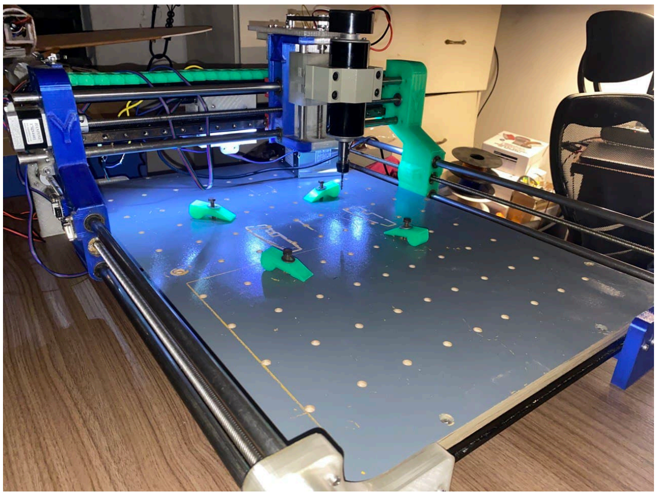
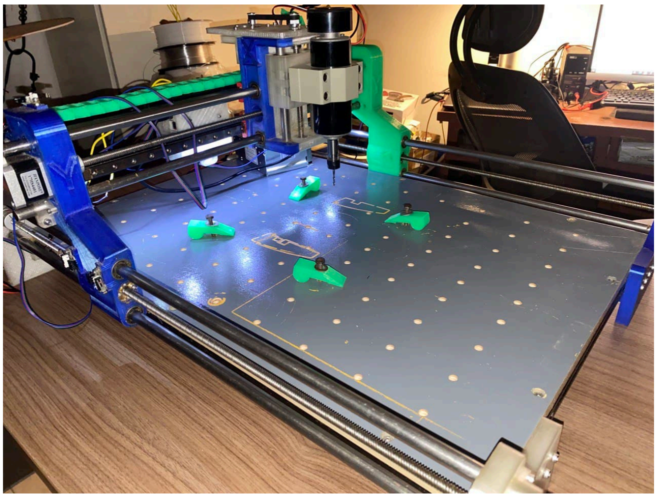
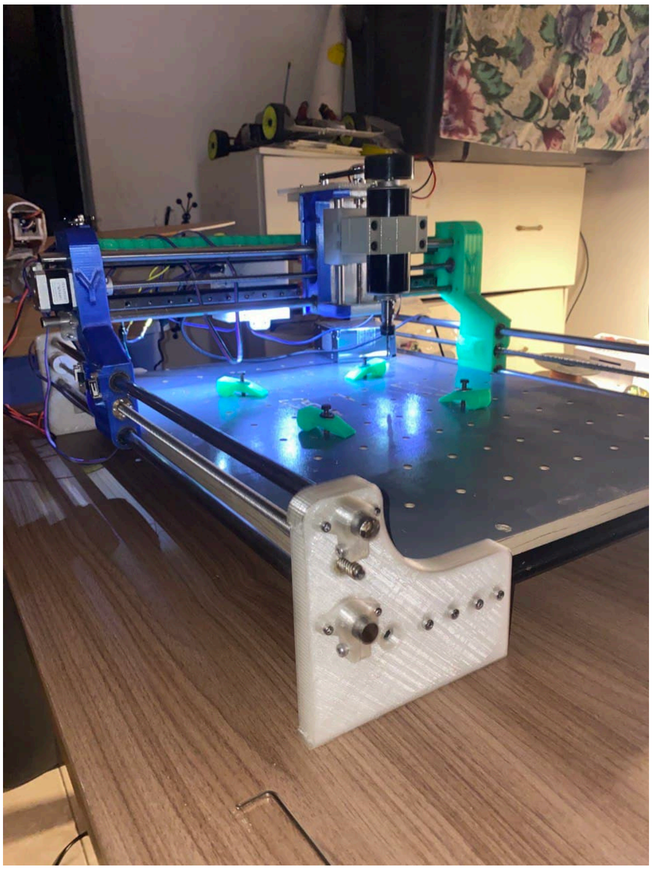
DIY 3D Printed CNC







STEP 1: Parts

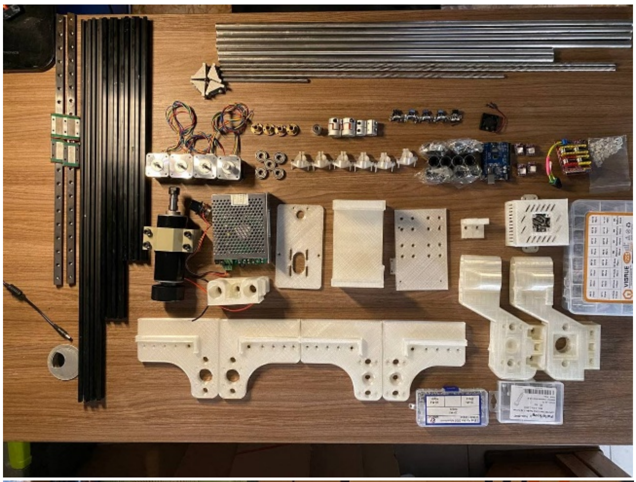
Here you can find an Excel sheet with all the parts, quantities, and various links. Below you can find a complete list of everything we need.

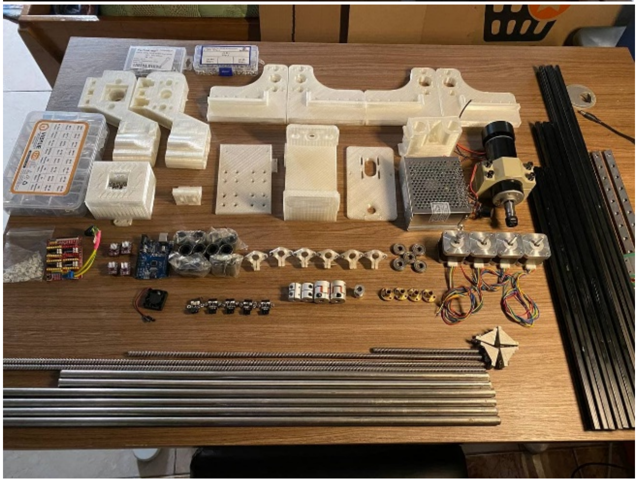
Mechanical Components:

- Aluminum profiles 20x20mm 700mm long (X2)
- Aluminum profiles 20x20mm 540mm long (X2)
- Aluminum profiles 20x20mm 445mm long (X2)
- 12mm rod 750mm (X2)
- 12mm rod 600mm (X2)
- 12mm rod 143mm (X2)
- Lead screw 725mm (X2)
- Lead screw 515mm (X1)
- Lead screw 160mm (X1)
- 12mm linear bearing (X12)
- 5mm – 8mm Coupler (X3)
- 608zz bearing (X4)
- Pack of T nut M2, M3, M4, M5(X1)
- Pack of M2, M3, M4, M5, M6 x 25mm screws (X1)
- 200 2-GT timing belt
- 16T GT2 timing belt pulley 5mm bore.
- 20T GT2 timing belt pulley 8mm bore.

Electronics components:

- Nema 17 1.7A Stepper motors (X4)
- Arduino CNC shield (X1)
- Stepper drivers (A4988 or DRV8825) (X4)
- Arduino (X1)
- 12V 3A or >3A Power supply (X1)
- DC connector (X1)
- Jumpers (X14)
- Machifit 500W spindle 110-240V power supply unit.
- 500W Spindle or 775 DC motor (X1)





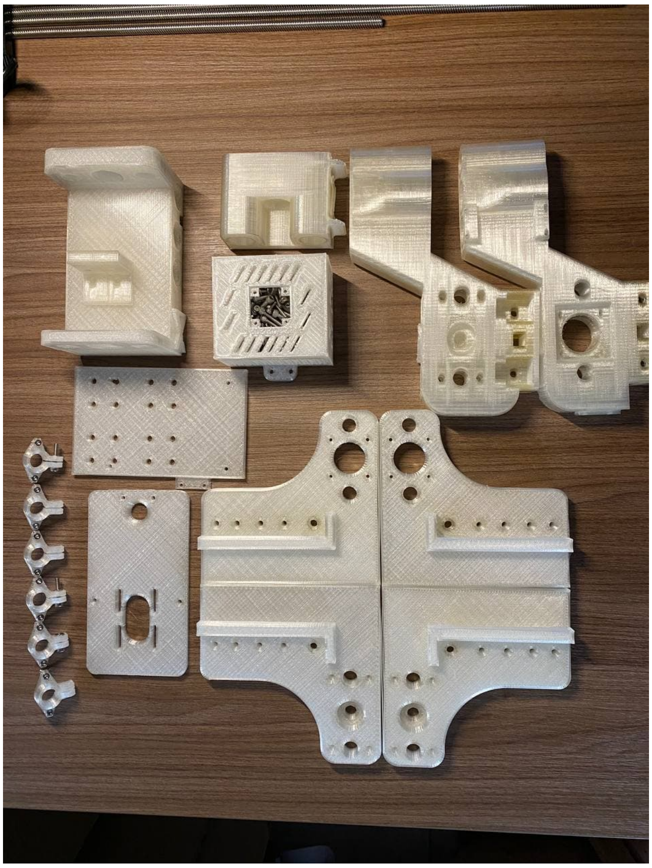
Step 2: 3D Printing

3D printed parts are very important in this project so I would like to talk more about how to print and postprocess them.

A lot of people may say that it is extremely important to keep infill super high but from what I noticed using very high infill does not help a lot, of course, there is nothing wrong with using high infill but in my opinion infill of about 20-50% is fine. Perimeters should be a minimum of 5 layers which has a bigger effect on strength and gives the material the strength needed as opposed to infill percentage.

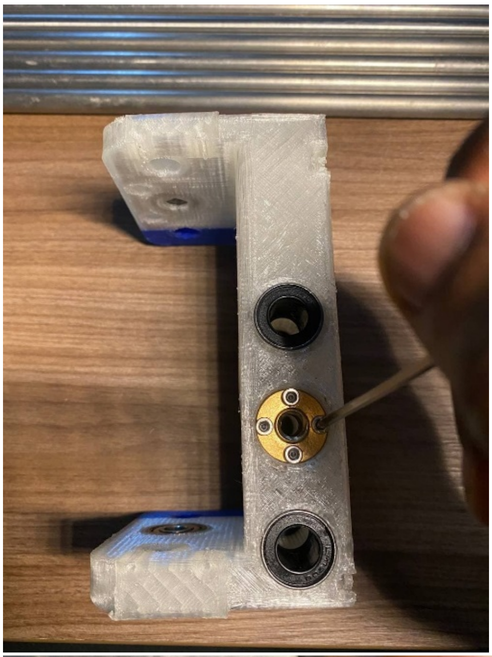
I printed all my parts with **PLA** but it is better to print them with **PETG** cost of PETG is almost the same and both of them are easy to print but PETG is a little bit more flexible so it's harder to break it.

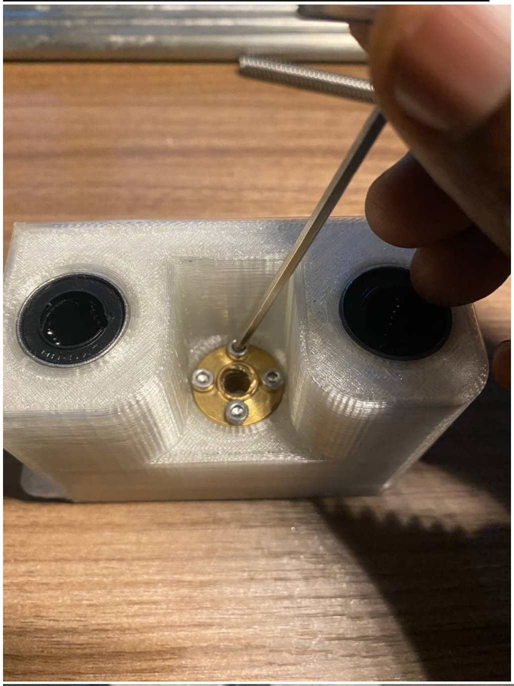
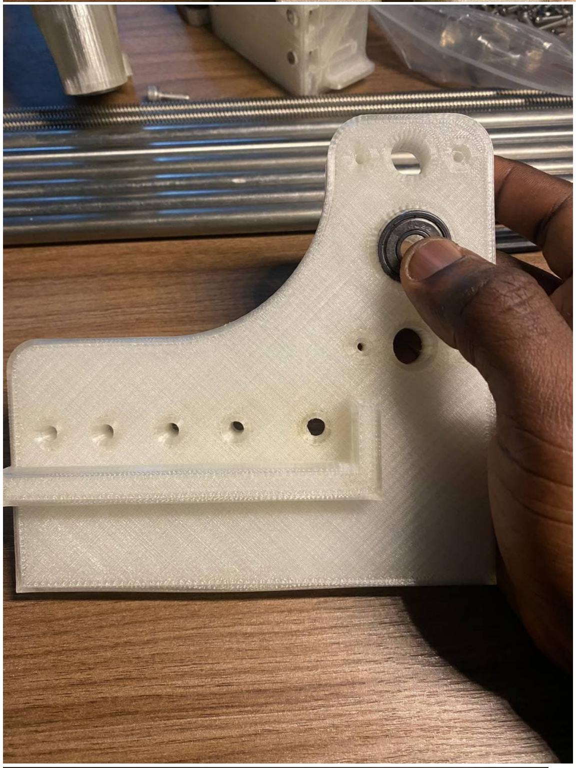
For some of the 3D models, you need to use supports, make sure to put them in the proper orientation so that there is not a lot of support material to remove and that you are able to remove it.

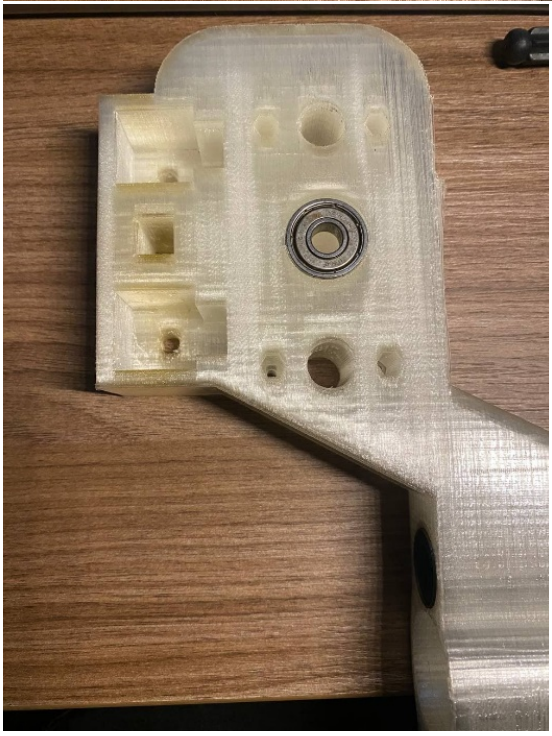


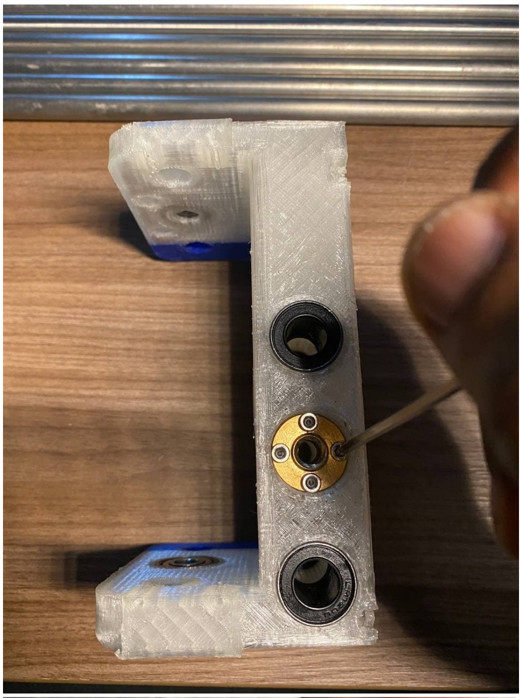
Step 3: Prepare for Assembly

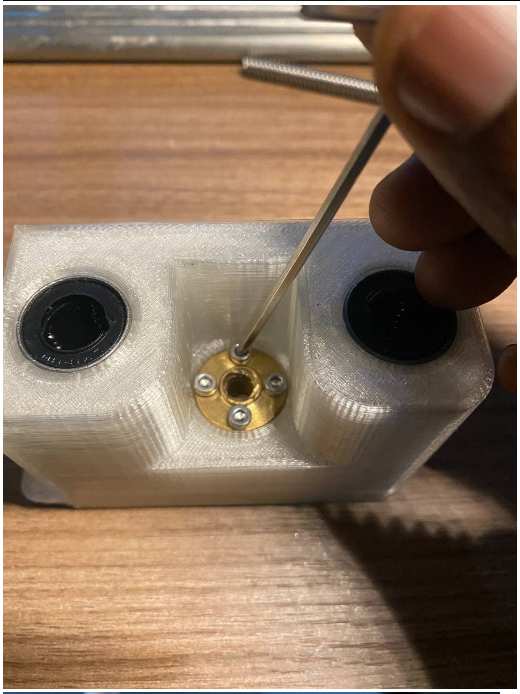
Before assembling all the components, you may need to cut them to the proper length. If you have access to a miter saw use it to cut aluminum profiles that way you will have a perfectly straight edge of cut. I found those rods and lead screws impossible to cut with a hand saw so you need to use an angle grinder to do that. At this point, it is also a good idea to put in place all the bearings. I did it using a small vise, as I said depends on the quality of your 3D prints you may need to sand those slightly be careful because you do not want to break any part :)



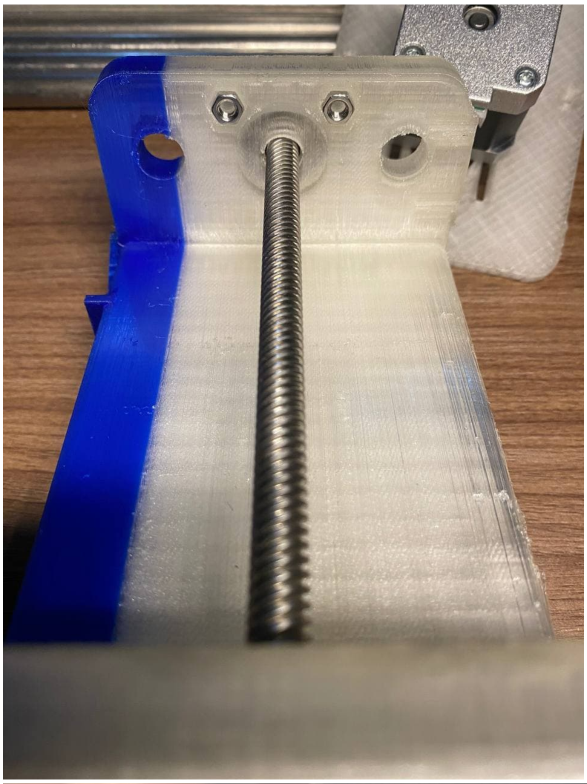
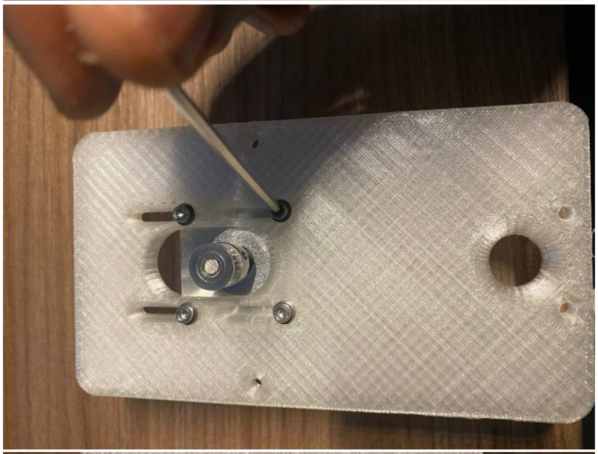
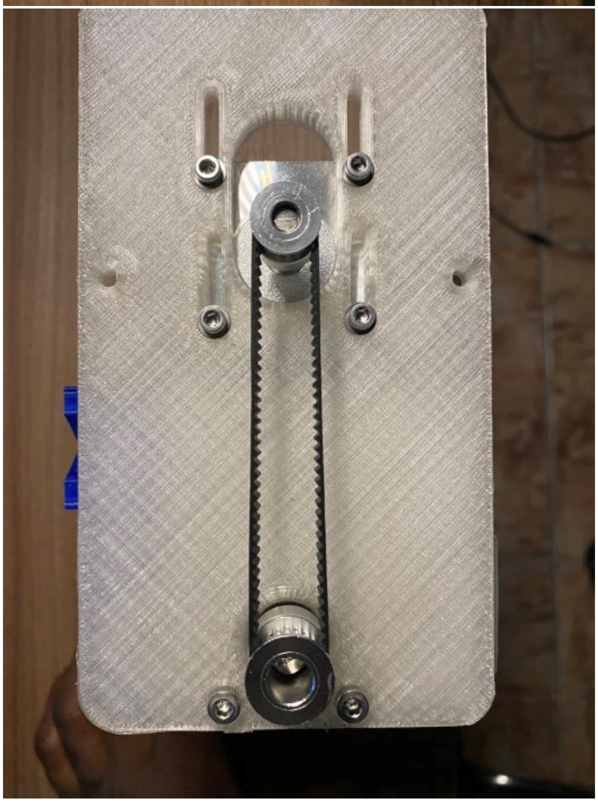
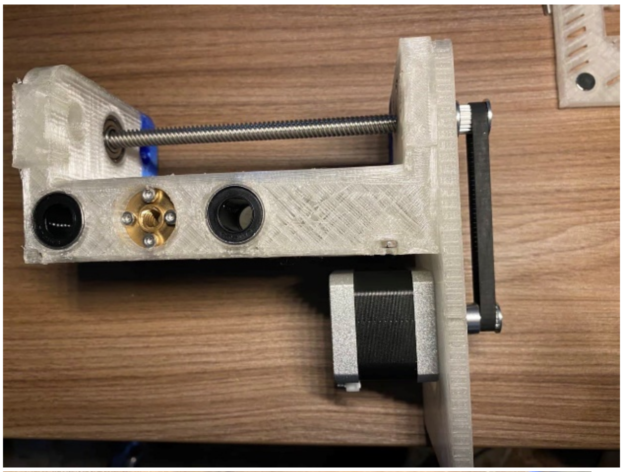
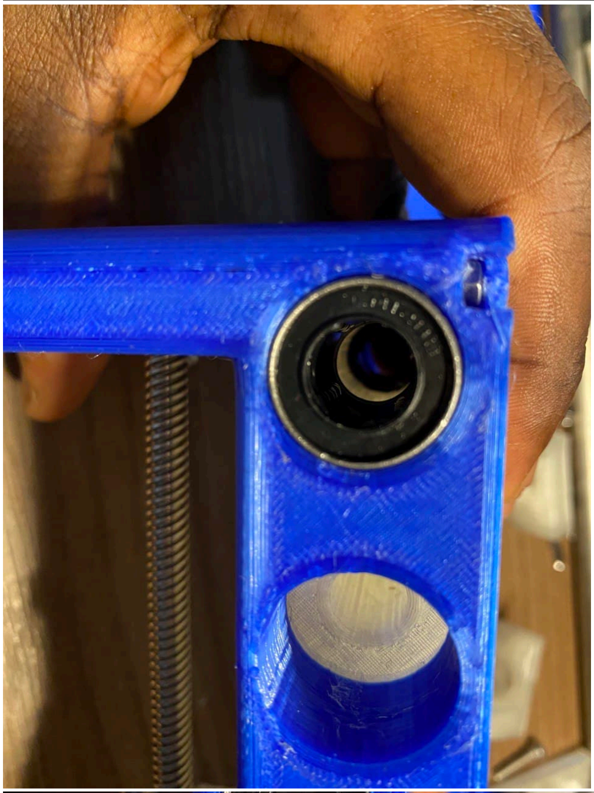
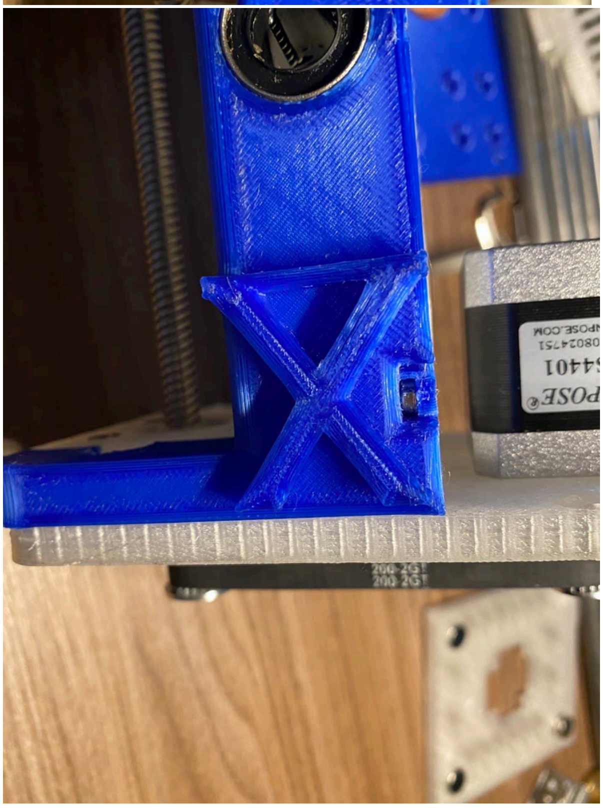


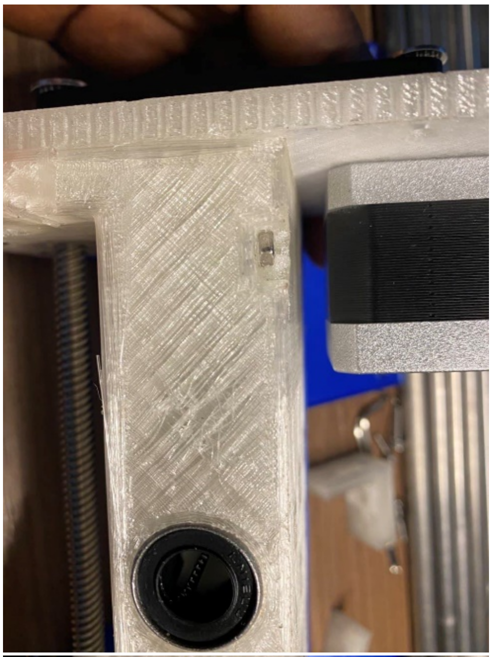


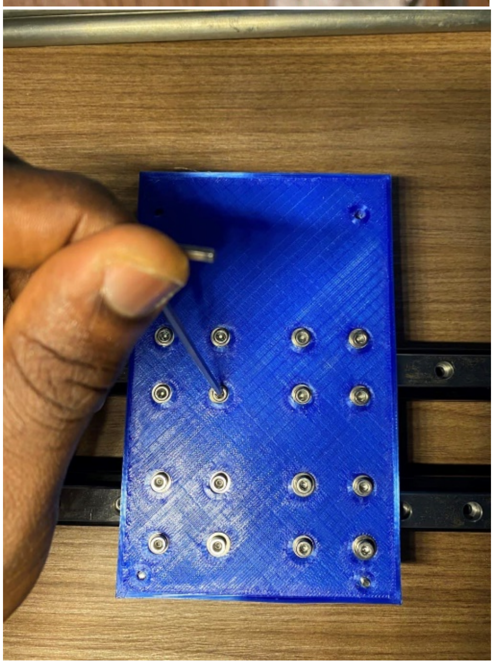
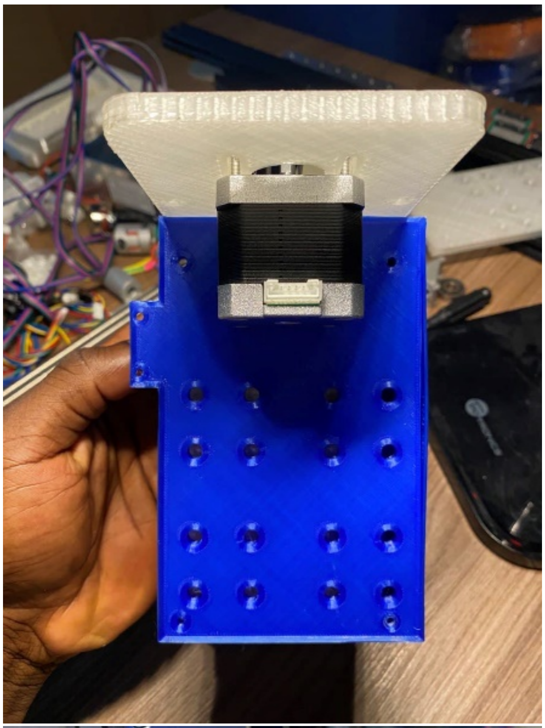
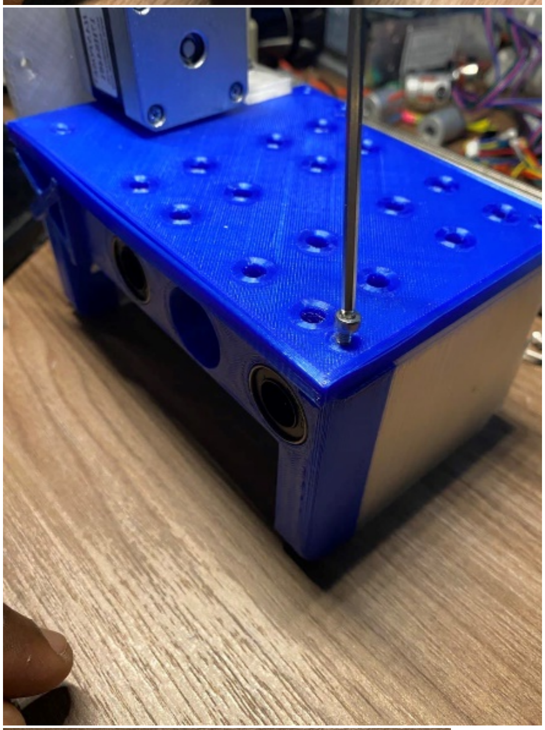
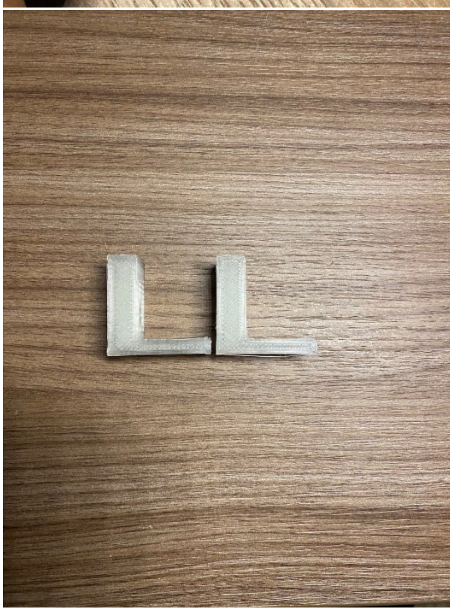


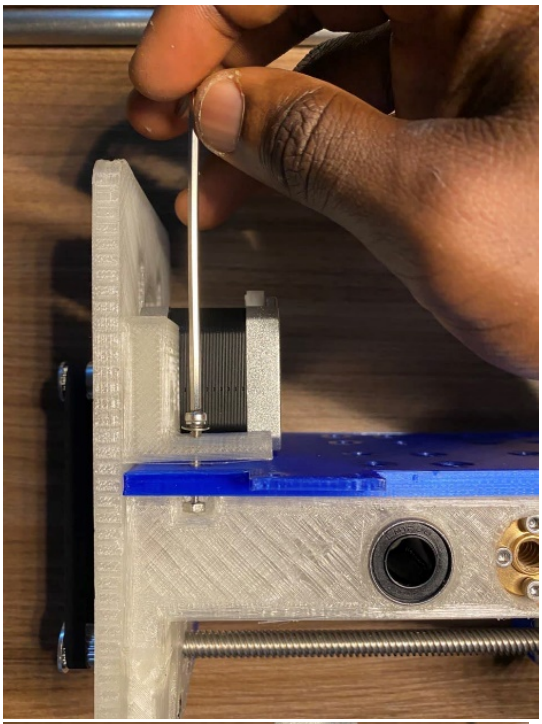
Step 4: Z Axis

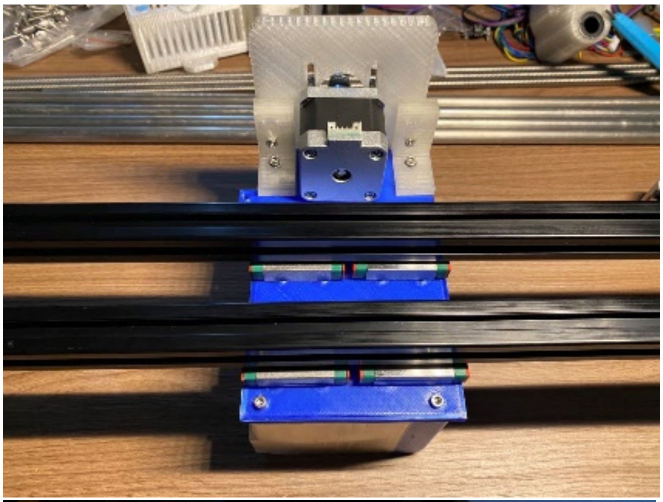
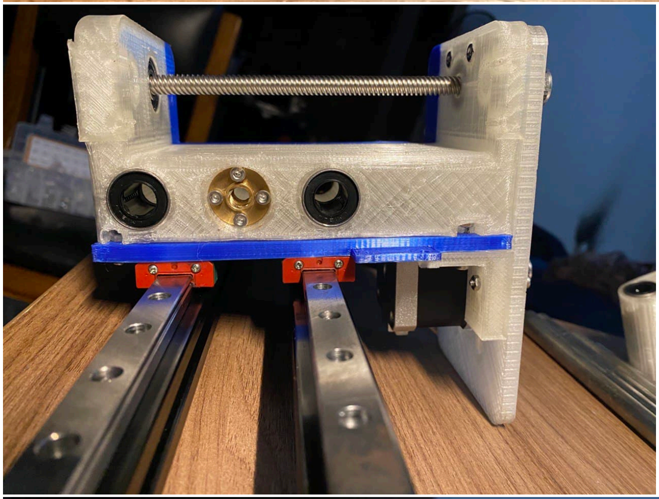
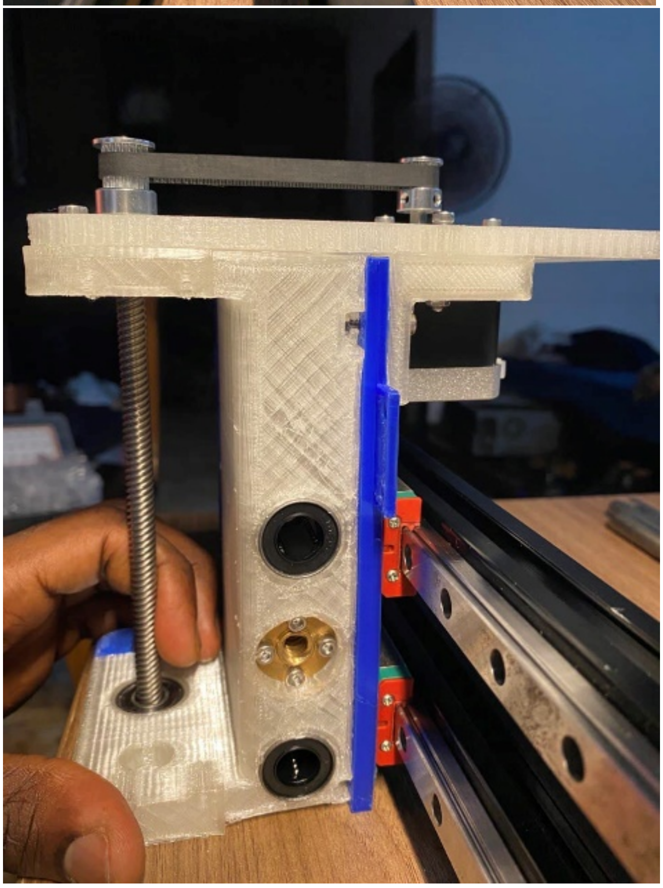
To make things easier we will start with the assembly of the Z axis. Put two rods in Z-axis carriage but not all the way through because we will put the 500W spindle holder too. 500W spindle holder should move freely on the linear bearings. 608zz bearings should be already in place in the hole on the bottom and top of Z-axis carriage. Now we can install a stepper motor with a lead screw, 16T & 20T GT2 pinion. Fix the motor with M3 screws and make sure that both rods are secured at the bottom. To make it easier for further use point the stepper motor connector backward because that is where we will install electronics.



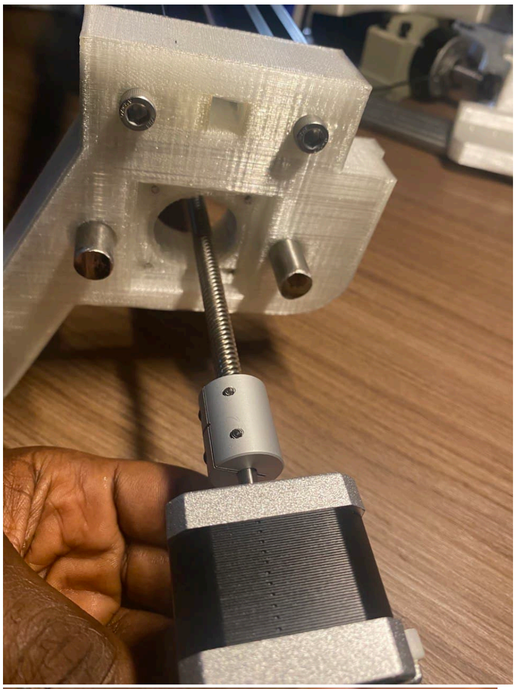





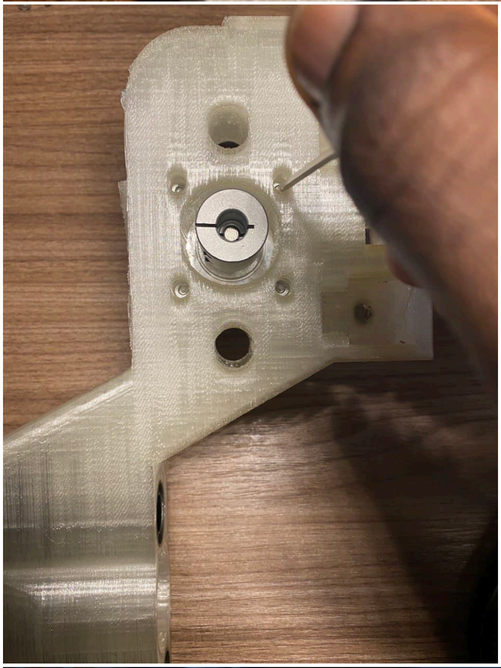


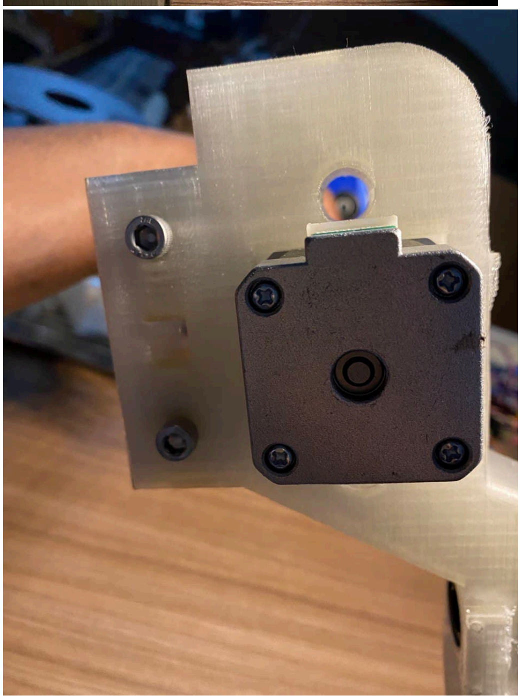




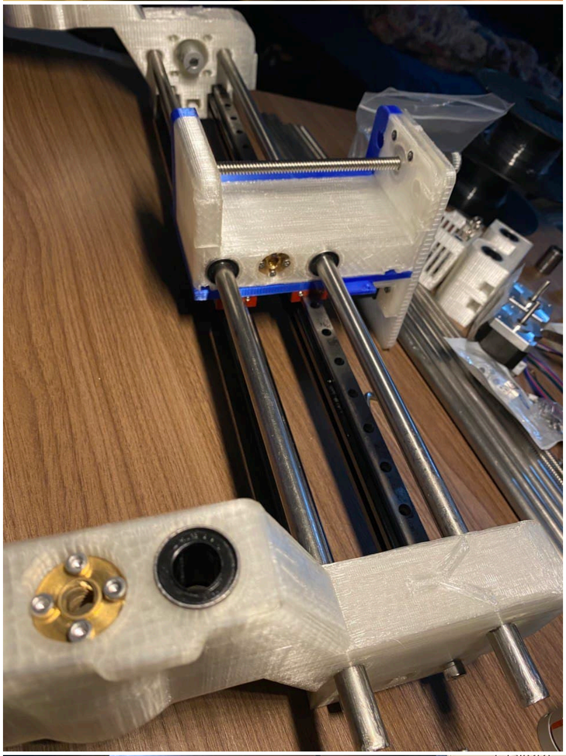
Step 5: X Axis

Tighten brass nuts to both 3D printed parts. Grab one of the X-axis carriages and join two rods to it. Then put a Z-axis carriage on those rods and close with the other X-axis carriage on the opposite side. Attach a motor with a lead screw to 3D printed part with M3 screws.



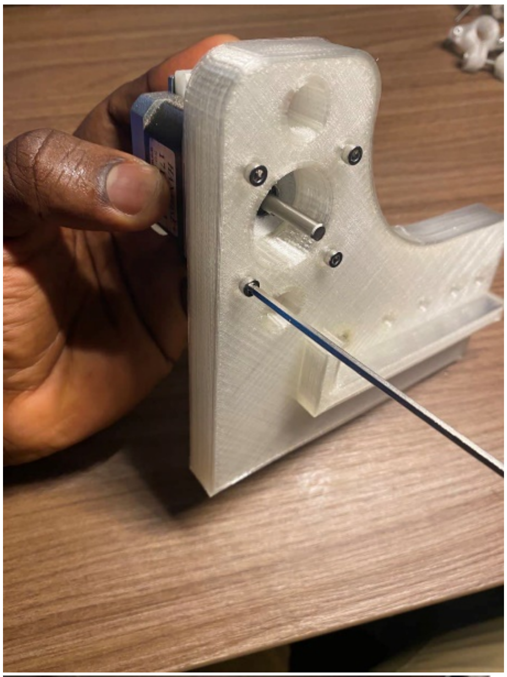
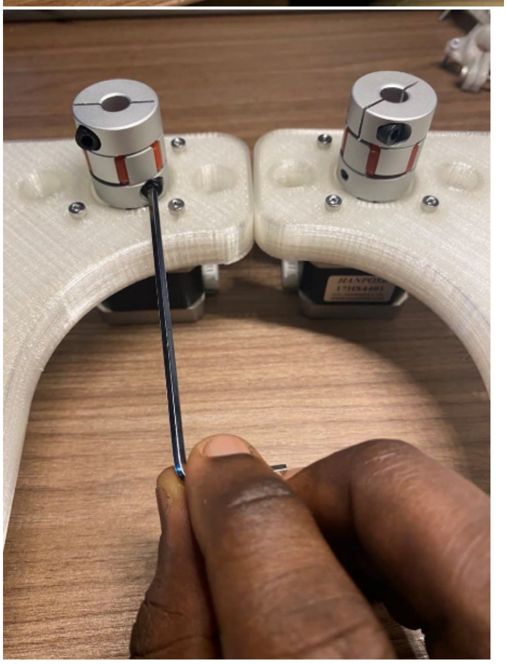


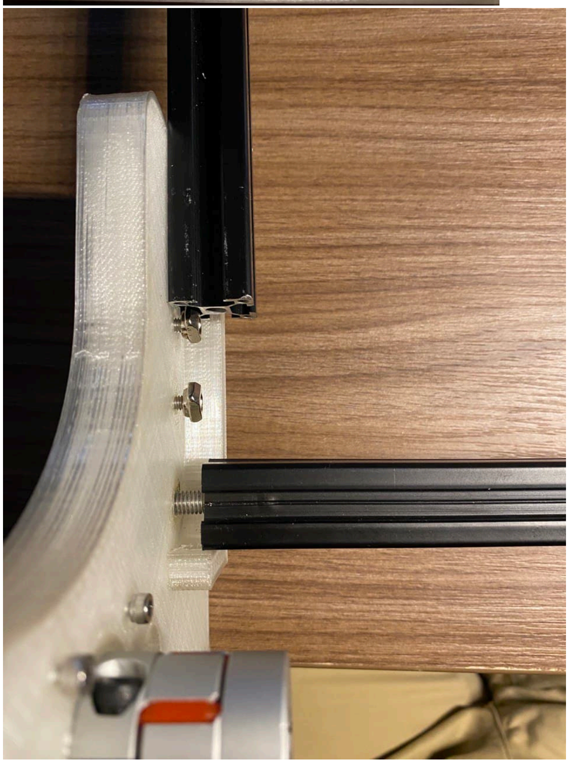
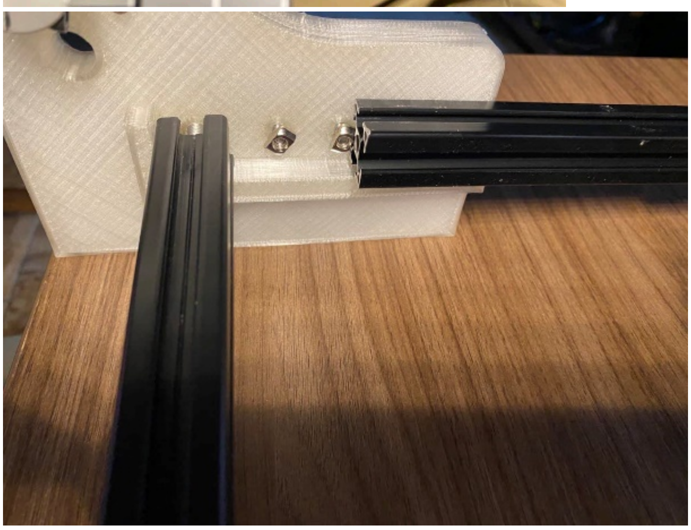


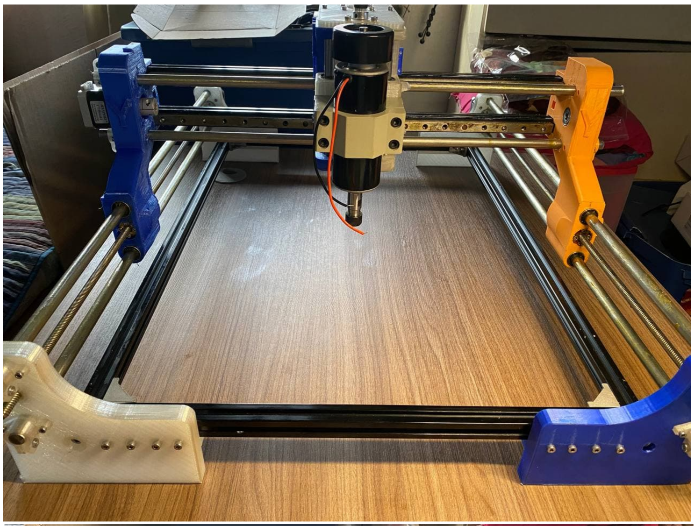


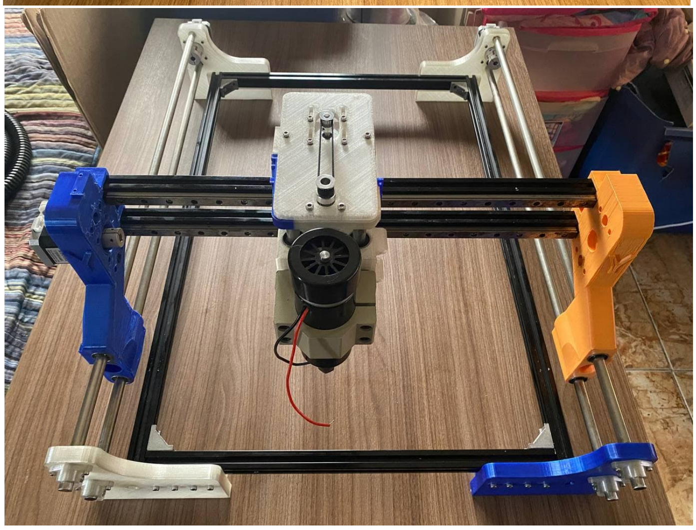
Step 6: Y Axis and Aluminum Frame

Y-axis is directly connected to the main frame of this machine. It is made of 20x20mm aluminum extrusion profiles connected with screws to ensure rigidity. I choose 20x20mm profiles because those are easy to get, inexpensive and it dictates the size of this machine. Once you have profiles cut to a length that you want, we can start drilling holes. We need to drill holes on the ends of longer profiles. On both ends of 6 aluminum profiles, we must make a thread with a tap. It is a good idea to pre-drill a hole for the tap with 5.2mm drill bit and then create an M6 thread. Let us start by attaching stepper motors to 3D printed parts with M3 screws. We can also fix couplers to the motors. You can slide the 3D printed part with a motor on to the longer aluminum profile. On the other side, you can fix a shorter profile as shown on the pictures. Tighten the screws. Also, do not forget to tighten an M6 screw on the side of the longer aluminum profile. Do the same on the other side. We already installed Y-axis motor supports and lead screw support, right now we must attach the lead screws and Y-axis rods. It is time to connect the X axis with the Y-axis, grab the X-axis (with Z-axis already installed) and put it on the rods and lead screws, you will have to rotate lead screws with your fingers to push the X-axis back a little bit.

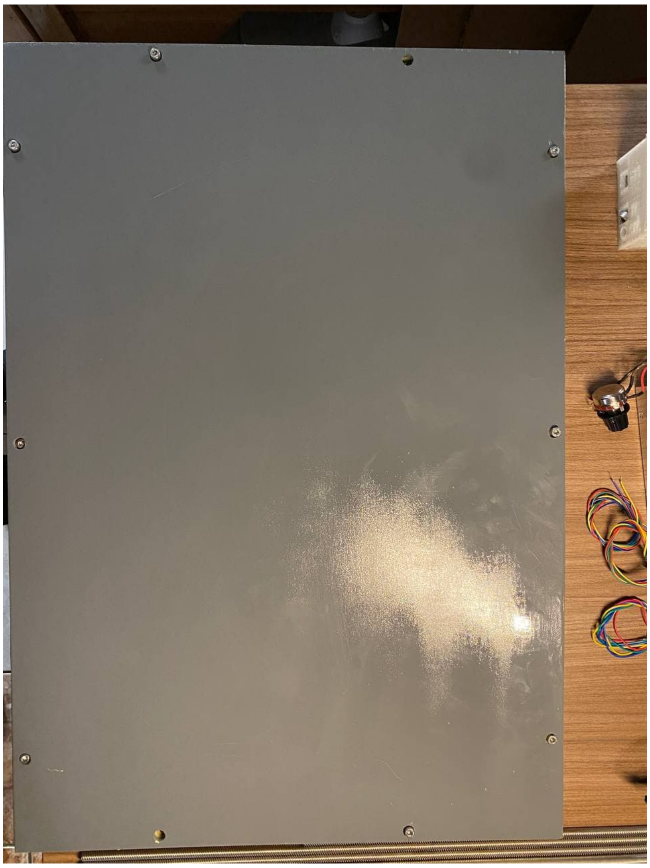


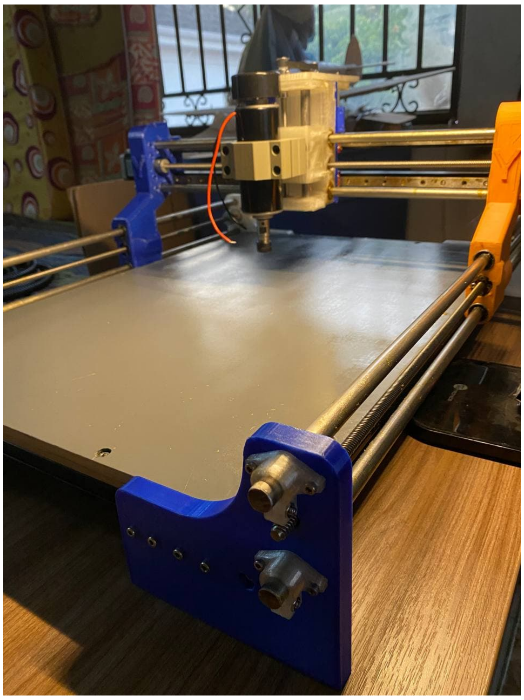


Step 7: Table

I had to find something that would be good cutting table bed for the CNC. A table with slots would be great and it is expensive. I could make it out of aluminum plate or even steel but that's hard to cut (especially to cut it straight with an angle grinder). As most of us (makers) I do not have a huge CNC plasma, waterjet or laser that can cut such materials but I have a jigsaw so I can make it out of plywood. I finally decided to use a table saw to cut it straight, but corners should be cut with jigsaw or handsaw. Plywood is strong enough, it is easy to cut, and you can easily buy it anywhere, so it seems to be a perfect choice. With another 3D printed tool, I drilled holes on the edge of this plywood to attach it to an aluminum frame with M5x10mm screws and hammer nuts. I also added threaded inserts to the table so that I can use M5 screws to attach material to the table of CNC. You can buy something like this online, you need to drill a hole and put it in place with a hammer, simple and cheap upgrade that is useful.

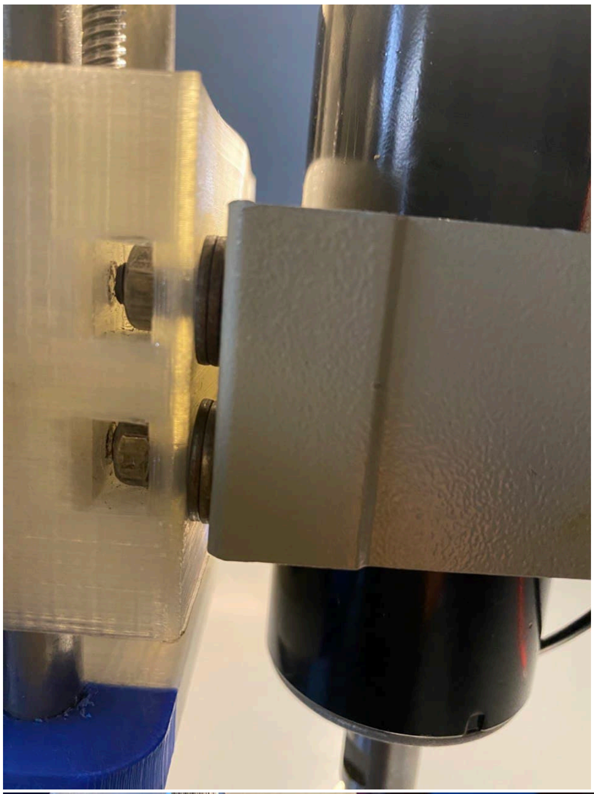
Waste board - a piece of material that you can mill in when you mill all the way through the material, and you do not want to destroy table of your CNC. It should be replaced after some time.

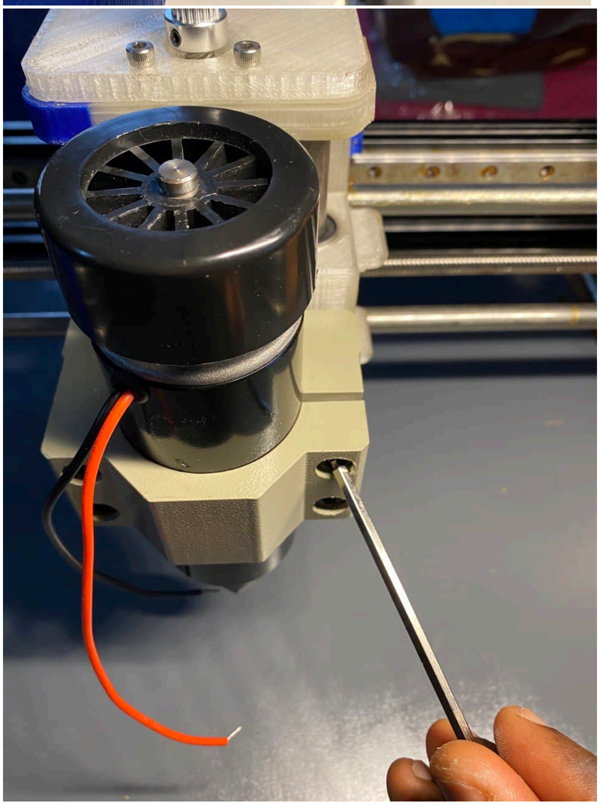




Step 8: Spindle

Unscrew the top plate which the Z axis stepper motor is attached to and pull out both 143mm long steel rods (12mm diameter) if already installed. Now insert the spindle motor carriage and slide the 143mm rods from the top through the bearings of the spindle carriage all the way to the bottom of the Z axis carriage. Screw back the top Z stepper motor plate and bolt the spindle motor holder to the 3D printed spindle carriage.





Step 9: Install GRBL

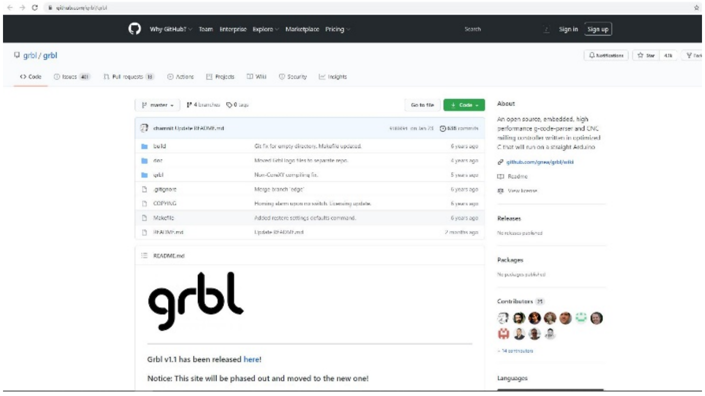
We will need an Arduino with a USB cable and software that you can download here: https://github.com/grbl/grbl. Once you have a .ZIP file downloaded from a link above you can add to Arduino IDE as a library. Go to file examples and open an example from GRBL tab. You should see just one line of code, nothing more, that is ok. Connect Arduino to the computer and upload a program just like any normal program. And that is it GRBL is installed on Arduino, you do not have to modify any code. If you have problems with this step, try to google "how to install GRBL on Arduino" you will and tons of tutorials on how to do that and how to troubleshoot your problems. There is also one thing to change, you can do this through the serial monitor in Arduino IDE or console in CNCjs. All we must do is send 3 simple commands:

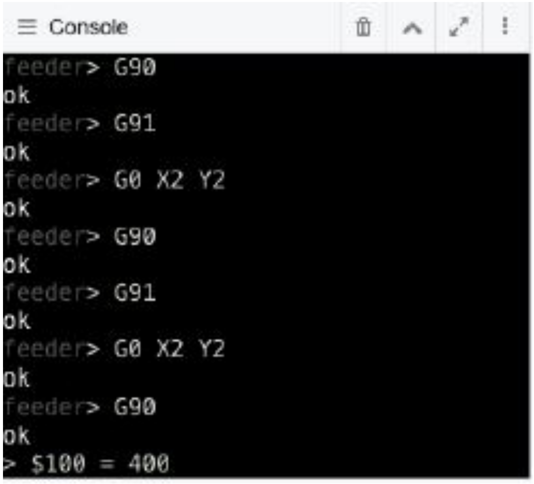
$100 = 400

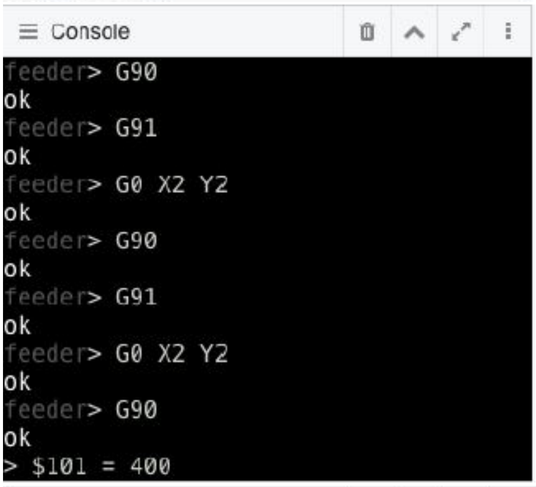
$101 = 400

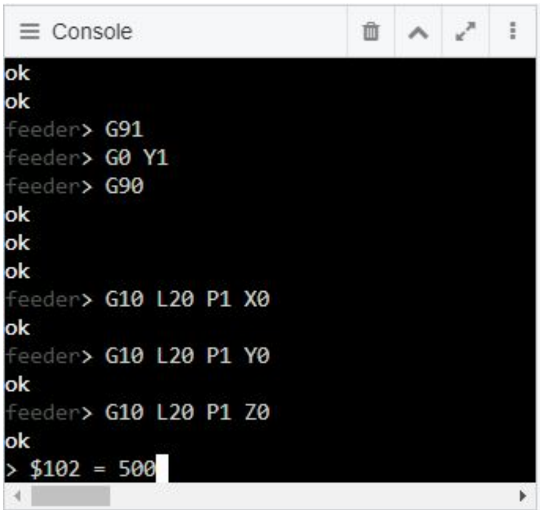
$102 = 500

Send those commands separately. Depends on the resolution of your stepper motors and micro stepping that you used you may need to use a different value than 400.





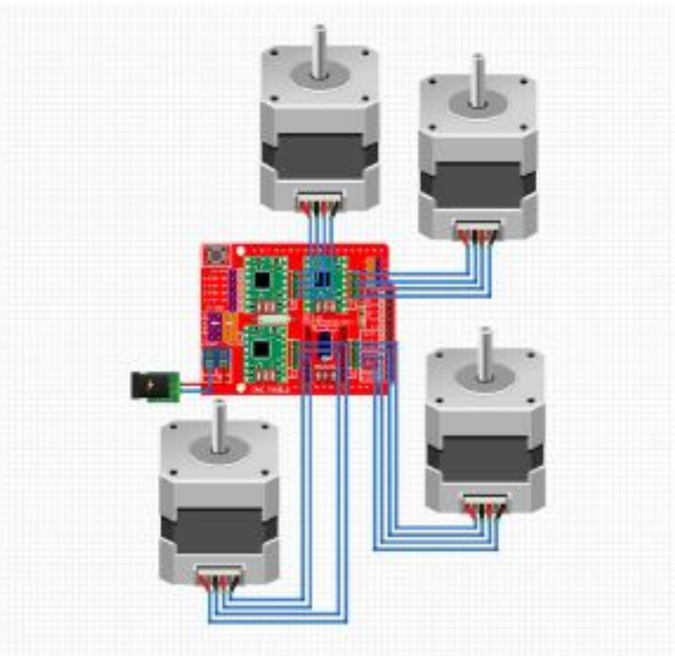


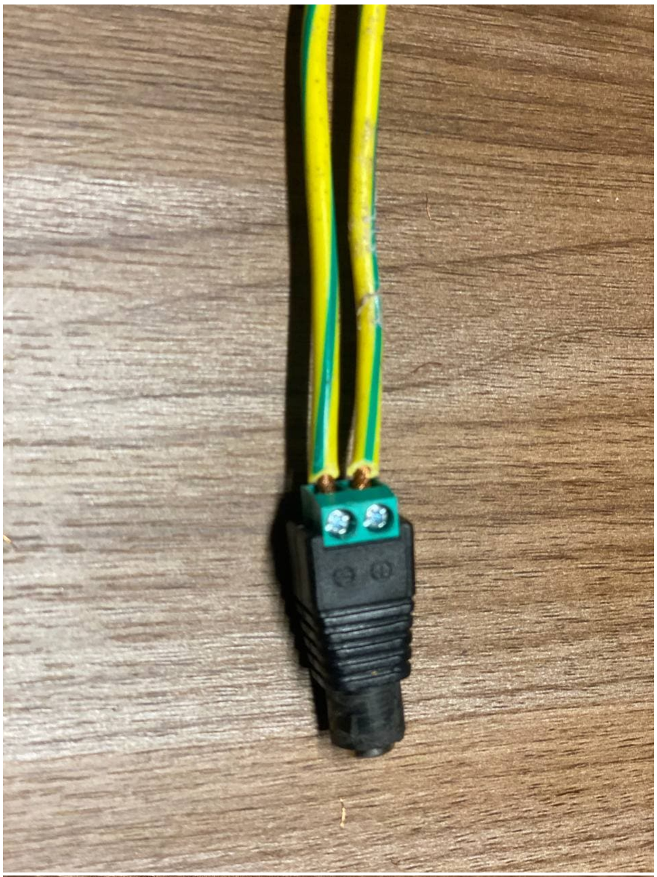


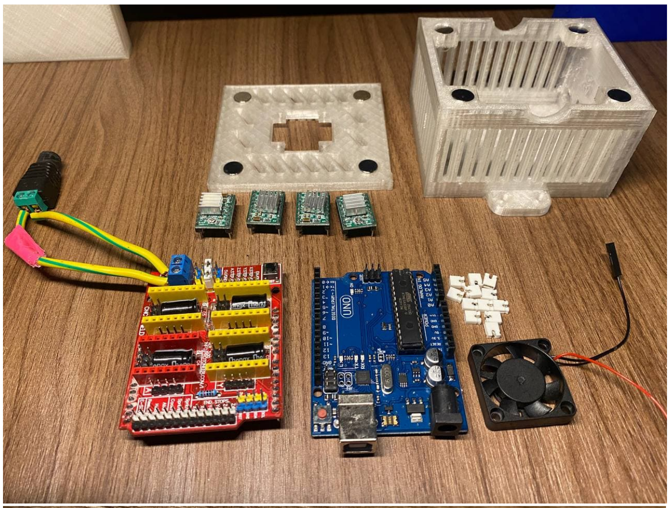
Step 10: Electronics

This might be the most difficult part, but I will try and make it as simple as possible. It is hard to make a schematic of connection between a CNC shield and stepper motors because there is no such part as CNC shield in almost any software.

- Firstly, I found the CNC shield right here: https://github.com/Protoneer/Fritzing_Parts .
- Secondly, before we will plug 4 stepper drivers to the CNC shield (there are only three on the schematic, but we need 4), we need to connect jumpers because connectors for those are under stepper drivers.
- Those jumpers enable micro stepping we need to have all 3 connectors connected so that is the total of 12 jumpers, but we also need 2 of them to mirror the movement of Y axis motor to the A motor and we can do so by putting two jumpers on the left side of the shield.
- Now you can plug stepper drivers and then stepper motors.
- How to plug stepper motors? It depends on the motors that you have there is no easy answer. If you notice that your motor is going in the opposite direction than it should you need to plug the motor the other way around (disconnect it, rotate 180 degrees around Z axis and plug back in place).
- If you want, you can connect end stops to the right side of the CNC shield.
- Finally, we can connect the power supply or the connector to the shield to the screw terminal labeled as 12-36V. And that is all for the connection, not that hard.



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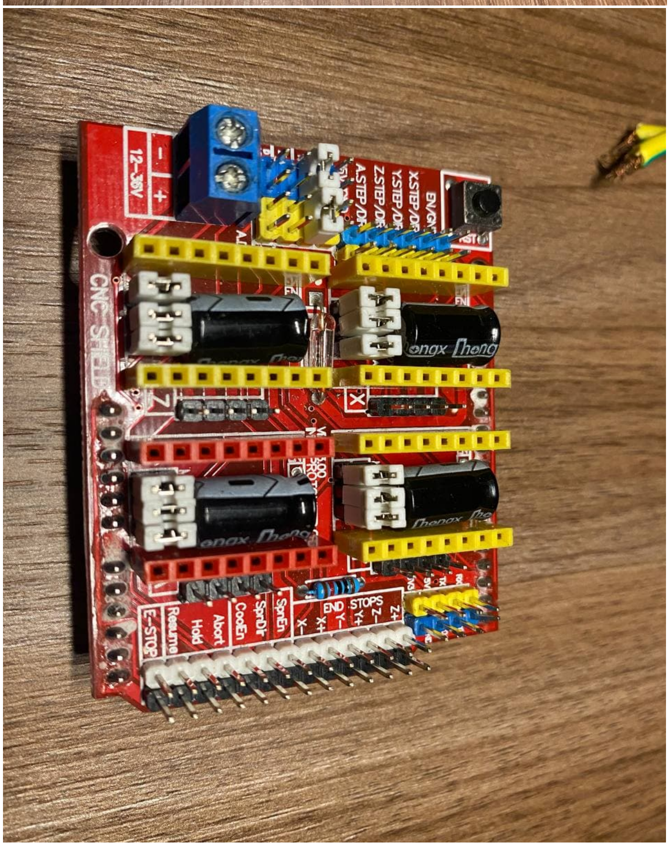
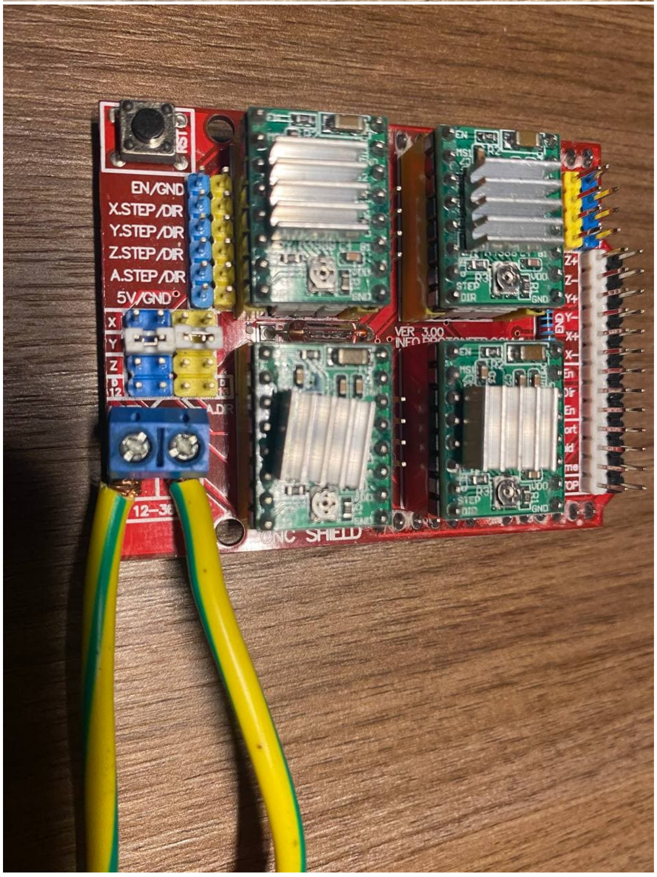
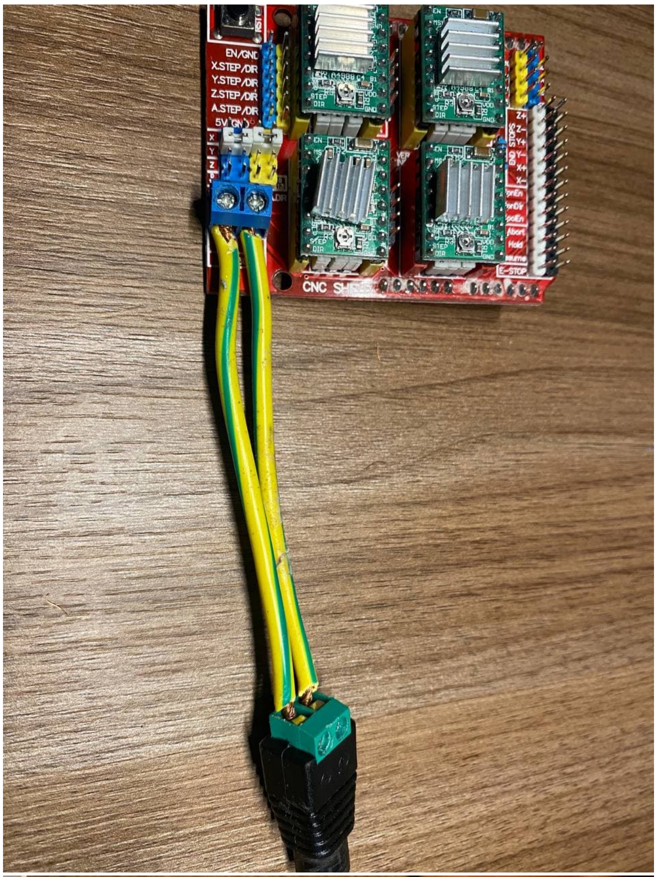
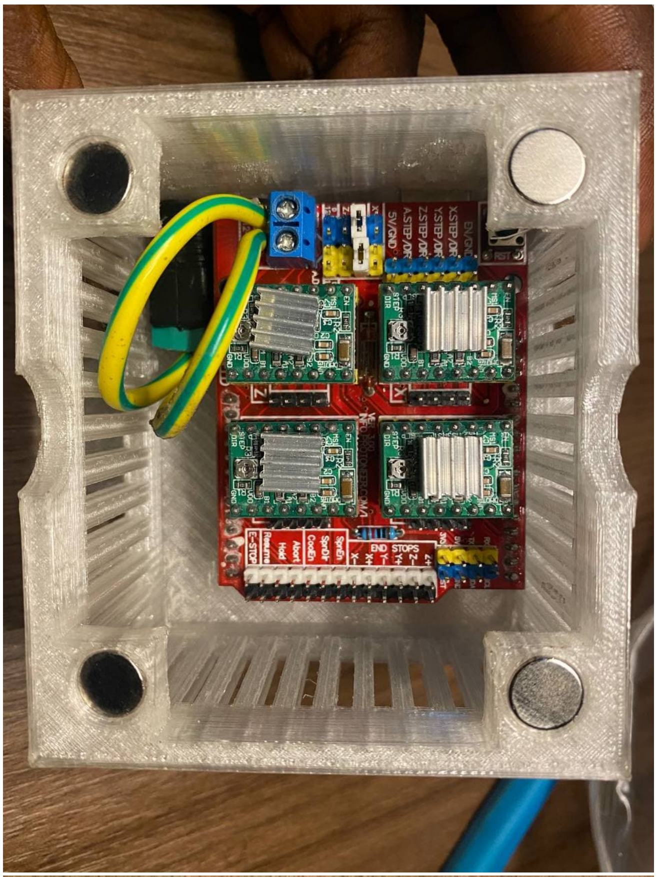
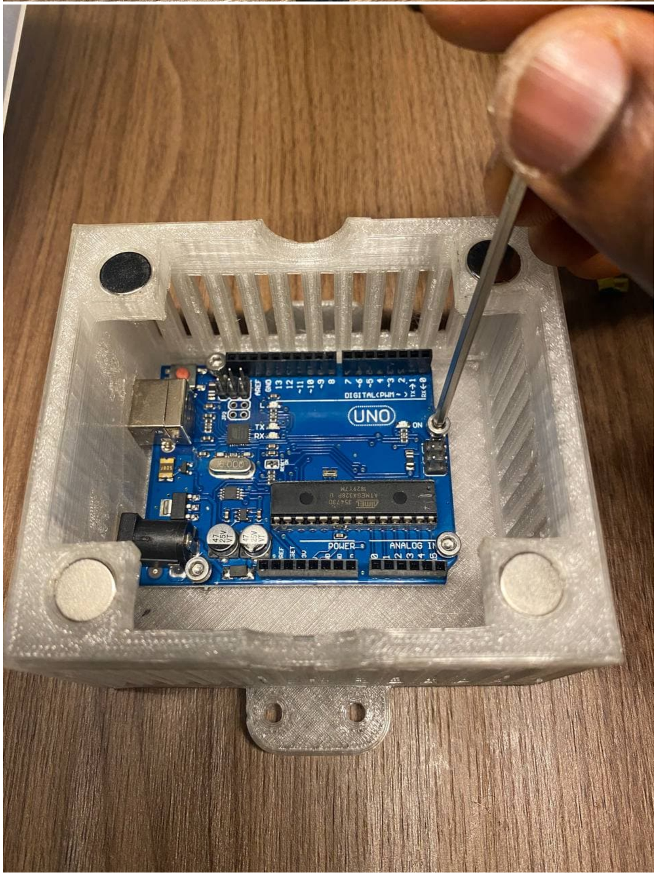

12-36V
CNC SHIELD
END STOPS
E-STOP
Resume
Hold
Abort
CoolEn
SpnDir
SpnEn


EN/GND
X.STEP/DIR
Y.STEP/DIR
Z.STEP/DIR
A.STEP/DIR
5V/GND
CNC SHIELD
12-36


EN/GND
X.STEP/DIR
Y.STEP/DIR
Z.STEP/DIR
A.STEP/DIR

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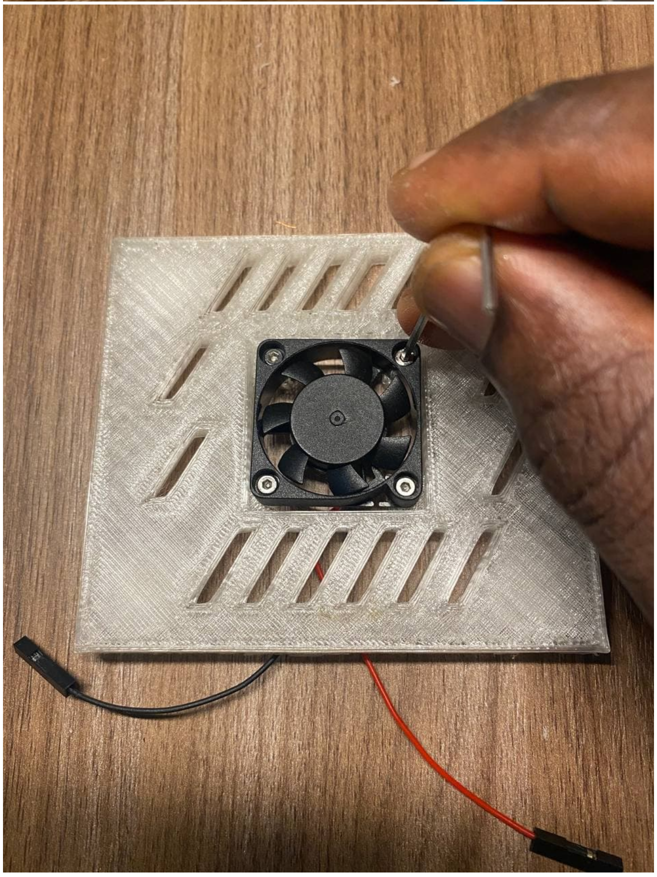
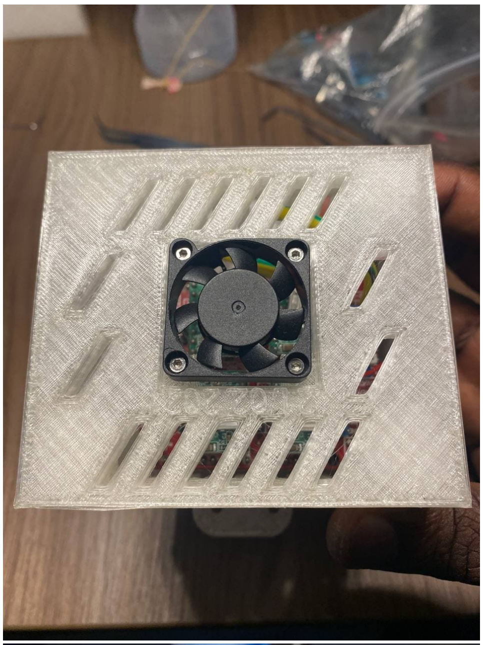
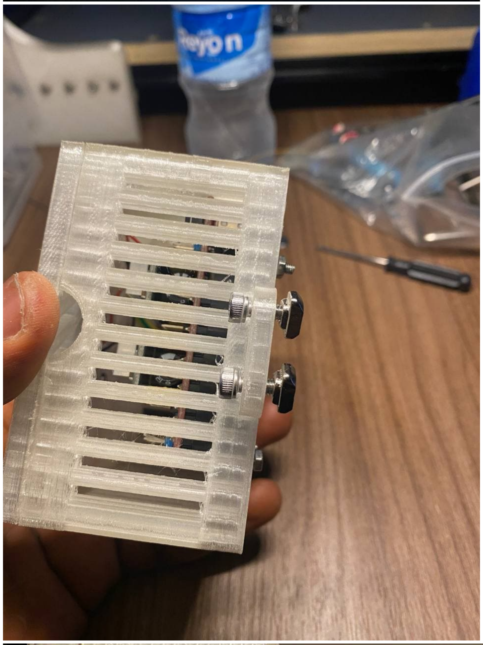
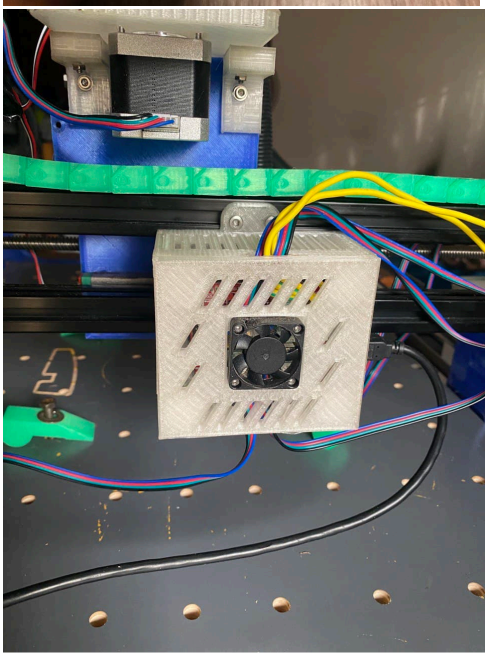






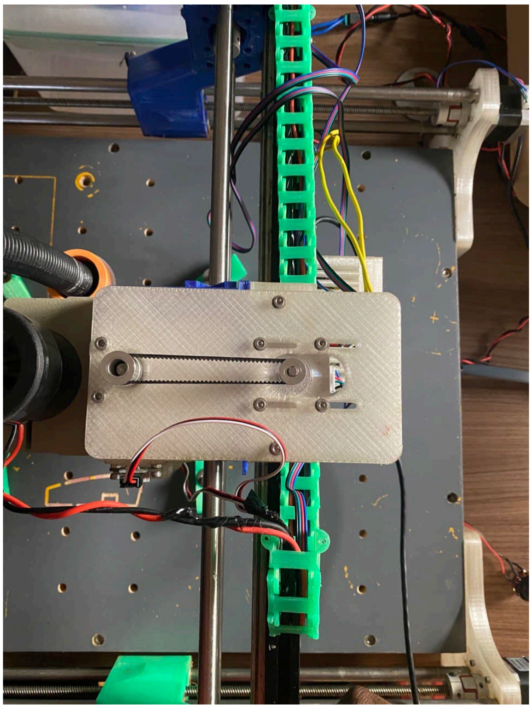


Step 11: Power Supply

Initially, I used a 12V 30A power supply, but that was overkill for this project. I swap this power supply with my lab bench power supply to see how much current is needed to run it. I found out that max current consumption is smaller than 2A, so I bought a 12V 6A power supply. Generally, there is nothing wrong with having too powerful power supply but there is no need to spend the extra money and this huge, bulky, 30A beast is just ugly. Right now, I have a simple power supply with DC plug so I can easily connect it to the machine. Keep in mind that depends on the motors and other electronics that you use you may need a stronger power supply than 3A.

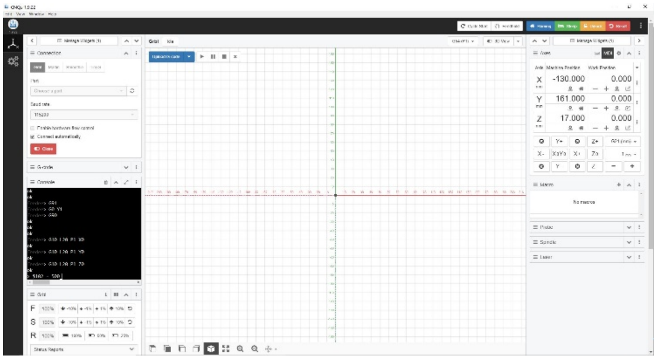
Step 12: Cable Management

It is always good to keep your cables tidy. You can choose a lot of different ways to do the cable management, I prefer to use this 3D printed cable drag chain and mount it to the aluminum profile as it is professional and durable. Keep in mind that cable management is very important in CNC machines because you do not want to cut cables while milling and you also do not want those cables to jam your machine and destroy your material while milling.



Step 13: CNCjs

That is the software for the computer, through it we will control our machine, send gcode and change some parameters through its console in GRBL. There is a lot of different gcode sender options like GRBL controller, mach3 and path pilot but I chose CNCjs because it is free and unlike every other software it looks incredibly good and is easy to control! You can install it on mac, windows, and Linux another great advantage! You can even install it on a raspberry pi and control through browser away from the machine! All of that for free in an open-source software! Sounds like a perfect solution and it really is so far for me. You can download it here: https://cnc.js.org/. If you have problems with connecting to the machine: most likely that's because wrong baud rate, try to change the baud rate in CNCjs to 11520.



Step 16: Safety

Safety is a very important aspect of CNC machining, there is a lot of dangerous things that can damage you, you do not want to be damaged so here are my tips on how to stay safe with such machine. Fortunately, NEMA 17 motors are not that fast, and torque is as great as with some servo motors used in industrial CNC machines. But there is still a fast-spinning spindle and danger of crushing your fingers. While machining there are chips flying all over the place so we need to have a safety glasses (because safety is number one priority) and depends on the material that we are machining (wood, MDF) we may need a mask. It is also a good idea to build an enclosure. Another safety improvement would be to add a big red safety switch so that in case something bad happens you can easily stop the machine (we can also do that in CNCjs but it takes more time and isn't that reliable). Keep in mind that material and bit may be hot after machining and make sure that machine finished its operation before putting your hands in the working area. Machining for a longer period is very uncomfortable for ears so hearing protection is recommended. I also thought about using active noise canceling headphones, should be perfect for a CNC machine because noise is very consistent, but I do not have any headphones like this and those are quite expensive. Keep in mind that those are just some tips from me about safety while dealing with a CNC machine, there is a lot of things that can go wrong, and you must be careful and think to be as safe as possible.

Step 18: How to Mill?

Choosing proper feeds and depth of cut is just about experimenting. Start slow and shallow, slowly increase the speed, and see what happen. Be careful, it is easy to break a milling bit. Keep in mind that going slow is as bad as going too fast, you need to be in between for best results. Here are the settings that I use:

Wood, MDF:

- Feed: 800mm/min
- Depth of cut: 3mm

Usually, I use adaptive clearing for everything and 2d contour for contour cut on fusion 360s' manufacturing tab.

Acrylic:

- Feed: 500mm/min
- Depth of cut: 1mm

Aluminum:

- Feedrate: 800mm/min
- Depth of cut: 0.2mm
- Spindle at full speed