AUTODESK Instructables

DIY Mini CNC Laser Engraver.

By Maggie Shah in CircuitsArduino
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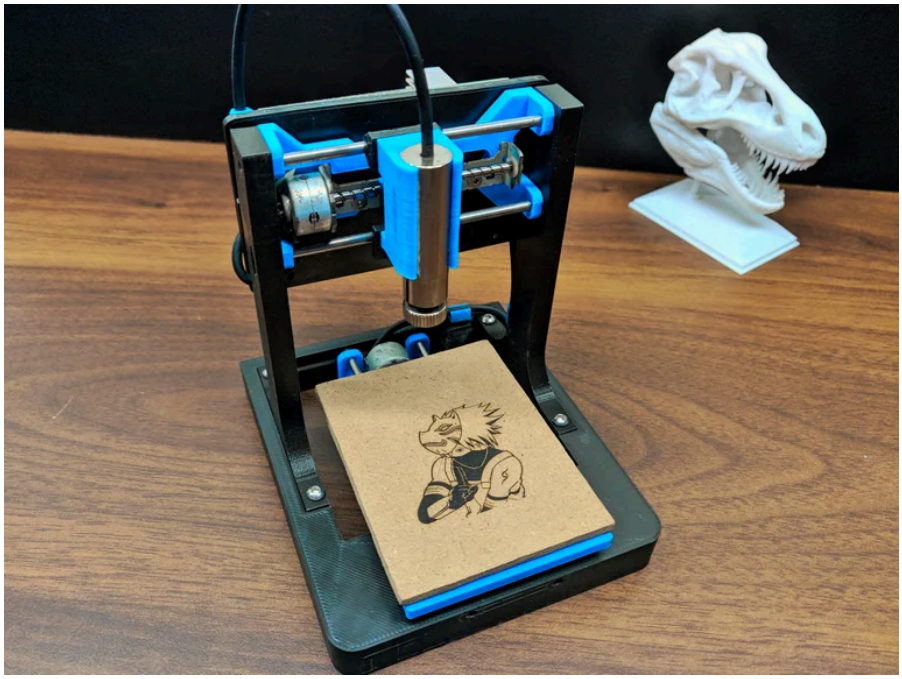
Introduction: DIY Mini CNC Laser Engraver.



This is an Instructables on how I Remixed my old CNC Laser engraver and made a Stable version of an Arduino based Laser CNC engraver and thin paper cutter using old DVD drives and using 25 0mW laser.

Old Version of My CNC :https://www.instructables.com/id/Mini-CNC-Laser-Wood-Engraver-and-Paper-Cutter/

Old version was not much stable and had some wobble due to uneven parts, so I decided to make a stable version of it using 3D printed parts. Which gave me excellent results in laser engraving eve n in very tiny details, this machine is cable of doing the work well. You can see the details in the ey e of the engraved picture.

Playing area is 40mm x 40mm max.

Step 1: Parts and Materials Required

- Arduino Nano (with USB cable)
- 2x DVD drive stepper mechanism
- 2x A4988 stepper motor driver modules (or GRBL shield)
- 250mW Laser with adjustable lens (or above)
- 12v 2Amps power supply minimum
- 1x IRFZ44N N-CHANNEL Mosfet
- 1x 10k resistor
- 1x 47ohm resistor
- 1x LM7805 voltage regulator (with heatsink)
- Blank PCB Board
- Male and Female Headers
- 2.5mm JST XH-Style
- 2pin male connector
- 1x 1000uf 16v capacitor Jumper cables
- 8x small neodymium magnets (which I have salvaged from DVD lens mechanism)
- 1x 2pin plug in screw terminal block connector
- Zip ties (100mm)
- Super Glue
- 6x M3x12 screws
- 8x M2x5 screws
- Laser Safety Glasses

"LASER SAFETY GLASSES are must needed in this project".

Step 2: Printed Parts

STL files, see the attached file or go to : https://www.thingiverse.com/thing:3521286

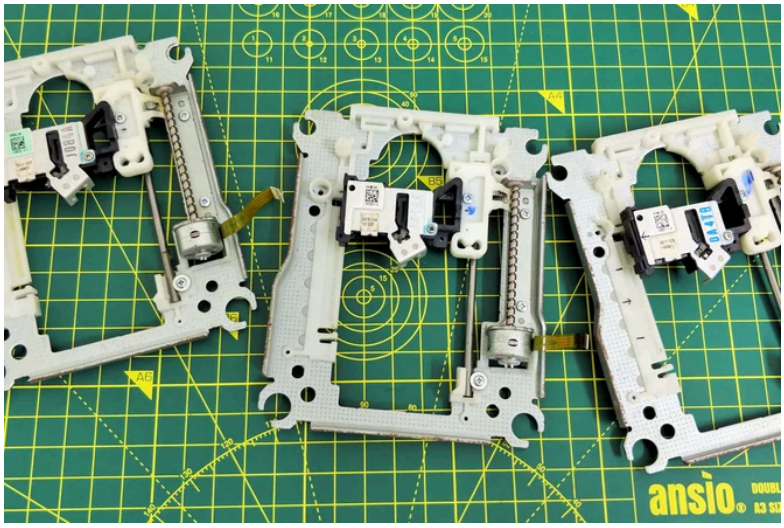
All Parts are printed in ABS material.

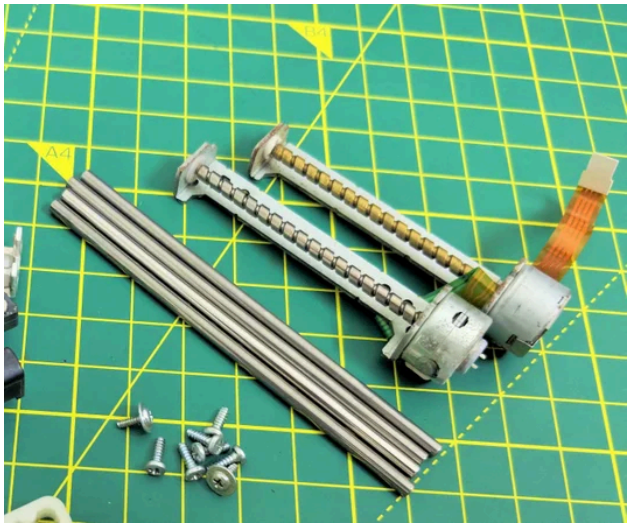
Print Settings:
Layer height: 0.2mm

Infill: < 25%

Supports: No

Step 3: Taking Apart the DVD Drive Stepper Mechnaism





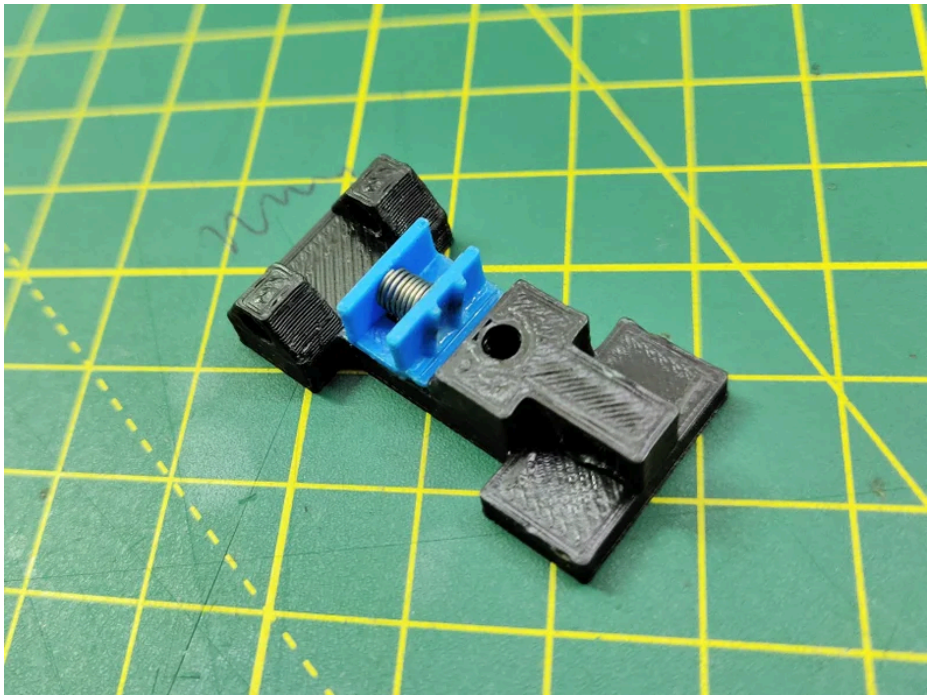
Two DVD driver mechanism are required, one for the X-Axis and the second for the Y-axis.
Using a small Phillips head screw driver I removed all the screws and detached stepper motor, the sliding rails and the follower.
The stepper motors are 4-pin Bipolar Stepper Motor.

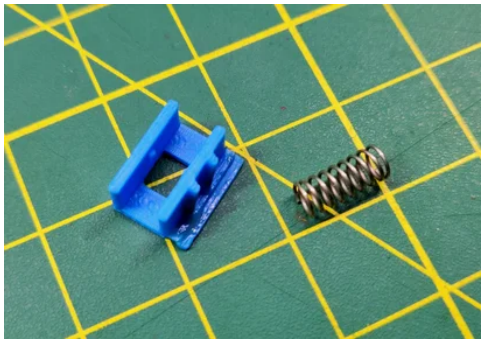
The small size and low cost of a DVD motor mean that you can't expect
high resolution from the motor. That is provided by the lead screw. Also, not all such motors do 20 s teps/rev. 24 is also a common spec. You'll just have to test your motor to see what it does.

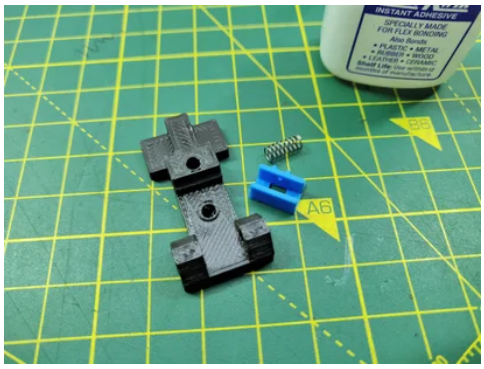
Procedure for calculating the resolution of the CD Drive Stepper motor:

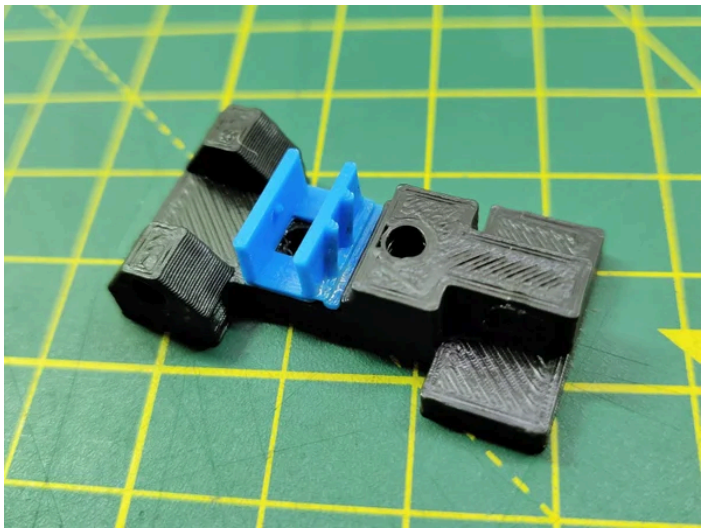
In order to measure the resolution of the CD/DVD drive stepper motor,
a digital micrometer was used. The distance along the screw was measured. The total length of the screw using a micrometer, which turned out to be 51.56 mm. To determine the lead value which is t he distance between two adjacent threads on the screw. The threads were counted to be 12 thread s within this distance. Lead = distance between adjacent threads = (total length / number of thread s = 51.56 mm) / 12 = 4.29mm/rev. The step angle is 18 degrees which corresponds to 20 steps/rev olution. Now that all the information needed is available, the resolution of the stepper motor could b e calculated as shown below: Resolution = (Distance between adjacent threads) / (N Steps/rev) = (4.29mm/rev) / (20 steps/rev) = 0.214 mm/step. Which is 3 times better the resolution required whic h is 0.68mm/step.

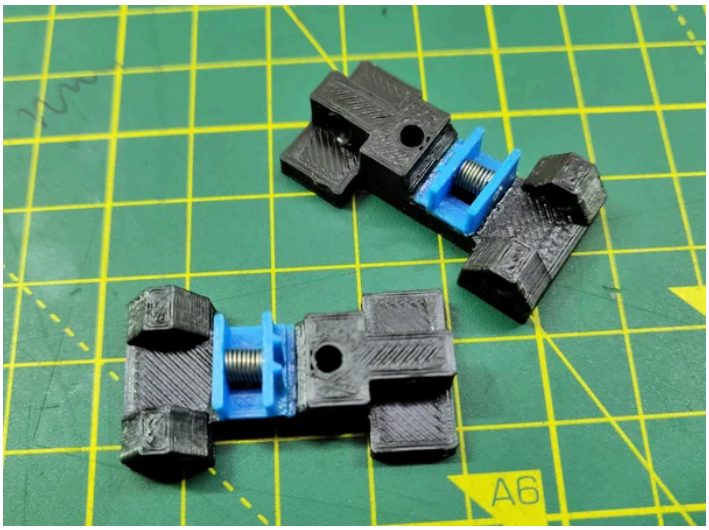
Step 4: Preparing the Slider.





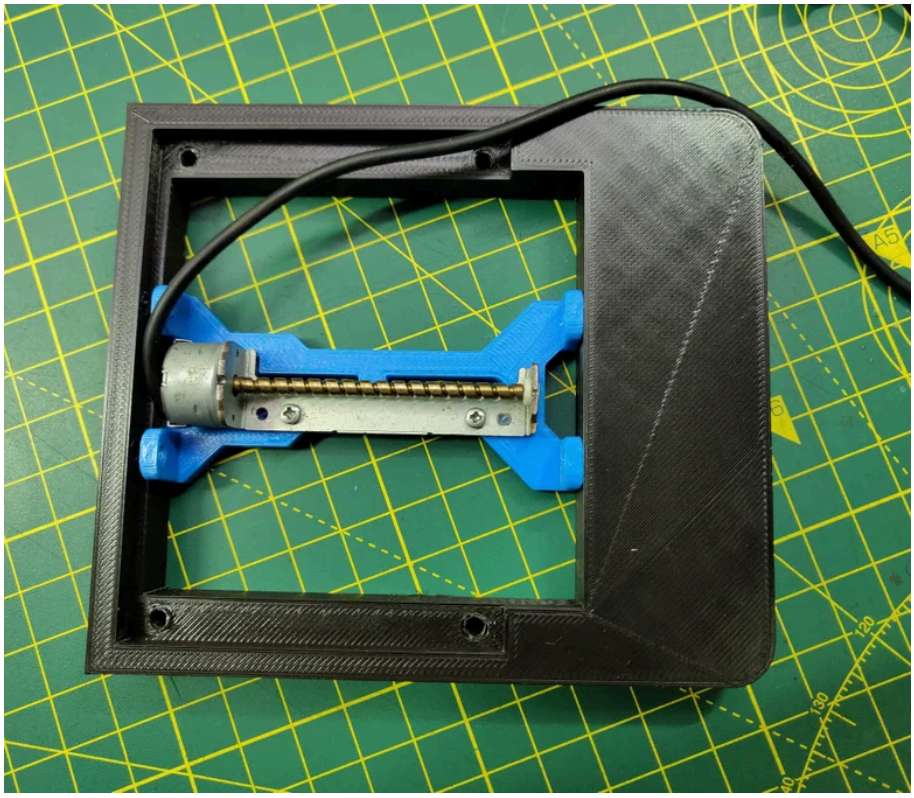
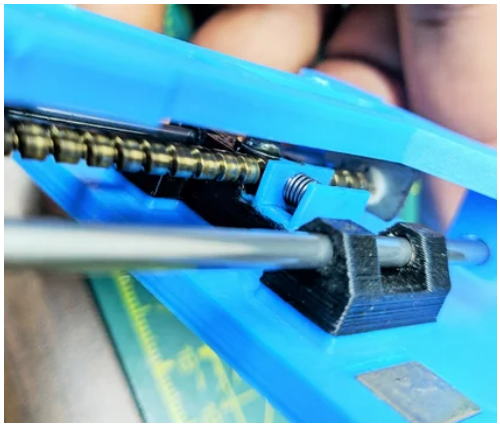
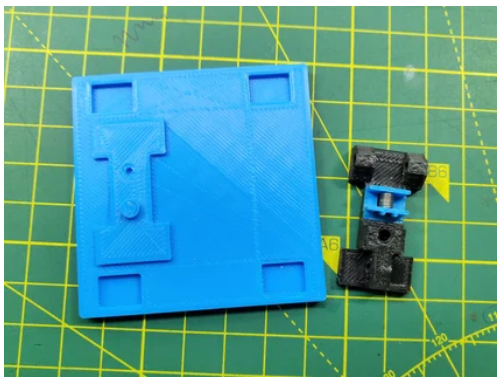
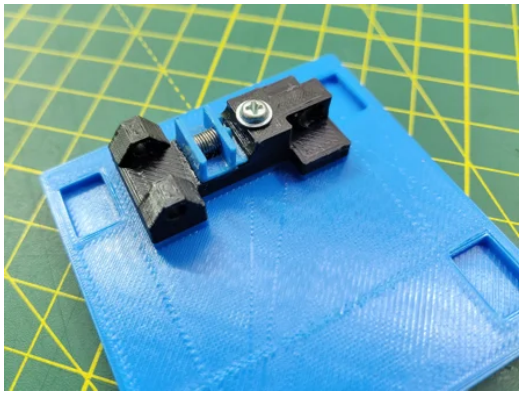


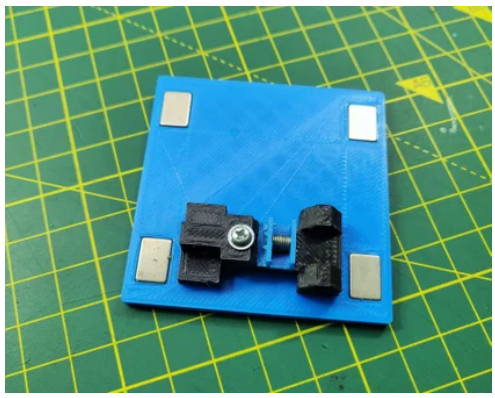
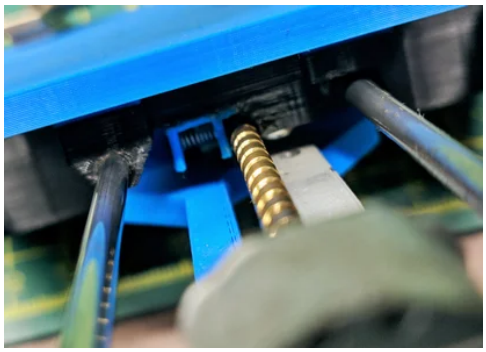
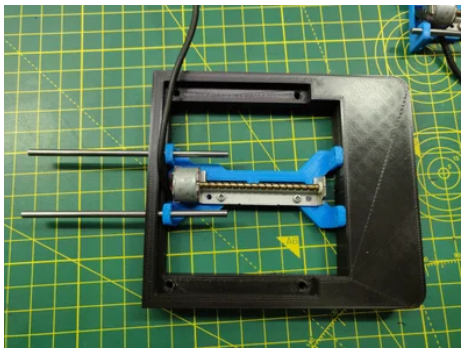
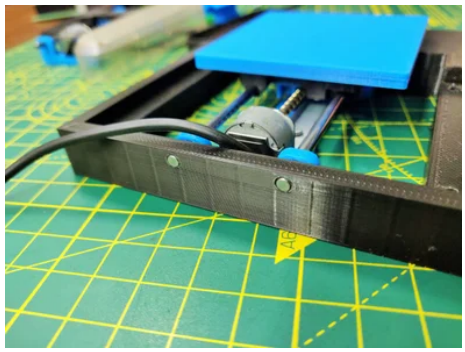




Using Super Glue I've glued the slider and the guide into one part. Spring is attached to maintain th e tension between the guide and the lead screw to avoid black-lash.

Step 5: Assembling the Slider Rails for the Y-Axis

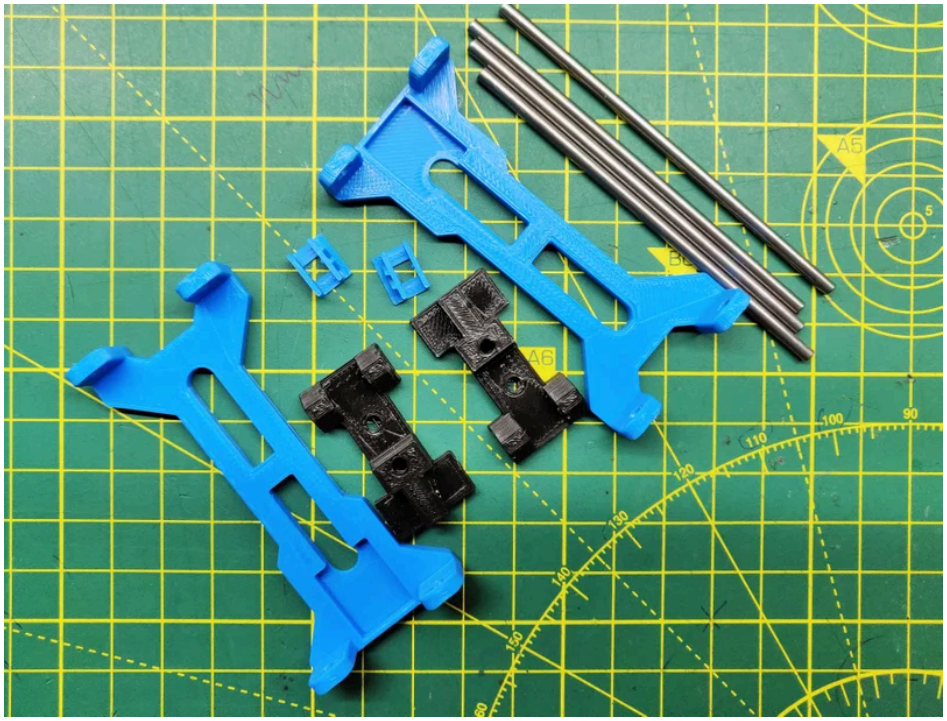
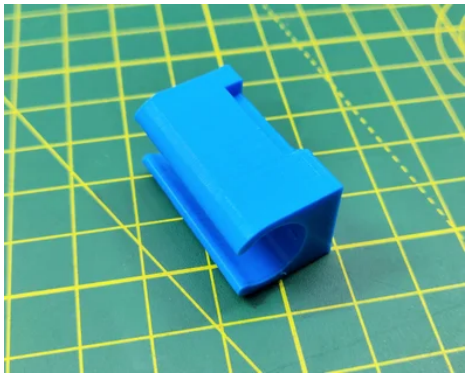
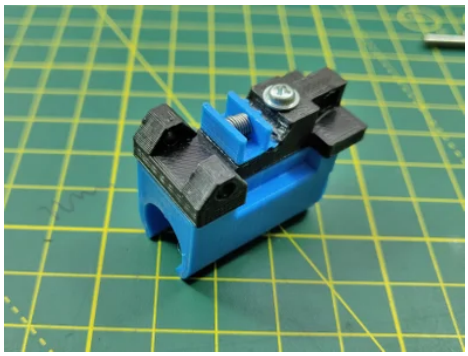





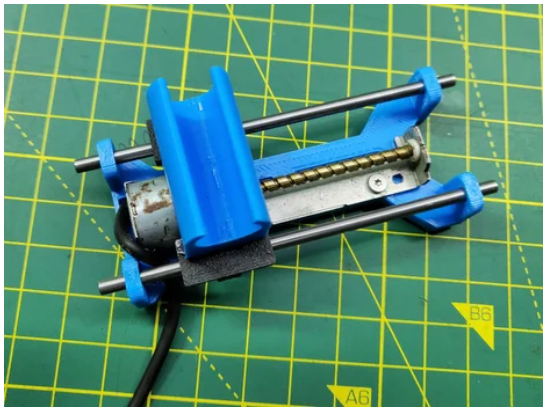
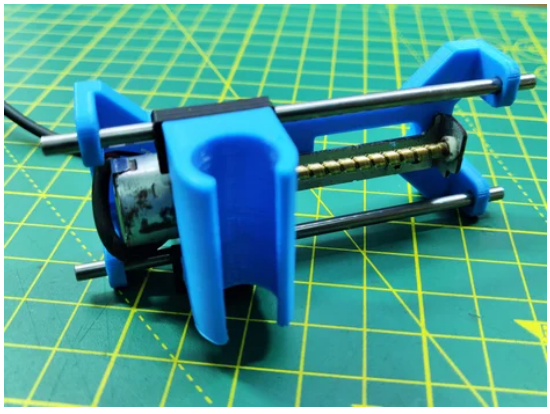
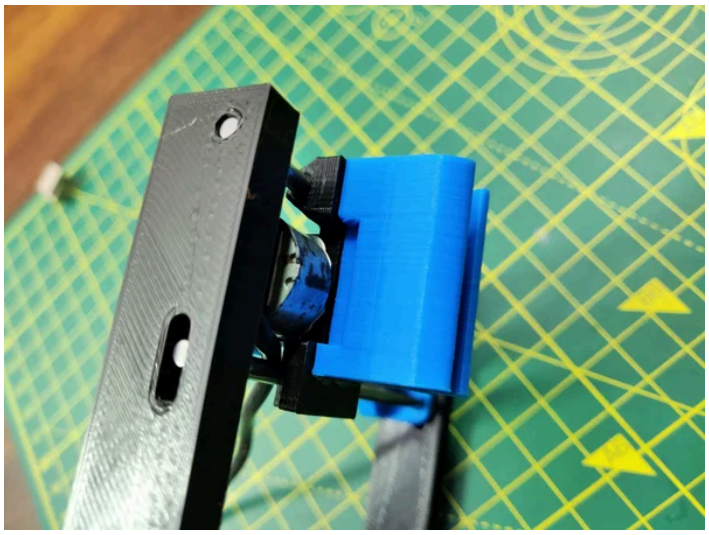
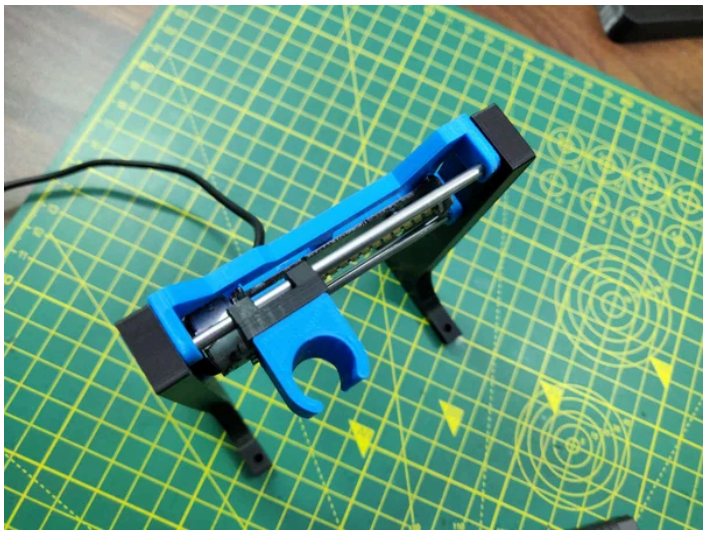





Before assembling the slider into the base I've glued 4x small neodymium magnets (which I have s alvaged from DVD lens mechanism) into the X-plate. This magnets will helps in holding the work pi ece to the working area.

The smooth rod will keep the sliding mechanism intact to the base.

Step 6: Assembling the Slider Rails for the X-Axis

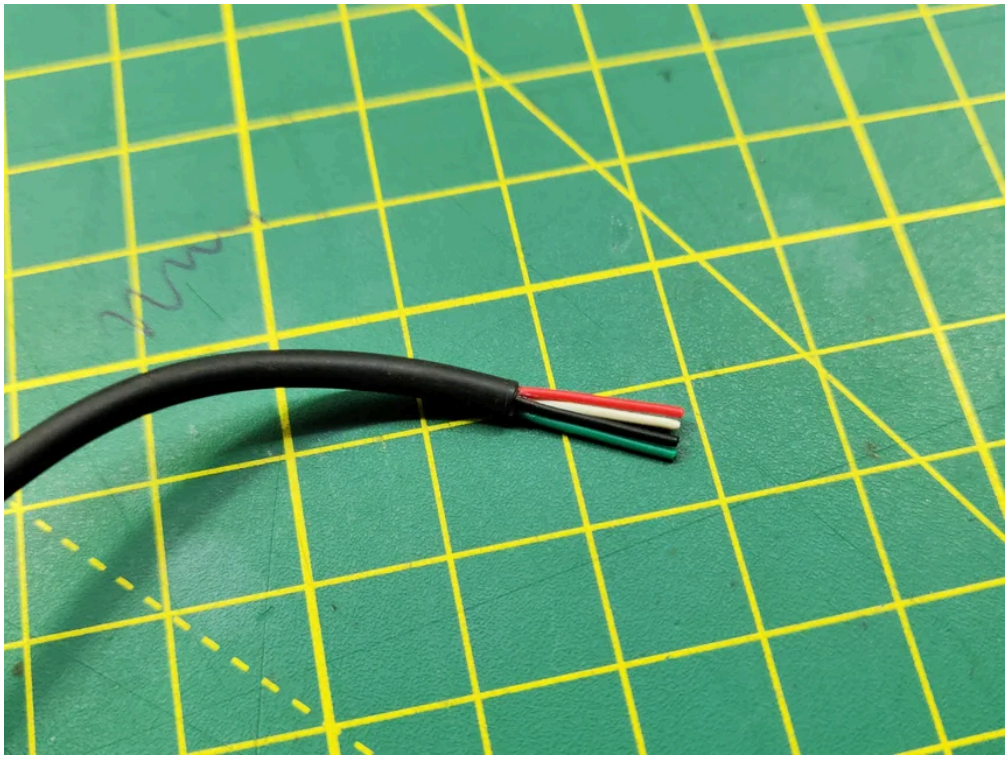




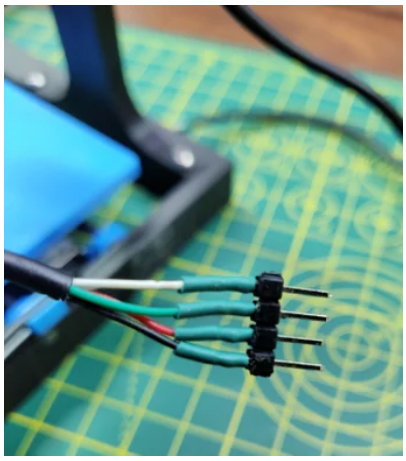





Here, using super glue and screw I've attached the guiding mechanism to the laser housing.

Attached the stepper motor onto the place using the screws and afterwards inserted the smooth ro ds and guiding part into the holes given by keeping in mind that slider is moving freely not too hard. And attached the side frame pillars to it.

Step 7: Wiring of Stepper Motors





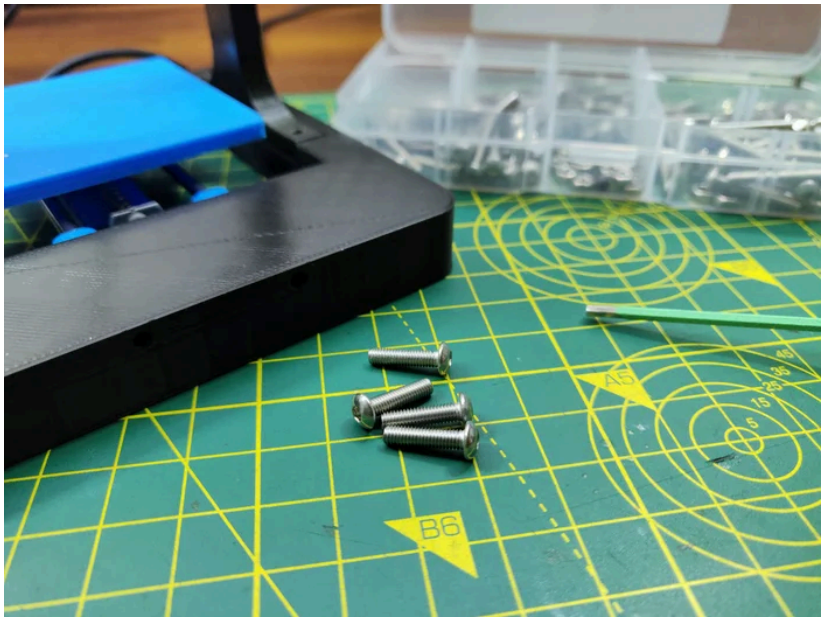
For the stepper motors I've used old usb cable, because it has 4 wire inside and have a cover on it, and it is more flexible and easy to work with.

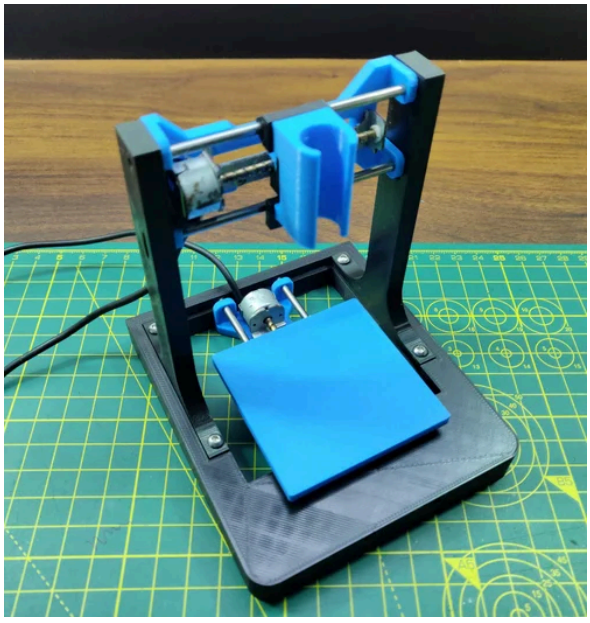
Using continuity mode in Multimeter determine determine 2 Coil, Coil A and Coil B.

I made 2pairs of wire by selecting colours, one pair for the Coil A and second for the Coil B.

Soldered them and used heat shrink tube on it.

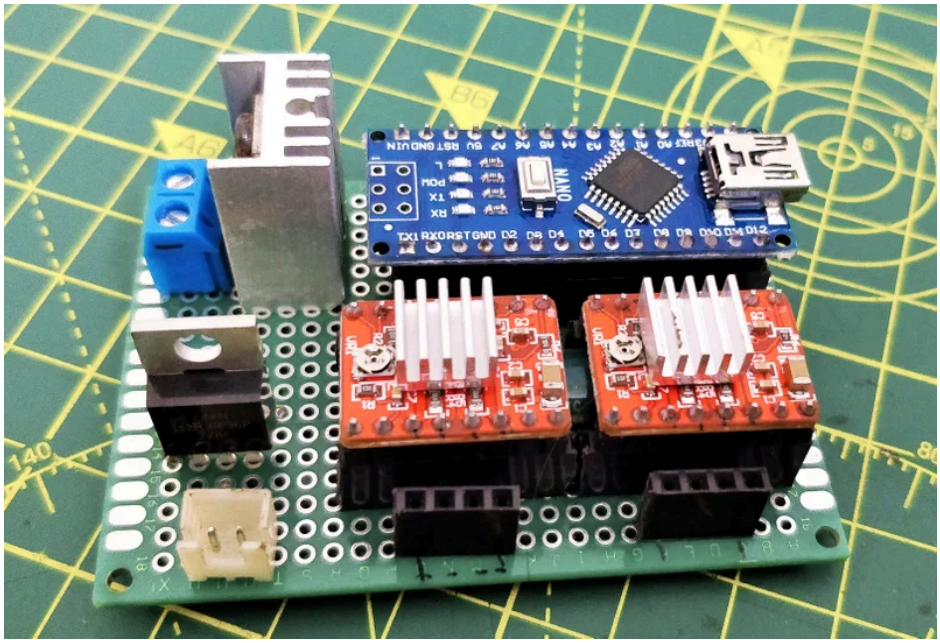
Step 8: Combing the X and Y Axis

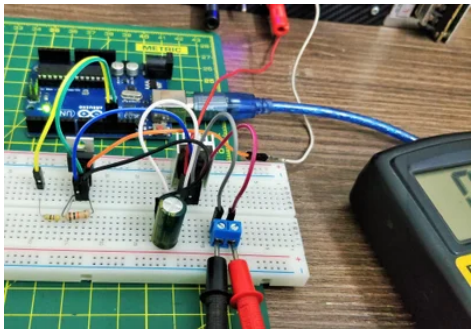


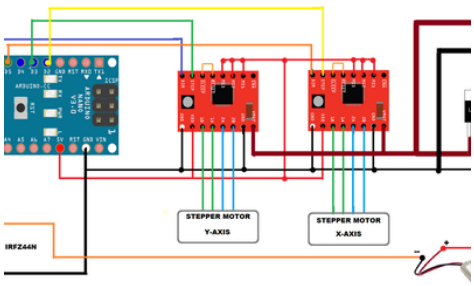


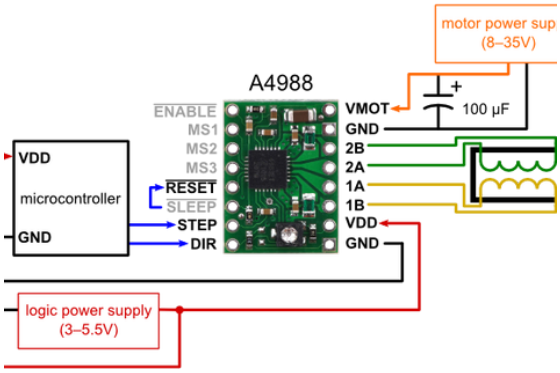
Using 4x M3x12 screws, combined the base and two side frame into one assembly.

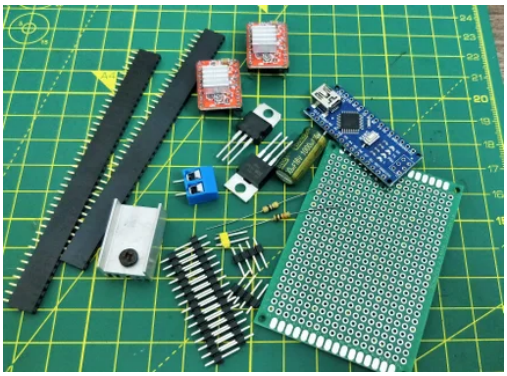
Step 9: The Electronics

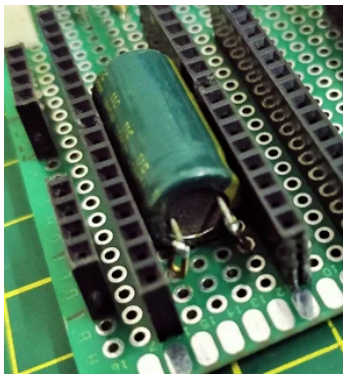


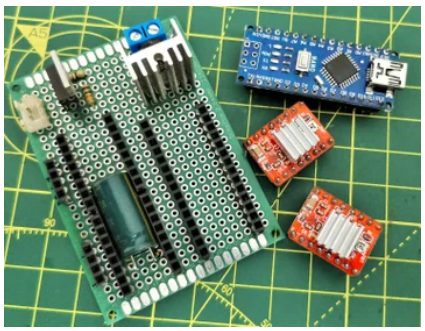


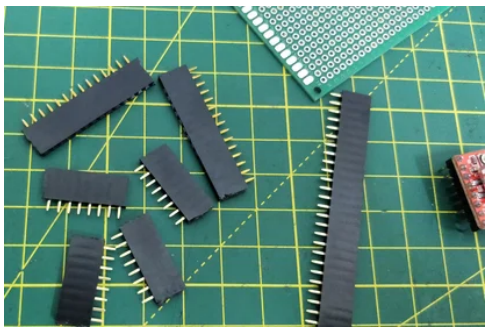


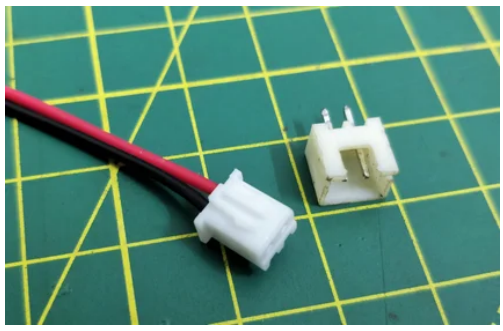


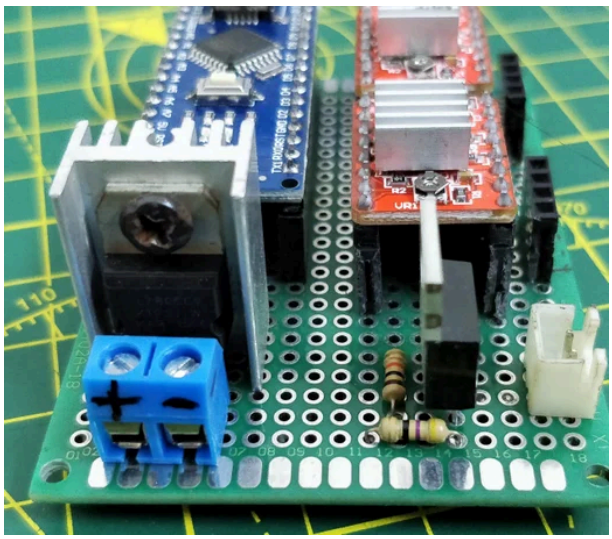












PARTS USED FOR THE DRIVER ARE:

- Arduino Nano.
- 2x A4988 Stepper motor drivers.
- 1x IRFZ44N N-CHANNEL MOSFET.
- 1x LM7805 Voltage regulator with Heatsink.
- 1x 47ohm and 1x 10k resistor.
- 1x 1000uf 16V capacitor.
- 1x 2.5mm JST XH-Style 2pin male connector.
- MALE and FEMALE Header Pins.
- 1x (20mm x 80mm blank PCB).

In GRBL the digital and analog Pins of Arduino are reserved. The
'Step' pin for the X and Y axes is attached to digital pins 2,and 3 respectively. The 'Dir' pin for the X and Y axes is attached to digital pins 5 and 6 respectively. D11 is for laser Enable. The Arduino get s power through the USB Cable. The A4988 Drivers through external power source. All ground shar e common connections. VDD of A4988 are connected to 5V of Arduino. The laser I've used runs on 5V and has built in constant current circuit. For the constant 5V source from the external power sup ply LM7805 voltage regulator is used. Heatsink is compulsory. The IRFZ44N N-CHANNEL MOSFE T works as an elelctronic switch when receives digital high signal from pin D11 of Arduino. NOTE: 5 V from Arduino nano can't be used beause the laser draws more than 250mA and the Arduino Nan o is not capable of delivering that much of current.

Configuring Micro Stepping for Each Axis.

MS0 MS1 MS2 Microstep Resolution.

Low Low Low Full step.
High Low Low Half step.

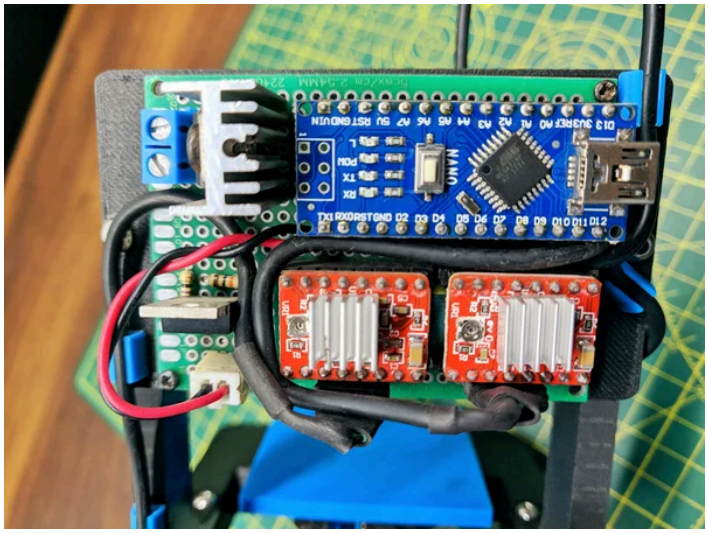
Low High Low Quarter step.

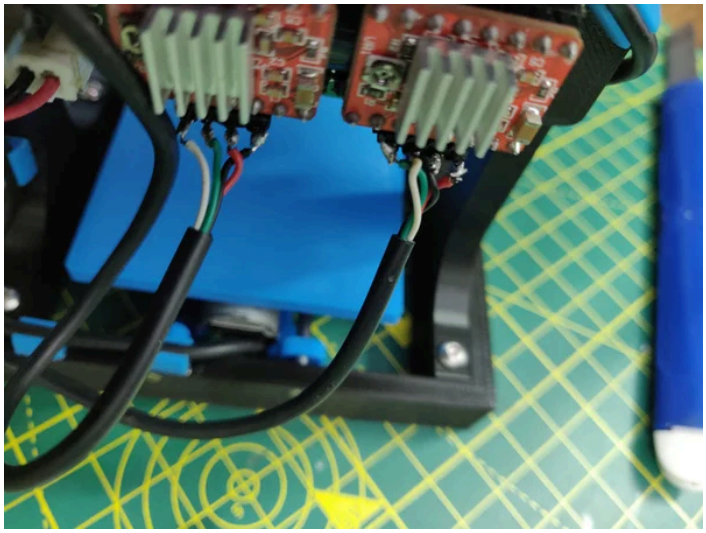
High High Low Eighth step.

High High High Sixteenth step .

The 3 pins (MS1, MS2 and MS3) are for selecting one of the five step
resolutions according to the above truth table. These pins have internal pull-down resistors so if we leave them disconnected, the board will operate in full step mode. I've used the 16th step configura tion for smooth and noise free. Most (but certainly not all) stepper motors do 200 full steps per revol ution. By appropriately managing the current in the coils it is possible to make the motor move in s maller steps. The Pololu A4988 can make the motor move in 1/16th steps - or 3,200 steps per revol ution.The main advantage of microstepping is to reduce the roughness of the motion. The only fully accurate positions are the full-step positions. The motor will not be able to hold a stationary position at one of the intermediate positions with the same position accuracy or with the same holding torqu e as at the full step positions.Generally speaking when high speeds are required full steps should b e used.

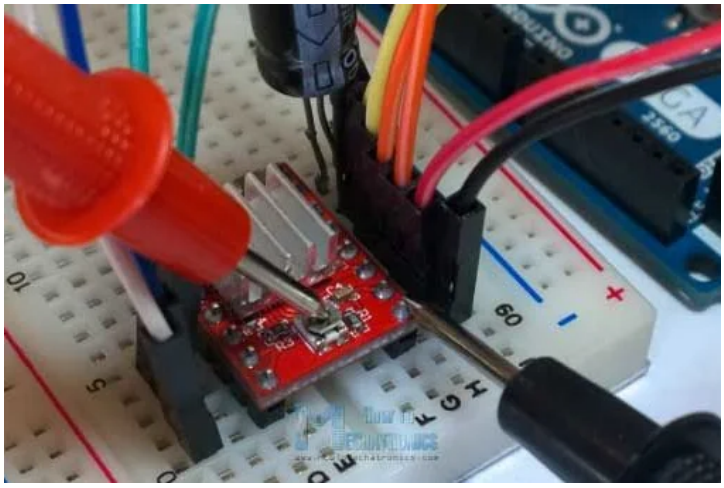
Step 10: Assembling the Electronics to Frame.

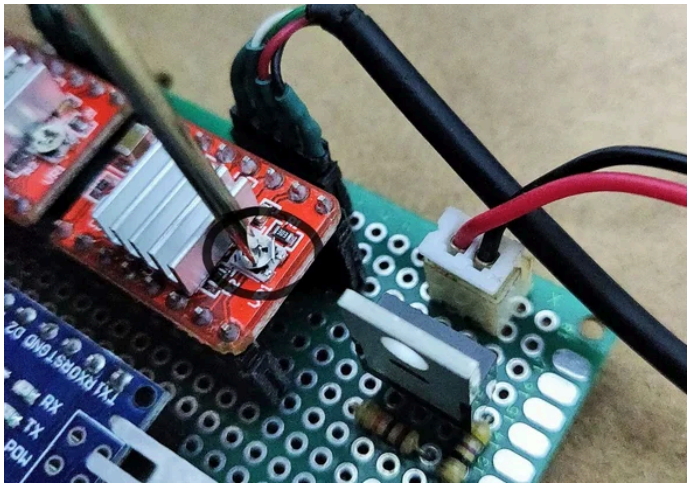




Assembled the driver board on the back plate using 2x M2 screws and to the frame of the machine using 2x M3x12 Screws. Plugged in the connections for the Stepper motors X ,Y and the Laser.

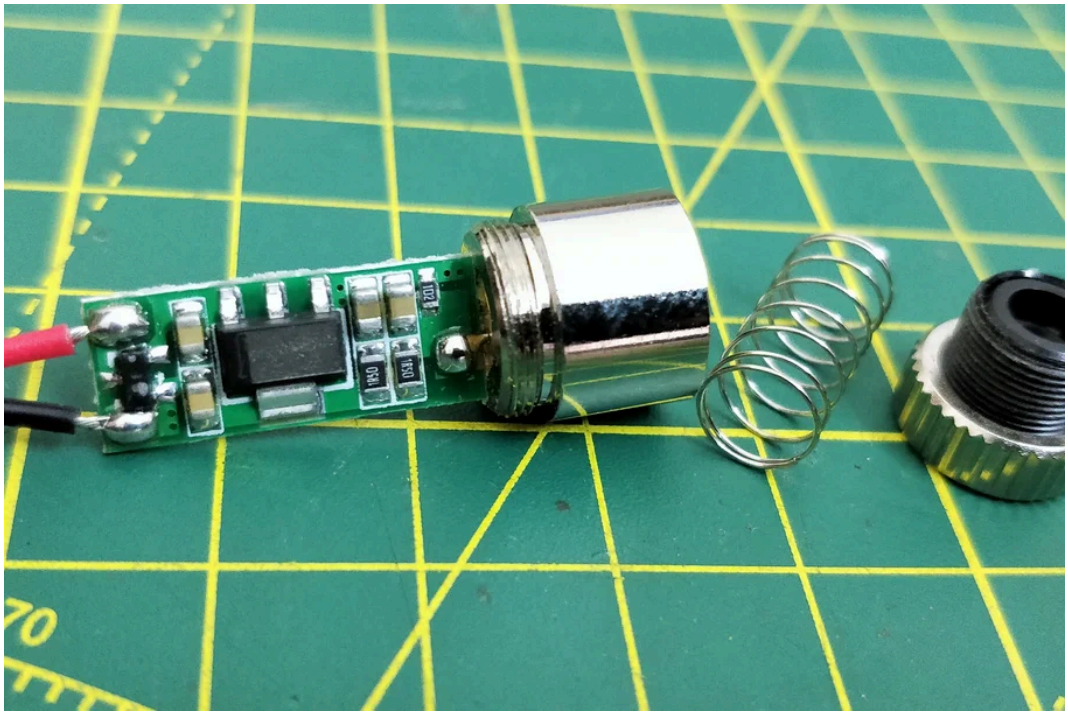
Step 11: Adjusting the Stepper Driver Current

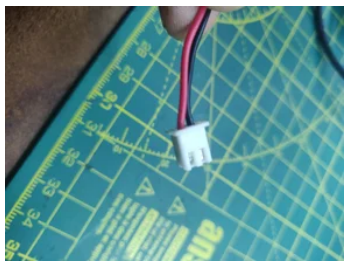




To achieve high step rates, the motor supply is typically much higher than would be permissible wit hout active current limiting. For instance, a typical stepper motor might have a maximum current rat ing of 1A with a 5Ω coil resistance, which would indicate a maximum motor supply of 5 V. Using suc h a motor with 12 V would allow higher step rates, but the current must actively be limited to under 1A to prevent damage to the motor. The A4988 supports such active current limiting, and the trimm er potentiometer on the board can be used to set the current limit. One way to set the current limit i s to put the driver into full-step mode and to measure the current running through a single motor coi l without clocking the STEP input. The measured current will be 0.7 times the current limit (since bo th coils are always on and limited to 70% of the current limit setting in full-step mode). Please note t hat changing the logic voltage, Vdd, to a different value will change the current limit setting since th e voltage on the “ref” pin is a function of Vdd. Another way to set the current limit is to measure the voltage directly on top of the potentiometer and to calculate the resulting current limit (the current s ense resistors are 0.1Ω). The current limit relates to the reference voltage as follows: **Current Limi t = VREF × 1.25** So, for example, if the reference voltage is 0.6 V, the current limit is 0.75A. As men tioned above, in full step mode, the current through the coils is limited to 70% of the current limit, so to get a full-step coil current of 1A, the current limit should be 1A/0.7=1.4A, which corresponds to a VREF of 1.4A/1.25=1.12 V. See the A4988 datasheet for more information. Note: The coil current c an be very different from the power supply current, so you should not use the current measured at t he power supply to set the current limit. The appropriate place to put your current meter is in series with one of your stepper motor coils.

Step 12: Laser Assembly

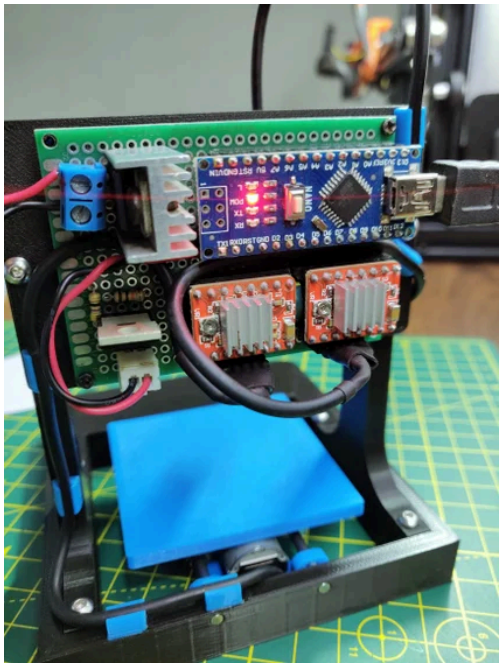


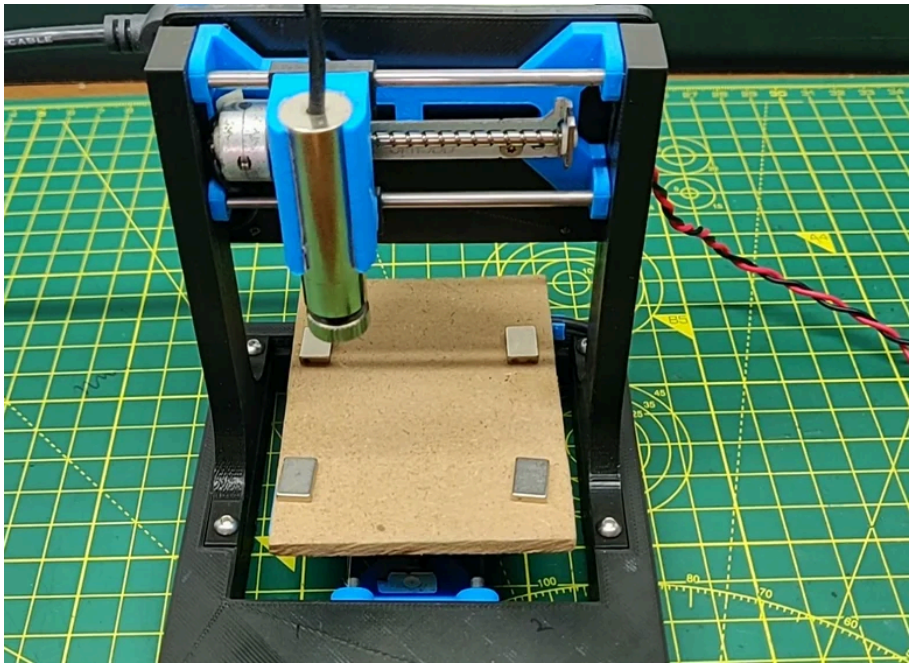


The laser I've used is Focusable Laser Module 200-250mW 650nm. The outer metal housing work as a Heatsink for the laser diode. It has focusable lens for the adjustment of laser dot. Connect the laser wire terminal to the laser socket on the driver board.

You can get one Here.

Step 13: Getting Ready!





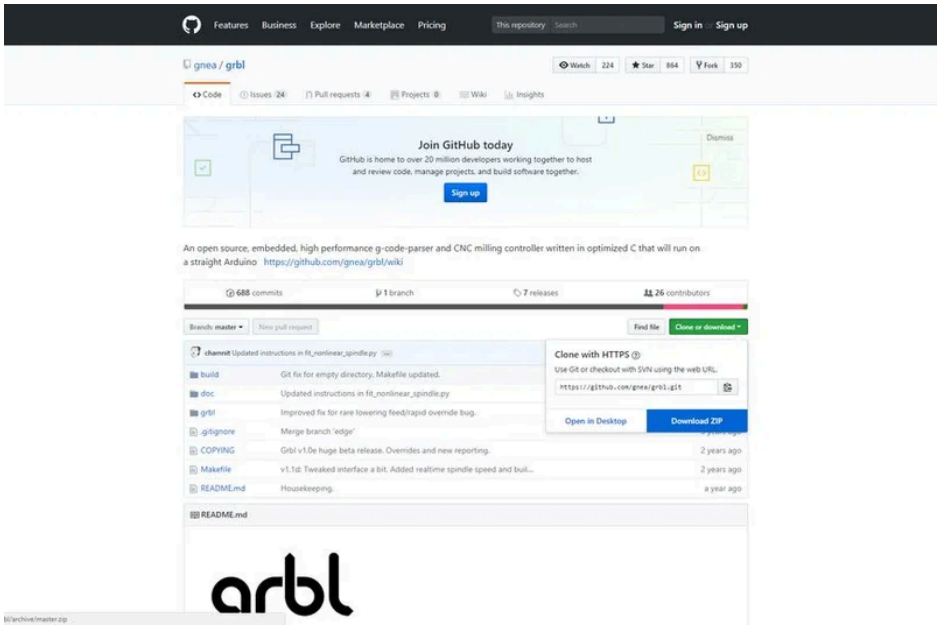
Using four small Neodymium magnets lock the working piece on the working bed and set the X and Y-axis to initial position (home). Power up the driver board through External power source, and Ard uino Nano to Computer through a USB A to USB Mini B Cable.

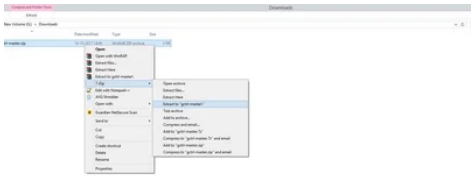
Also power the board through a external power source.

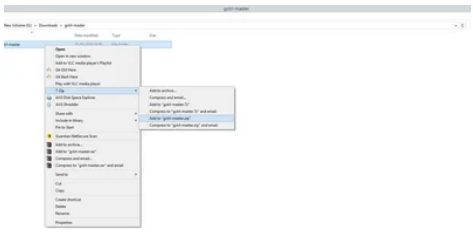
SAFETY FIRST.

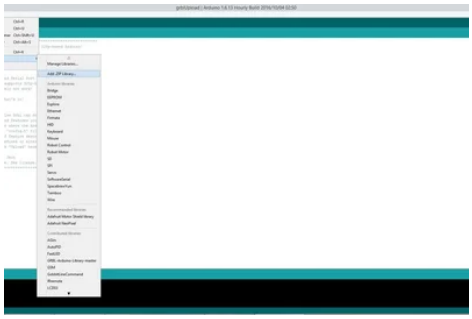
LASER SAFETY GLASSES ARE MUST NEEDED

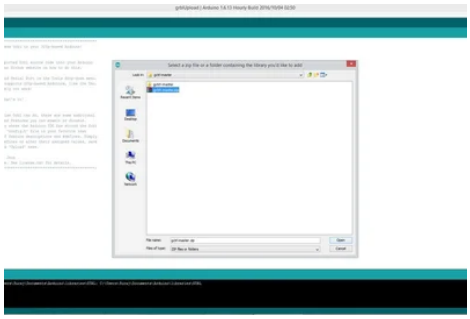
Step 14: GRBL Firmware

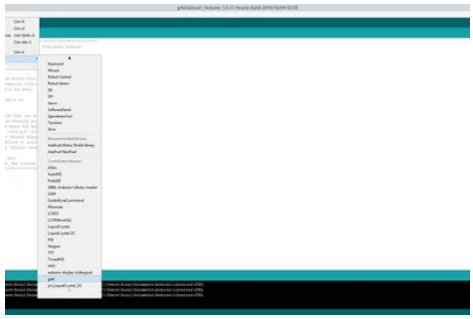






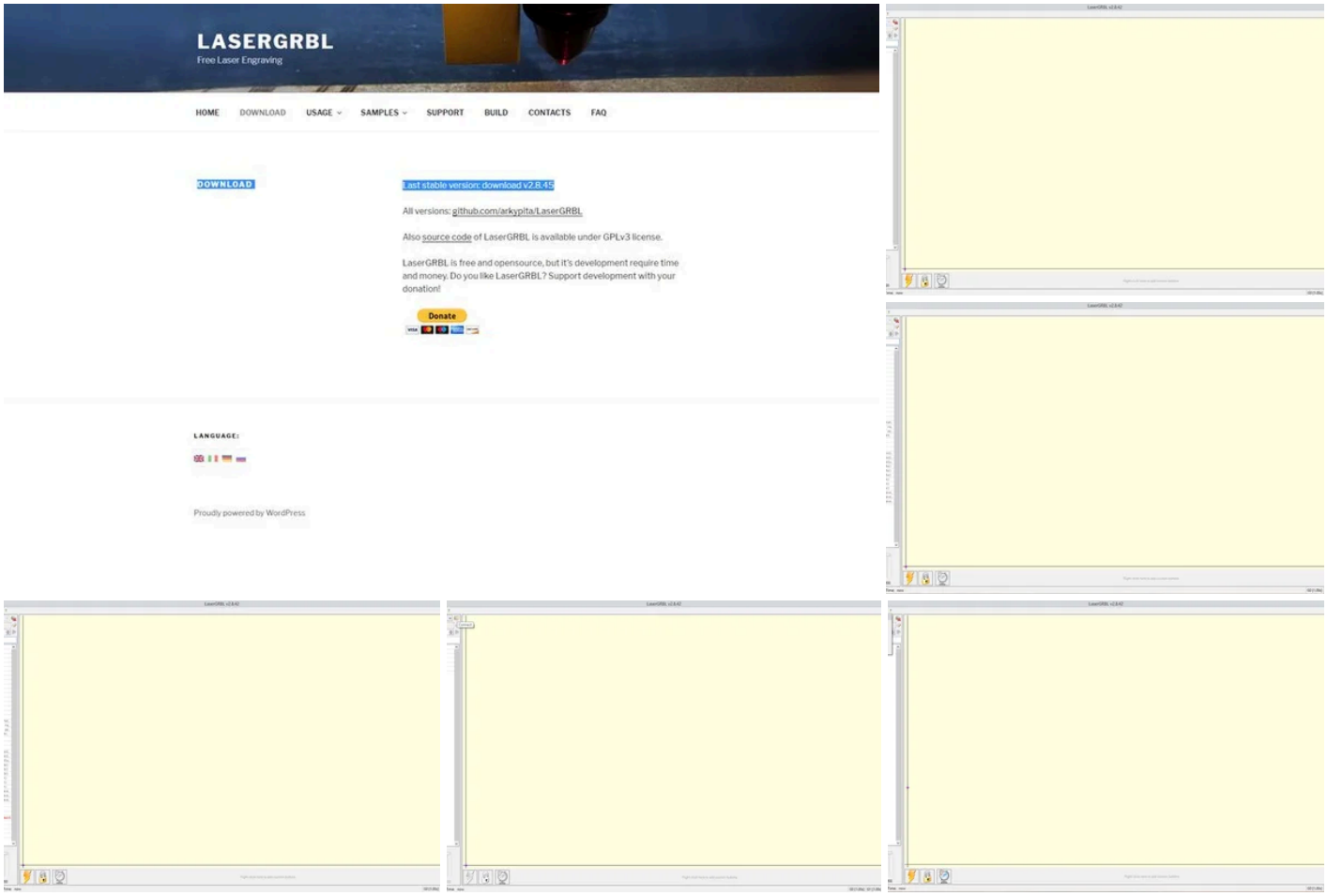






1. Download the GRBL , Here
2. Extract on the desktop the grbl-master folder, you find it in the file master.zip
3. Run the Arduino IDE
4. From the application bar menu, choose: Sketch -> #include Library -> Add Library from file.ZI P
5. Select the folder grbl that you can find inside the grlb-master folder and click on Open
6. The library now is installed and the IDE software will show you this message: The library is ad ded to your library. Check the “libraries Inclusion” menu.
7. Then open an example called "grbl upload" and upload it to your arduino board.

Step 15: Software to Send G-CODE



Also we need a software to send G-Code to CNC for that I've used the LASER GRBL

LaserGRBL is one of the best Windows GCode streamer for DIY Laser Engraver. LaserGRBL is able to load and stream GCode path to arduino, as well engrave images, pictures and logo with internal conversion tool.

LASER GRBL Download.

LaserGRBL constantly checks for COM ports available on the machine. The list of ports allows you to select the COM port which your control board is connected on.

Please select the proper baud rate for the connection according to your machine firmware configur ation (default 115200).

Grbl Settings:

$$ - View Grbl settings

To view the settings,type $$ and press enter after connecting to Grbl. Grbl should respond with a lis t of the current system settings, as shown in the example below. All of these settings are persistent and kept in EEPROM, so if you power down, these will be loaded back up the next time you power up your Arduino.

$0=10 (step pulse, usec)

$1=25 (step idle delay, msec)

$2=0 (step port invert mask:00000000)

$3=6 (dir port invert mask:00000110)

$4=0 (step enable invert, bool)

$5=0 (limit pins invert, bool)

$6=0 (probe pin invert, bool)

$10=3 (status report mask:00000011)

$11=0.020 (junction deviation, mm)

$12=0.002 (arc tolerance, mm)

$13=0 (report inches, bool)

$20=0 (soft limits, bool)

$21=0 (hard limits, bool)

$22=0 (homing cycle, bool)

$23=1 (homing dir invert mask:00000001)

$24=50.000 (homing feed, mm/min)

$25=635.000 (homing seek, mm/min)

$26=250 (homing debounce, msec)

$27=1.000 (homing pull-off, mm)

$100=314.961 (x, step/mm)

$101=314.961 (y, step/mm)

$102=314.961 (z, step/mm)

$110=635.000 (x max rate, mm/min)

$111=635.000 (y max rate, mm/min)

$112=635.000 (z max rate, mm/min)

$120=50.000 (x accel, mm/sec^2)

121=50.000 (y accel, mm/sec^2)

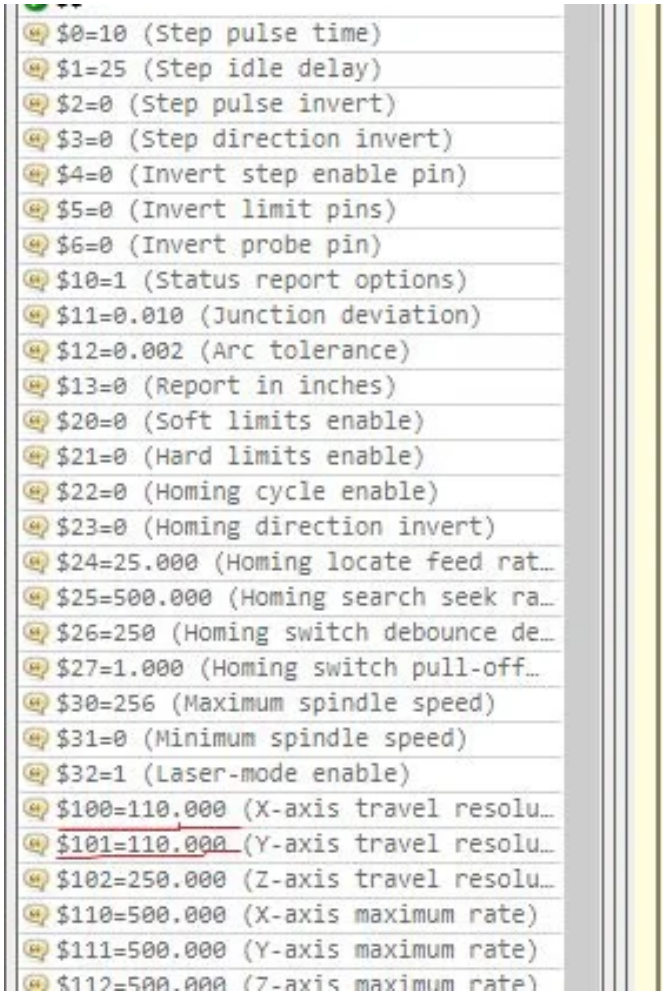
$122=50.000 (z accel, mm/sec^2)

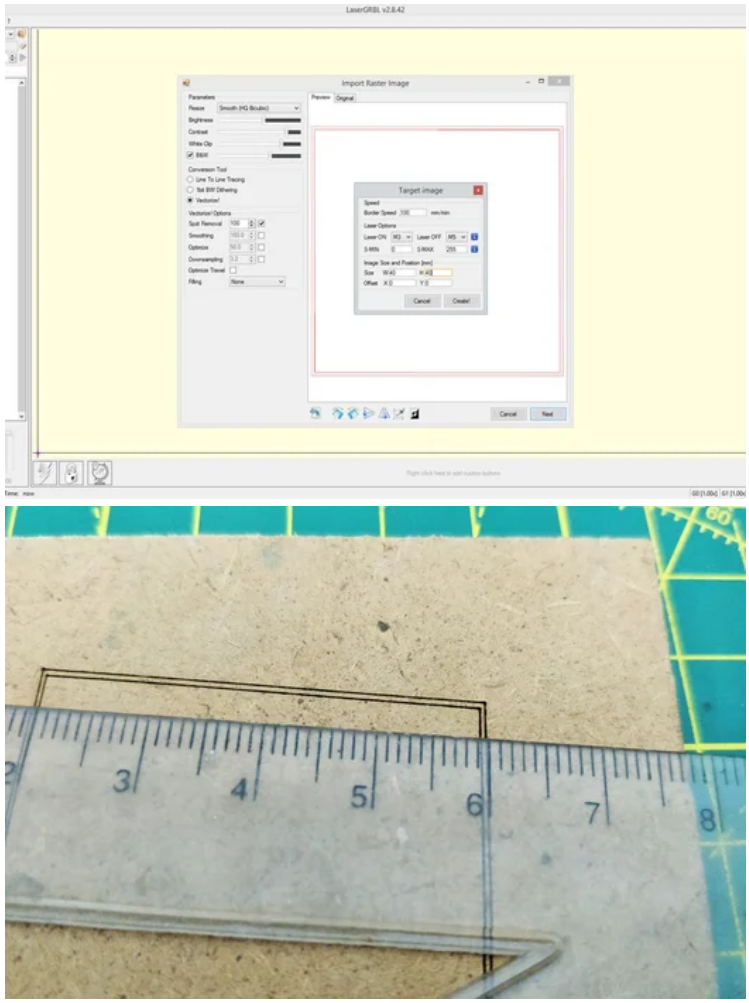
$130=225.000 (x max travel, mm)

$131=125.000 (y max travel, mm)

$132=170.000 (z max travel, mm)

Step 16: Tweaking the System





Here comes the Most Difficult part of the Project.

-Adjusting the laser beam into the smallest dot possible on the work piece. This is the Tricki est part which require time and patience using trail and error method.

-Tweaking the GRBL settings for $100, $101, $130 and $131

My setting for the GRBL is,
$100=110.000

$101=110.000

$130=40.000

$131=40.000

I tried engraving a square of 40mm sides and after so many error and tweaking the setting of grbl, I get the proper 40mm line engraved from the both X and Y-axis. If the resolution of X and Y-Axis are not same the image will scale in either direction.

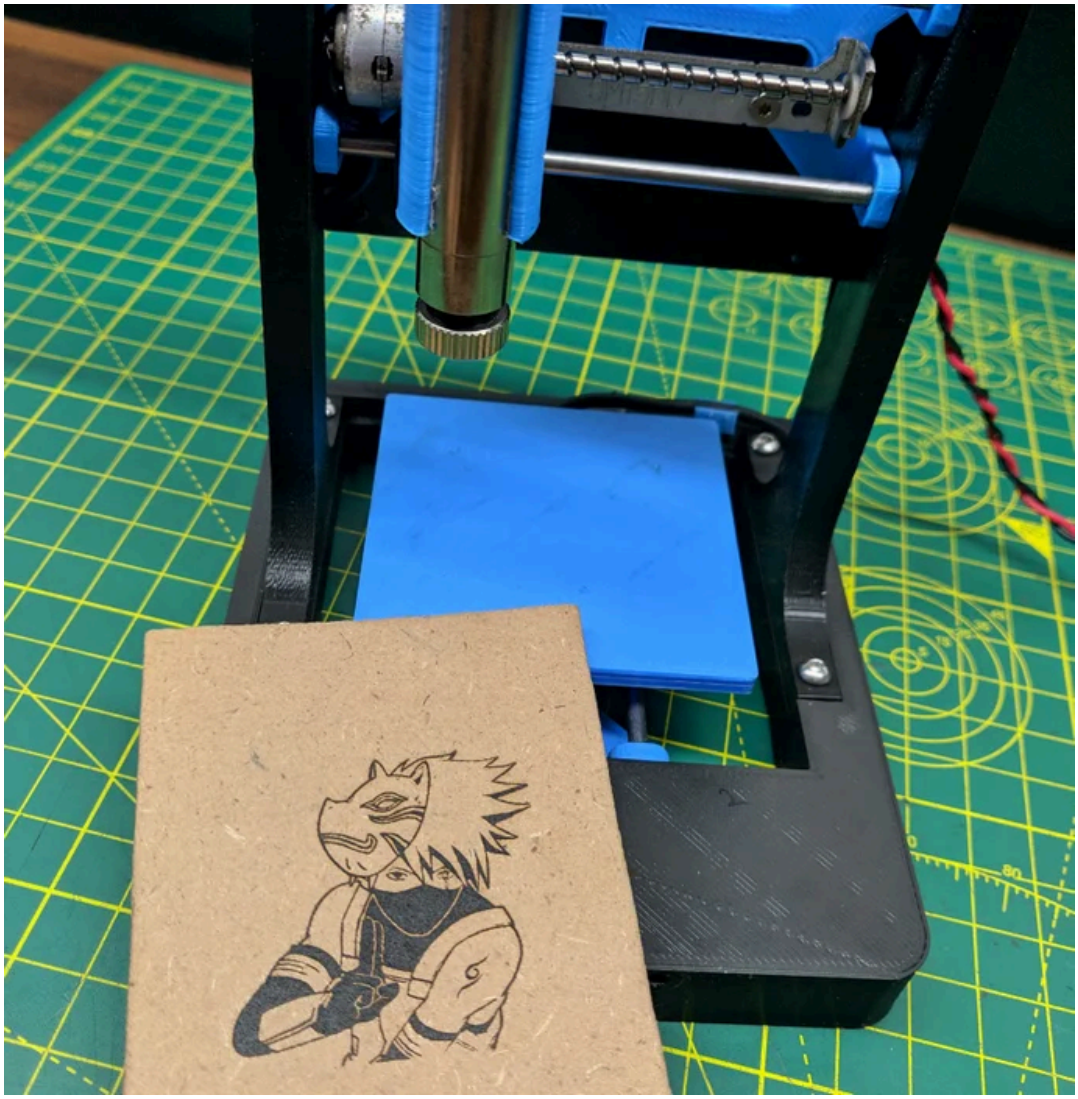
Keep in mind not all Stepper motor From DVD Drives are the same.

It is lengthy and time consuming process but the results are so satisfying when tweaked.

LaserGRBL user interface.

- Connection control: here you can select serial port and properbaud rate for connection, accor ding to grbl firmware configuration.
- File control: this show loaded filename and engraving process progress. The green “Play” but ton will start program execution.
- Manual commands: you can type any G-Code line here and press “enter”. Commands will be enqueued to command queue.
- Command log and command return codes: show enqueued commands and their execution st atus and errors.
- Jogging control: allow manual positioning of the laser. The left vertical slider control movemen t speed, right slider control step size.
- Engraving preview: this area show final work preview. During engraving a small blue cross wil l show current laser position at runtime.
- Grbl reset/homing/unlock: this buttons submit soft-reset, homing and unlock command to grbl board. On the right of unlock button you can add some user defined buttons.
- Feed hold and resume: this buttons can suspend and resume program execution sending Fe ed Hold or Resume command to grbl board.
- Line count and time projection: LaserGRBL could estimate program execution time based on actual speed and job progress.
- Overrides status an control: show and change actual speed and power override. Overrides is a new feature of grbl v1.1 and is not supported in older version.

Step 17: Wood Engraving



Raster import allows you to load an image of any kind in LaserGRBL and turn it GCode instructions without the need of other software. LaserGRBL supports photos, clip art, pencil drawings, logos, ico ns and try to do the best with any kind of image.

It can be recalled from “File, Open File” menu by selecting an image of type jpg, png or bmp

The setting for engraving is different for all materials.

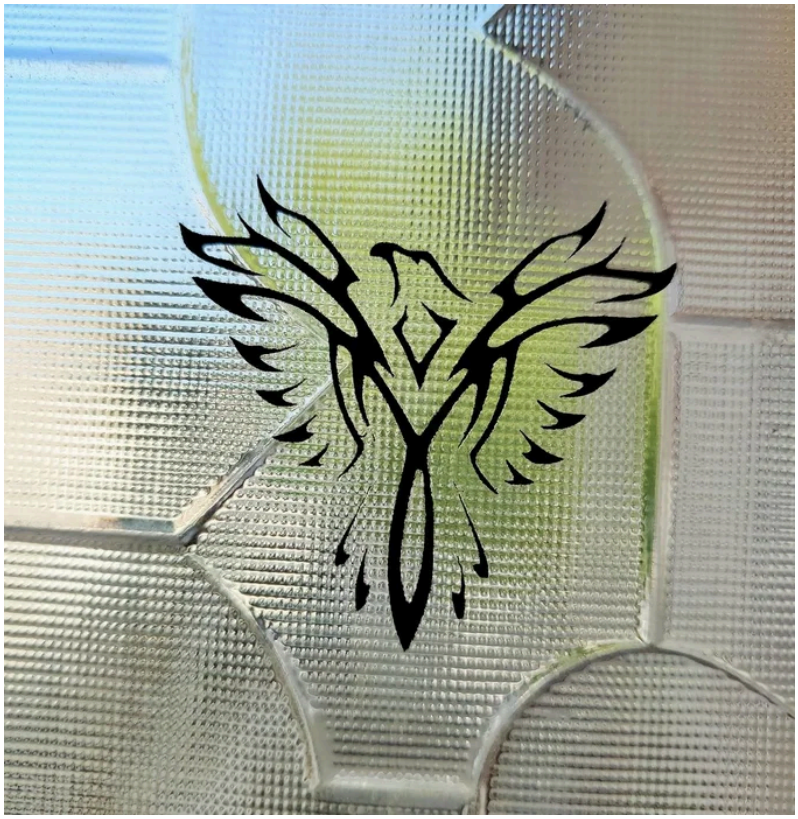
Define the engraving speed per mm and Quality- lines per mm Video Attached is the time-lapse of t he whole process.

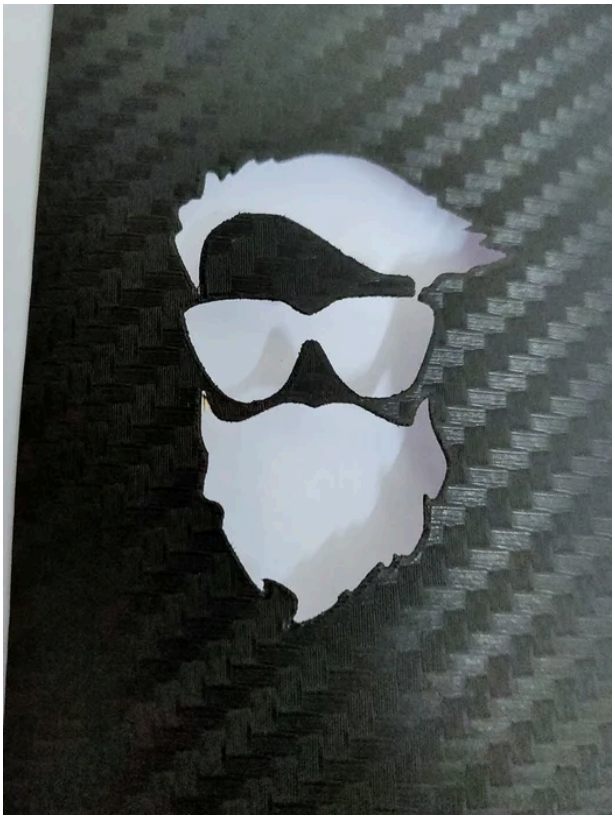
Step 18: Thin Paper Cutting

This 250mW Laser is Also capable of cutting thin papers, but the speed should be very low i.e. not more than 15mm/min and laser beam should be properly adjusted.

Video Attached is the time-lapse of the whole process.

Step 19: Vinyl Cutting and Making Custom Stickers





I have made some Custom vinyl sticker. Boarder speed changes with respect to the colour of the vi nyl used.

Dark colours are the easy to work with while the Lighter colours are some tricky.

The above Images demonstrate how to use vinyl sticker which are made using the CNC.

But keep in mind that burning vinyl releases carcinogenic fumes. They smell really bad.

♥ Special thanks to the GRBL Developers :)

I hope you liked this project, let me know in the comments if any queries, I would like to see photos of your CNC machines too!

Thanks!! for Your support.