bearings are installed using the hardware shown in photo #3 with the 3/8” washer on the outside and a modified 5/16” washer on the inside. A modified 5/16” washer is a 5/16” washer bored to an ID of 3/8”. This is done because a regular 3/8” washer will rub against both the inner and outer races of the bearing but the OD of the 5/16” washer is such that only the inner race is supported allowing the bearing to spin. Tighten the top bearings securely but keep the bottom ones loose for now. The bolts should be tight enough that the bearings won’t shift under a reasonable amount of force, but don’t tighten them up so tight that the washers crush the plywood beneath them. The consequences of this are outlined in Note 2 later on. 5.2 Next item to install is the 8mm idler bearings for the timing belt. These have a 5/16” washer on the inside in the counter bore, and two ¼” washers on the outside to provide the required standoff. ¼” washers are used for the same reason as the modified 5/16” washers for the v-groove bearings. Photos #4,5,6,7 shows the setup. 5.3 The v-groove bearings can now be tightened against the rails. Start by sliding the bearings over the rails (Photo #9), hopefully you followed the note in step 4.4 and held off from putting on the belt supports, if not, remove one per side to get the bearings over the rails. The top bearings are already tightened so only the four bottom ones required attention. I don’t have any pictures of this step as it requires both hands to do. For each set of top and bottom bearings, squeeze the bearings together with your fingers while tightening the bolt. I wrapped the bearings in a towel as you’ll want to squeeze them together as tight as possible but they have rather sharp edges. Once you have completed this step for both bearings per side you should be able to grab the gantry side and twist it every which way without any noticeable play (hold down the rail when you test this as they should still be loose; we’ll get to tightening them up at the end of this step). Note 1: Up to this point everything should have gone together smoothly as long as the holes have been drilled within 1/16” of their indicated positions which should be do-able even with hand tools (its been designed to be forgiving like that). There is a chance that you won’t be able to get enough separation between the bearings to get them on the aluminum flat if the holes haven’t been located within the specified tolerance. If this happens, re-tighten the top bearings making them sit as high up in the holes as possible and retry the assembly. If this still doesn’t solve the problem the bottom holes will have to be re-bored to a larger size. These holes haven’t been given the same amount of wiggle room as the others to keep as much material as possible under the washers to prevent crushing. Note 2: I have not mentioned aligning the gantry side to the vertical during this step (when I say vertical I mean when viewed from the side. With the bearings tight around the rail the gantry side will automatically align itself to be vertical to the base when viewed from the front. If it is not, the most likely culprit would be a washer that has crushed the plywood around it from tightening the bolt far too much. If this has happened you should remake the gantry side as it will be close to impossible to get all the bearings lined up in the same plane.) If the top bearing holes are drilled in line with each other and the bolts are registered on the same face (top or bottom of the hole) then the gantry side will sit within a degree or two from vertical. Any misalignment (angular and height above the base) will be taken up in the connection of the gantry side with the gantry assembly. Having this flexibility in the design later on allows for you to focus on getting one pair of bearings tight around the rail at a time instead of worrying about multiple things at once. 5.4 The last item for the gantry sides are the limit switch “bumpers” that trigger the limit switches. Shown in Photos #10 & 11 they only go on the side the limit switches are on and can be modified in length by using a different length of hex bolt. Tighten these by hand until the end of the bolt bottoms out on the plywood pushing against the cross nut. Do not use a wrench on these as you can easily over tighten and crush the plywood. The belt supports can finally be installed as per step 4.4 so go ahead and put them on now. Fabricated parts required: 1x Gantry Assembly 1x X rail Top 1x X rail BottomHardware required: 6x ¼” x 2 ¼” hex bolt 6x ¼” washer 6x ¼” cross nut 8x 8-32 x 1 ¼” machine screw 8x 8-32 nut 16x #8 washer Once you’ve built the Gantry assembly you’ve already finished the hardest part of this step. The squareness and stiffness of the machine depends on how square the gantry assembly ends are. Take the time to double check these before proceeding. 6.1 Take the gantry assembly and loosely attach it with the ¼” bolts and cross nuts (6 of each) using a ¼” washer underneath the bolt head. Photos #1,2&3 show all the bits and pieces. 6.2 With the gantry assembly loosely in place, tighten the three 8-32 machine screws on one of the Y rails to lock it in place. Try to get the rail so that the bolts are roughly centered in their holes and the rail is parallel to the base side. 6.3 With one of the rails locked down, tighten the three ¼” hex bolts on that side. While you tighten the bolts, hold a square up to the front face of the gantry assembly to keep it square to the base and line up the bottom to be around 4" from the base (Photo #7). The actual distance you can get from the base surface will depend on the how the v-grove bearings were installed but shouldn’t be out by more than an eighth of an inch. The height isn’t terribly important but being square to the base is, focus on that when tightening the bolts. 6.4 You can now tighten the three ¼” hex bolts on the other side. Tighten the bolts evenly not one at once keeping an eye on how the gantry assembly comes together with the gantry side. Similar problems may be encountered as covered by Note 1 of Step 5. If everything goes together nicely there will be no gaps as in Photo #6 when the bolts are tightened loosely. Four issues in alignment could be encountered: 1) A gap anywhere and with the rails parallel to one another and the gantry sides vertical when viewed from the front is a sign that the gantry assembly sides aren’t square and flat. 2) A gap at the top bolt and with the gantry side leaning outwards when viewed from the front is a sign that the rails aren’t able to distance themselves far enough apart. 3) A gap at the bottom bolt and with the gantry side leaning inwards when viewed from the front is a sign that the rails aren’t able to distance themselves close enough together. 4) A gap at the middle/ back bolt and with the rails not parallel to one another when viewed from above is a sign that the gantry assembly ends aren’t square. Issues 1 & 4 require modifications to the gantry assembly. Issues 2&3 may be resolved by adjusting the rail that was tightened down in step 6.2 In the case of #2, loosen the rail and retighten as far out as possible, or as far in as possible in the case of #3. Should this adjustment not be enough measure the distance between holes in the base and the length of the gantry assembly; drill the holes in the base larger to give more flexibility or reduce the length of the gantry assembly as required. 6.5 Once the gantry assembly is square and all six bolts are tightened, slide the gantry (now the gantry sides and gantry assembly are all attached I will simply refer to it as the gantry) to one end of the base. Side it back and forth an inch or two to make sure the rail has moved to the proper distance from the other rail and everything is smooth. Once you’re happy with it tighten the 8-32 machine screw on that end to tighten the second rail. Slide the gantry down to the other end and repeat the process of sliding the gantry back and forth. Tighten the middle machine screw and then the end one. At this point both Y rails should be secured to the base, the front face of the gantry square to the base and the gantry free to slide the length of the rails with no play nor binding. This process has come across as laborious and tedious but I had no problems assembling things on the first go which took under five minutes. Hopefully my success will be repeatable and if not the details provided will be enough to trouble shoot any problems. 6.6 Moving on to the X axis rails, attach the aluminum flats using washers on both sides and tightening finger tight. I put together a quick height gauge using a square of scrap of wood and a C-clamp to position the lower rail (Photo #10). Clamp the wood to a height that supports the aluminum rail with 1/8" clearance from the bottom of the Gantry (required to give the V-groove bearings room to seat). With the rail supported on the wood at one end, tighten the end machine screw. When tightening, try to keep the rail level, more on this in a second. Move to the other side and support the bottom rail on the wood and tighten. If the rail was perfectly level after you tightened the first screw you will be done, however, if there was any misalignment, the rail would have rotated around the screw that was tightened first when you adjusted it at the other end and will not be even along its length. Go back and forth leveling it out, slowly honing in on making it snug against the wood block along the whole length. This took me 2-3 iterations to achieve. Make sure the wood block doesn’t shift while doing this! Really I should have used two C-clamps to hold it in place to stop it sliding down. Take your time on this step to get it right. If the rail isn’t a consistent height along its length, your cutting tool will not run at a consistent height over the work piece. Once things are set up right, tighten the two inner bolts. 6.7 Once you’re happy with the bottom rail, set the top rail parallel to the bottom. The bottom rail is our datum and the top rail needs to be a consistent distance apart. If the distance isn’t consistent, the trolley will be smooth running without play in the middle, will have excessive play on one end and will bind on the other. I used a pair of digital calipers locked to the required length as a measuring tool. These are not necessary and are overkill, a trammel or a ruler with two pieces of wood clamped to it similar to that used previously will be more than adequate for the task. As usual, position the upper surface of the rail to be 1/8" inches clear of the top of the gantry to provide clearance for the V-groove bearing. The distance between rails is just shy of 5 ¼" (Note: I am doing a terrible job of measuring the distance in Photo #11, the edges of the rails should be an equal distance from the tips of the calipers). Adjust the height of the rail as in step 6.6 until consistent along the entire length. Fabricated parts required: Bearing block ¼" steel rodHardware Required: Stepper motor 2x MXL timing belt pulley ¼" to ¼" spider coupling ¼" ID skate bearing ¼" shaft collar 3x 8-32 x 2” machine screw 3x 8-32 x 1 ¼” machine screw 9x #8 washer 6x #8 nut This is my favorite step as it uses the fewest and most basic fabricated components, is simple to complete and gives you a sense of achievement without doing a whole lot. 7.1 Start by attaching one of the timing belt pulleys to the front shaft of the stepper motor. Dry fit the stepper to get the position of the pulley right so that it protrudes out the side and lines up with the idler bearings below (Photo #16). Note: For all shaft accessories, line up the set screw with the flat on the shaft when tightening. Design Note: The timing belt pulleys I purchased have annoyingly small set screws for a ¼" shaft, half the size of those on the ¼" shaft collar. When I initially assembled this machine and ran through the trials I found that if the machine had a catch the timing pulleys would come loose from the shafts. I was happy to see this as the failure mode as when something goes wrong something has to give and having to retighten a pair of set screw whenever I have an accident is far better than having to remake a component that bent or broke. The pulley on the far side of the stepper motor is exposed and you can just walk up with an Allen key to tighten it (after all, that was the point of this design) however the set screw on the stepper motor side is tucked away in the gantry side. Tightening this required removing the stepper motor and dismantling the shaft. To avoid taking the machine apart every time the tool catches I chose to install the pulley with some auto body filler on the flat of the shaft to prevent the pulley from coming loose (Photo #3). I kept the pulley on the other side as-is to act as the weakest link in the system and maintain the fail safe design. 7.2 Bolt the stepper motor onto the inside of one of the gantry sides (Photos #4-7). The face of the stepper will register snuggly in the 1 ½" hole. You only need three bolts to keep the motor in place saving you the trouble of getting into the upper corner with a screw driver to tighten the fourth one up. Washers are only required on the outer surface against the plywood. 7.3 Next position the bearing block on the opposite side (Photos #8,9). Measure the height of the stepper motor shaft from the base and try to get the center of the bearing block hole to match, Within 1/16" to 1/32" is good enough here. Use three 8-32 bolts to bolt it in place with washers on both sides. I used 2" bolts but 1 ½" would be ideal but I didn’t have any on hand. The overhang from the 2" bolts does not cause an interference issues and is purely aesthetic. I may cut these down to size later if they still bother me down the road. 7.4 Attach the spider coupling to the back shaft of the stepper motor (Photo #10 &11).   7.5 With the ¼" ID skate bearing and ¼" shaft collar on the steel shaft, feed one end through the bearing block and one into the spider coupling. Tighten the setscrew on the spider coupling (Photo #12). 7.6 Slide the bearing into the recess in the bearing block and tighten the shaft coupling while pressing it into the bearing. (Photos #13,14). 7.7 The final step is to attach the second pulley on the steel shaft. Line up with the idle pulleys below (Photos #15,16). Design note: This arrangement works but can be improved. When the timing belts are highly tensioned they pull down on the pulleys. The pulley on the stepper motor side is very secure and does not deflect, but on the far side the bearing in the bearing block holds but the steel rod bows with up to an eighth of an inch deflection in the middle of its span. This can be counteracted in two ways, either installing another bearing block in the middle of the span or making the existing bearing block deeper so that it can hold two bearings. Fabricated parts required: Trolley 4x 5/16" modified washersHardware required: MXL timing belt pulley Stepper motor 4x #8-32 x 2 ½ machine screw 30x #8 washer 12x #8 nut 2x ¼" ID skate bearing 10x ¼" washer 2x ¼" x 1 ½" hex bolt 2x ¼" nut 4x 3/8" V-groove bearing 4x 3/8" washer 4x 3/8" nut 4x 3/8" x 2" hex bolt 4x 3/16" V-groove bearing 4x 3/16" x 1 ½" stove bolt 4x 3/16" nut 8x 5/16" washer 3x 10-24 x 4" stove bolt 6x 10-24 nut The trolley piece I am using has been modified a few times to fix interference issues. There are seven extra holes where the 3/16" bearings and the anti backlash supports had to be relocated. 8.1 Attach the timing belt pulley to the stepper motor’s front shaft. Orient with the collar facing the motor and approximately 1/16" from the face plate. 8.2 Attach four 2" machine screws to the motor mounting holes with washers against the faceplate 8.3 Thread on a #8 nut and a washer to each machine screw. 8.4 Feed the machine screws through the mounting holes on the trolley. 8.5 Thread a #8 nut on each machine screw with a washer between the nut and the trolley. Adjust so that the nut face is flush with the end of the machine screw. 8.6 Tighten the middle nuts against the trolley to clamp the motor in place. The stepper motor is now fixed parallel to and offset from the trolley face. Photos #3&4 8.7 Install the ¼" idler bearings by stacking four ¼" washers and a ¼" skate bearing on the stepper motor side and sliding a ¼" x 1 ½" hex bolt with washer through the mounting hole on the trolley. Carefully slide a nut over the end of the bolt and tighten. The four ¼" washers bring the bearings into the same plane as the pulley which will eventually line up in plane with the X rail and timing belt. Photos #5&6 8.8 Mount the 3/8" V-groove bearings as done previously with the bearing and modified 5/16" washer on the stepper motor side and the 3/8" washer on the side of the bolt head. Tighten the top two bearings and leave the bottom two loose. Photos #7-9 8.9 Mount the 3/16" V-groove bearings by stacking a 5/16" washer, three #8 washers and the bearing on the front face of the trolley with a 5/16" washer under the nut on the stepper motor side. The goal is to have all four bearings offset the same distance from the trolley face. To achieve this use washers from the same box/batch and inspect them for imperfections that prevent them from sitting flat. The 5/16" washers are used as I had issues with crushing of the plywood when I first assembled the trolley. Photos #10-13 8.10 The final step until the sled is completed is to attach the anti backlash supports. These are bolted to the trolley as shown in Photos #14-16. My custom spindle is made from an AC motor pulled from an old vacuum cleaner power head and parts from a rotary tool. The donor tool was the cheapest one I could find and was picked up for $10 on sale (Photos #1,2). Opening it up (Photo #3) you can see all the bits we're after: the spindle with shaft, bearings and collet and a nice speed control circuit on its own board. The parts not used are the plastic case, the brushes and field windings. The spindle assembly has the commutator, laminated rotor core and cooling fan all built onto the shaft (Photo #4). The plastic cooling fan and the commutator came off easily using another rotary tool with a cut off disk but the rotor core was significantly more difficult. The alternating layers of iron laminations and varnish were bomb proof and I burnt through five cut off disks without making more than scratches on the surface. Using a hammer and chisel I managed chip away at the iron laminations layer by layer and got everything off (Photo # 8). Don't use a good chisel for this job, mine had large chunks removed from the cutting edge when I was done and required significant grinding to get a new edge.Fabricated Parts Required: 1x Sled 1x Bottom spindle bracket 1x Spindle motor bracket 1x Top spindle bracket 1x Stepper motor bracket 1x Stepper motor plate 3x Bearing clamp 1x Spindle motor plate 1x Spindle 2x Z-axis rails Auto body filler 1x shaft coupling 1x Z-axis drive rodHardware Required: 1x stepper motor 13x 8-32 x 1" machine screw 1x 8-32 x 1 1/4" machine screw 20x 8-32 nut 29x #8 washer 6x 8-32 x 3/4" machine screw 2x 6-32 x 1/2" machine screw 2x 6-32 nut 1x elastic band 1x Spindle Motor 2x set screws 1x 1/4" ID skate bearing 2x 1/4" nut Building the sled and the custom spindle has a lot to it so I have broken it out into two parts. Part one with cover installing the components and part two covers making the belt pulleys, run-out and making a shaft coupling. All photos show the motor and spindle having pulleys made from auto body filler. This was from the first assembly of the machine and shouldn't have been done at this stage. They are made in the first parts of Step 11. Finding a small flat belt the right size to drive the spindle was difficult. Local stores didn't have anything sutable and I didn't want to go to the hassle and expense of purchasing one online. I tried to make one from a larger belt by cutting it to length and splicing it together but the join was too weak. At the grocery store one day I noticed the heavy duty elastic bands around bunches of broccoli and thought it would make the perfect belt. This turned out to be the right length and has held up well so far. 10.1 Take the sled and put #8 washers in the counter bores on the back side. Photo #8 10.2 Install the Bottom spindle bracket with two 8-32 x 1" machine screws, washers and nuts. Photo #9. When installing the AL brackets, keep one edge a set distance from the edge of the sled so that they are all parallel and in line as shown in Photo #14. 10.3 Attach the motor to the motor plate using the mounting screws that held the motor to the part it was taken off of. You won't have the pulley on yet as shown in Photo #10. I salvaged this motor from an old vacuum power head but have also seen the same unit in a new paper shredder. They seem to be a generic item and a little digging should turn one up. 10.4 Attach the motor plate to the Spindle motor bracket using two 8-32 x 3/4" machine screws, washers and nuts. Photo #12 10.4 Attach the motor bracket to the sled using 8-32 x 1" machine screws. The spindle, elastic band and spindle bearing clamp all have to be assembled at this stage. The arrangement should look like Photo # 13. The bearing clamp has a 6-32 x 1/2" machine screw to secure the bearing with two #8 washers. The clamp is attached to the Bottom spindle bracket using two 8-32 x 1" machine screws, washers and nuts. 10.5 Attach a bearing clamp to the Top spindle bracket and attach the bracket to the sled with two 8-32 x 1" machine screws, washers and nuts. Photo #14. 10.6 Tighten the 6-32 machine screws on the bearing clamps to lock the spindle in place. Check that the spindle axis is parallel with the edge of the sled and square to the front face, adjusting if necessary.Continued from Step 10 11.1 Apply auto body filler to the motor shaft and to the spindle in line with the motor shaft. This is best done in three or four layers or the weight of the filler will make it sag before it hardens. The elastic band cannot be removed but can be pulled out of the way. Photo #1 11.2 The pulley on the motor shaft was shaped by wiring up the motor and holding a sanding block up to it while the motor turned. The pulley should be shaped with a gentle crown to allow the belt to self centre while running. The pulley diameter is around 3/8" but would be better being the same diameter as that on the spindle (3/4") to run at a 1:1 ratio. Photo #2 11.3 To shape the pulley on the spindle I coupled the spindle to the flex shaft of another rotary tool using a piece of 1/8" rod and clamping both to the bench (Photo #3). The photo doesn't show the assembly at the same level of construction as this photo was taken the first time I assembled the machine. The pulley should be around 3/4" in diameter to have a good amount of surface contact with the belt to prevent slipping. As with the motor shaft a slight crown should be included to help tracking. Photo #4 shows the belt around the two pulleys. Rotating the spindle by hand I was disappointed to see more run-out that I expected. Setting up a dial indicator I measured the run-out at the cutting bit to be 8 thousandths of an inch (Photo #5) and 6 thousandths at the collet (Photo #6). I hadn't taken any measurements of the tool as it came out of the box but being a cheap tool I expect this was how it came and not caused from the abuse of chiselling off the rotor. To get a baseline I measured my other rotary tool (Photo #7) and found the run-out to be 4 thousandths at the cutting bit on the tool itself and a comparable 6 thousandths when using the flex shaft. Doing a google search I found this site covering the same problem. Using the advice to only tighten the collet finger tight I found I could reduce the runout to a workable level. 11.4 The Z-axis rails (Photo #9) and stepper motor bracket can be installed next. The rails are attached at the bottom using 8-32 screws in the dedicated holes. At the top, the rails and stepper motor bracket are attached using the same holes in the sled (Photo #10,11). The aluminium brackets should have been positions parallel to one of the edges of the sled. The Z-axis rail should be offset from the same edge using the method used in step 4.2 using an off cut of aluminium extrusion. The other rail was positioned about 1/8" off the far edge using the same method as step 6.7 11.5 The stepper motor plate, stepper motor, Z-axis drive rod and bearing clamp can all be attached to complete the assembly (Photo #12). The stepper motor and stepper motor plate are attached to the bracket using three 8-32 x 3/4 screws and one 1 1/4". The longer screw goes on the back right corner of the stepper. A 3/4" screw needs to be used on the other back corner of the stepper motor to avoid interference with the nut attaching the Z-axis rail to the sled. The bearing clamp is attached to the bracket with a single 8x32 x 3/4" screw. Two 1/4" nuts are sinched together flush with the top of the inner bearing race. The 1/4"x1/4" shaft coupler was custom made using recycled HPDE from milk jugs using the following sub steps. 11.5.1 Form a cylinder of HDPE. Photo #13,14. The method of forming the material is detailed in Step 21. A tomato paste can was used as a mould. 11.5.2 Mount the cylinder on a wood lathe using a scroll chuck. Photo #15 11.5.3 Turn the stock down to the desired diameter. Photo #16 11.5.4 Bore a 1/4" hole. Photo #17 11.5.5 Drill two holes to the set screw minor diameter. Photo #18 11.5.6 Tap the holes and the part is ready for set screw and assembly. Photo #18 If you don't have a wood lathe with a scroll chuck or you don't want to be melting milk jugs in your oven you can just go out an buy a shaft coupler for $10 or so, but what's the fun in that? Fabricated Components Required: 2 piece anti backlash nutHardware Required: 12x #8 washer 6x #8 spring nut The trolley and sled assemblies are complete and need to be installed and squared to the gantry. 12.1 Start by tightening the V-groove bearings on the trolley around the X-rails. The trolley should be as square to the base as possible but can be a degree or two out. All four bearings should be running on the rails so that the trolley slides smoothly without any play. 12.2 Put two flat washers and one spring washer on each of the 4" bolts attached to the trolley with the spring washer between the flat ones. Slide one half of the anti-backlash nut over the 4" bolts 12.3 Slide the sled between the 3/16" V-groove bearings. Put the other half of the anti-backlash nut, two flat washers, one spring washer and a nut on the 4" bolts. Keep the anti-backlash nut clear of the threaded rod as in Photo #5. 12.4 The spindle should be square to the bottom of the Bottom spindle bracket. Rest the bracket on something parallel to the base, I used a piece of 1x3 (Photo #4), to support the sled and hold it square to the base. With the sled supported, squeeze the v-groove bearings together around the Z-rails and tighten while keeping the sled square to the base. A flat wrench will be needed to hold the nuts at the back of the trolley. The spindle wrench from my rotary tool is 3/16" and was just long enough to reach the nuts. Do not over tighten the bolts or you will crush the plywood and it will be impossible to have the axis run smoothly without play. 12.5 With the Z-axis running smoothly it is time to form the anti-backlash nut. The nut has been shown preformed as I did this step the first time I assembled the machine. The nut is made from recycled HDPE like the coupling. HDPE is an ideal material for this part as it forms perfectly around the rod giving no play and has a low coefficient of friction so the motor can spin. To form the nut around the threaded rod use a pencil torch or equivalent (I used this style) to heat the rod pointing the flame on the rod just below the nut. When the rod has heated up, press the two halves together being careful not to touch the hot metal. Hold the nut in place for a couple of minutes to allow the plastic to cool. If you move it away before it has solidified around the threads it will pull away like melted mozzarella cheese and won't take a crisp outline of the threads. To protect the machine I covered the nearby areas with tinfoil to dissipate the heat from any stray movements with the torch. I tried to angle the torch away from any parts behind the rod but managed to catch the end of the Spindle motor plate leaving it a little bit singed (Photo #8). 12.6 Tighten the nuts on both sides of the anti-backlash nut so the spring washers press the nut into the threaded rod (Photos #6,7). Play around with how much force is required to lock the axis in place but not too much to bind the axis. The support under the sled can be removed and the machine will support itself (Photo #9). Hardware required: 3x MXL timing belt 6x 3/16" x 2" eye bolts 12x 3/16" nuts 24x #8 washers 6x 6-32 x 5/8" machine screw 6x 6-32 nuts The timing belts are what converts the rotary motion of the stepper motors into precise linear motion along the axis. The belts are clamped onto eye bolts and the tension is adjusted by tightening the nuts on the eye bolts. 13.1 The first step to assembling the timing belts is to locate the two holes per end needed to clamp the belts in a loop. Test fit the components and mark where holes should be located if looped around the eye as in Photo #1. I purchased closed loop belts and simply cut them open using an utility knife. 13.2 Drill/punch the holes into the timing belts at the points marked. Use a 1/8" drill or an awl to form the holes. The material will be flexible and the resulting hole will be smaller than the bit diameter. The holes should be similar to those in Photo #3. 13.3 Assemble the timing belt anchors by looping the ends of the timing belt around the eye bolts and closing the loop using 6-32 machine screws (Photos #2,3). The holes will be smaller than the screws but twisting them while pushing will get them though the hole. The grooves should be on the inside of the loop and clamped shut making sure the grooves are meshed. The completed assembly should look similar to Photo #5. 13.4 For the Y-axis, loop the belts around the pulley and idler bearings and then bolt the eye bolts to the steel belt clamps (Photos #7-9). The Y-axis was designed to be the correct length for the belts used so there is no excess. The slots in the belt clamps are oversized to allow for adjustments in the belt positioning; adjust them so that the belt lines up with the idler bearings and the eye is far enough away from the base that it clears the gantry side when it is at the extent of its travel. 13.5 For the X-axis there is excess length in the belt. Instead of cutting the belt to length I tied the excess out of the way as shown in Photo #10 in case I wanted to make the axis wider in the future. It is a tight squeeze to get the belt around the idler bearings and motor mounting bolts and onto the pulley. Don't try and snake the eye bolt through because it wont fit. Make a loop in the middle of the belt and feed it up past the idler bearings and over the pulley. Position the eye bolts so that the belt is in line with the idler bearings which should also be close to in-line with the X rail. Photos #10,11. 13.6 Finally tension the belts by tightening the outside nuts on the eye bolts. Try to apply equal tension on the belts. Once you are satisfied with set-up, tighten the inner nuts to prevent the eye bolt from rotating. The gantry should be square before the timing belts were installed but by tightening then to different tensions they will try to pull the machine out of alignment. The machine can be brought back into alignment in three easy steps: 14.1 Tape down some scrap paper and using a square, draw a line perpendicular to one of the Y axis rails. Photo #1 14.2 Loosen the set screw on the spider coupling so that the two sides are uncoupled. Move the gantry so that when a strait edge is held flat against the X rails its forward edge is in line with the line drawn in step 14.1 Photo #2. 14.3 Take a similar measurement on the other side of the gantry (Photo #3). If the line is further forward than your measurement, tighten the front eye bolt; if it is further back, tighten the back back one. When a measurement taken on both sides of the gantry has the strait edge landing flush with the line the gantry is square and you can tighten the set screw on the spider coupling. Hardware Required: 5x nominally closed momentary push button switch (3 red, 2 black) 15.1 Solder two conductor 26 gauge wire to each limit switch. Determine the length of wire required to reach the desired location of the controller box. I have chosen to place mine below the table at the back. I do not have a cable management system in place but will implement one once I gain some experience using the machine and get a feel for what will work best. 15.2 Attach a red limit switch (Y home) on the front belt support on the side the limit switch “bumpers” were installed in step 5.4. A black one (Y limit) goes on the same side at the back. Red limit switches designate home positions and black, extents of travel. Photos #2-4 show how the limit switch interfaces with the limit switch “bumper”. The wire for the home switch is run under the table to the controller box and the switch at the back simply drops strait down into the box. 15.3 Attach a red limit switch to the left side of gantry (X home) and a black one (X limit) on the right hand side (Photos #5-6). Feed the wire from the home switch through the hole next to the belt clamp and run the wire down the back of the gantry. Threading #8 nuts on the bolts protruding from the top X rail and gently clamping the wire keeps the wire in place. Feed the wire through the hole on the opposite side and bundle it with the wire from the switch on the right hand side. Photos #7-9 15.4 Attach the Z-home switch to the bearing clamping block under the anti backlash nut. Hot glue was used to position the switch as required. Photos #10-11 The machine is now fully assembled and ready to hook up to the driver board. Foam board (Extruded polystyrene rigid insulation) is the perfect prototyping material for the CNC. High feed rates and aggressive cutting depths can be used allowing prototype parts to be machined quickly and at $20 for a 2' x 9' x1" board you can afford to make mistakes without hurting your wallet. Multiple fluted high speed cutting bits (similar to this one) work better than double fluted router bits. When using sharp tools the finish can be quite good (such as this done on my first machine). Using the cutting bit on harder materials causes it to loose its edge and it will leave a fuzzy finish on the foam. The lesson here is to segregate your cutting bits based on material which lead to me building the bit holder in Step 18. The first thing I like to do when machining a new material or after making adjustment to the machine is to cut out calibration shapes to see how well the machine is performing. A 2" square and circle are shown in Photo #1 with dimensions shown as measured using a pair of digital callipers. Before cutting these make a strait cut in the material and measure the width of the groove. A 1/8" bit won't cut out a perfect 0.125" because the cutting bit isn't likely to be exactly 1/8" and there will be some spindle runout. Because there is very little force on the tool when cutting foam this test shows the performance of the drive train and not the stiffness of the machine. When taking measurements I keep in mind that the machine has a resolution of 0.004" which is smaller than the error from my cheap pair of digital callipers. Measurements to look for on these shapes are as follows: -the square is a square and not a rectangle. If one side is shorter than 2" it shows that the corresponding axis is loosing steps/slipping. -The circle has a consistent diameter when measured at various angles. If this doesn't check out but the edges of the square were correct it shows that the X and Y axes aren't square and the square was actually a parallelogram. With a maximum resolution of 0.004" on the X and Y axes I was more than happy with the results. Next I did the CamBam drilling tutorial using a 1/16" drill bit. Testing 3D shapes I cut a miter gear and a sprocket using CAD files downloaded from sdp-si.com. CamBam files for all parts are attached.Miter_top_surface.cbSkull.cbSprocket.cb Calibration cuts in plywood yielded good results. The shapes were accurate and had very good surface finish. All photos show the surface finish strait off the tool. The feed rate was limited by the spindle power and the noise level. I have no reason to believe the machine would't be able to make more aggressive cuts if a palm router/laminate trimmer was installed. My local tool store happened to have their off-brand rotary tool bits on sale so I got a good selection of different styles to try at a fraction of the price for name brand bits of a similar quality. Any rotary tool bits you can buy at tool stores will be marginal in terms of the quality of cutting edge they are shipped with and their ability to hold an edge when sharpened. In order to get the best possible performance and cut quality you'll have to look at purchasing speciality 1/8" shank cutters from suppliers on the internet or upgrade to a 1/4" spindle so that you can use the much higher quality standard router bits. To maximize their cutting life I've built a tool holder to separate the cutting bits based on the material they are to be used on. The piece was cut out of a piece of 1x4 using the following steps: 1) The letters were engraved using a 3/32" end mill. Letter depth is 1/16" 2) Two rows of 1/8" holes were drilled with 7 holes per material. 3) Four 3/16" holes were cut per material. 4) The lettering was lightly sanded using a flat sanding block to clean up any rough edges. When cutting with the grain or on a down hill cut the cutting bit gave a crisp edge. When cutting across the grain or on a climbing cut the tool left fibers on the upper edge. A down spiral cutting bit would solve this problem and give a crisp edge all around the lettering. 5) The engraved lettering was painted being careful to stay within the lines. 6) The excess paint was sanded away giving a clean edge to the lettering. The tool bit holder is complete and ready to be filled with rotary tools of all sizes. bitholder.cb For my first real project I wanted to make something that demonstrated the advantage of using a cnc machine and its capabilities. I originally was going to build a model sailboat but decided it didn't quite fit the bill as it is possible to construct one using traditional methods (but must slower and a bit less precise). I had recently been reading articles on propeller design for human powered vehicles from the great archive available on the International Human Power vehicle Association’s website. Of particular interest is Eugene Larrabee’s article in the 1984 Volume 3 Issue 2 detailing the process of designing propellers using the minimum induced loss method. I have attached a spreadsheet that performs the calculations and outputs the propeller particulars when given the power, speed, rpm and radius as inputs. (Edit 29/4/2012, calculation spreadsheet now attached) For my propeller I used the parameters P=200W Speed = 3 m/sec RPM= 200 Radius = 22cm Number of blades=3 (Ooops! didn't realize this mistake until I was finished making the propellers) I put the information into Rhino3D, a 3D CAD program that is very good for creating complex surfaces (a trial version is available here) and generated a line for the leading and trailing edges using the chord and pitch distribution from the spreadsheet. To generate the propeller surface I used the Sweep2 command using section profiles between the edges. The propeller has both geometric twist (change in angle of attack over its length) and aerodynamic twist (change in airfoil cross section). The propeller has a constantly changing cross section going from a heavily modified NACA 4418 cross section at the root to house the bossing, transitioning to a 4415 at the 1/3 radius mark, 4412 at roughly the 2/3 point and blends into a point at the tip. To produce a two part mold I split the propeller in half at its widest point to avoid any undercuts and created a box around both sides to create top and bottom molds. The resulting parts have very complex curvature and would be extremely difficult if not impossible to make by hand with a reasonable amount of precision, making it the perfect project for a cnc machine. To make an assembly I sketched out an end cone and two piece hub to bring everything together. The geometries are attached in iges format. I wanted to find out how suitable polystyrene foam would be for a single use composite mould. A two piece mould was machined and used to layup two carbon fiber propellers. The two mould halves were cut out using a 0.075” rouging cut (Photos #7&11), 0.05” finish water line cut (Photo #8) and a vertical scan line pass (Photos #9,10 &12) taking around an hour per side. The 3/32” bit used for the finishing passes did not leave as crisp a surface as the larger bit leaving a fuzzy surface. As soon as the moulds had been removed from the machine I realized that I had not included holes for indexing pins; luckily I didn’t have any issues aligning the two sides without them. The first step to preparing the mould was to give them a quick once over with 400 grit sand paper (Photo #15). The goal was not to shape the material and remove the remaining scan lines but to take off as much of the fuzz as possible. The moulds were then given two coats of thinned latex paint (Photo #16,17). Using thinned paint prevents build-up that would change the profile. The purpose of these coats is to give the foam a better surface to sand against to take off the remaining “fuzzies”. With the paint fully dry I used 200 grit wet/dry sanding paper and sanded with a bit of water (Photo #18). A final coat of paint may be required to fill any thin areas after sanding. When I was happy with the surface quality of the mould I applied 6 coats of mould release wax according to manufacturer’s directions. Because I wanted to get two parts out of this mound I followed up with a precautionary layer of PVA applying it in two thin coats. I had only prepped the top surface of the moulds but to protect the mould from epoxy seeping out from the joint I spread a layer of Vaseline around the edge to prevent the mould from being glued shut. With the moulds prepared they are ready for laying up the carbon fiber. Before I began this step I got all the tools and materials I required and cleaned my work area. Working with composites is much cleaner and more enjoyable when things are set up properly before you begin. All my work with epoxy and spray paint was done out on my balcony to avoid breathing in fumes. Will all the items in Photo #1 on hand I started by cutting out strips of carbon fiber to the rough shape of the propeller. Photo #2 Next I mixed up the resin and hardener. I ended up needing 30ml of epoxy which can all be mixed at once as it has a working time of over an hour. I applied a coat of epoxy to the mould surface and laid down the first strip of carbon fiber (Photo#3). I wetted out the fiber making sure it was fully saturated and repeated the procedure of laying down a new layer and wetting out. Each new layer was narrower than the previous building up thickness in the middle but not at the trailing edge where the profile tapers off. Progress was gauged using a popsicle stick laid across the mould as in Photo #4 showing which areas require more fiber. A 2" long section of 1/8" key stock was embedded in the propeller with 1" protruding. Small offcuts were used to pack in around the shaft. When one side of the mould was built up to the required thickness the second half was laid up in the same manner. With both halves completed the moulds were brought together and lined up (Photo#5). With the mould lined up a stack of text books (I knew they would come in handy one day) was placed on top compressing it together. A good amount of epoxy and carbon fiber came out at the seam making me glad I had applied that layer of Vaseline to the sides. Photo #6-8. The end of the mould at the propeller tip had a tendency to slide apart due to the slanted surface. A C-clamp kept the mould aligned on this end. After twelve hours the epoxy had jelled but had not hardened completely. I had a utility knife around the seam and popped the mould apart with little difficulty (Photo#9-11) I was pleased to see that the mould release has done its job and the mould had survived with little to no damage. Using a utility knife I trimmed away the swarf on the propeller as it is much easier to do before the epoxy hardens (Photo #12). With the excess trimmed off I put the propeller back into the mould to keep its shape until finished curing. Once the propeller had sat for 24 hours I repeated the process for the second one. After the second propeller had sat for 30 hours the epoxy had fully set and was ready for sanding. I used 120 grit sand paper from a sanding belt and 220 grit wet dry paper. Wet sanding is more efficient than dry and eliminates the nasty carbon dust that would be produced otherwise. After cleaning up the leading and trailing edges as well as sanding away minor surface flaws the propellers looked as shown in Photo #14. They are smooth but dull. To finish the propellers I applied four light coats of clear gloss finish (Photo #15). Light coats are important here; I got excited and laid down too much finish causing runs that had to be removed using 600 grit paper. This step covers my process of recycling platic milk jugs into billets and machining them into the hubs for the propeller. This process was also used to make the shaft coupler and anti backlash nut. HDPE (or High Density Polypropylene) is a great material to work with as it is hard, easy to machine and has a low coefficient of friction. This site has a good breakdown of how it compares to other engineering plastics. When bought in sheet form it is fairly expensive but it is laying around your house in a variety of forms, milk jugs, other food grade containers, cutting boards etc. The process I use has been refined after many trials and represents the best method I have tried so far. I started by searching instructables and the web to find what others had done and found this one. I tried this method several times changing different parameters each time but melting the plastic in oil didn't give the final consistency I was after. My next idea was to melt the platic in a tin can that was submerged in oil. I neglected the effect of bouyancy and had problems keeping the can submerged. My first thought was to place a weight on top of the can but this made it too top heavy and prone to tipping over, not something you want when it is in hot oil. I thought I found the perfect solution by attaching the can to the bottom of the pan using magnets but when the oil gets up to temperature the heat is enough to break down the magnetism of the rare earth magnets I used. The next step of the evolution of this process was to melt the plastic in the oven and is the method I used here. The first step is to clean out some milk jugs, take off the labels and reduce them into flakes. I do this with a pair of scissors while watching tv. I can only do about four jugs at a time which takes around an hour before I start to get blisters from using the scissors. The flakes should be as small as you have the patience for, as reducing the size in half requires four times the cutting time. The smaller the flakes are the easier it will be to eliminate voids in the plastic. Cutting the milk jugs up by hand is very tedious and I have tried to come up with better methods. I can tell you one that doesn't work is using a paper shredder. HPDE is used in tick tac lids as it is very flexible and won't break due to fatigue when flexed. This property means that it will not shred in the paper shredder but will deform enough to go in half way and get stuck. I cut up four milk jugs aiming for flakes 3/4" x 1/8" in size (Photos #1,2). I cleaned up three tuna tins for use as moulds. I have made billets from all sizes of cans from tomato paste for the shaft collar and larger tomato cans depending on what I want to use the plastic for. (Photo #3) Next I filled the tins up with flakes. When melted these will compress and the tins will have to be topped up. (Photo #4) With the oven preheated to 350 degrees Fahrenheit I put the tins in for half an hour. HPDE has a melting temperature of 266 F and an extrusion temperature of 350-500F. With a household oven the temperature can be expected to swing +/- 25 F as the heating element cycles on and off. Trying different temperature settings I fould that at 375F and over the plastic would burn and give off an unpleasant smell. I've settled on 350F as the best temperature to use taking longer to melt the plastic but avoiding overheating issues. After the half hour I removed the tins from the oven and press down the partially melted flakes with an old spoon to compress the material and try to remove any voids (Photo #5). If the tins are out of the oven for over a minute or so the extremities will begin to cool and transition from opaque to white. I kept putting in the tins in for half hour stints and after two hours they were fully melted. I gave them one last press with a spoon to try and get the surface as even as possible to minimize machining afterwards. Photo #6. When fully melted they are fully opaque. The material is not runny but has a sticky gooey consistency. I have tried many different methods of heat cycling the plastic to minimize internal stresses. If the pieces are thin enough and taken out of the oven at this point and left to cool, they will warp. The easiest way to minimize the heat stess is to just turn off the oven and walk away. The plastic will retain heat remarkably well and will be too hot to handle even after several hours. I leave them overnight to be sure everything has cooled down slowly. There is enough shrinkage when cooled that the parts come out easily from the tins even when there is a slight lip on the inside. Photo #7. After cooling the recycled plastic is ready to be machined into propeller hubs. Starting with the top hub the top surface is machined flat (Photo #8). The excess plastic is cut away using a hack saw (Photo #9). The piece is then flipped over and the bottom surface is machined flat (Photo #10). Next the five holes are machined with an end mill (Photo #11), and then the recess for the bolt head (Photo #12). A 1/8" groove is cut for the propeller shafts (Photo #13). The last step for this side is to cut out the circular profile. The part is now flipped over and recesses cut for the nuts (Photo #14). The bottom hub is similar with the top surface of the piece machined flat (Photo #16,17) and then flipped over and flattened again (Photo #18,19). Holes and a 1/8" groove are machined next (Photo #20) and finally the profile cut out (Photo #21,22). Not shown, but the final step is to flip the piece over one more time and machine the recesses for the bolt heads. As I progressed through the steps I tried different cutting speeds and depths. I discovered by the end that I was not taking deep enough cuts which resulted in the bit chattering on the surface. The facing cuts would have been much cleaner such the recess in Photo #8 had I taken off twice as much material per pass. Drawings for the hubs are attached. (Edit 29/4/2012, propeller hub drawing now attached) Propeller Hub.pdf The end cone is the attachment to the hub that makes the assembly more aerodynamic (or hydrodynamic) when travelling through a fluid. The base diameter is 2" to match the hub diameter and the height is 2" chosen to give a streamlined surface without being too long. The overall shape is a parabola what has been reloved around a central axis. To build it a plug was machined from 1" polystyrene foam in two halves (Photo #1). 0.05" was left at the bottom to stop the parts coming loose on the last pass (Photo #2, I need to learn how to use the holding tabs feature in CamBam when I get the time). The two havles were then glued together using a thin layer of white glue after the swarf was removed with a utility knif and some 220 grit sandpaper (Photo #3). To give the endcone a hard durable shell I covered it in a layer of fiberglass using the vacuum bag method using the following steps: -I assembled the materials in Photo#4. I was working outside with good ventilation to protect myself from the fumes. -I measure out the epoxy in to 2:1 ration of resin to hardener using the measuring cups. Shown in Photo #5 is 15ml of mixed epoxy, I ended up using 30ml. -Starting the fiberglassing I wetted out a piece of fiberglass cloth 3"x3" (larger than the cone's base) onto the piece of waxed MDF. Photo #6 -Next I placed the foam endcone plug in the middle of the wetted fiberglass. Photo #7 -and draped a piece of fiberglass cloth over it. Photo #8 -I wetted out the cloth until all areas were saturated with resin. In Photo #9 I still have creases in the cloth. These will not lay flush even after vacuum bagging so small slits will have to be cut in the fiberglass overlapping the edges to smooth the material out. -Next an oversized piece of peel ply is layed over the fiberglass. Photo #10 -And then a layer of breather cloth (Photo #11). I put an elastic band around everything at this stage to hold it all together while I made the bag. Photo #12 -I placed everything on one side of the vapour barrier (Photo #13) and doubled the plastic over sealing the edges with duct tape while inserting an air

line from underneath the breather cloth and out a corner (Photo #14) -The exit point of the air line is the hardest place to seal. I used plasticine around the airline as shown in Photo #15. This takes a long time to get right an is quite frustrating. The next time I vacuum bag something I will take the time to make a proper sealed connection using brass fittings. - A vacuum is now applied using a pump made from this instructable. With this setup I can pull up to 25" Hg. -After 24 hours to let the epoxy cure the part was taken out (sorry, forgot to snap a picture of this step), the excess glass cutoff around the bottom, a coat of primer applied and sanded to be flush with the propeller hub. Photo #16 -When I was happy with the fairing (more a function of the time I had available than the results, it could have been a lot better) I gave it a couple more coats of primer. Photo #17 -I cut out a recess on the bottom and using autobody filler attached a #6-32 nut and washer. I covered a 1/2" long #6-32 machine screw in Vaseline to prevent the autobody filler from sticking to it and assembled it through the mounting hole in the propeller hub (Photo #18). This makes it possible to remove the endcone from the top side of the hub. I later decided that removing it wouldn't be necessary so I faired the hub and endcone together with drywall compound and made them one piece. -Using metalic autobody spray paint I had on hand (Photo#19) I gave the endcone/top hub assembly and the bottom hub three coats of paint followed by a layer of clear coat. Photo #20 So here it is, the final assembled propeller. The parts are assembled as shown in the exploded view in Step 19. The main purpose of this project was to demonstrate the feasibility of making a mould from expanded polystyrene to create an accurate composite part. This process has been a resounding success with the cnc machine successfully machining a complex surface and imparting that geometry to the composite part. With this process a piece can be created in three evenings worth of work: Day 1: Mould machined (1-2 hours depending on complexity) Mould painted and sanded (1 1/2 hours give warm enough temperatures and thin coats being applied) Mould prepared with release wax and PVC (1 hour for 5 coats of wax drying for 10 min between applications and a coat of PVA left to dry overnight) Day 2: Layup of composite (1 hr) Day 3: Sanding and finishing of part (1-5 hrs depending on many factors) The HDPE hub turned out alright but shows a lot of promise for using the material in the future. As mentioned in Step 21, more practice is required to get the optimum feeds speed and depth to achieve the best surface quality possible with my set-up. A few voids can be seen in the material but these are nothing compared to what I was getting when I first started. With a bit more refinement I am confident I can make consistently void free blocks. The weakest part of the lot is the end cone which comes down to not spending enough time fairing the surface before painting. In the future I will try vacuum bagging parts like this one in a female mould so, like the propeller blades, the final shape can be as accurate as the cnc machined part. The machine has been up and running for nearly a month now and has logged around 7-8 hours of cutting time without any major problems. At around the 3-4 hour mark I had to re-tighten the V-groove bearings on the X & Z axes but these have not loosened since then. The following are a few observations I have made while using the machine. The pulleys on the Y axis have come loose more often that I liked. The problem wasn't the time require to re-tighten them but that they would have to be checked before each use to make sure they were secure. I had cut out a propeller end cone to find out it was circular because I hadn't noticed the pulleys had come loose. To solve this problem I attached 1/4" shaft collars to the pulleys using 10 minute epoxy as shown in Photo #1. All of the HDPE parts were cut using this setup without the pulleys loosening. When running at less than 30 inches per minute the movement of the machine is slightly jittery as the discrete steps of the stepper motors is magnified. In the future I will be replacing the 40 tooth pulleys with 20-30 tooth versions to increase the resolution of the machine and make it;s movement smoother. I imagine these will come with the same size set screws as before so I will take the time to bore out the threads and re-tap them to accept 8-32 set screws as are on the shaft collars. I had expected the aluminum rails to show signs of wear from the contact with the V-groove bearings as this was experienced on my first machine. The rails have worn a little bit as shown in Photo #2 but shouldn't require replacing any time soon. I will make a concious effort to use different parts of the machine when cutting smaller items so that the wear isn't concentrated in a particular area. If this becomes a problem I might consider making my own V-groove bearings from HDPE and fitting them around a skate bearing. The HDPE against aluminum should have very low friction and good wear characteristics. The part I was the most concerned about was the elastic band driving the spindle. This had taken a bit of damage during the construction process and I didn't know how quickly it would wear if it was slipping over the pulleys. Photo #3 shows the elastic band in good conditions with minor wear that as taken off the lettering. The pulleys in Photo #4 show a bit more wear but is mostly cosmetic. The home-made spindle has performed well and as been quiet enough to use in an apartment but I would like a bit more power and the ability to use higher quality 1/4" shank router bits. I will be looking out for garage sales to pick up a 1/3 HP induction motor (similar to the one in this) and trim router to make a beefier hight powered version of the current spindle. I bought a few items thru them and I'm very satisfied Date of experience: June 14, 2025EBay, it's a scam the min you order something and cancel it within seconds, seller Automatically decline to cancel Sends item and docs credit card or bank account!! Total eppin scan. They will tell you, eBay Customer service, to accept the item. Call them immediately and they will refund your account. Well, let me tell you right now. That you're so full of it.Date of experience: June 09, 2025Bought an expensive CPU with RAMs, was in communication with the Seller as it was not working. After long troubleshooting, we concluded that it is vendor locked. The seller offered to find that Vendor system so the CPU would work. All sounds good, the only issue is that it would arrive 2 weeks after the available return. Agreed with seller to file for returns to win some time for the motherboard to arrive. As the motherboard arrived, yet again it is locked under password. After communicating that to the seller, was just banned out of Ebay, with no way to return these defective parts, no communication with the seller to solve the password issue... Far from safe system for usersDate of experience: February 06, 2025My first time buying off of the ebay site and the delivery time was changed 3 times now no information at all about the part I ordered, not a big deal as it was only $22 dollars and my credit card company will get me refunded but I won't be buying anything off of ebay again. Date of experience: June 04, 2025Great team, I contacted them about the package QR code, and they resolved the issue within a couple of minutes. Outstanding support over there! A++Date of experience: June 19, 2025I'm posting (Royal Mail) my last ebay sold item today, quite honestly it's (selling) become more trouble than it's worth, the process is constantly changing and has become much too complicated , for example Royal mail postage is no longer (stopped within the past two weeks) available, sellers can no longer access the buyers address unless one activates an ebay postage label, monies earned now sits in an ebay pot as opposed to being directly transferred to the sellers bank account thus attempting to encourage sellers to spend their earned money on ebay products, hardly any sellers are using the bidding process, I haven't worked out why but preferring the "buy it now" option, ebay have gradually maximized profits and cutting out the middleman (Royal Mail and PayPal) in ebay's financial favor, this process reminds me of George Orwell's Animal Farm were all Animals start out being equal then the Pigs gradually take charge, as I've stated as far as ebay selling is concerned I'm done! Date of experience: June 19, 2025Ebay is truly disgusting and heartless, they have indefinitely suspended my account after I provided ALL documents they requested and I have 100% feedback. They are happily withholding my money for 190 days while I suffer to make ends meet. Customer service agents are heartless and robotic. Shame on you Ebay, I have no idea how these people sleep at night. Date of experience: May 19, 2025They are helping sellers over buyers also letting sellers block you for no reason sellers canceling orders on you then they up the price real nice thing to do to a paying customerDate of experience: June 14, 2025Buyer beware! Returning an item was very difficult. They do not have a good customer service. You can't speak with a real person to resolve issues. The instructions on the website are very confusing. I've spent 3 days trying to figure out how to make a simple return. I will not buy from EBay again !Date of experience: May 17, 2025Awful!!!!! Terrible complicated setting up postage. It worked fine before. Terrible hidden fees for buyers. It worked fine before. They now hold your money, so they earn interest off it!! I set 'no returns accepted' and wrote it on description, but had to refund a buyer, even though item WAS as described, or they would take the money off me anyway. Thiefs!! Something I posted was delivered a week ago, but no funds available to me. Very very hard to contact anyone. I've taken all my selling items off now. eBay is completely broken now!! It used to be good. But it's now unusable. What foolish idiots the ebay bosses are. Date of experience: June 18, 2025I recently started searching for items of interest on eBay so I could buy them on my visit to US. eBay suspended my account without me ever having added a card, having bought something, or having violated any policy. I contacted their support, exchanged 9 emails and every single time, there was a template response that there was some risk to eBay because of me. 9 emails exchanged, their outsourced support keeps sending me Macro responses repeating the same thing with 0 effort spent on trying to help a person who is actually interested in buying products. fwiw, i was interested in buying a watch.Date of experience: April 21, 2025They changed the delivery service to só called (simple delivery) it has caused me issues & stress & I am out of pocket.I spoke to eBay - they wernt bothered & didn't want to deal with the issues- just blamed the courier when it is them at fault- I'm furious. It's not the first time I've had problems with eBay either & up until now I had 100% positive feedback however it could be affected now because of eBay themselves- ironically. Also the simple delivery can allow scamming easily aswell but eBay are not bothered either.Date of experience: June 17, 2025This may be hard to believe but I ordered a Camelbak 50 oz pack on Ebay. The seller made an offer of $30 USD..I am 100% sure. " this item qualifies for no duties or taxes" (or something to that effect) came up as I checked out. Today..I get this e- mail from DHL E-commerce asking me to pay..what looks like a brokerage fee of $12.50 and GST/PST of $5.49. I refused to do so..as I am a senior (and there are lots of SCAMS) around. So..then it says " we will proceed with the delivery of the package and if it clears customs and no duty..so be it. This is VERY DISHONEST not to mention after I said NO..why do you still proceed to deliver it to me????.with me hoping it passes through customs with no duty? The fact it still passes thru and you continue tells me this: WE were trying to RIP YOU OFF for those fees while the package was still in the U S. ABSOLUTELY DISGRACEFUL!Stay away from this site..I will never trust anything AMERICAN again!Date of experience: June 18, 2025eBay is probably a good site. But it doesn't suit me anymore, because eBay sellers have the right not to deliver the goods to you after receiving your money. Also, on the eBay site, sellers may not return your money if they fail to deliver the goods you bought. And the eBay site will not help you in any way when you personally find yourself on eBay in a situation without money and goods.Date of experience: June 17, 2025Long-time Member Treated Poorly – eBay Ignores Australian Consumer LawI've been an eBay member for over 16 years, but my recent experience has been incredibly disappointing. I purchased an item that was never posted, and the seller completely ignored my messages. Despite having clear evidence, eBay refused to issue a refund and hid behind their internal policies.What's worse is that eBay's policies blatantly disregard Australian Consumer Law, which clearly states that if an item isn't delivered within a reasonable or agreed timeframe, the buyer is entitled to a refund—end of story.On top of that, eBay fees have skyrocketed over the years while customer service and buyer protection have gone in the opposite direction. For a platform that used to pride itself on trust and safety, it's now become a joke.Extremely disappointed. After 16 years of loyalty, it's clear eBay no longer values its users or respects the laws of the countries it operates in.Date of experience: June 18, 2025Sellers DO NOT engage this platform for your merchandise. You may encounter selling merchandise, shipping merchandise, being left positive feedback by your buyers and eBay NOT releasing funds because 'tracking' (on a shipping label eBay sells you) does not indicate delivery. What an ABSOLUTELY ILLEGAL RACKET!!!On top of that, the collectible coin category is full of counterfeit items that even if you use the "Report this item" function to properly bring the matter to eBay's attention, you may get a response that eBay found nothing against their policy. I found this strange as they absolutely do have a no counterfeit policy (as does the United States of America where eBay is headquartered). I guess when eBay profits, they don't care about US LAW or aiding counterfeits whose efforts undermine the hard working money of everyday Americans.Then there's the "Customer Service." hahaha. Try finding a phone number: it'll take you a while. Try getting someone you can understand: you'll need to ask for a 'supervisor.' Try getting them to adhere to their own policies: you'll die before that happens. The lack of any concern for the needs of a paying seller on their platform is nearly as bad as their quite literally stealing money from paying sellers on their platform.A product of silicon valley and the anti-American policy pushing party, eBay's unaligned policies and actions have proven it unworthy of US consumers and sellers.Date of experience: June 17, 2025They took down listing for no reason.Date of experience: June 17, 2025They are thieves, just selling an item for $55 and they were without any shame collecting the half of it for them. What? ...legal SCAMMERS Date of experience: June 17, 2025I wanted to order a car part with ebay. I did not realize that I had an expensive car part already in the ebay shopping cart from a month earlier, something I no longer needed.I hit the order button for the part I needed, not realizing the expensive part was still in the cart. The order for two items went through. This was on a Saturday. Within 5 minutes, I sent a note to the seller, and hit the cancel button. A few days later, the seller shipped the item. The item was received and now I am required to pay return shipping of over $20. I have written the seller 3 or 4 times, and the seller will not respond. Ebay has no easy way to ask them to intervene. Finally, I got through to an ebay customer service agent. They basically said it was my tough luck, the seller does not have to do anything, not even respond. I let the ebay representative know that with Amazon, several times I have cancelled an order within a few minutes. The response was that Amazon does thing differently, so they can do that. I've been using ebay for about 16 years, and this is a real disappointment. Date of experience: June 07, 202502-13013-49229 order number I bought the product but the product was not delivered to me, I wrote to ebay about it, it will be 1 month and they still haven't refunded me, I am disappointed and I want the refund to be madeDate of experience: May 24, 2025 Are you learning & researching on how to make your own CNC kits for beginners? Review this DIY guide on how to build a CNC machine step by step from scratch. Learning how to build a CNC machine from scratch is easier than you might think. We have broken down the DIY process into a series of easy-to-follow steps for beginners. From buying parts to installing software, our DIY guide will walk you through how to easily make your own CNC machine.What is a CNC Machine?A CNC machine is an automated power tool that uses computer program to control the motor to drive the three axes of X, Y and Z to move back and forth along the tool path generated by CAD/CAM software according to G-code commands. Finally, the tool on the spindle completes the carving, cutting, and milling results.Things To ConsiderWhen it comes to CNC machines, everyone will think of its high cost and complex programming operations, which make us feel unfathomable about it. In fact, we know and learn CNC by making some simple and low cost CNC machines, which has enabled us to upgrade from a beginner to an expert in modern CNC technology. The difficulty of DIY a CNC machine lies in the high cost of the machine kits and the difficulty of machining, and the setting and use of the software is relatively simple. After a month of studying and researching CNC, I decided to build my own Mach3 controlled CNC machine kits using locally available materials.Building Difficulty: Moderate.Building Duration: 16 Days.DIY Tools: Bench vices, electric drills, hand saws, sample punches, taps, reamers, calipers, benders, and screws.Getting StartedThis guide is all about creating a functional CNC machine with the following features.1. The gantry structure has good stability, large processing format, compact and lightweight desktop design, light weight and easy to carry.2. It can be used to cut and mill PCB, PVC, acrylic, MDF, wood, aluminum, and copper.3. Its machining accuracy can reach 0.1 mm, which can meet the requirements of most PCB boards, molds, stamps and signs.4. Its cost is under $1,000, and the assemble is convenient and easy.5. The parts and raw materials used can be found or bought locally, which reduces worries.6. The DIY process does not require too complicated tools.7. Mach3 controller, easy to use.8. The spindle is driven by a stepping motor with high precision.How to Build a CNC Machine Structure?This CNC machine adopts a fixed gantry structure. The whole machine is divided into a base table, a gantry frame, an X-axis carriage, a Y-axis worktable, and a Z-axis carriage. The drive stepping motor of the Y-axis worktable is fixed on the bottom plate. , screw, and two smooth bars and gantry as the Y-axis table sliding guide.On the gantry, the drive stepping motor of the X-axis carriage, the lead screw and the two smooth bars used as the sliding guides of the X-axis carriage are fixed. On the X-axis carriage are fixed the driving stepper motor of the Z-axis carriage, the lead screw and the two smooth bars used as the sliding guides of the Z-axis carriage.There are L-shaped fixing brackets and U-shaped retaining rings for fixing the spindle on the Z-axis carriage.The nut matched with the lead screw is welded on the carriage of X, Y and Z axes.How to Make a CNC Machine Circuit?The circuit consists of three identical stepping motor drive parts of X axis Y axis Z axis. Now take the X-axis as a column to illustrate its working principle.Stepper Motor Driver Circuit with L297/L298The circuit is mainly composed of two stepper motor dedicated drive integrated circuits L297 and L298. The main function of L297 is pulse distribution. It generates output logic pulses at its output terminals A, B, C, and D to drive L298. L297 also has two PWM choppers to control the phase winding current and realize constant current chopper control to obtain Good torque frequency characteristics.The X-axis pulse from HDR1 (pin 2) enters the CLOCK (pin 18) of U1 (L297) and is processed by U1 at its output terminals A, B, C, D, C (pins 4, 6, 7, 9) to generate The output logic pulse enters U2 (L298) to drive the double H bridge at its output terminals (pins 2, 3, 13, and 14) to output step pulses to drive the stepper motor to rotate.L298 is a dual H-bridge high voltage and high current power integrated circuit driver.L297 and L298 are used to form a complete drive system, which can drive two-phase stepper motors with a maximum voltage of 46V and a current of 2A per phase.The SYNC (pin 1) of U1 is the synchronization pin connected to the pin 1 of U3 and U5 to realize the synchronization of multiple L297s.Stepper Motor Driver Control BoardThe ENABLE (pin 10) of U1 enables the control pin to control the output logic. When it is low, INH1, INH2, A, B, C, D are all forced to low level to make the L298 driver not work. CONTROL (pin 11) is used to select the control of the chopper signal. When it is low level, the chopper signal acts on INH1, INH2, and when it is high level, the chopper signal acts on the A, B, C, D signals. The former is suitable for the single-stage working mode and the two modes can be used for the stepping motor of the bipolar working mode.The VREF (pin 15) of S1U1 is the reference voltage adjustment pin, and the voltage of this pin is adjusted to set the peak current of the phase winding of the stepper motor.Stepper Motor Driver KitsThe cw/ccw (pin 17) of U1 is the pin for specifying the rotation direction of the X-axis stepper motor, and the direction specifying signal for the X-axis from HDR1 (pin 6) is connected to this pin.HALF/FULL (pin 19) is the excitation mode control pin. When it is high, it is a half-step driving mode, and when it is low, it is a full-step driving mode. RESET (pin 20) is an asynchronous reset signal, and its function is to reset the pulse distributor.D3-D26 are the freewheeling diodes of the H-bridge of the L298 driver.How to Setup Mach3 CNC Controller?Mach3 is the most commonly used CNC controller for CNC machines. Its installation is simple. First, insert the Mach3 motion card on the computer motherboard. In the Windows operating system, the Mach3 driver will be installed by default.USB Mach3 3 Axis CNC Controller KitYou can also choose DSP, NcStudio, Mach4, Syntec, OSAI, Siemens, LNC, FANUC, and other CNC controllers.How to Install & Use CAD/CAM Software?The most common CAD/CAM software for CNC machines include Type3, ArtCAM, Cabinet Vision, CorelDraw, UG, MeshCAM, Solidworks, AlphaCAM, MasterCAM, UcanCAM, CASmate, PowerMILL, Aspire, Alibre, AutoCAD, Fusion360, Autodesk Inventor, Rhinoceros 3D, which can design 2D/3D drawings to generate machining tool paths.CAD/CAM SoftwareHow to Assemble CNC Machine Kits?The bottom table, X-axis carriage, Y-axis worktable, and Z-axis carriage are made by a bending machine with 1.5-2mm cold-rolled steel plates, which can ensure the most ideal machining accuracy. If there is no benders, it can also be manually bent with a hand hammer on a large vise. During hand hammer processing, a pad iron should be added to the work piece to avoid leaving hammer marks on the work piece. After bending, further shaping is required. None of the planes are warped and form a 90-degree angle to each other. In order to ensure the correct punching position, the needle point of the scribing needle that is parallel and perpendicular to the first scribing line should be thin, the scribing line should be accurate, and the sample punch positioning socket should be careful and accurate.CNC Machine KitsFor example, punch a hole with a diameter of 6 mm in two times. First, use a 4 mm diameter drill to drill the hole. Determine whether the 4 mm diameter hole is accurate according to the cross positioning line. If it is not accurate, use a garden assorted file to correct it. , and finally ream the hole with a 6mm drill bit, so that the hole position error is relatively small.The gantry can be cut with a hand saw from the iron keel of the anti-static floor with a wall thickness of 1.2mm according to the drawing, and it can be bent, processed and shaped on a vise. The light bar used as the X, Y, Z three-axis guide rail requires a smooth surface with a smooth diameter of 8-10mm. It can be solved by dismantling the slide rail of the used dot matrix printer and the inking rubber roller in the old laser printer cartridge. The two smooth bars in each direction should be of equal length and the end faces should be flat. Drill holes in the center of the end faces to tap M5 wire, and fix them with 5mm bolts. The workmanship must be horizontal and vertical, especially the two light bars in each direction must be absolutely The parallelism is very important, it determines the success or failure of the production.The lead screw of the three axes is a lead screw with a diameter of 6mm and a pitch of 1mm. This lead screw can be used to cut the required length from the long lead screw sold in the hardware store for the decoration of the ceiling. The resistance and clearance should be small, and the nut is welded in the corresponding hole of the carriage to minimize the backlash and improve the accuracy of the engraving machine.The sliding sleeve is a brass hose connector purchased in a hardware store. It is necessary to select the inner diameter slightly smaller than the diameter of the sliding bar, and then use a manual reamer to twist the inner diameter to precisely match the sliding bar. If necessary, polish the optical axis with metallographic sandpaper, cut the sliding sleeve into 6 mm long sections, a total of 12 sections, and then use a high-power soldering iron to solder it into the corresponding hole of the carriage. Do not place the sliding sleeve during welding. If the solder penetrates inside, use zinc chloride as a flux to ensure the soldering quality. When assembling, be careful that the resistance of the sliding table is small and consistent. If the resistance is large, the sliding sleeve can be reheated with a soldering iron to meet the requirements.The shaft of the stepper motor and the screw rod are connected through a copper tube of a 6mm diameter rod antenna. The screw rod and the copper tube are firmly welded and ensured to be concentric. The other end of the copper tube is inserted into the stepper motor shaft, and then drilled horizontally. A pin is inserted into a small hole to fix it, and the other end of the screw rod is welded with a nut on the carriage.This CNC machine can be flexibly controlled according to the size and size of its own materials, but the whole machine should not be too large to avoid poor rigidity.How to Operate a CNC Machine?Before CNC machining, a list of machining programs should be prepared in advance:1. Determine the processing procedure of the part and the tools and cutting speed used for processing.2. Determine the contour connection point of the part.3. Set the position of starting and closing the knife and the position of the coordinate origin.Write the numerical control instruction set according to the prescribed statement format, input the instruction set into the numerical control device for processing (decoding, operation, etc.), amplify the signal through the driving circuit, drive the servo motor to output the angular displacement and angular velocity, and then convert the components through the execution component. The linear displacement of the worktable is realized to realize the feeding.Let's start operating a CNC machine with the 9 steps as following.Step 1. CNC Programming.Before machining, the CNC programming should be analyzed and compiled first. If the program is long or complicated. Don't program on the CNC machine, but use the programming machine or computer programming, and then back up to the CNC system of the CNC machine through a floppy disk or communication interface. This can avoid occupying machine time and increase the auxiliary time of machining.Step 2. Turn on Machine.Generally, the main power is turned on first, so that the CNC machine has the power-on conditions. Start a CNC system with a key button and the machine tool is powered on at the same time, and the CRT of the CNC control system displays information. Connection status of clam and other auxiliary equipment.Step 3. Set Solid Reference Point.Before machining, establish the movement datum of each coordinate of the machine. This step should be performed first for the machine of the increase control system.Step 4. Start CNC Programming.According to the program medium (tape, disk), it can be input by tape machine, programming machine or serial communication. If it is a simple program, it can be input directly on the CNC control panel by keyboard, or input segment by segment in MDI mode for remote segment processing. Before machining, the origin of the piece, tool parameters, offset, and various compensation values must also be input in the program.Step 5. Program Editing.If the entered program needs to be modified, the working mode selection switch should be placed in the editing position. Use the edit key to add, delete, and change.Step 6. Program Inspection & Debugging.First, lock the machine tool and only run the system. This step is to check the program. If there is any error, it needs to be edited again.Step 7. Workpiece Fixing & Alignment.Fix and align the workpiece to be processed, and establish a benchmark. The method adopts manual incremental movement, continuous movement or manual wheel movement of the machine tool. Set the starting point to the beginning of the program, and set the reference of the tool.Step 8. Start CNC Machining.Continuous machining generally uses program additions in memory. The feed rate in CNC machining can be adjusted by the feed rate switch. During machining, the feed hold button can be pressed to pause the feed movement to observe the processing situation or perform manual measurement. Press the cycle start button again to resume machining. To ensure that the bowl is correct, it should be re-checked before adding. During milling, for flat curved pieces, a pencil can be used instead of a tool to draw the outline of the part on the paper, which is more intuitive. If the system has a tool path, the simulation function can be used to check the correctness of the program.Step 9. Turn off Machine.After adding, before turning off the power, pay attention to check the status of the CNC machine and the position of each part of the machine. Turn off the machine power first, then turn off the system power, and finally turn off the main power.FAQsThe most common types of CNC machines to be made by yourself include CNC routers, CNC lathes, CNC mills, CNC grinders, CNC drills, CNC lasers, and CNC plasma cutters.The cost of DIY CNC machine kits includes computer, control board, machine parts and accessories. Most of the cost is concentrated in hardware, which depends on the accuracy you required for you CNC machining plan, and the average cost is under $1,000.CNC machines can do milling, turning, cutting, carving, engraving, marking, grinding, bending, drilling, cleaning, welding for metal, wood, plastic, foam, fabric, and stone.Spindle motor is the core part for CNC machines. It is necessary to buy the right spindle motor for your business plans, all depending on the materials you are machining and the precision required for your projects.One is whether to choose a screw or a ball screw for the choice of the transmission system. Here I actually suggest that it is much better to choose a ball screw. Although I use a lead screw, I still recommend choosing a ball screw. The ball screw has high precision and small rotation error. And in the process of transmission, the sound is very small. The transmission process of the screw is the friction between metal and metal. Although the sound is not very loud, the rotation error will become larger and larger after the friction time is long.As long as the CNC machine is working, the stepper motor is working. If the motor is not selected carefully, then first the motor is very easy to heat up. The motor is hot when the machine starts working, which should not be what we want. The torque of the motor is also a problem to be considered, and it is easy to lose steps if the torque is insufficient. So don't be greedy when choosing a stepper motor.CautionsWhether you are building an affordable CNC router, or making the best budget CNC lathe machine, even working with DIY the cheapest CNC milling machine, the first caution is the power supply of the CNC machine. There are three stepping motors and one spindle motor on the machine. Therefore, the current of the CNC machine is very large in the process of use. When purchasing a DC power supply, a DC power supply with a larger rated current should be purchased. The determinant of the speed of the spindle motor is the voltage of the DC power supply. The higher the voltage, the faster the maximum speed of the spindle can rotate, so the voltage cannot be too small.In summary, I suggest that the rated voltage of the self-made CNC machine is about 30V and the rated current is at least 10A to ensure the normal operation of the machine. The voltage of 30V is mainly used on the spindle motor, and the stepper motor does not need such a high voltage. Because the stepper motor is driven by a screw, the torque can still be large even with a small voltage. So I suggest that only 12V is enough for the voltage supplied to the stepper motor. The stepper motor uses 12V, but the voltage provided by the DC power supply is 30V. Here, a transformer needs to be used. The power of this transformer should be high. The current of the three stepper motors must pass through this transformer. The heat dissipation of the transformer cannot keep up, resulting in serious heat generation. Precision in Motion: Building a CNC Lathe from Scratch When learning how to build a CNC lathe, understanding the essential parts and requirements is crucial. Here's a summary to get you started: Mechanical Structure: Sturdy bed, headstock, tailstock, carriage, and tool post. Electronics: Motors, controllers, actuators, and a programmable CNC unit. Materials: High-quality steel, aluminum, and machining components. Building your own CNC lathe is a rewarding, though complex, challenge. CNC lathes have transformed the manufacturing industry with their precision, speed, and versatility. At TMC Technologies, we understand that quality in CNC machine parts is non-negotiable. These machines can cut, drill, and shape materials like metals and plastics down to the micrometer, meeting the stringent demands of industries like aerospace, healthcare, and electronics. Furthermore, CNC lathes bring unparalleled efficiency to production lines, greatly reducing manual labor and increasing consistency. Whether you need precise, custom parts or large production runs, CNC lathes are up to the task. Learn more about how to build a cnc lathe: – cnc lathes – cnc machine tools – cnc turning machine Materials and Tools Needed When starting on the journey of building a CNC lathe, having the right materials and tools is essential. Here's a detailed look at what you will need: Steel and Aluminum Steel and aluminum are your primary materials for constructing the frame and various components. Steel provides strength and durability, making it ideal for the bed and other structural parts. Aluminum, being lightweight and easy to machine, is perfect for components that require precision without adding unnecessary weight. Bolts and Nuts A variety of bolts and nuts will be necessary for assembling the different parts of the CNC lathe. Ensure you have a range of sizes to accommodate different sections of the build. These fasteners will hold your frame together and secure other components, so opting for high-quality, corrosion-resistant options is advisable. CNC Control System The CNC control system is the brain of your lathe. Popular choices include Mach 3 and Acorn controllers. These systems convert your designs into precise movements of the lathe components. Mach 3 is renowned for its user-friendly interface and robust performance, making it a favorite among hobbyists and professionals alike. Pre-Fabricated Parts To save time and ensure precision, consider sourcing some pre-fabricated parts. These can include: Linear guides for smooth and accurate movement. Ballscrews for precise control of the X and Z axes. Spindle motors for driving the lathe. You can find these parts on platforms like Amazon or specialized CNC part suppliers. Additional Tools To assemble and fine-tune your CNC lathe, you'll need a set of tools, including: Wrenches and screwdrivers for tightening bolts and nuts. Measuring tools like calipers and micrometers for ensuring precision. Drilling and tapping tools for creating threaded holes. Welding equipment if you opt to weld parts of the steel frame. Summary Steel and aluminum for frame and components. Bolts and nuts for assembly. CNC control system like Mach 3. Pre-fabricated parts for precision and ease. Additional tools for assembly and calibration. Having these materials and tools on hand will set a solid foundation for your CNC lathe project. Next, we'll dive into the step-by-step guide on how to put everything together. Step-by-Step Guide on How to Build a CNC Lathe Material Gathering To start, you'll need to gather the essential materials. Steel and aluminum are crucial for constructing the frame and various components. Steel provides the necessary strength and durability, while aluminum is lightweight and easy to machine, making it perfect for precision parts. Additionally, a good variety of bolts and nuts will be required to assemble the different sections of your CNC lathe. High-quality, corrosion-resistant fasteners are advisable to ensure long-term durability. Consider sourcing some pre-fabricated parts to save time and ensure precision. These parts can include: Linear guides for smooth, accurate movement. Ballscrews for precise control of the X and Z axes. Spindle motors to drive the lathe. Frame Construction The frame construction is the backbone of your CNC lathe. Here's a quick rundown of the main components: Bed: The main base where all other components will be mounted. Steel is ideal for its strength. Spindle Stock: This holds the spindle and is crucial for accurate rotation. Tailstock Body: This supports the other end of the workpiece. X and Z Axis Slide: These slides allow the cutting tool to move accurately along the X and Z axes. Optional Y-Axis and Sub-Spindle: For more advanced setups, adding a Y-axis or sub-spindle can provide additional functionality. Installing the CNC Control System The CNC control system is the brain of your lathe. Popular options include Mach 3 and the Acorn controller. Mach 3: Known for its user-friendly interface and robust performance. Acorn Controller: Another excellent option for precise control. You'll also need a Variable Frequency Drive (VFD) for speed control and a spindle motor to drive the lathe. The VFD adjusts the spindle speed, providing flexibility for different machining tasks. Assembling the Components Now that you have your frame and control system, it's time to assemble the main components: Headstock: Holds the spindle and is mounted on the bed. Tailstock: Supports the workpiece from the other end. Tool Post: Holds the cutting tools and is mounted on the X-axis slide. Linear Guides: Ensure smooth, precise movement along the axes. Ballscrews: Provide accurate motion control for the X and Z axes. Calibration and Testing Calibration and testing are crucial to ensure your CNC lathe operates correctly. Here's a step-by-step process: Encoder: Install an encoder to provide feedback on the spindle's position. G-code Generator: Use software to generate G-code for your machining tasks. Homing to Encoder Pulse: Calibrate the machine to recognize the encoder's pulse as the home position. Threading: Test the lathe's ability to cut threads accurately. Rigid Tapping: Ensure the machine can perform rigid tapping, which involves synchronizing the spindle and feed rate precisely. By following these steps, you'll have a well-constructed CNC lathe ready for precision machining. Next, we'll dive into the key components of a CNC lathe to further improve your understanding and setup. Key Components of a CNC Lathe When building a CNC lathe, understanding its key components is crucial. Each part plays a vital role in ensuring precision and efficiency. Let's break down these components to give you a clear picture. Bed and Frame The bed is the main base of the CNC lathe. It provides stability and support for all other components. Typically made from steel, the bed must be rigid to withstand the forces during machining. A stable bed helps maintain accuracy in the machining process. Components mounted on the bed include: Spindle Stock: Holds the spindle and is crucial for accurate rotation. Tailstock Body: Supports the workpiece from the opposite end. X and Z Axis Slides: These allow the cutting tool to move accurately along the X and Z axes. Spindle and Motor The spindle is the heart of the CNC lathe. It holds and rotates the workpiece during machining. The spindle's precision directly affects the quality of the machined parts. Spindle Motor: Usually a 3HP, 3-phase motor, it drives the spindle. A powerful motor can handle tougher materials and larger workpieces without stalling. Variable Frequency Drive (VFD): Controls the spindle speed. The VFD adjusts the spindle's RPM, providing flexibility for different machining tasks. This is essential for achieving the desired surface finish and material removal rate. Control System The control system is the brain of your CNC lathe. It interprets G-code and controls the machine's movements. Acorn Controller: Known for its ease of use and precise control, this controller is a popular choice among CNC builders. Mach 3: Another robust option, Mach 3 is user-friendly and widely used in the CNC community. G-code Generator: Software that converts CAD designs into G-code, which the CNC control system uses to operate the machine. Tooling and Accessories The tooling is what actually cuts the material. Proper tooling is essential for precision machining and efficient operations. Quick Change Tool Post: Allows for rapid tool changes, increasing productivity. HSS Blanks: High-Speed Steel blanks are versatile and can be ground to create custom cutting tools. Carbide Tooling: Known for its durability and ability to maintain a sharp edge, carbide tooling is ideal for high-precision work. By understanding these key components, you can ensure your CNC lathe is built for precision and efficiency. Next, we'll explore advanced features and upgrades to take your CNC lathe to the next level. Advanced Features and Upgrades Automatic Tool Changer An Automatic Tool Changer (ATC) can significantly boost the efficiency of your CNC lathe. It allows for rapid switching between different cutting tools without manual intervention. One popular option is the passive automatic CNC tool changer, which uses a simple mechanism to swap tools quickly and accurately. Benefits of ATC: – Increased Productivity: Reduces downtime between tool changes. – Consistency: Ensures each tool is positioned accurately, enhancing precision. – Versatility: Easily switch between various operations like turning, boring, and threading. Another useful feature is the retracting dust shoe. It helps keep the work area clean by automatically retracting away from the tool path, preventing dust and debris from interfering with the machining process. High-Pressure Coolant System A high-pressure coolant system is essential for maintaining tool life and ensuring a quality finish, especially when machining tough materials. A 1000PSI pump is a powerful option that delivers coolant directly to the cutting zone, effectively removing heat and chips. Advantages of High-Pressure Coolant: – Improved Tool Life: Reduces heat buildup, which can wear out tools quickly. – Better Surface Finish: Keeps the cutting area clean, resulting in smoother finishes. – Improved Chip Removal: Prevents chips from re-cutting, which can damage the workpiece and tool. A thru-tool high pressure coolant system takes this a step further by channeling the coolant through the tool itself. This ensures that the coolant reaches the cutting edge directly, providing even more effective cooling and chip removal. Turret and Additional Axes Adding a turret to your CNC lathe can dramatically expand its capabilities. The turret holds multiple tools and rotates to bring each tool into position as needed. A Hirth coupling is often used in these turrets for precise positioning. It ensures that each tool returns to the exact same position every time, maintaining high accuracy. 4th Axis and Rotary Attachments: Incorporating a 4th axis or a rotary attachment allows for more complex machining operations. This is particularly useful for creating intricate parts that require multi-sided machining. Benefits of Additional Axes: – Complex Geometry: Enables machining of more intricate shapes and features. – Reduced Setups: Minimizes the need to reposition the workpiece, saving time and reducing errors. – Improved Flexibility: Allows for a wider range of machining operations, from simple turning to complex milling. By integrating these advanced features and upgrades, your CNC lathe can achieve higher productivity, precision, and versatility. Next, we'll answer some frequently asked questions about building and upgrading a CNC lathe. Frequently Asked Questions about How to Build a CNC Lathe How to Make a CNC Lathe Machine? Creating a CNC lathe machine involves several critical steps. Here's a simplified guide: Material Gathering: Start by collecting essential materials like steel, aluminum, bolts, and nuts. You'll also need pre-fabricated parts, which can save you time and effort. Frame Construction: Build the bed, spindle stock, and tailstock body. This forms the main structure of your lathe. The X and Z axis slides are crucial for movement, and you can optionally add a Y-axis or sub-spindle for more complexity. Installing the CNC Control System: A CNC control system like Mach 3 or an Acorn controller is necessary. This will manage the spindle motor and other components. Assembling the Components: Put together the headstock, tailstock, tool post, linear guides, and ballscrews. These parts are essential for the lathe's operation. Calibration and Testing: Use an encoder and G-code generator for precise calibration. Ensure everything is aligned and test the machine thoroughly before starting any production. Can You Build Your Own CNC Machine? Yes, you can build your own CNC machine, but it requires a strong understanding of both mechanics and electronics. Here's a brief overview: Parts: Collect all necessary parts, including the bed, spindle stock, tailstock, and X and Z axis slides. Pre-fabricated parts can be a big help. Software Installation: Install and configure the CNC control software. Mach 3 and Acorn controllers are popular choices. These will allow you to program and control the lathe. DIY Process: Follow detailed guides and community forums for step-by-step instructions. Websites like OpenBuilds offer plenty of resources. What is the Basic Structure of a CNC Lathe? Understanding the basic structure is key to building a CNC lathe. Here are the main components: Bed: The main base where all other components are mounted. It provides stability and support. Spindle Stock: Contains the spindle and spindle motor, which rotate the workpiece. Tailstock: Supports the other end of the workpiece and can be moved along the bed for different lengths. X and Z Axis Slides: These allow the cutting tool to move precisely across the workpiece. The X-axis controls the horizontal movement, while the Z-axis handles the vertical movement. By following these steps and understanding the basic structure, you can successfully build a CNC lathe machine. Next, we'll dive into the specifics of some key components you'll need for your build. Conclusion Building a CNC lathe from scratch is a complex but rewarding project. It involves gathering materials like steel and aluminum, constructing the frame, installing a CNC control system, assembling various components, and performing precise calibration and testing. This journey requires expertise in mechanics, electronics, and programming, but the result is a highly versatile machine capable of producing precision-machined parts. At TMC Technologies, we understand the intricacies involved in creating and maintaining CNC lathes. Our expertise in CNC precision machining ensures that every part we produce meets the highest standards of quality and accuracy. Custom Applications Every machining project has unique requirements. Whether you're in aerospace, automotive, or medical manufacturing, we tailor our solutions to meet your specific needs. Our team excels in custom tool design, ensuring each tool optimizes performance and durability. Tool Design and Fabrication Services Beyond tool design, we offer comprehensive fabrication services. From grinding and heat treating to light assembly, we provide a one-stop solution for all your CNC needs. Our advanced CNC machines and skilled machinists ensure every part we produce is of the highest quality. Choosing TMC Technologies means partnering with a company committed to pushing the boundaries of precision machining. We invite you to explore our capabilities to see how we can help you achieve unparalleled success in your projects. In the field of precision machining, every detail matters. Let us help you ensure that your work not only meets but exceeds expectations. With TMC Technologies, open up the full potential of high-precision CNC lathes and propel your business towards success. By leveraging our expertise and dedication to innovation, you can trust TMC Technologies to support your operations and deliver precision-machined parts that meet the highest standards. On: June 14, 2025 Posted in DIY CNC & Hobbyist Builds Comments: 0 Views: 66 cnccode Build your own CNC machine at home! Explore the best DIY CNC router, laser, plasma, and 3D printer build guides for hobbyists in 2025. Step-by-step plans, BOMs, electronics, and firmware tips for beginners and experts. Building your own CNC machine is more accessible than ever in 2025. With open-source hardware, affordable components, and a growing community of makers, anyone can build a CNC router, laser cutter, or even a 5-axis machine from home. This guide covers top DIY CNC projects, key design considerations, and where to find plans, kits, and support. Save money vs. prebuilt machines Customize size, features, and performance Learn CNC principles deeply Build skills in electronics, firmware, and mechanics The most popular hobby CNC build. Great for woodworking, plastics, foam, and light aluminum. Common sizes range from 300x300mm to 1000x1000mm. Control: Arduino + GRBL / ESP32 + FluidNC / Raspberry Pi + CNC.js Motors: NEMA17 or NEMA23 stepper motors with TB6600 or TMC drivers Structure: V-slot aluminum extrusion, MDF, or steel frame Spindle: Trim router or 500W–2.2kW spindle with ER11 collets Uses a diode or CO_2 laser to cut or engrave wood, acrylic, leather, and more. Laser Type: Diode (5W–20W) or CO_2 (40W+) Frame: CoreXY or Cartesian with belts and rails Safety: Use laser goggles, enclosures, and proper ventilation! For metal cutting on a budget. Requires careful grounding and electrical safety. Controller: THC (torch height control) recommended Frame: Steel gantry with linear rails Software: LinuxCNC or Mach3 with plasma post-processor Projects like V1 Engineering's LowRider CNC and Mostly Printed CNC use 3D printed parts and conduit pipe or rails. Budget-Friendly: Under $500 for a full build Flexible Sizes: Expandable to full sheet cutting Community Support: Active forums and upgrade paths Upgrade an existing manual machine to CNC using stepper motors and ball screws. Popular Conversions: Sieg X2, Harbor Freight Mini Mill, Atlas lathes Software: Mach3, LinuxCNC, PathPilot Arduino Uno / Mega or ESP32 (GRBL / FluidNC firmware) Stepper drivers (TMC2209, TB6600, DM542) Power supply (12V/24V, depending on motors) Limit switches, emergency stop, and probe inputs Stepper motor cables with shielded wiring CAD/CAM: Fusion 360 (free for hobbyists), FreeCAD, Carbide Create, Vectric Control: Universal Gcode Sender, CNCjs, OpenBuilds CONTROL Firmware: GRBL, FluidNC, Marlin (3D printer CNC mode) V1 Engineering – MPCNC and LowRider OpenBuilds – Modular CNC parts and forums GRBL GitHub – Firmware for Arduino CNC CNCZone – Active DIY CNC community Always use proper grounding and fuses Keep all stepper and power wiring shielded Use an enclosure for dust and debris Never leave the machine running unattended Frame and rails: $100–$200 Spindle and VFD: $80–$200 Stepper motors + drivers: $100 Controller board: $30–$50 Power supply and accessories: $50 Total: ~$350–$600 depending on build quality DIY CNC building is one of the most rewarding maker experiences. Whether you want to make signs, circuit boards, metal parts, or art—there's a CNC project for every hobbyist in 2025. Follow build plans, take safety seriously, and you'll have a powerful machine running in no time. For more DIY CNC ideas and tutorials, visit cnccode.com. Share This Article Are you interested in building your own CNC lathe? With the right tools and knowledge, it's possible to create a high-quality machine that can handle a variety of tasks. But where do you start? First, it's important to understand the basic components of a CNC lathe and how they work together. From there, you can begin gathering materials and designing your machine. Whether you're a seasoned DIYer or just starting out, building a CNC lathe can be a rewarding and challenging project that yields impressive results. So let's get started! How to Build a CNC Lathe: A Comprehensive Guide If you are interested in building a CNC lathe, you are in the right place. In this article, we will guide you through the process of building your own CNC lathe from scratch. We will cover everything from selecting the right components to assembling and testing your machine. So, let's get started! 1. Selecting the Components The first step in building a CNC lathe is to select the right components. You will need a spindle motor, a stepper motor, a lead screw, linear guides, bearings, and various other mechanical and electrical components. You should choose high-quality components that are compatible with each other to ensure the best performance. When selecting components, consider the size of the lathe you want to build and the materials you will be cutting. You should also consider your budget and the level of complexity you are comfortable with. 2. Designing the Lathe Once you have selected your components, you need to design your lathe. You can use software like AutoCAD or SolidWorks to create a 3D model of your lathe. This will help you visualize the machine and identify any potential issues before you start building. Read More: How To Change Spindle Speeds In CNC Lathe?You should also consider the size of the lathe, the cutting capacity, and the number of axes you want to control. The design should be flexible enough to accommodate any future upgrades. 3. Building the Frame The frame is the foundation of your lathe. You can build the frame using steel or aluminum extrusions, or you can weld your own frame using steel tubing. The frame should be sturdy and rigid to ensure accuracy and repeatability. You can use a CNC plasma cutter or a bandsaw to cut the frame components. Once you have the components, you can weld or bolt them together according to your design. 4. Assembling the Mechanical Components Once you have the frame, you can start assembling the mechanical components. You should mount the spindle motor, stepper motor, lead screw, linear guides, and bearings according to your design. You should also install the tool post, tailstock, and chuck. Make sure everything is aligned and tightened properly. 5. Wiring the Electrical Components The next step is to wire the electrical components. You will need to connect the stepper motor drivers, power supply, limit switches, and other electrical components according to the wiring diagram. You should also install the control board and connect it to your computer. Make sure everything is properly grounded and insulated. 6. Configuring the Software Once everything is wired up, you need to configure the software. You can use software like Mach3 or LinuxCNC to control your lathe. You will need to configure the software to match your lathe's specifications. You should also calibrate the machine to ensure accurate positioning and motion control. 7. Testing the Machine Before you start cutting, you need to test the machine. You should run a test program to check the machine's accuracy and repeatability. You should also test the machine's limits and make sure everything is working as expected. If you encounter any issues, you should troubleshoot and fix them before proceeding. 8. Adding Accessories Once you have a working lathe, you can add accessories to enhance its functionality. You can add a coolant system, a tool changer, or a workpiece probe. You can also add a protective enclosure to improve safety. 9. Benefits of Building Your Own CNC Lathe Building your own CNC lathe has several benefits. You can save money compared to buying a pre-built machine. You can also customize the machine to match your specific needs. Building your own machine is also a great learning experience. Read More: How To Input Program Into CNC Lathe?10. Conclusion Building a CNC lathe is a rewarding project that requires careful planning and attention to detail. By following the steps outlined in this article, you can build your own CNC lathe and enjoy the benefits of having a custom machine. Frequently Asked Questions Building a CNC lathe can be a challenging but rewarding task. Here are some common questions and answers that can help you get started. What is a CNC lathe? A CNC lathe is a machine tool that rotates a workpiece while a cutting tool is moved along various axes to create a symmetrical object. CNC lathes use computer-controlled systems to automate the cutting process, resulting in precise and repeatable parts. Building a CNC lathe requires a solid understanding of mechanical and electrical engineering principles. You will need to choose the right components, such as stepper motors and linear guides, and assemble them into a sturdy frame. You will also need to program the lathe's control system, which can be a complex task. What are the benefits of building a CNC lathe? Building a CNC lathe can be a great way to learn about machine design and gain hands-on experience with computer-controlled systems. It can also save you money compared to buying a pre-built machine, and give you the flexibility to customize the lathe to your specific needs. Additionally, a well-built CNC lathe can help you produce high-quality parts with tight tolerances, which can be useful for a variety of applications. What components are needed to build a CNC lathe? There are several key components that are needed to build a CNC lathe, including a sturdy frame, stepper motors, linear guides, a spindle motor, and a control system. The frame should be made of a rigid material, such as aluminum or steel, and should be designed to minimize vibrations. The stepper motors and linear guides will control the movement of the cutting tool along the various axes, while the spindle motor will rotate the workpiece. The control system will allow you to program the machine's movements and adjust its settings as needed. It's important to choose high-quality components that are compatible with each other and will work well together. You may also need additional tools and equipment, such as a CNC controller and software, to assemble and operate the lathe. Read More: How Does A CNC Lathe Machine Work? How do I program a CNC lathe? Programming a CNC lathe can be a complex task that requires a solid understanding of computer programming principles. You will need to choose a programming language, such as G-code, and create a series of commands that tell the machine how to move the cutting tool along the various axes. You will also need to set the lathe's parameters, such as feed rates and spindle speed, to ensure that it operates correctly. There are many resources available online that can help you learn how to program a CNC lathe, including tutorials, forums, and software packages. It's important to take your time and carefully test your programs before running them on the machine to avoid damaging the lathe or producing faulty parts. What safety precautions should I take when building and using a CNC lathe? Building and using a CNC lathe can be dangerous if proper safety precautions are not taken. When building the lathe, be sure to wear appropriate personal protective equipment, such as safety glasses and gloves, and follow all manufacturer's instructions. When using the lathe, be sure to keep your hands and clothing away from moving parts, and avoid wearing loose clothing or jewelry that could get caught in the machine. It's also important to keep the lathe clean and well-maintained, and to regularly inspect the components for signs of wear or damage. Never leave the lathe unattended while it is running, and be sure to turn off the power and unplug the machine before making any adjustments or repairs. In conclusion, building a CNC lathe is a challenging but rewarding process that requires a lot of hard work and dedication. With the right tools and resources, anyone can learn how to create a machine that can produce high-quality parts with precision and accuracy. One of the key factors to keep in mind when building a CNC lathe is to make sure that you have a solid understanding of the principles of machining and programming. This will enable you to create a machine that can handle a wide range of materials and produce parts that meet your exact specifications. Finally, it's important to remember that building a CNC lathe is not a one-time event. It's an ongoing process that requires continuous learning and improvement. By staying up-to-date with the latest advancements in technology and refining your skills over time, you can create a machine that will serve you well for many years to come. [contact-form-7 id="1578" title="Contact form"] Please compress the file into a ZIP or RAR file before uploading. Alternatively, send through your RFQ by email. enquires@unitymanufacture.com