Gatoino assembly manual

The whole process of building Gatoino is available in video form with chapters. You can find it here: https://www.youtube.com/watch?v=tEiQNNClb9U

Version 1.0

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Before you start

You can either start with flashing the software of the Arduino or soldering the board. The order doesn't matter so feel free to start with any of those two.

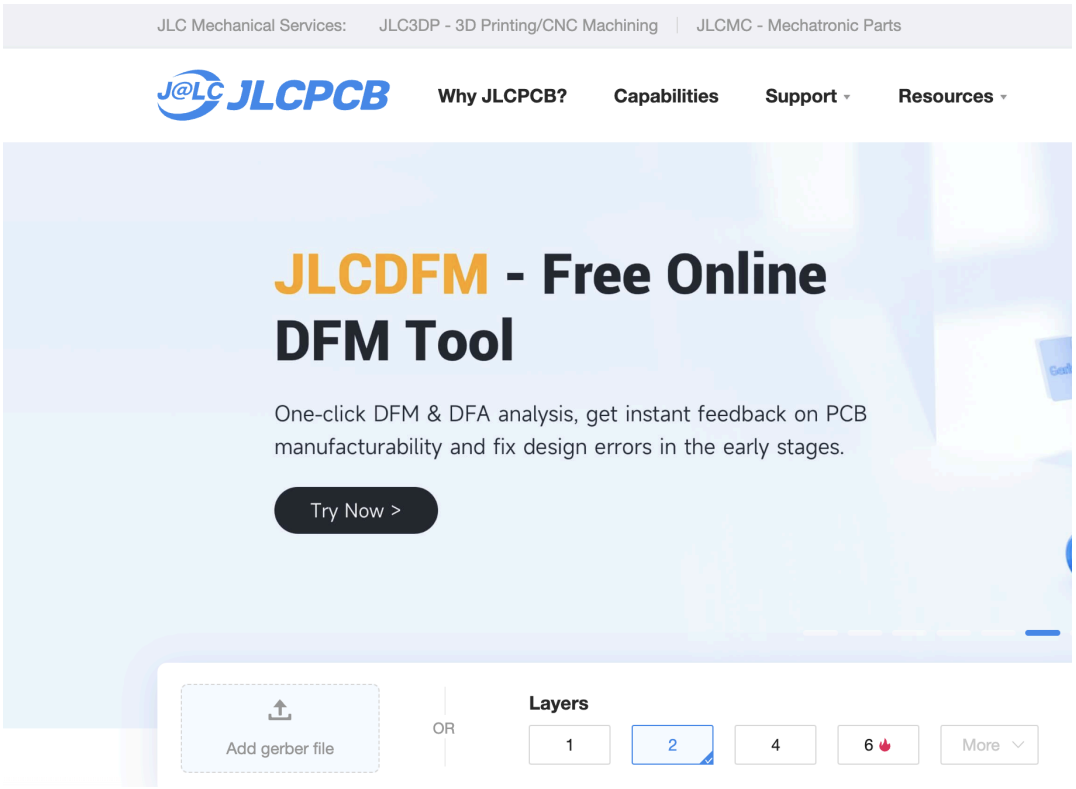
If you bought the mirrors in the correct size already you're fine, otherwise you'll need to cut a larger piece into the given dimensions. You'll need them later in the assembly process.

Ordering the board from JLCPCB

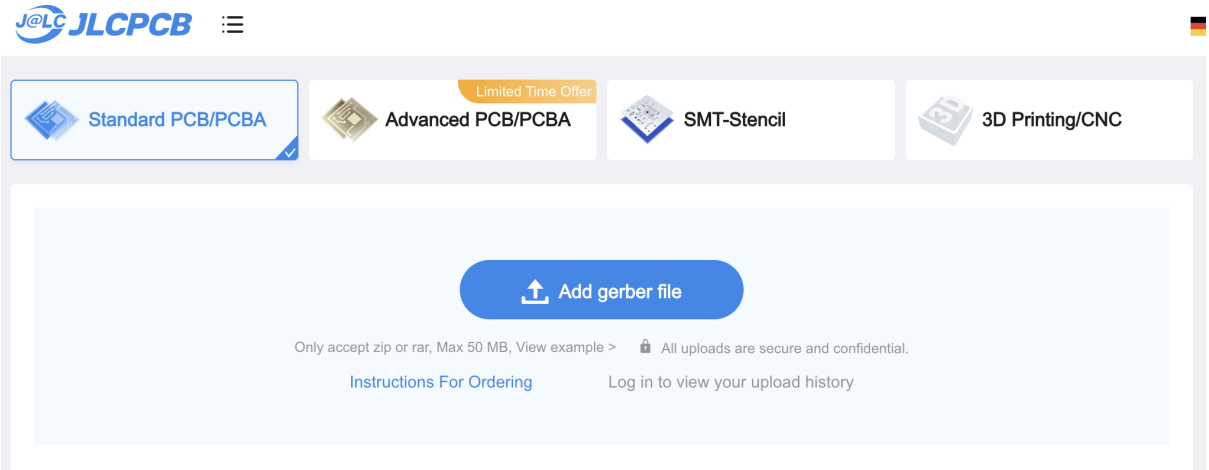
Since I only ever ordered boards from JLCPCB I will describe the process using their service. They also handle everything customs related, at least in Euope, possibly also in the US. If you're already experienced feel free to use whatever vendor you like or even make the PCB yourself.

In case you do order from JLCPCB you would do me a huge favor by using this affiliate link: https://jlcpcb.com/?from=SmallBatchFactory. It doesn't cost you anything extra, but I earn a small commission.

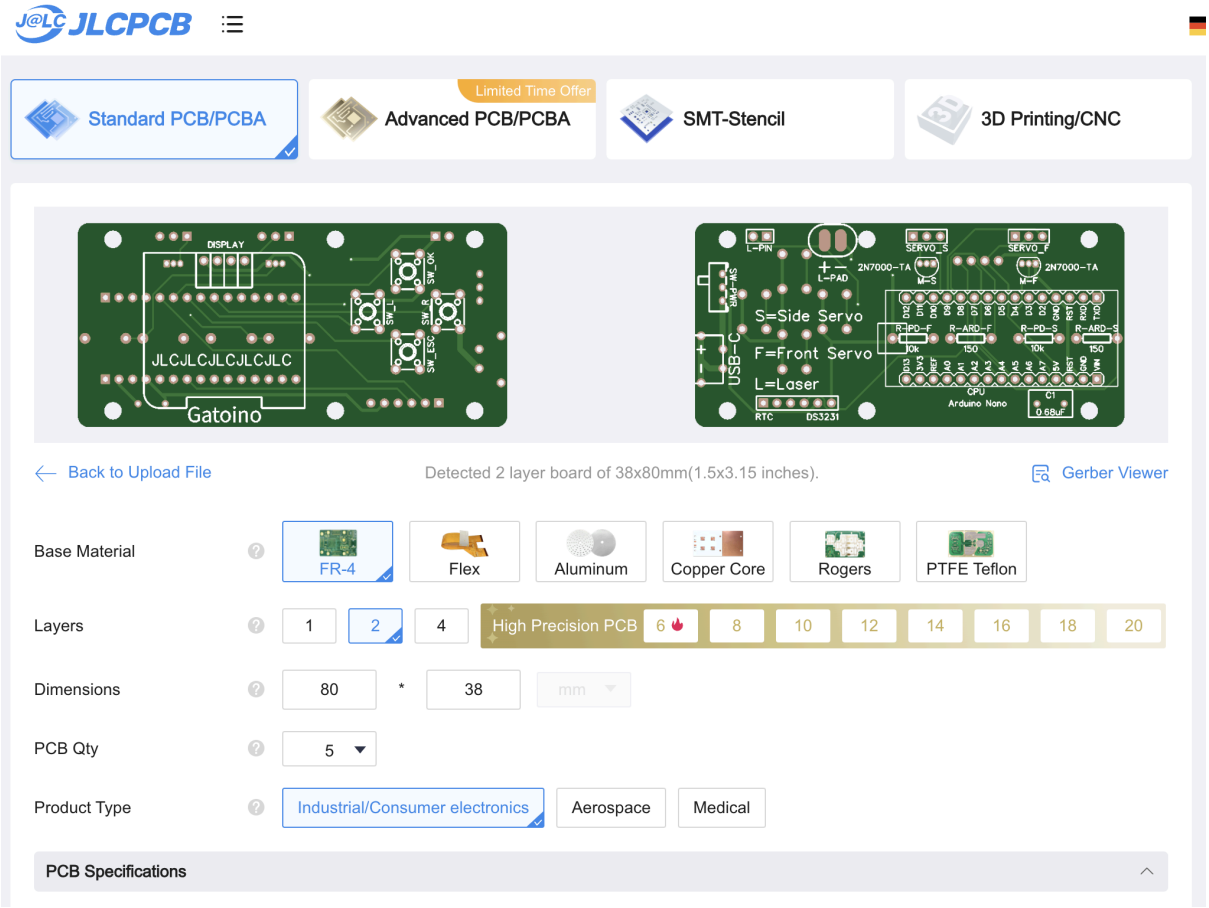
Don't be intimidated by the many options you'll see on the website, ordering your own custom PCB is actually quite straight forward. In any case you need to upload the "Gerber file" which is provided as a ZIP archive with the rest of the Gatoino files.



If you select "Add gerber file" on the landing page you can directly upload the file.

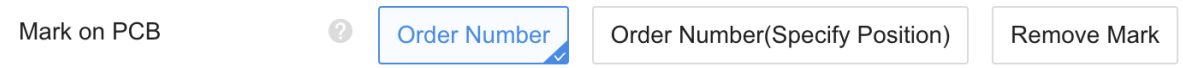


Other paths might lead you to the “PCB configuration” site without a gerber file. You can also upload the file here.

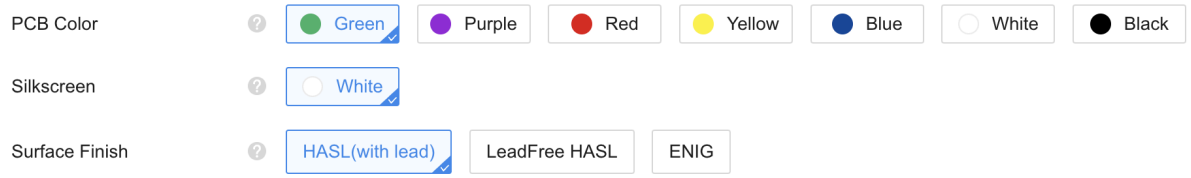


After uploading the file the website should look like this with a plethora of available options below. You don’t actually need to change anything and could already go ahead and place the order. The minimum “PCB Qty” is 5, which is a chapter per item price than larger quantities. This is made possible because your order is used to fill otherwise wasted space on larger

PCB orders. In case you mess something up you'll still have spare boards or you can build multiple Gatoino.

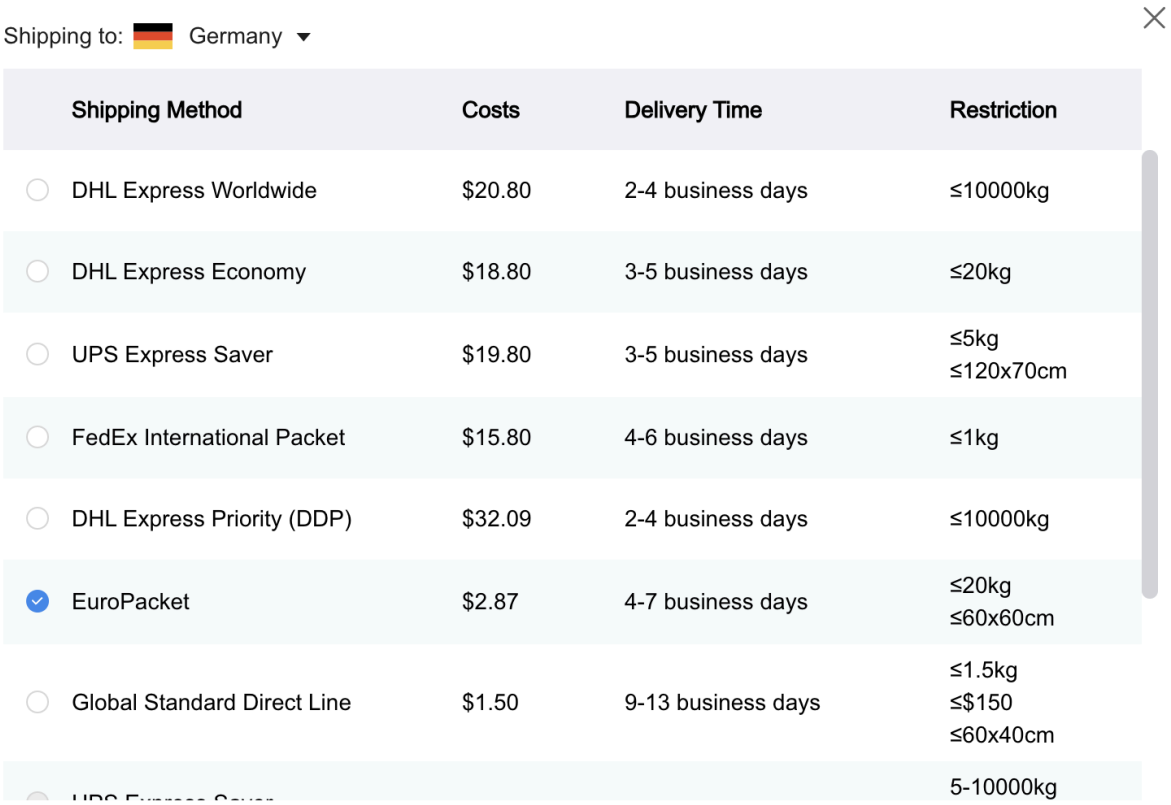


JLC will print an order number on the boards to distinguish them in production. You can select "specify position", since the necessary marker is already on the board design. This comes at no extra cost. You can also opt to remove that mark but it costs a small fee.



You can also select a board color of your choosing. Green is usually produced faster than other colors, but not by much. You can also select Lead Free surface finish for a small premium. ENIG is a gold plated finish, but costs a rather large premium, especially for small quantities.

That's already everything necessary for the board. Choose a shipment option you prefer. For Europe "EuroPacket" is usually best since it means they'll handle everything customs related and then ship from their German warehouse.



The rest of the order process works as with any other online order. In the checkout process you have to double check if your preferred shipping method is still selected. In my case it was changed to DHL Express and I needed to set it again.

Printing the STL files

The print files are all oriented for easy printability already. You don't need any special settings. I recommend using 3 perimeters, 4 bottom and 5 top layers. Infill of 15% is fine.

Since Gatoino doesn't get hot you can use PLA, assuming you don't want to expose it to hot environments. Feel free to use PETG or whatever you have on hand if you want to. I also tested resin for the gears, but got too much size variation. Printing precision is crucial so avoid getting warped parts.

Every part is needed once, no exception.

- Gears: (there is a scaled 99% version included in case you get too much friction)
    - Half Gear upper Mirror
    - Large Gear Lower Mirror
    - Servo Gear Lower Mirror
    - Servo Gear Upper Mirror
- Laser assembly:
    - Laser Cage
    - Laser large upper Mirror Axis
    - Laser small lower Mirror Axis
- Electronics:
    - Controls Frontplate
    - D-Pad (either 8mm or 12mm, depending on your buttons)
    - OLED Bracket
    - Power Switch Slider (Use the "larger hole" file if the regular one doesn't fit)
- Case:
    - Main Case
    - Case Lid

Soldering the circuit board

General information

The order in which the electronics are soldered in this manual is on purpose to make the process as easy as possible. Therefore the parts with the least height are soldered first.

All parts need to be flush with the circuit board in order to fit the case flawlessly. The mosfets, as shown later, are allowed to stick out 2-3mm to make visual inspection of the soldering joint easier.

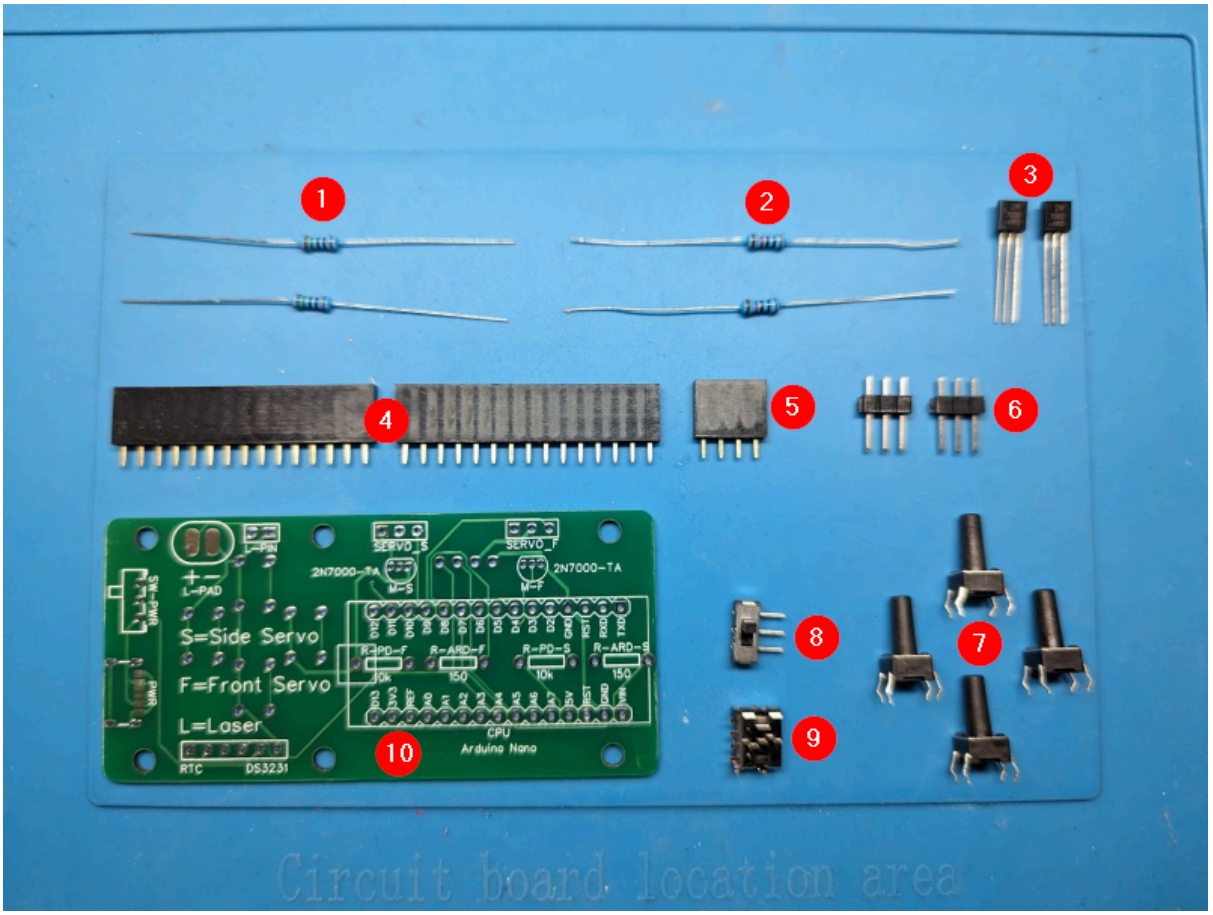
Soldering joints need to be filled with solder completely to ensure a stable electrical connection.

Apart from the solder itself a bit of additional soldering flux can be helpful in some situations. It makes fixing accidental short circuits easier.

All parts are meant to be mounted on the side of the circuit board where the names and markings are.

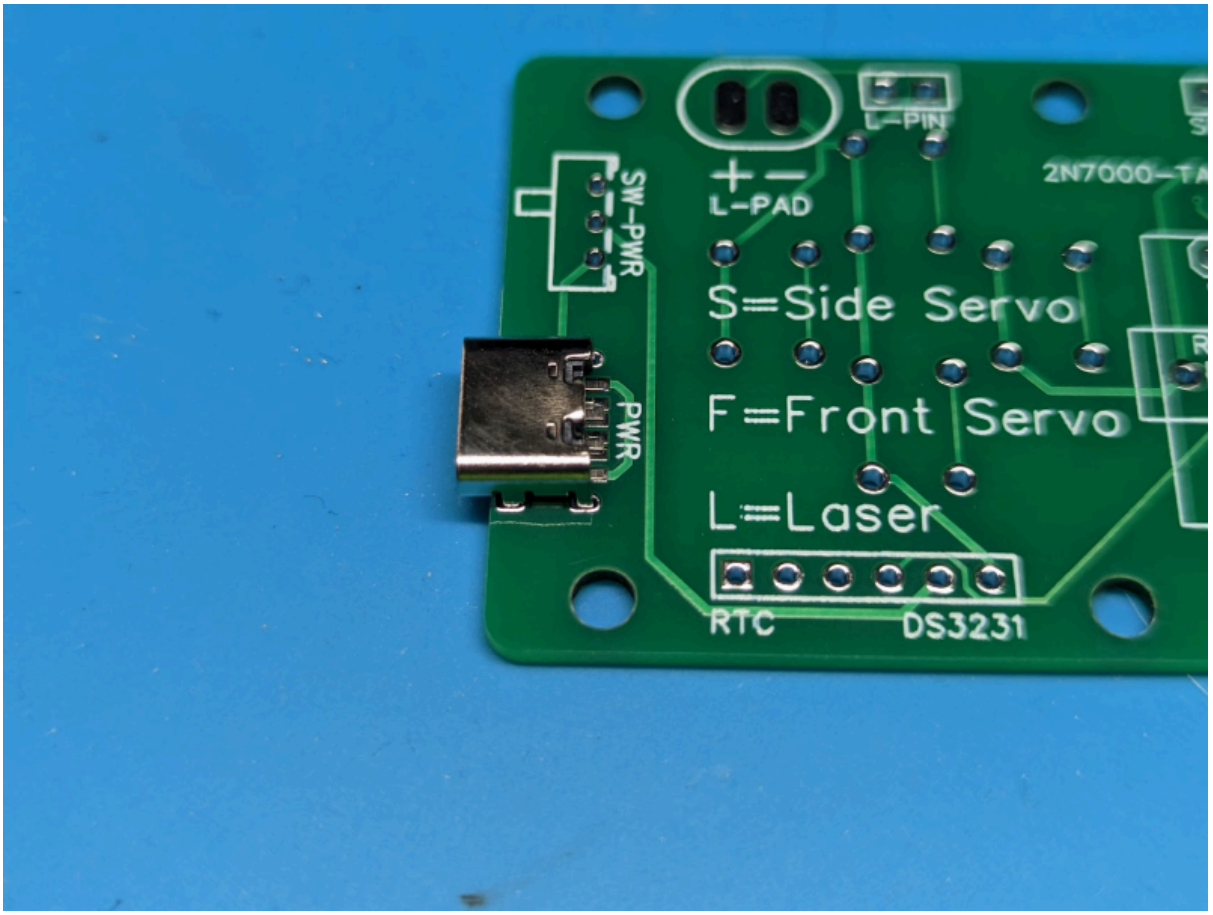
Due to constant improvement some parts or positions shown in this manual might be slightly different. The overall layout is the same though.

The soldered parts of the circuit board

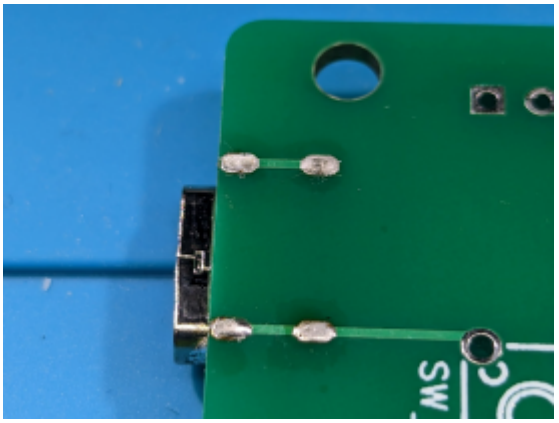


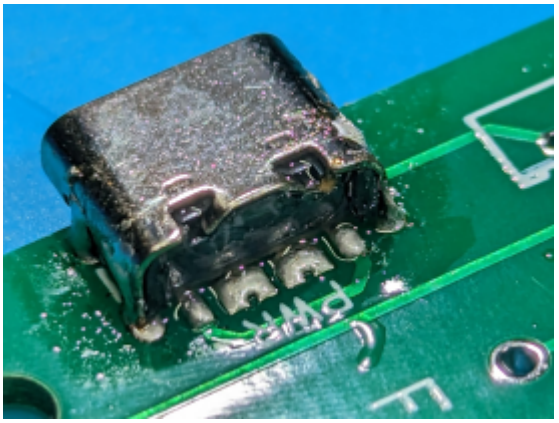
1. 2x Resistors of 150 Ohm (Brown-Green-Black-Black-Brown)
2. 2x Resistors of 10.000 (10k) Ohm (Brown-Black-Black-Red-Brown)
3. 2x Mosfet 2N7000
4. 2x Female 15 Pin Headers (for Arduino)
5. 1x Female 4 Pin Header (for the Display)
6. 2x Male 3 Pin Header (for Servos)
7. 4x Buttons (8mm or 12mm length)
8. 1x Toggle switch (Power On/Off)
9. 1x USB-C power only port
10. 1x Main circuit board

USB-C Port

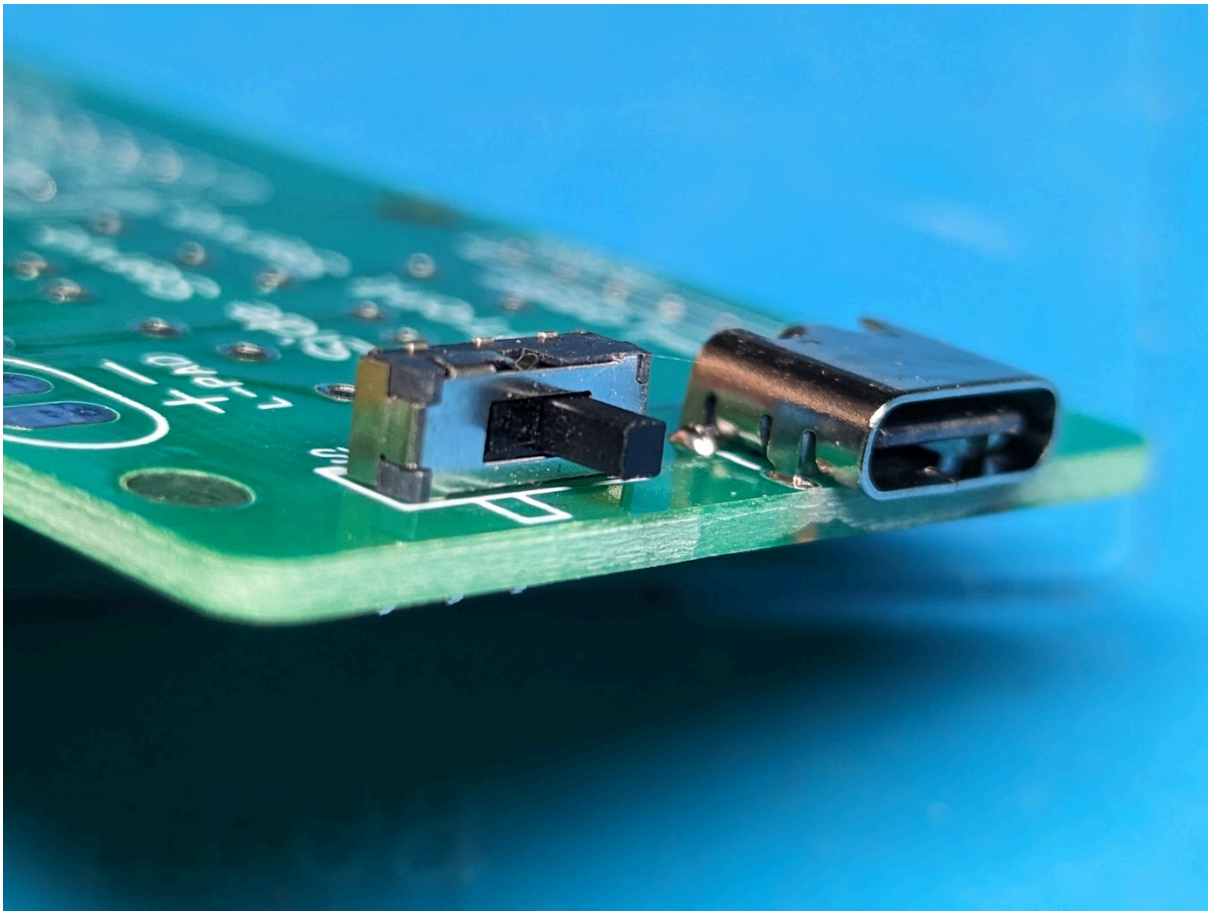


The port needs to sit perfectly flush on the board. First only one pin on the side of the port is soldered to roughly fix it in place and check for flushness. If it's not flush yet just reheat the solder and move the port to sit flush. If it sits fine you can then proceed to solder another pin on the other side of the port and check again. If everything is still flush you can then proceed to solder the rest of the pins.

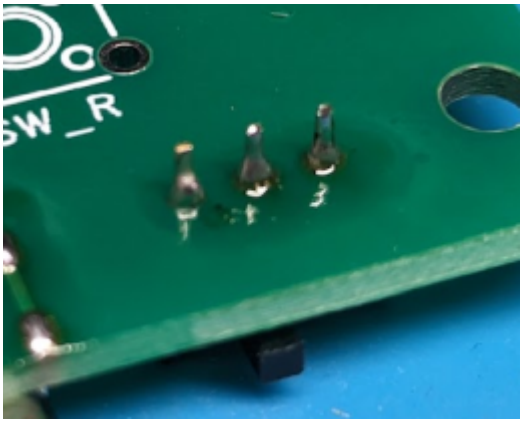




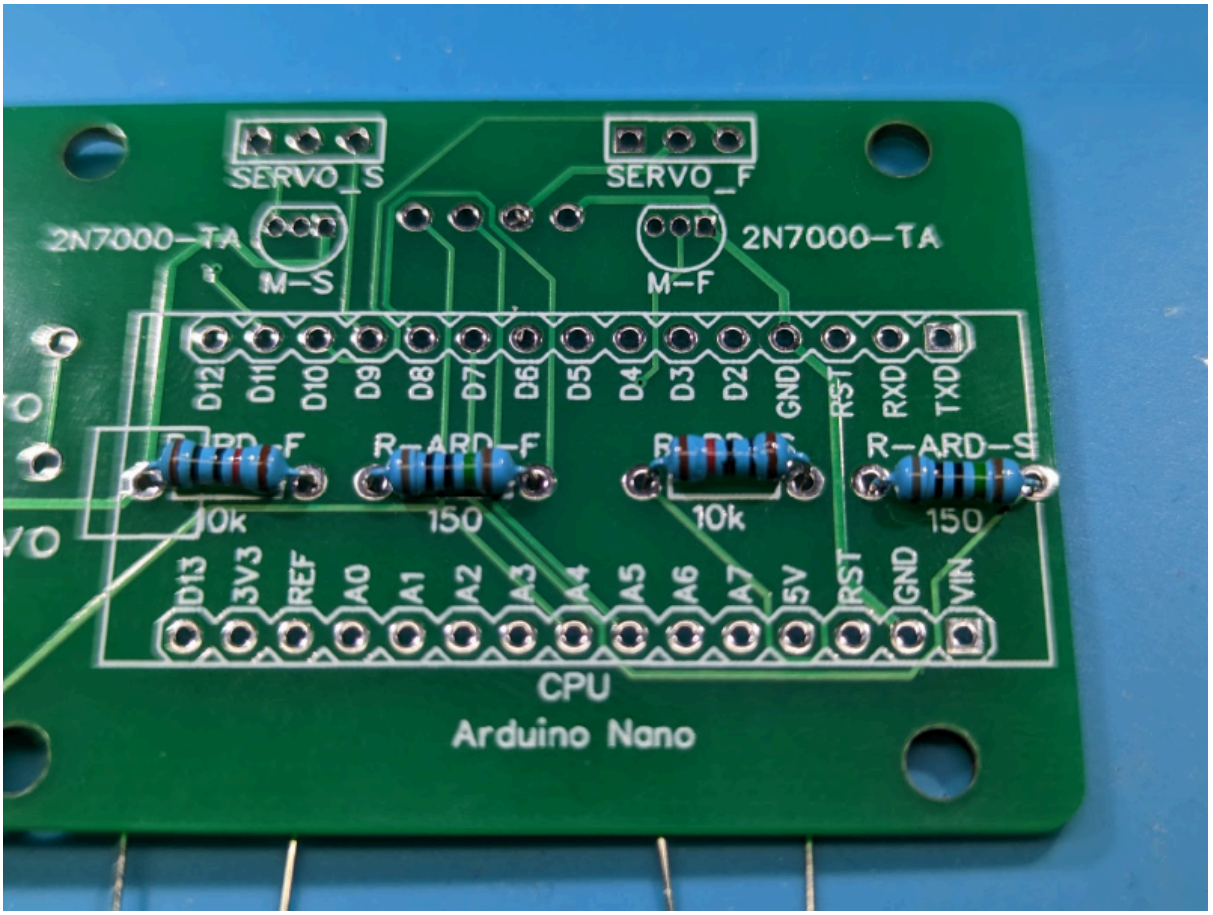
On-/Off Switch



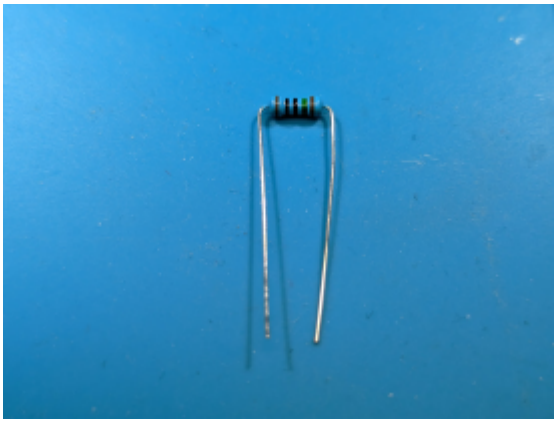
The on/off switch needs to be flush as well. As before, solder one pin first, ideally the middle one, and check that it sits flush and parallel to the board's edge. Then proceed to solder the other pins. You don’t need to cut them after soldering.

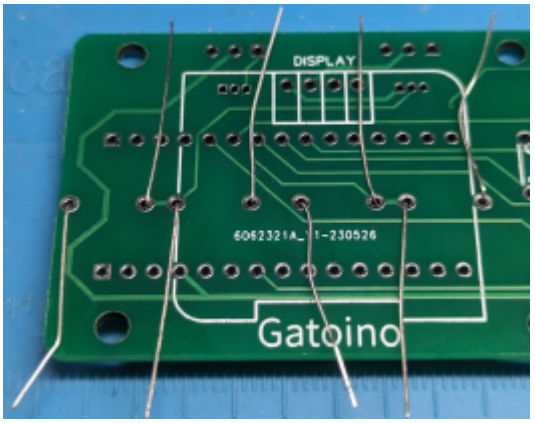


Resistors

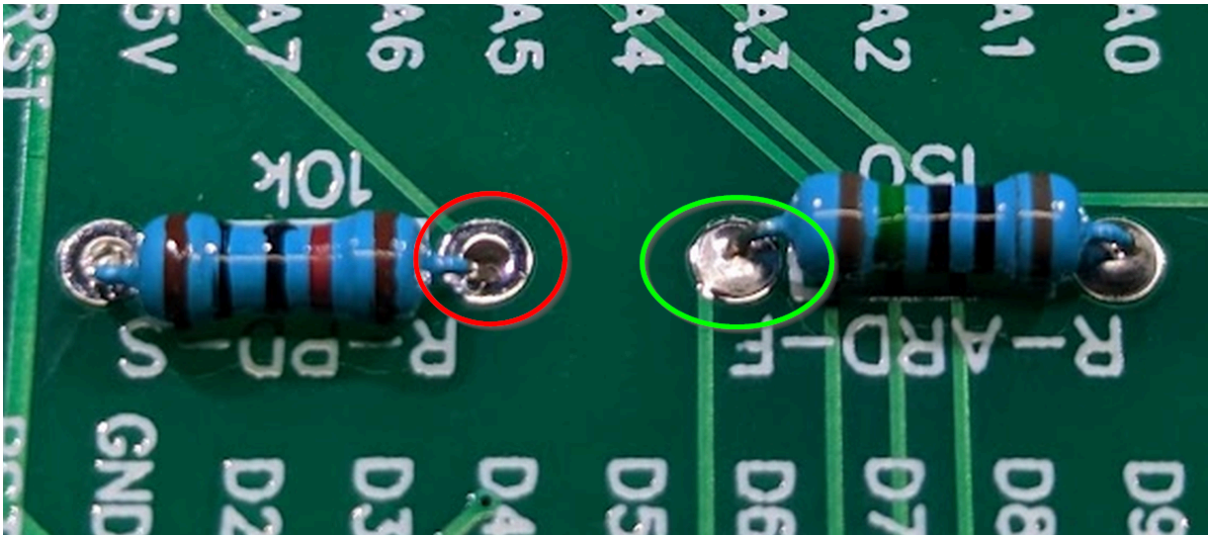


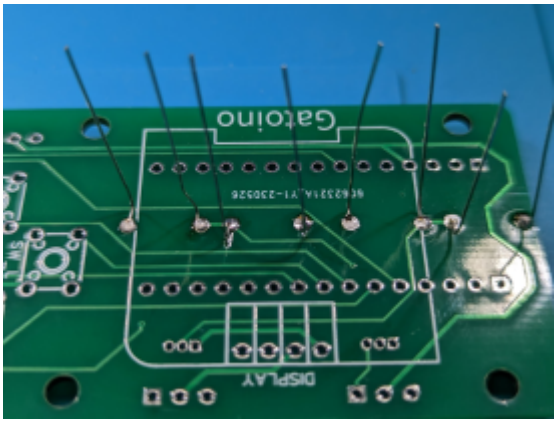
The legs of the resistors need to be angled 90 degrees close to their body in order to fit the holes. They're easiest to solder if the legs are angled in different directions after insertion, this way they can't fall out anymore. You can also angle them left and right and do them one after another.

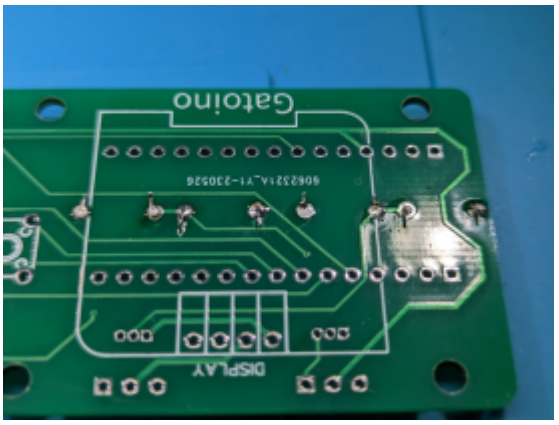




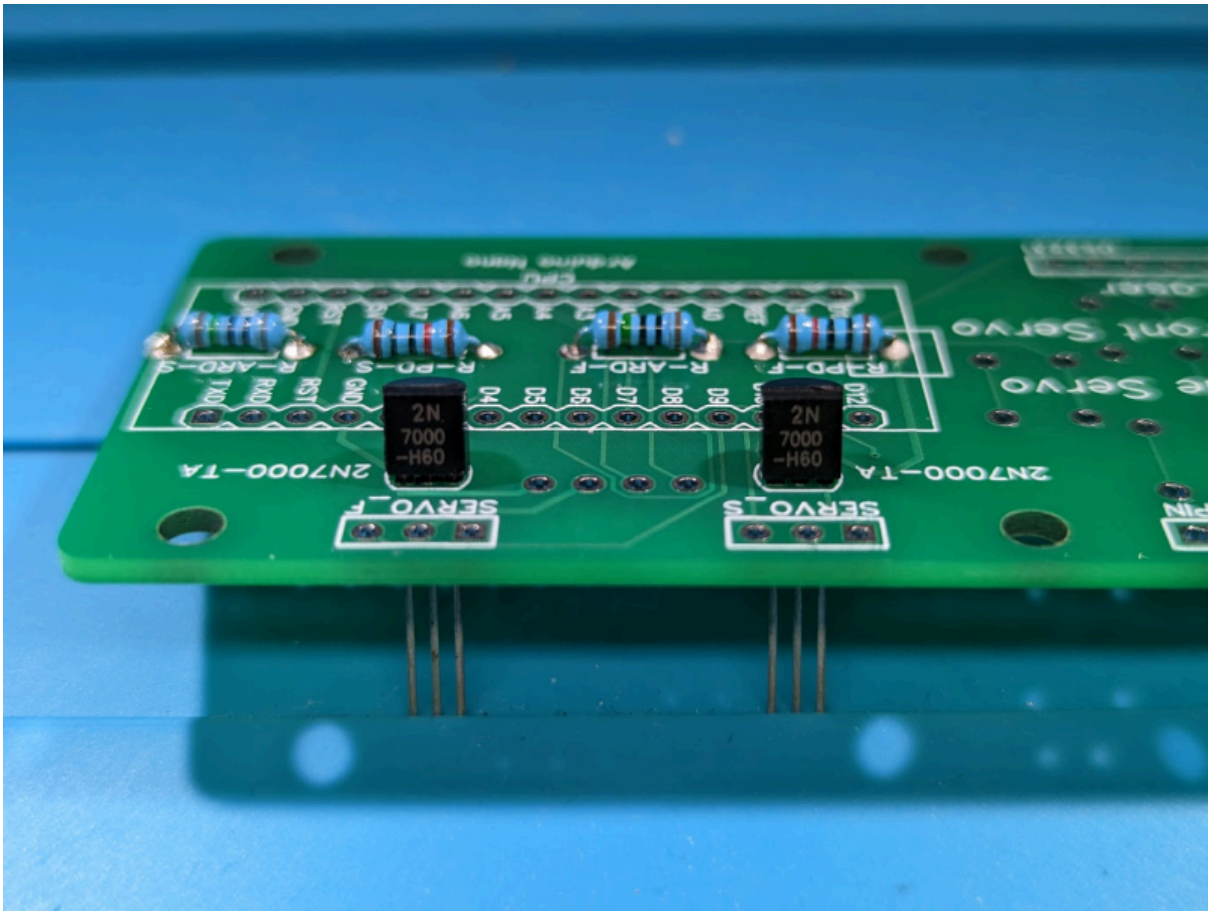
Make sure the hole is thoroughly filled with solder. After soldering the legs of the resistors need to be cut.



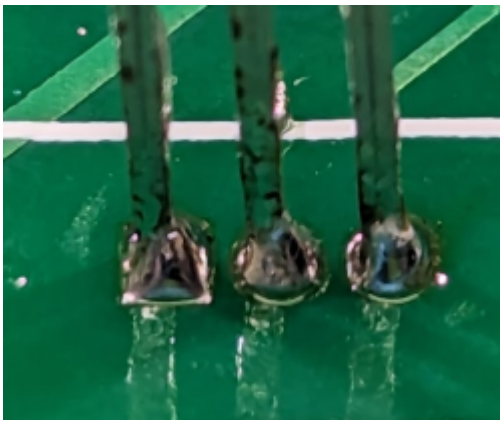


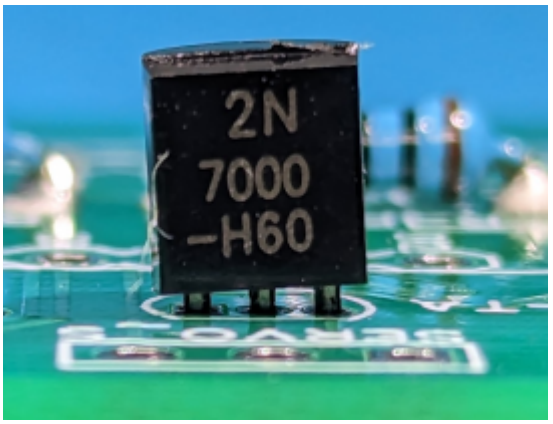


Mosfets



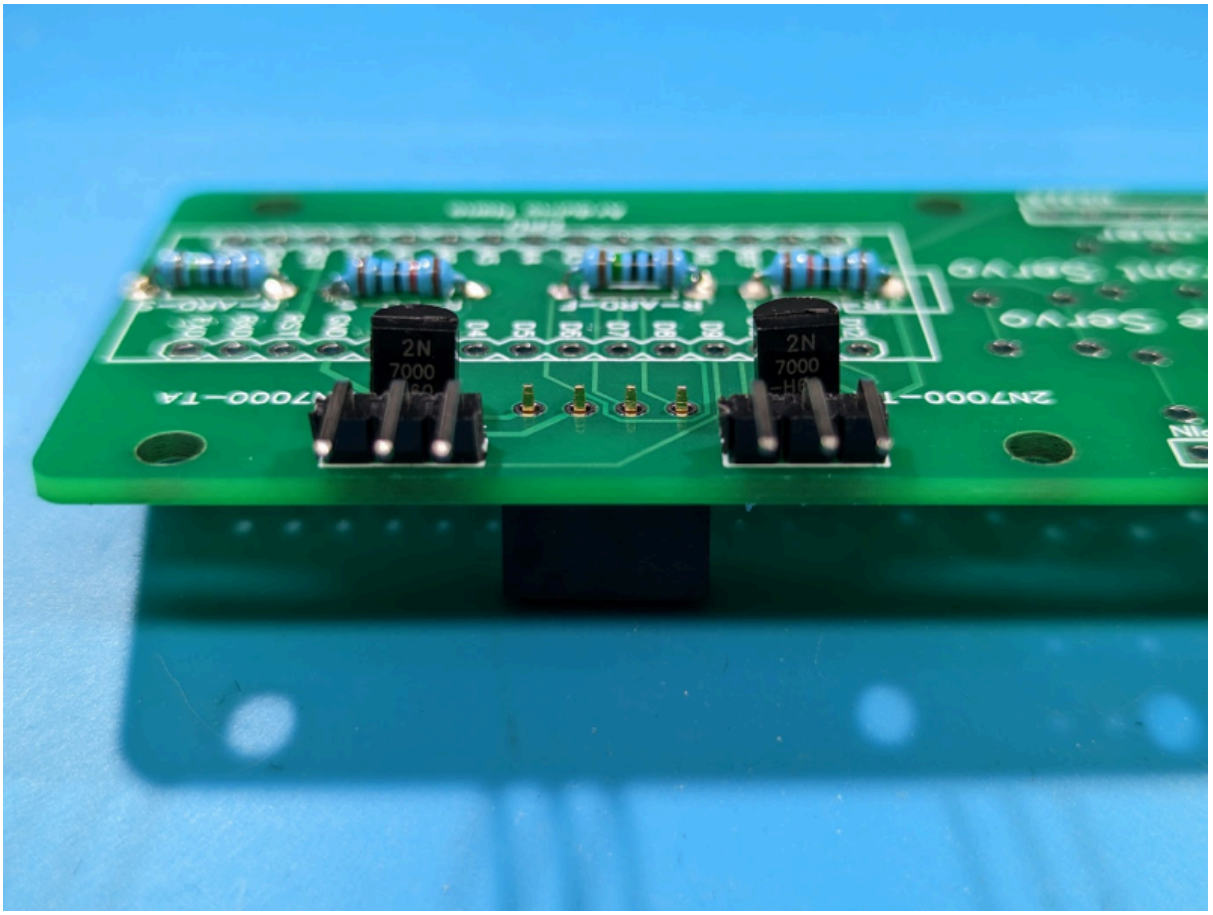
Since the MOSFETs are rather small you need to be extra careful here. Having the body stick out a few millimeters helps you identify potential shortcuts after soldering. They don't need to be perfectly flush anyway. After soldering the legs are cut once again.





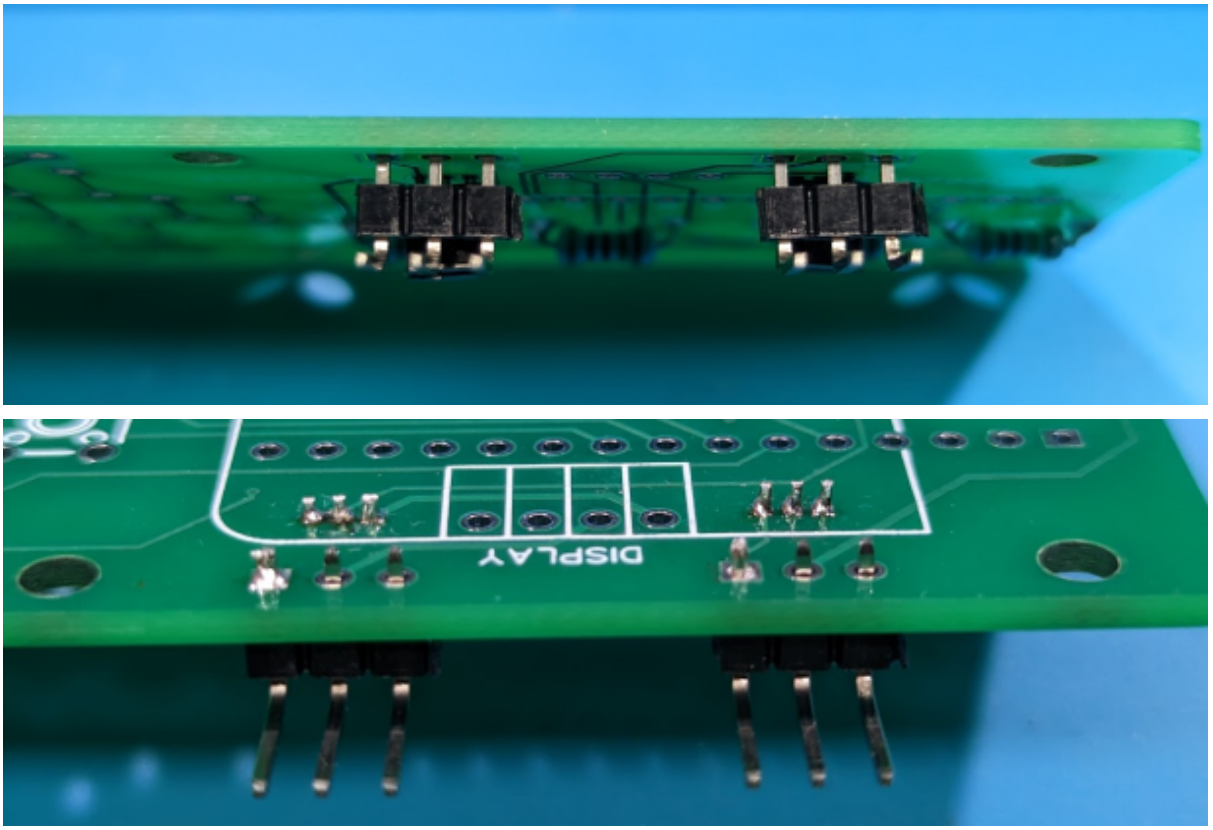
In case of a short circuit between two pins it is often helpful to heat that solder up again and then do a swift swipe of the irons tip through where the short circuit is. By that the solder often gets dragged with the irons tip and the short circuit is resolved.

Servo Pins

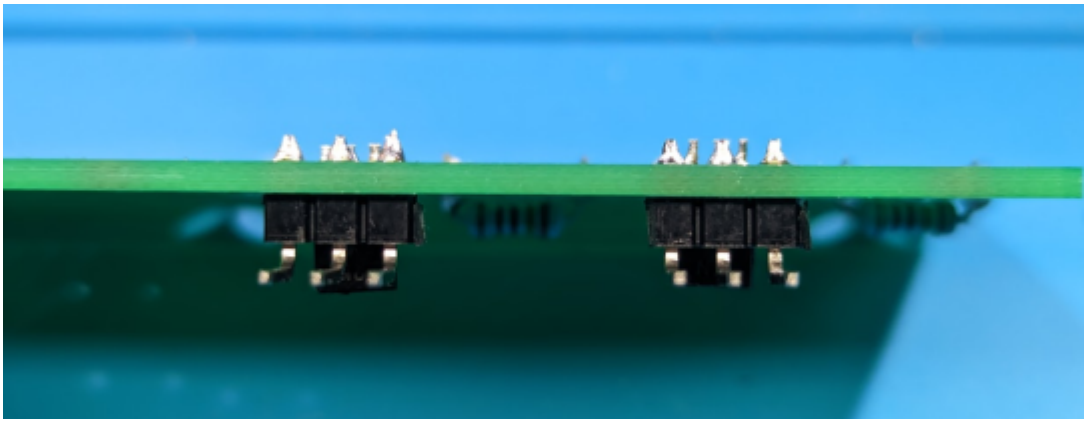


You don’t need angled pins for this to work but it makes for more clearance of the cables to the case than the straight version. Since this is not rocket science you can use any of both or just bend them a bit yourself.

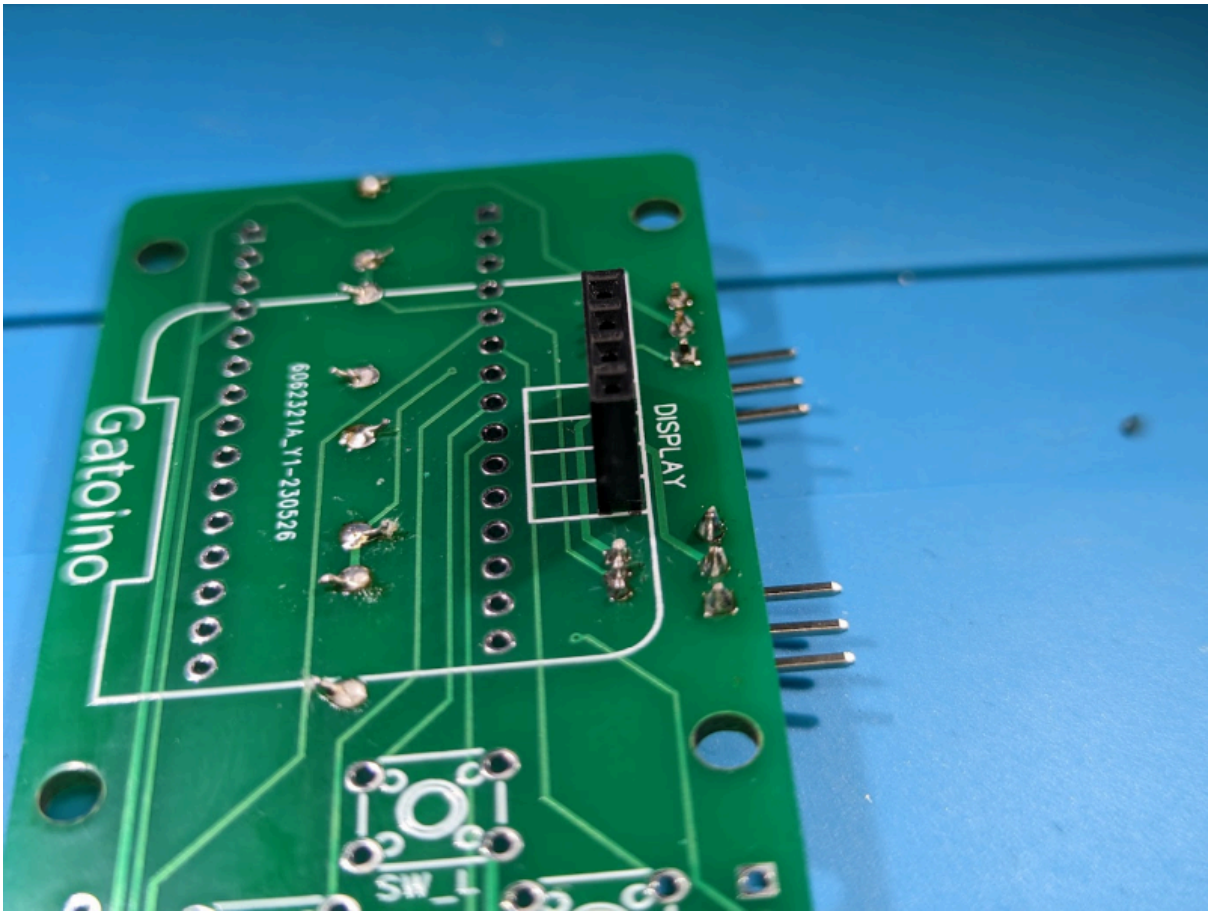
As usual solder one pin first and check if it sits flush. You can always reheat that single pin and then change the position of the pin header. Be careful, the pins get hot pretty fast. A pair of pliers is helpful here.



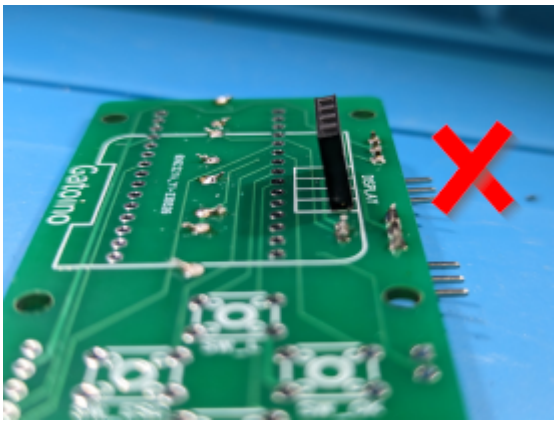
Then you can solder the rest of the pins. Make sure they all have properly filled holes.



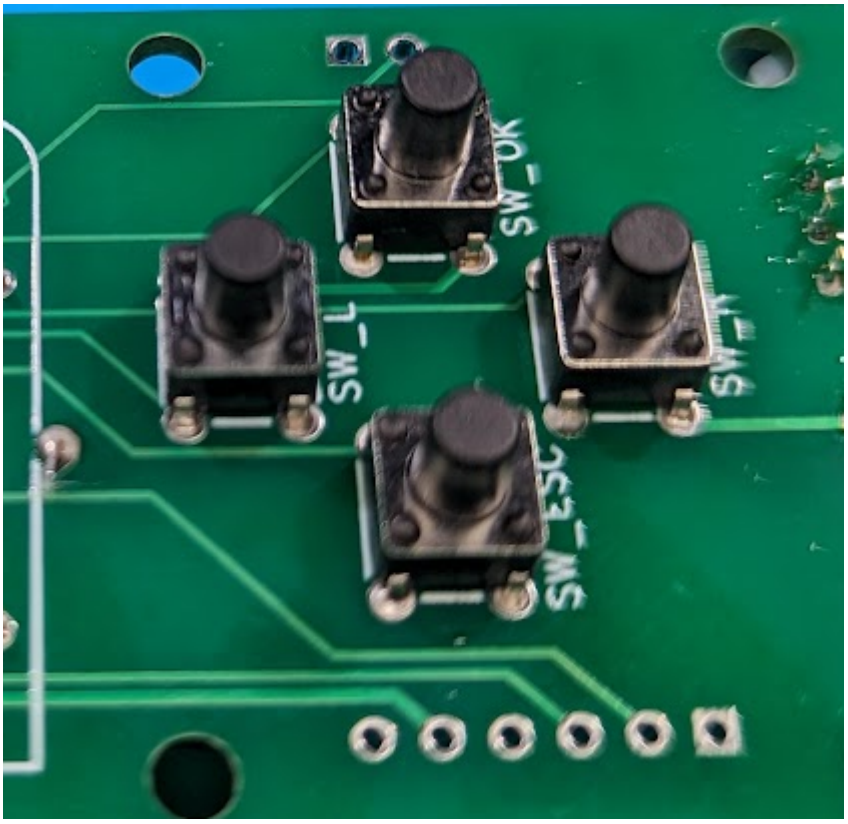
Display Pin Header



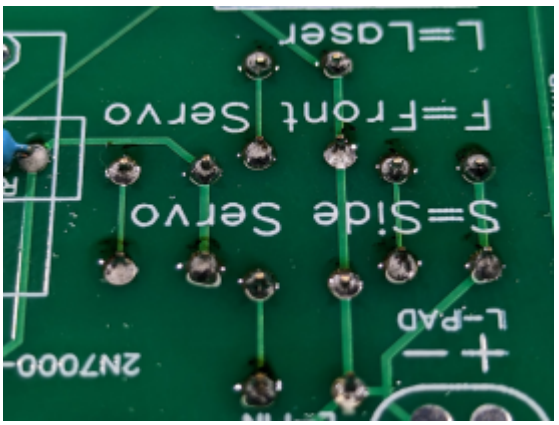
The display pin header is solder just like the servo pin headers. It's extremely important that it has a 90° angle to the board in order to have it fit into the case later. It doesn't have to be totally perfect since all components can still be bent to some degree. Just make sure it doesn't look like the image below.



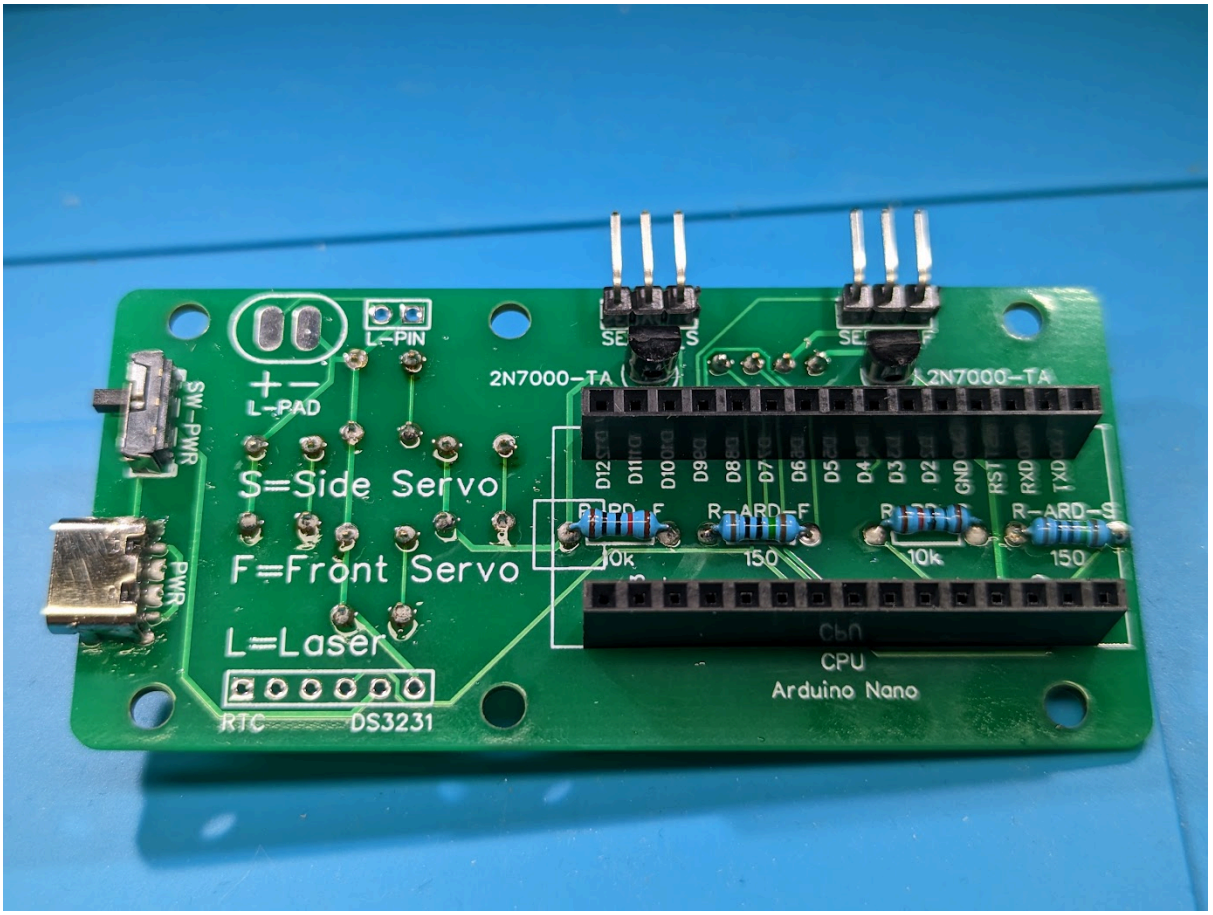
Buttons



The buttons have to be perfectly flush with the board surface. Otherwise the controls might be too tight later on. As usual, solder one pin first, then check for flushness. Solder the one diagonally second. If everything is still flush you can solder the rest.

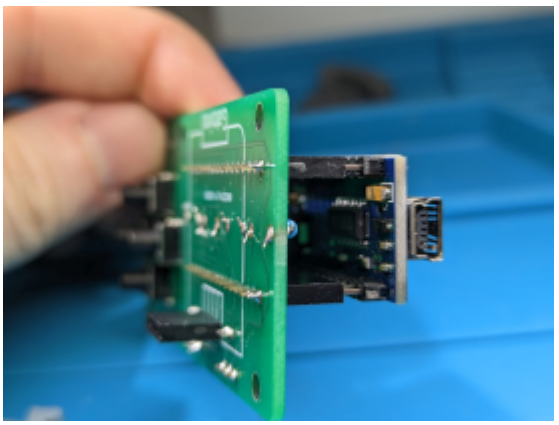


Arduino Pin Header and capacitor

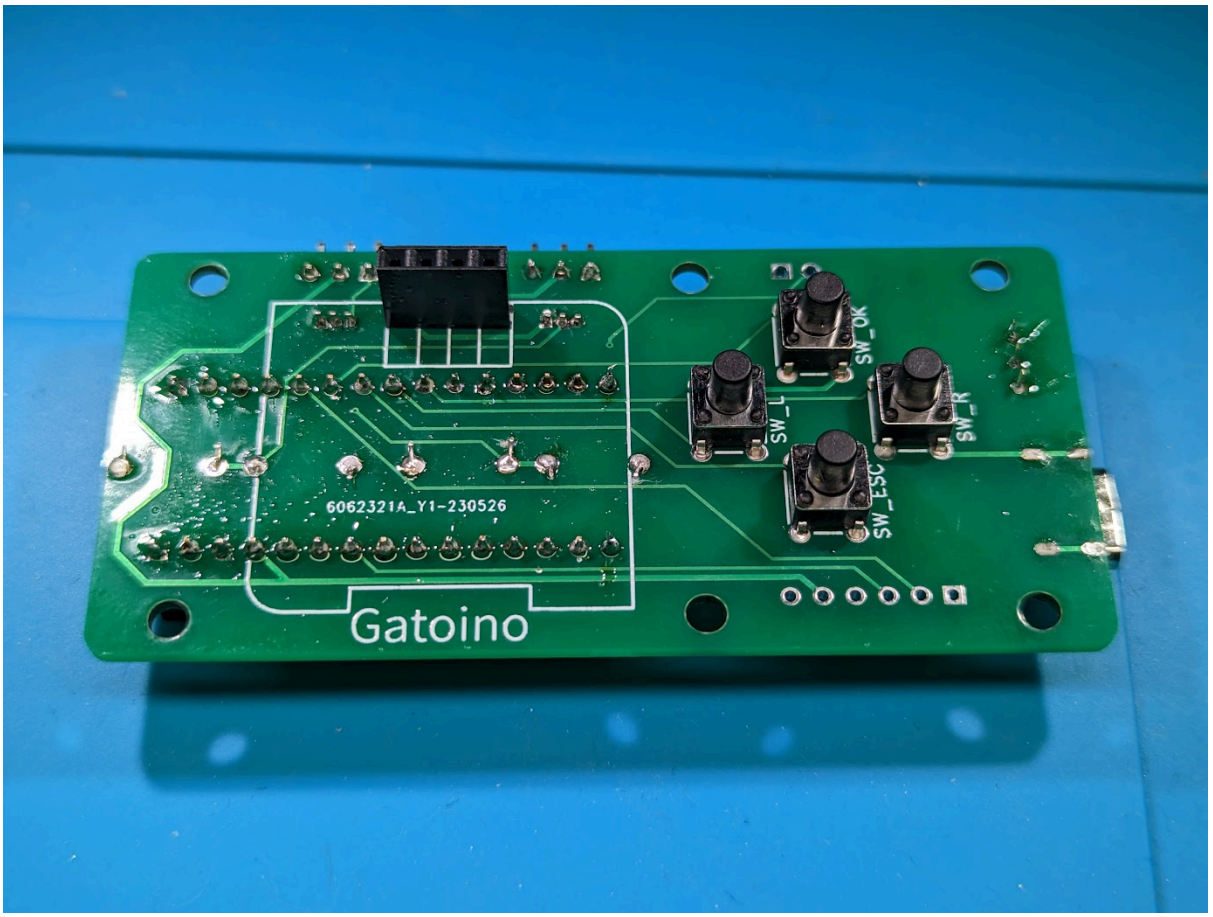


If you opted to omit the pin headers you can also solder in the Arduino directly. The process is pretty much the same. Make sure the Arduino doesn't touch the resistors. The pins are long enough.

Again solder one of the end pins first. To keep the board level when soldering the header you can use the half-gear of the laser assembly. It has the ideal thickness for this use case. You can check if the pin headers are aligned by semi-plugging the Arduino in. Don’t put it in completely since it takes quite a bit of force to get it out again which could damage the board if you only soldered one pin so far.



After soldering the rest of the pins the board is done for now. Later on we need to solder the laser diode so don't put it away yet.



Installing the Software

Necessary prerequisites

The Gatoino software relies on a few libraries in order to work. With the **exception of MD_Menu** you can install those libraries directly in the Arduino IDE. Since I needed to do some enhancements to MD_Menu the one in the IDE lacks a few features. It is provided as a ZIP file together with the rest of the Gatoino software and you can directly get it from GitHub as shown below. I've marked the versions I used and made sure everything works. Never versions often work as well but if this is not the case get the version listed here. One example is version 2.6.1 of OneButton, which takes up more space than 2.5.0 and therefore exceeds the memory capacity of the Arduino Nano.

Gatoino Arduino Firmware: https://github.com/ensoniq2k/ArduinoCatLaserpointer

MD_Menu 2.3.5: https://github.com/ensoniq2k/MD_Menu

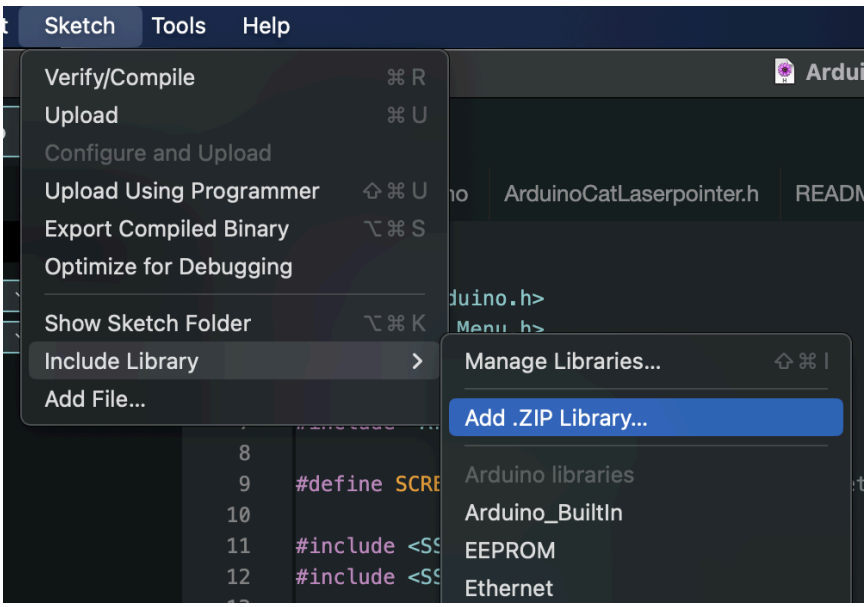
AsyncTimer **2.4.0**: https://github.com/Aasim-A/AsyncTimer
OneButton **2.5.0**: https://github.com/mathertel/OneButton
SSD1306ASCII **1.3.5**: https://github.com/greiman/SSD1306Ascii

Adding the libraries

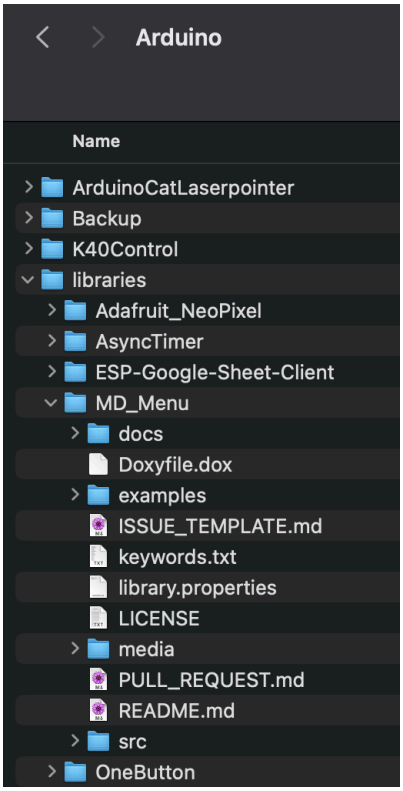
If you encounter issues at any point you can find further information on installing libraries in the official Arduino documentation.

Adding MD_Menu

The simplest way to add a ZIP library is via the "Sketch" menu in the Arduino IDE. Select "Include Library" and then "Add .ZIP Library". In the following file dialog select the file MD_Menu.zip.



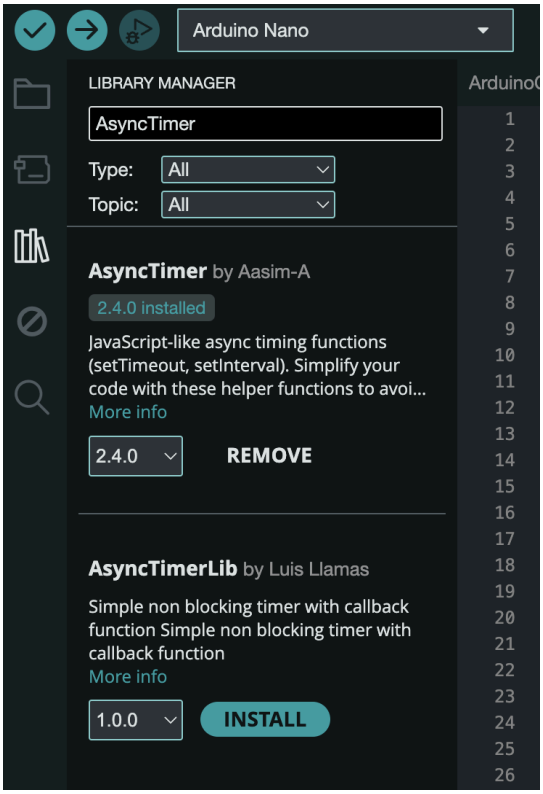
Alternatively you can also copy the ZIP-file content directly into the Arduino IDE library folder. Where that folder resides depends on your machine's settings. On Windows it is in your User folder. On Mac there is a "libraries" subfolder in the folder you selected when installing the IDE.



Downloading libraries in the Arduino IDE

The rest of the libraries can be added directly in the Arduino IDE. You don't have to download and shuffle around ZIP-files (if you don't want to).

The process is extremely simple. You open the library manager by clicking "the books" symbol in the left menu bar (highlighted in white in the image below). You then type in the name in the search bar and press enter. The library you searched for and possibly a few similar will get shown in the list. Just click "install" and after a brief moment it should show "remove", which means it is now installed. If you have any problems using the newest version of any library you can also change the version in this dialog by clicking the box to the left of the INSTALL / REMOVE button and selecting the version I listed above.

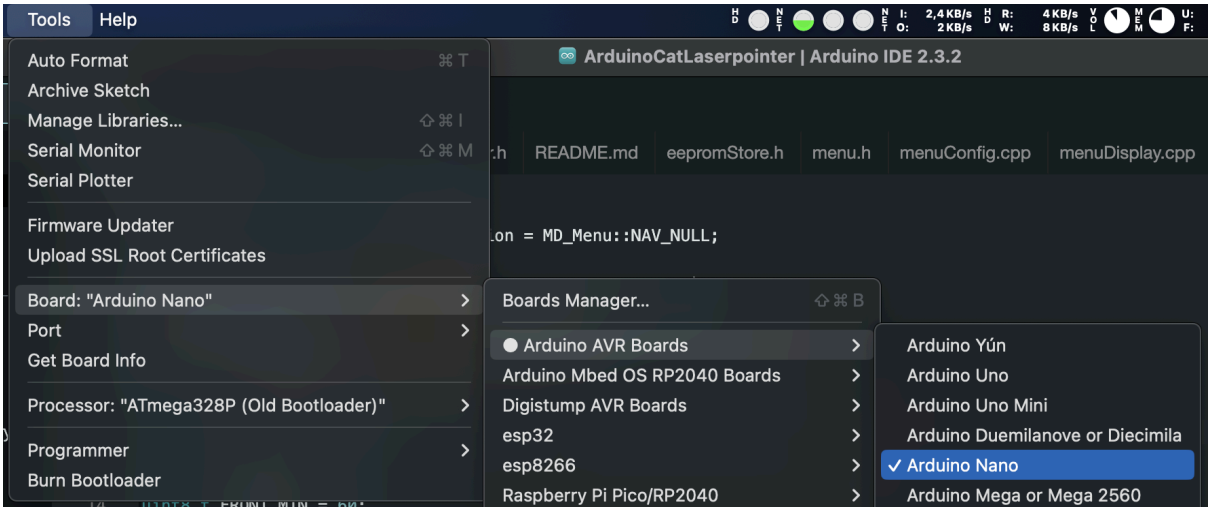


Flashing the Arduino

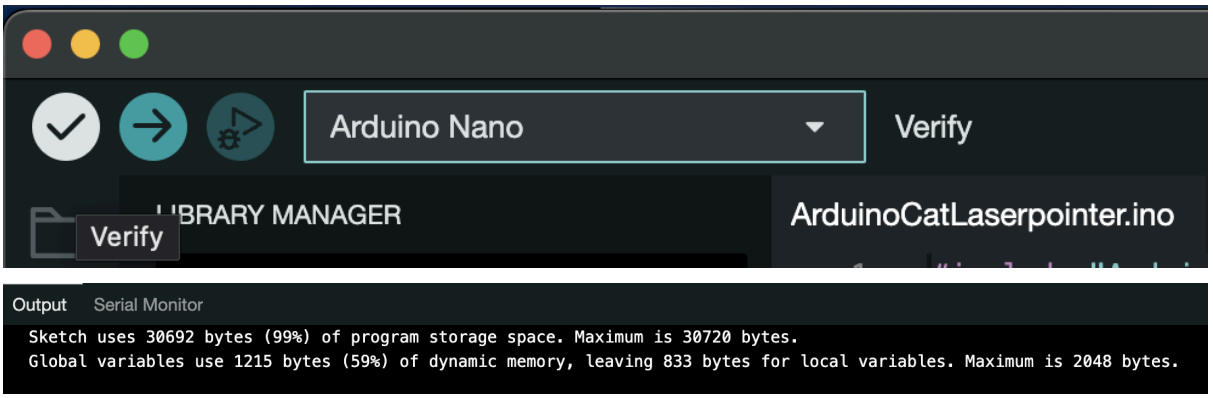
With all necessary libraries installed we can now flash the firmware to the Arduino. The first step is to open the sketch by loading the file “ArduinoCatLaserpointer.ino”.

If you haven’t already you need to set the appropriate Board and Port. The board is an Arduino Nano as shown below. The port depends on your machine. If in doubt you can unplug and replug the Arduino and see which port disappears and appears.

Some Chinese clones also require you to select the Processor to “Old Bootloader”. In any case it is an ATmega328P, the 168P doesn’t have enough memory and is rather rare anyway.



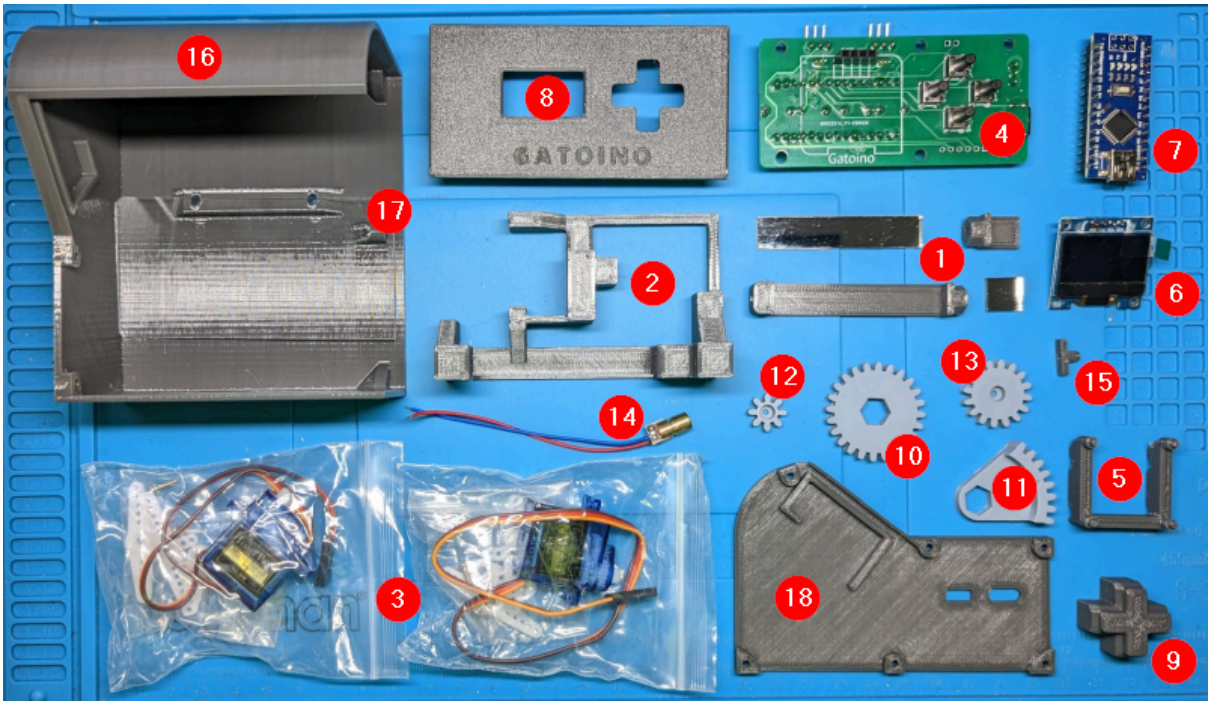
With the right Board selected you can then run “verify” from the top left menu. It should result in a success message as shown below. If it says something about “sketch too large” it is probable that a never version of some library now needs more space and you need to install the version listed under “necessary prerequisites”.



If verifying was successful you can then proceed to flashing the software by clicking “Upload”. The IDE will tell you when the process is finished and after that the Arduino is ready to control the Gatoino we’re about to build.

Gatoino assembly

The Gatoino components

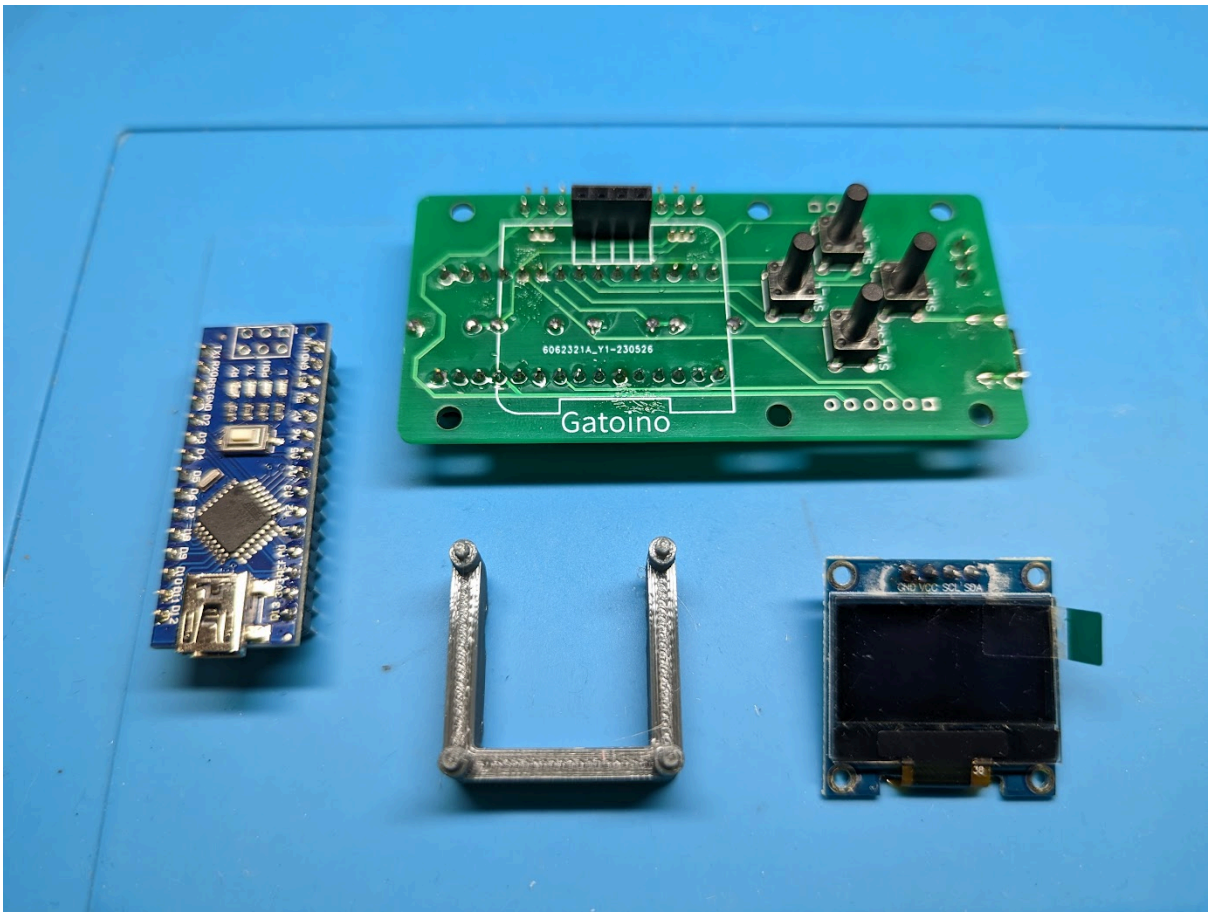


1. Mirrors and mirror axis
2. Laser cage
3. 2x Servo 9g
4. Mainboard
5. Display frame
6. OLED Display
7. Arduino Nano (Main Control Unit)
8. Front control panel
9. Directional Pad (D-PAD)
10. Gear Side axis
11. Gear Front axis
12. Gear Side Servo
13. Gear Front Servo
14. 5v Laser Diode
15. On/Off Switch slider
16. Main Case
17. Front Window (barely visible, lying inside the case)
18. Case lid

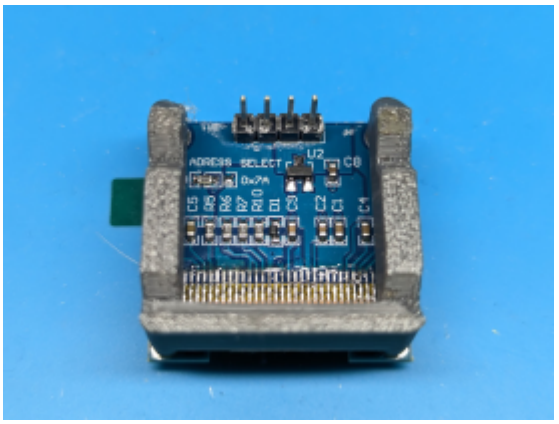
Not in image:
6x Screw M3x6, 2x Screw M3x10; 1x Screw M3x25; 8x Screw M2x6

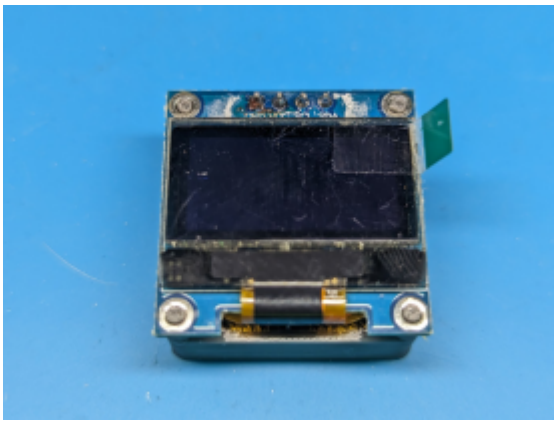
Electronics Assembly

After the board is soldered we can assemble the electronics. We'll check if the device works and we need to center the servos in order to assemble them with correct alignment.

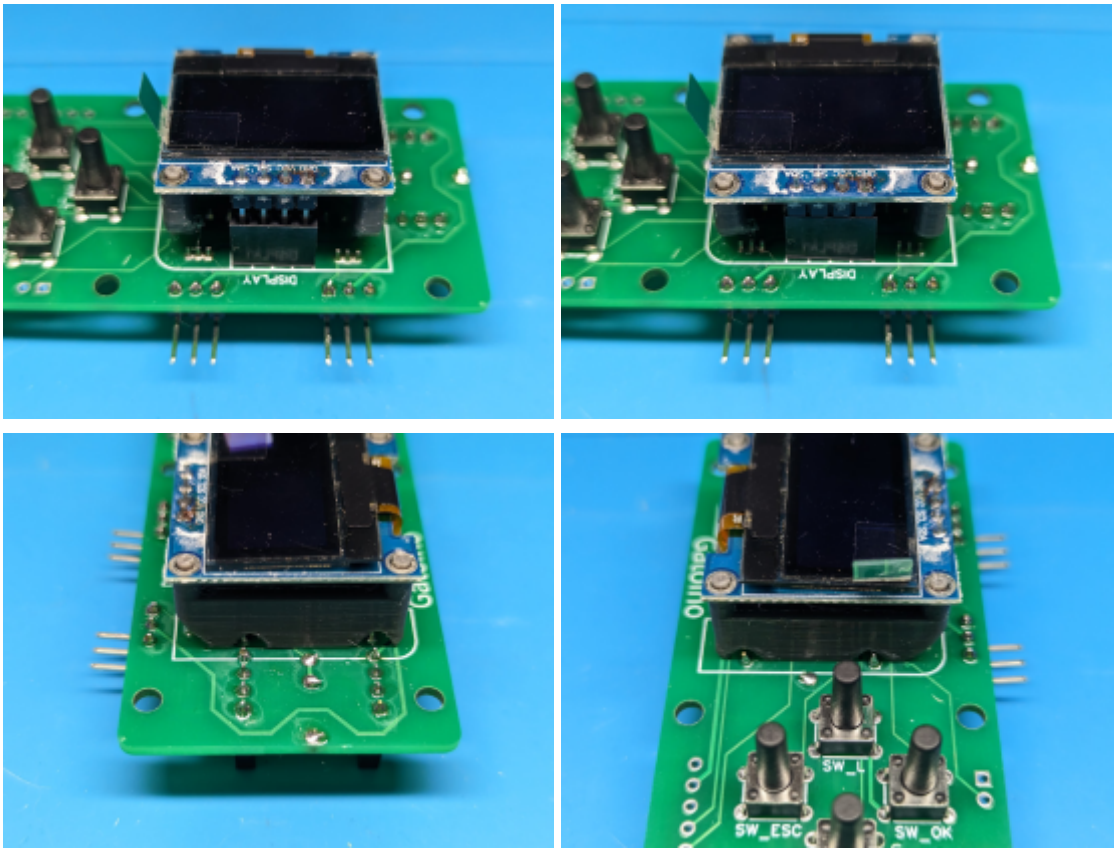


The display is plugged into the spacer first.

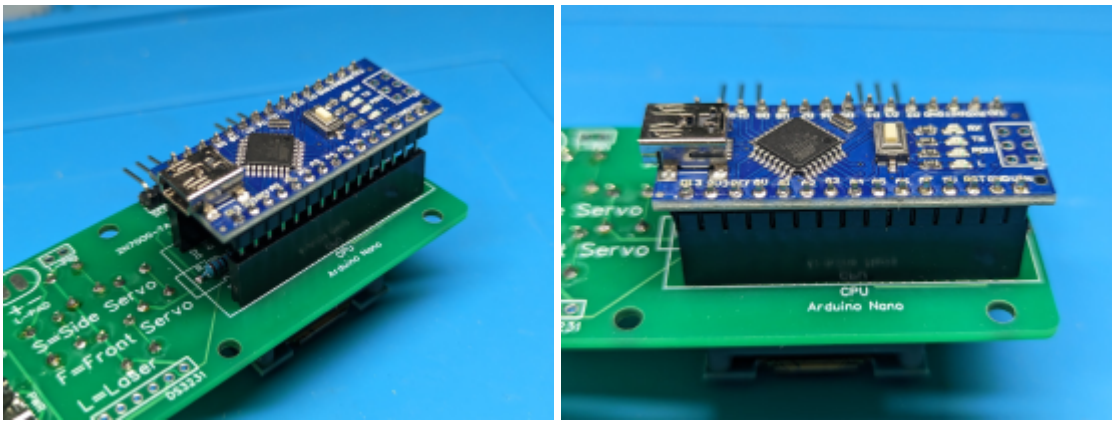




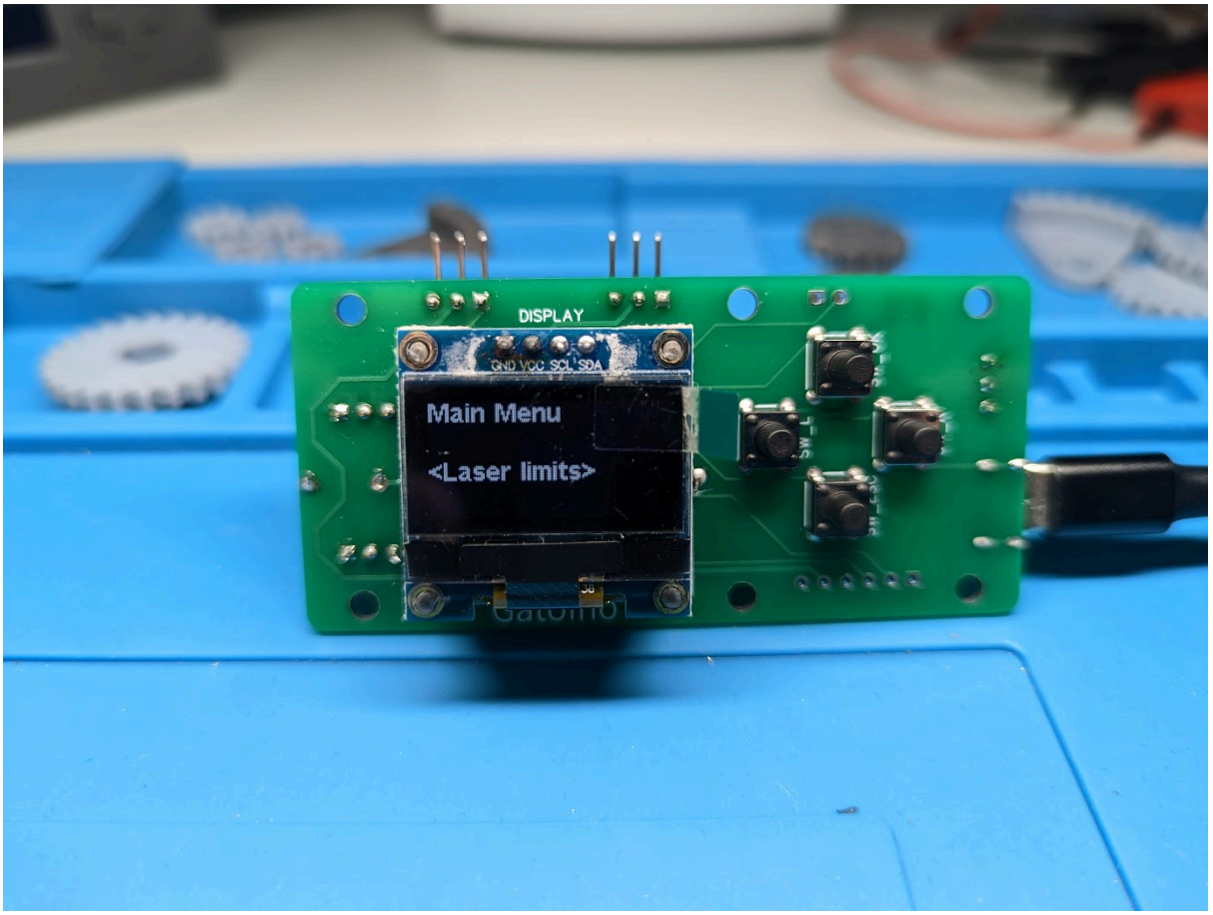
It is then plugged onto the board. The spacer has openings for the soldering joints of the Arduino pin headers to fit below.



The Arduino is then plugged in as well.

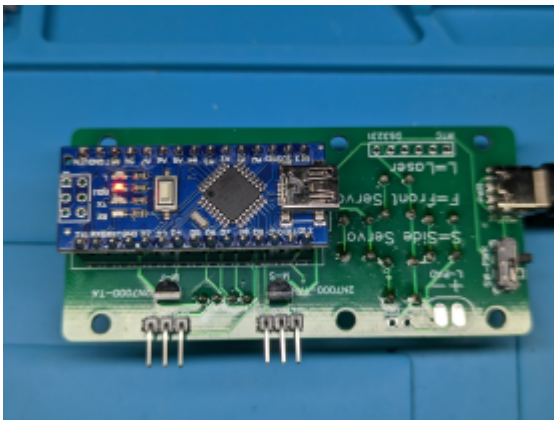


Testing the electronics



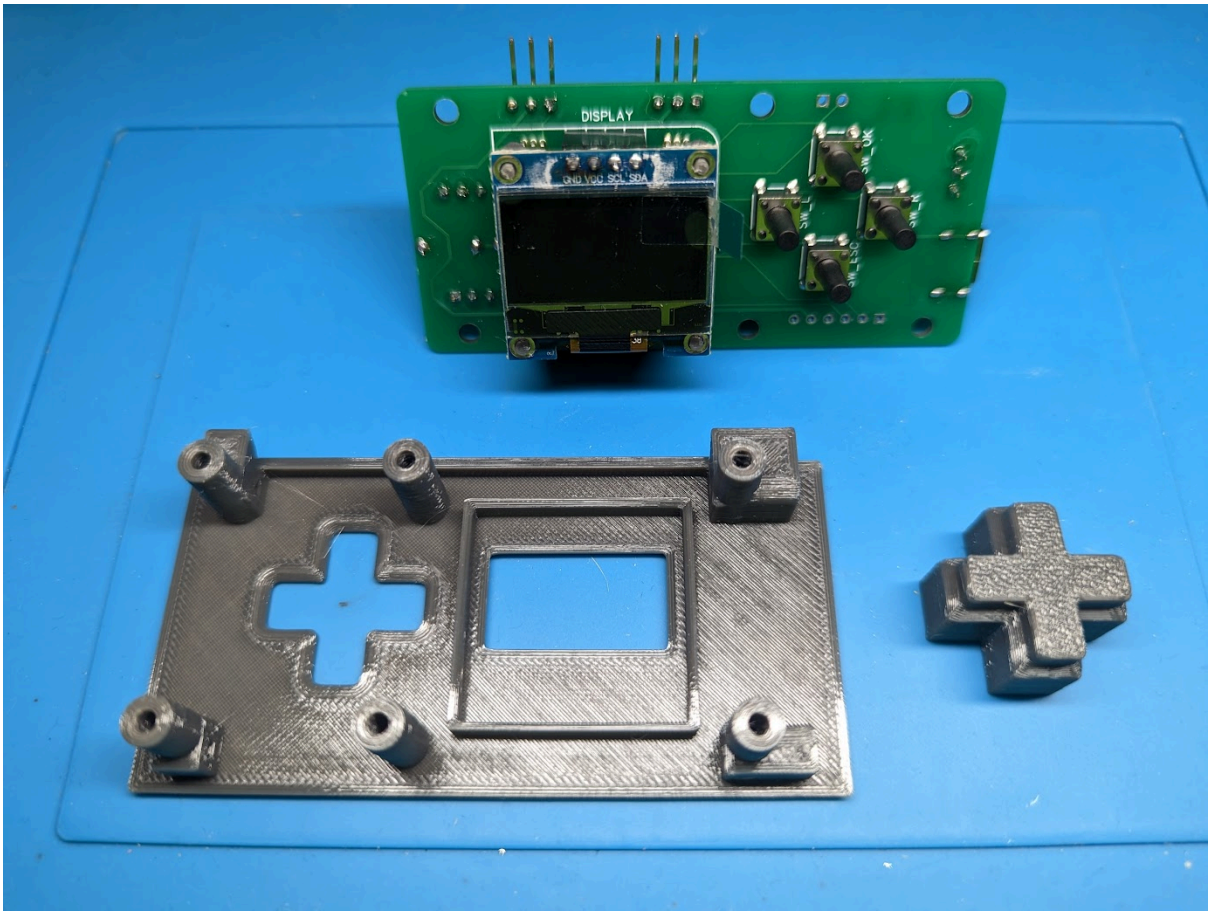
The board can now be connected to a 5v USB power supply. Pure USB-C power supplies usually don't work since they require more complex communication to negotiate the needed voltage with the device. A regular USB-A type power supply that only supplies 5v is needed. To start the device the power switch needs to be moved in the direction of the USB connector. If the software is flashed correctly you will see a splash screen showing "GATOINO" after a few seconds. With a press of the upper button, marked "SW_OK" you can enter the menu. Try going right and left inside the menu with SW_R and SW_L. You can enter any menu option by pressing SW_OK and leave without changing anything with SW_ESC.

You can also plug in the servos to check if they move as intended. The brown wire of the servos need to face the direction of the USB-Port (the plug's metal parts are visible from behind, not from the side of the display. By leaving the menu (screen goes blank) and then pressing down once more. This starts the laser game and moves the servos randomly. Note that they don't necessarily move both at the same time and sometimes they stand still. This is part of the game logic. Observe the servos for a couple of seconds and they should both be moving at least for a moment. If that's the case they both work fine. They'll usually also emit a humming noise while being active, this is normal. How much the noise is noticeable depends on the quality of the servos.

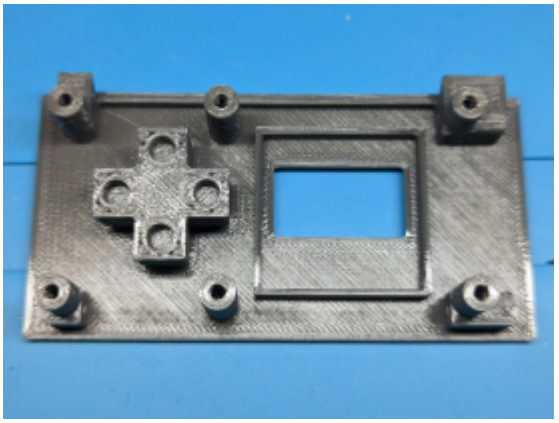


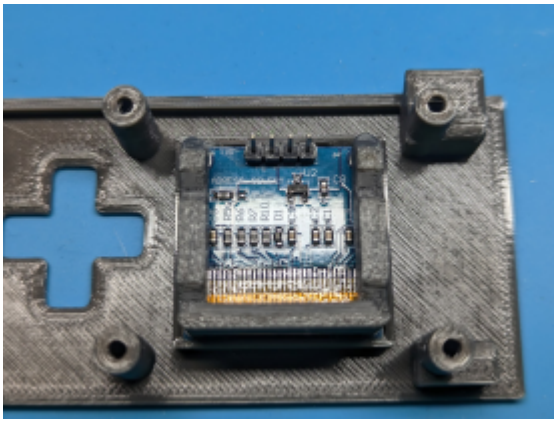
While turned on the Arduinos LED is activated.

Assembling the control panel

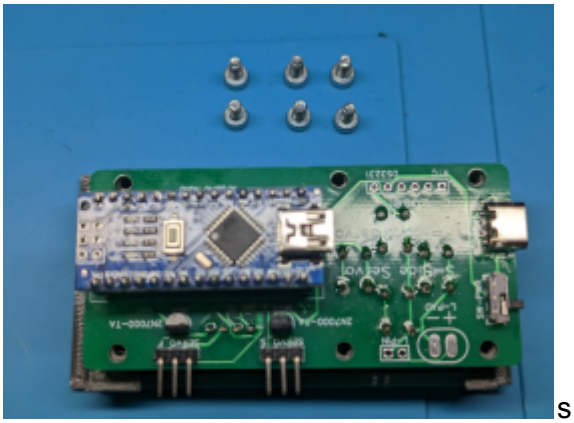


To mate the board with the control panel you'll first put the D-PAD into the cross-hole. Additionally you remove the display from the board and put it into the square hole by hand. This is because there is a slight resistance when putting it in and you want the display to be as flush with the front as possible. The display's connectors might not sit 100% flush later on but that is no issue.





You can now connect the board to the display connector and add the six M3x10mm screws. ^Only tighten them so far that the screws are flush and the board barely can’t move anymore. Too much pressure will probably result in a cracked board at some point.

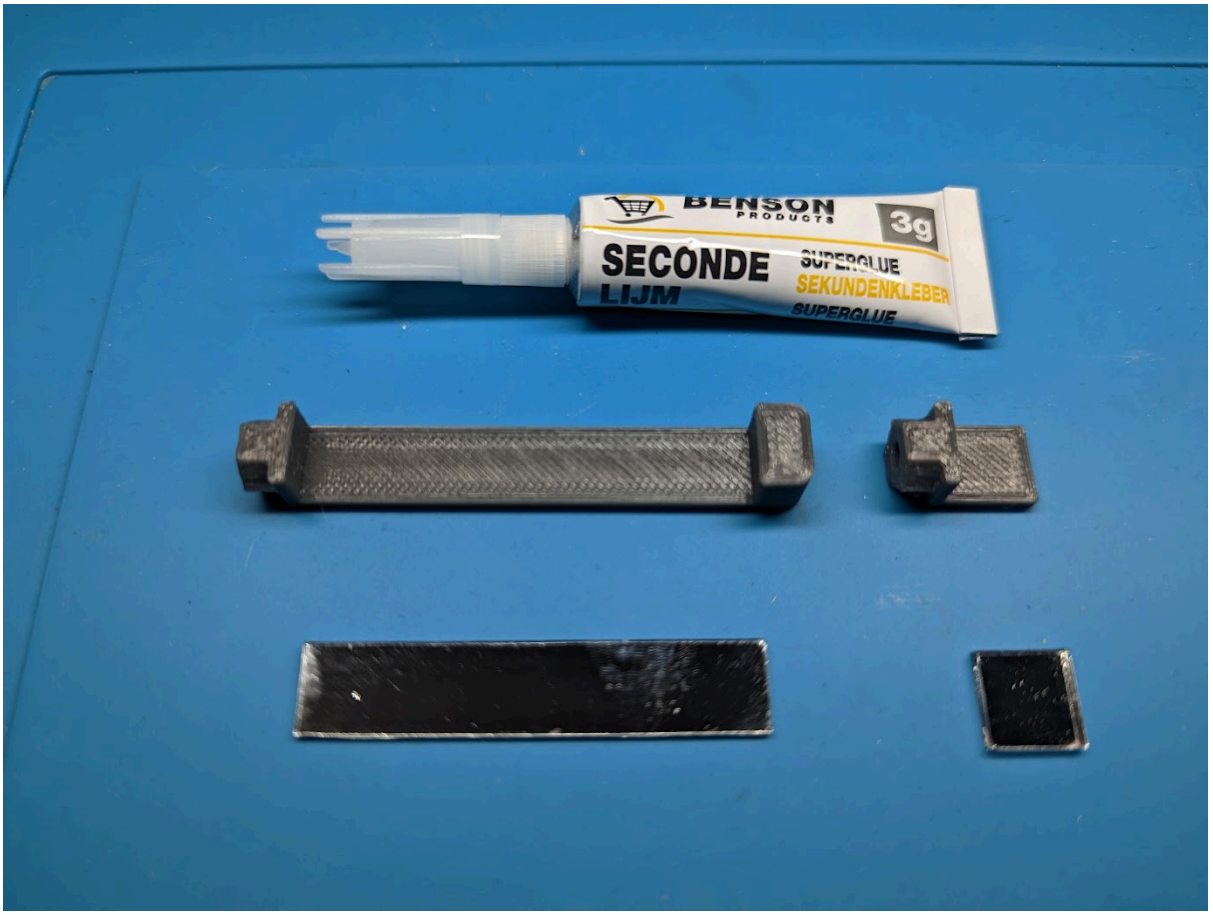


s

With this the front panel is already fully assembled. We’ll need it to center the servos shortly.

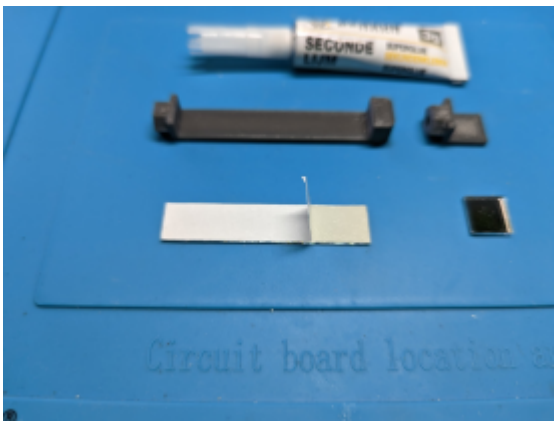
Laser Cage Assembly

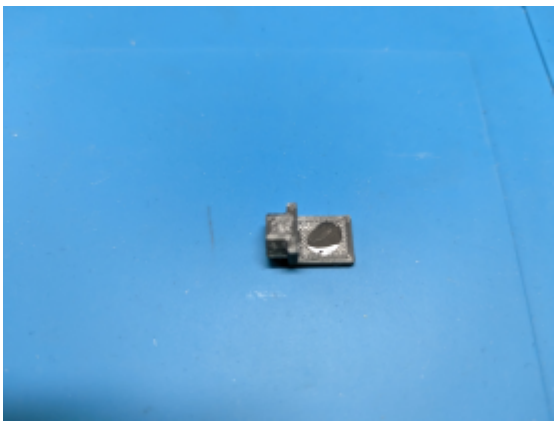
Gluing on the mirrors

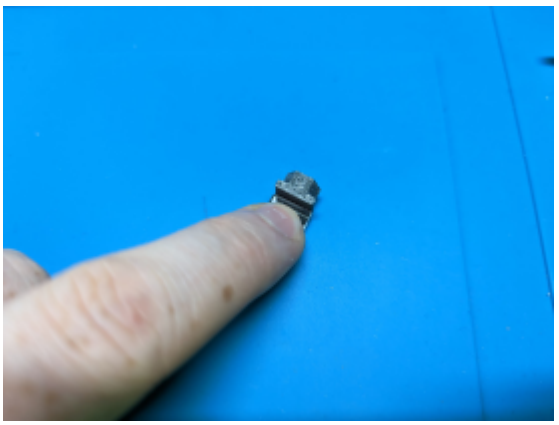


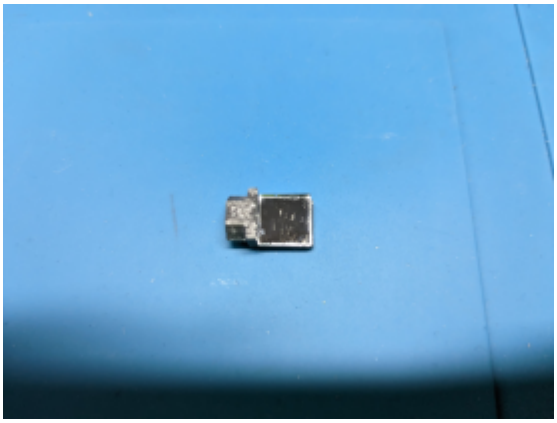
The mirrors are glued to their respective axis. It’s easiest to use superglue. Make sure the mirror doesn’t have any foil on its back. Some come with adhesive tape but I still recommend adding glue since that tape doesn’t bond that well with printed parts. Make sure the glue is fully cured before you proceed.

Only use a small amount of glue as shown, more isn’t necessary and will squeeze out to the sides anyway. The part won't be under physical stress. You can hold the mirror in place with your fingers but don’t forget to give it a quick wipe to remove fingerprints afterwards.


SEGUNDE



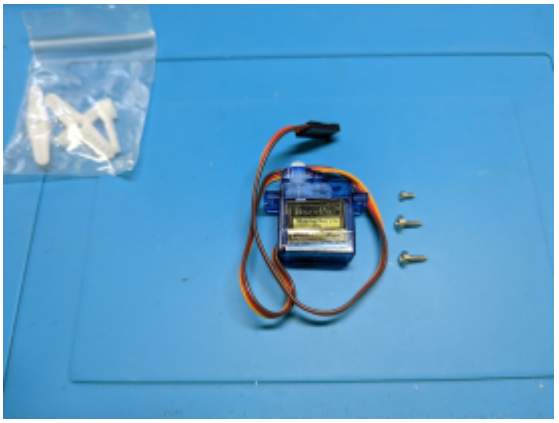


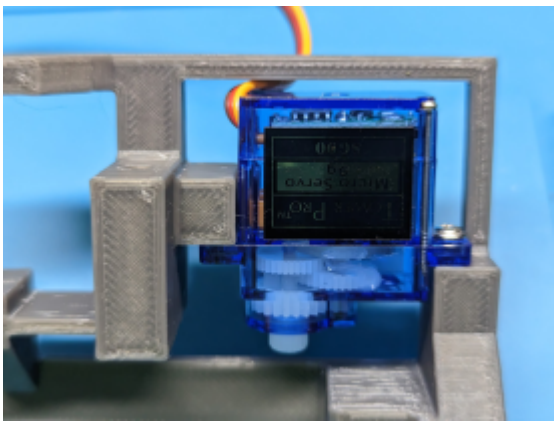


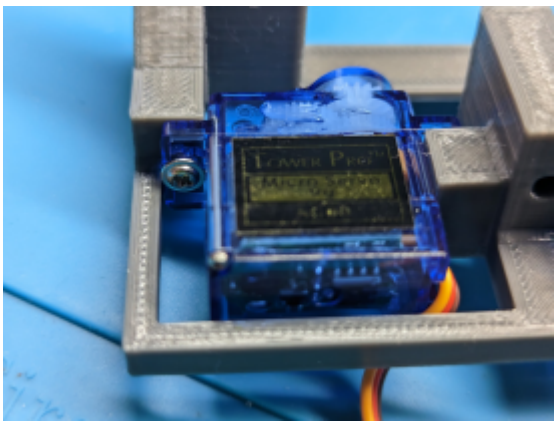
Servo assembly

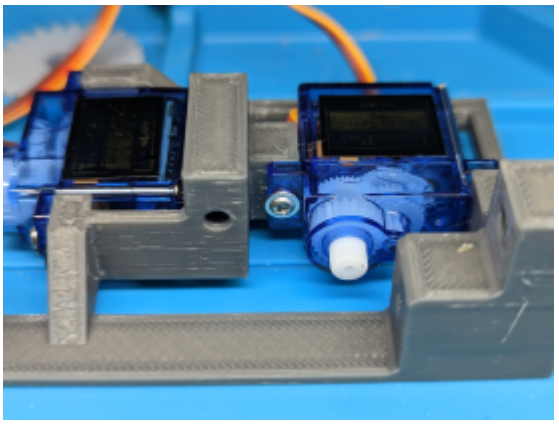
The servos usually come with three screws and a few adapters for RC vehicles. We don’t need those adapters. The two larger screws are used to fix it to the laser cage. The small one is for the gear.

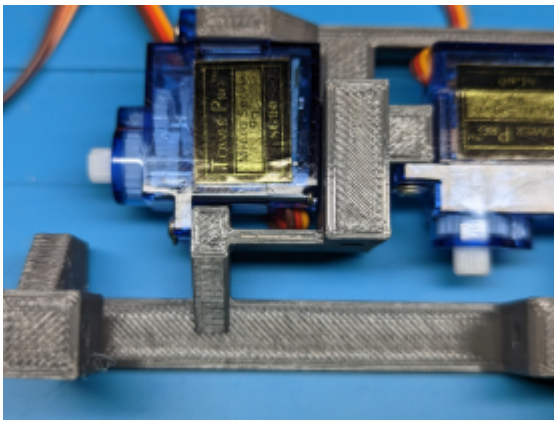
The servo cables need to be routed downwards to not interfere with the moving mirror axis as shown in the foto.

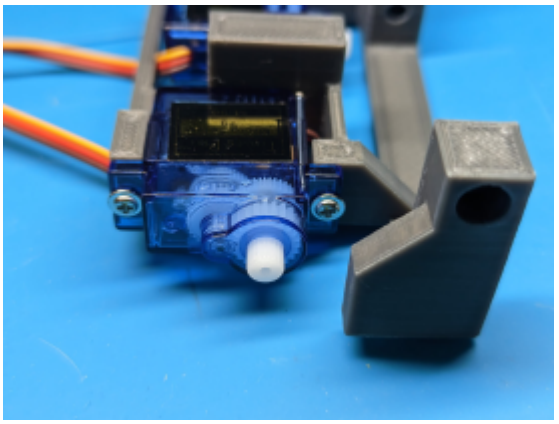




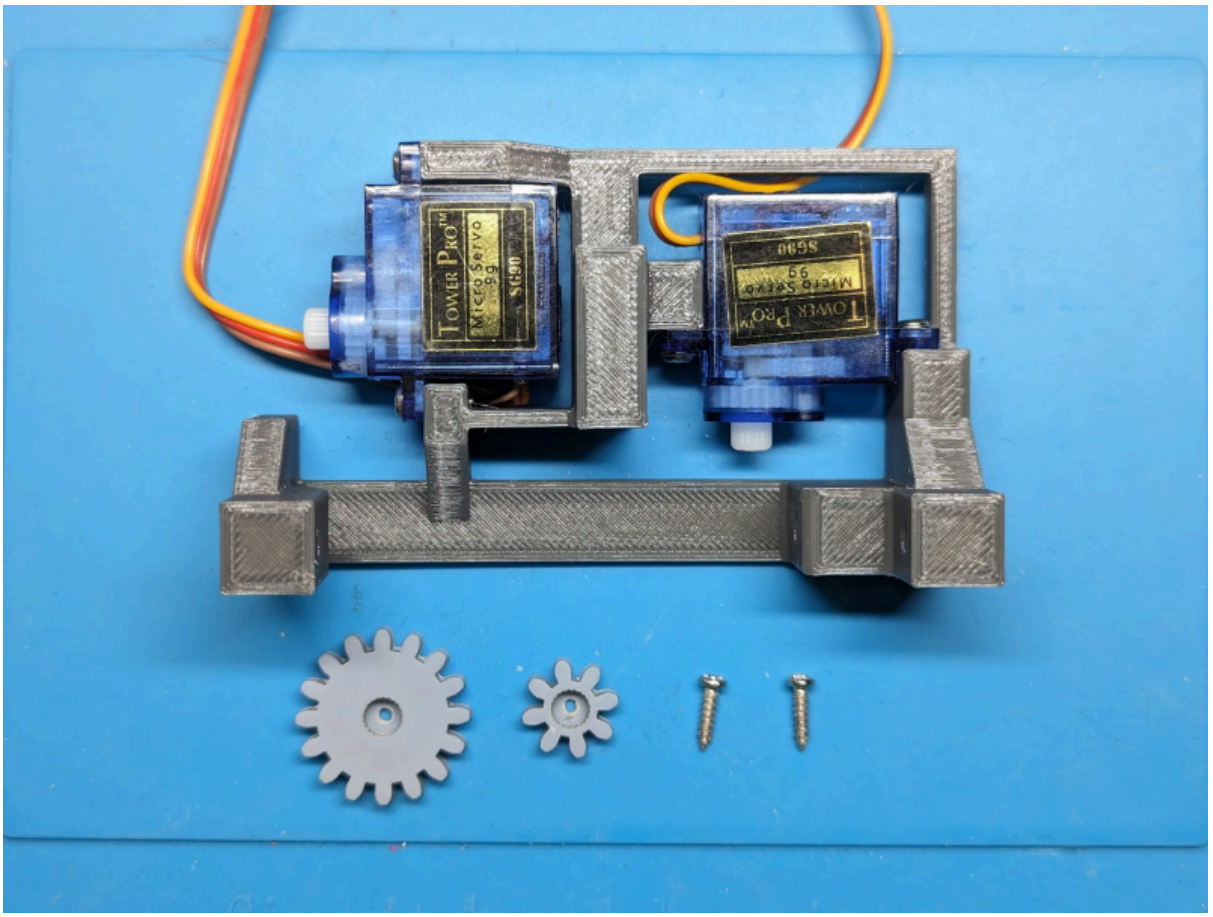




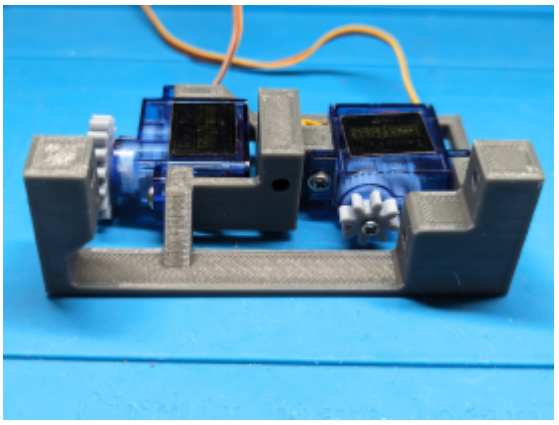


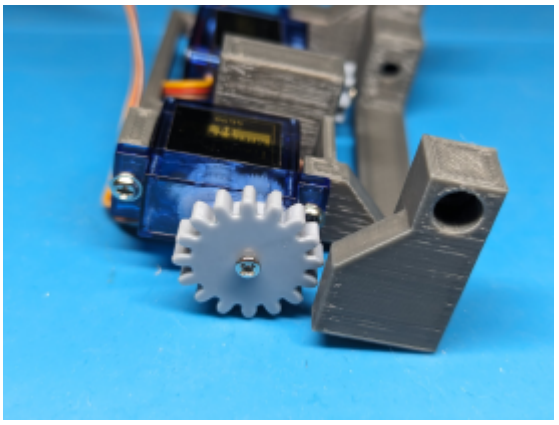


Installing the servo gears



The gears for the servos should sit fairly tight on the axis. Don't over tighten the screw since it's threaded into plastic. The mirror axis can be moved with almost no force so there is no issue with slippage.



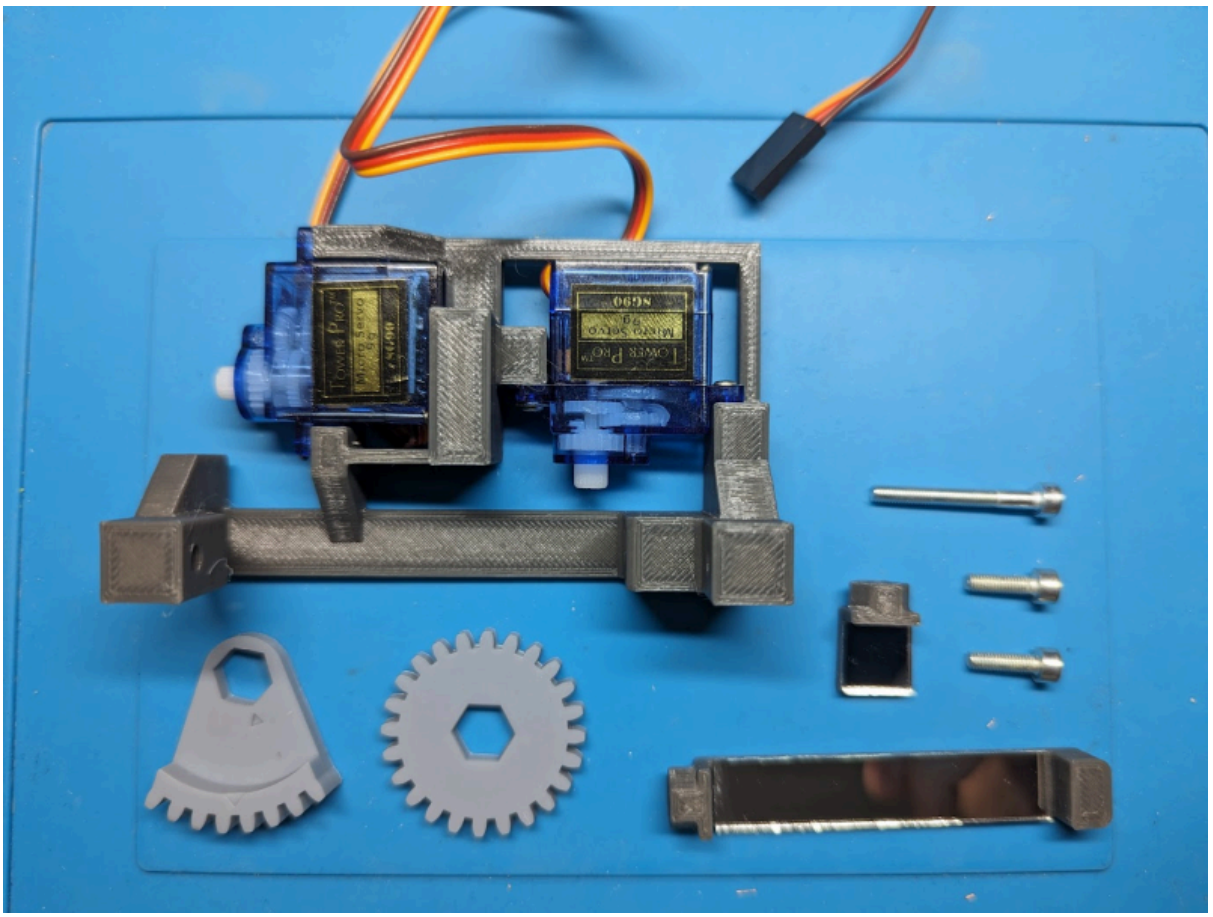


Centering the servos

Before we add the mirrors we need to center the servos in order to ensure a maximum freedom of movement in all directions.

Connect the board to the 5v USB power supply again and turn it on by moving the power switch in the direction of the USB port. After the splash screen disappears press “Up” to enter the menu and then “Right” multiple times until you reach “Center Servos”, then press “Up” again. If everything is soldered correctly both servos will now center themselves. It’s totally possible that they are already centered. They usually emit a bit of a buzzing sound when they’re active, that’s totally normal.

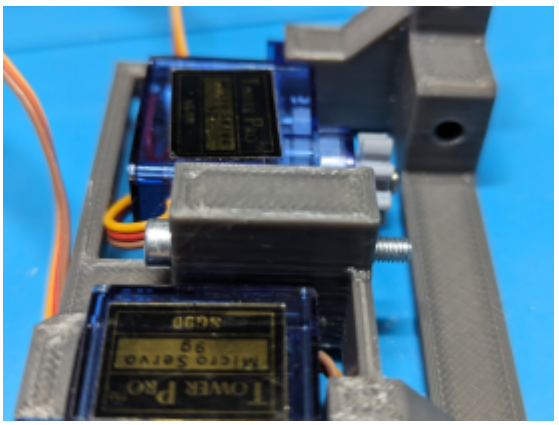
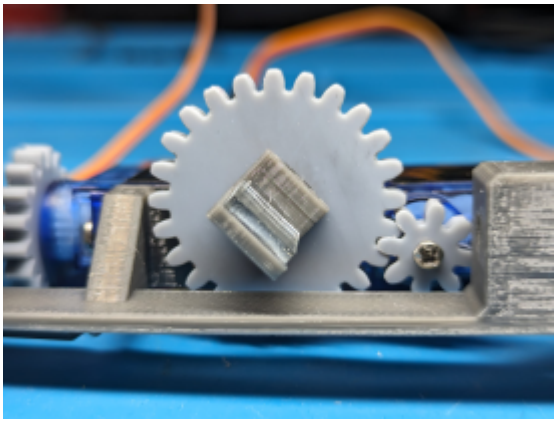
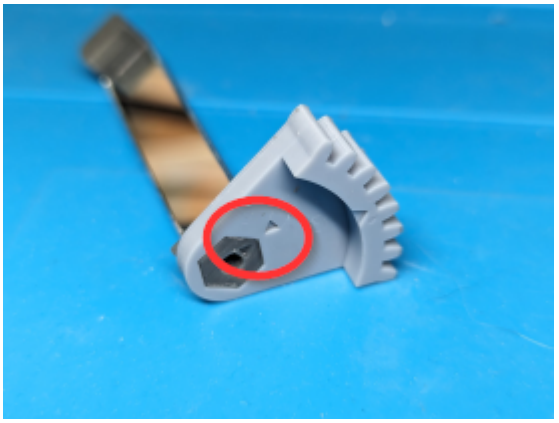
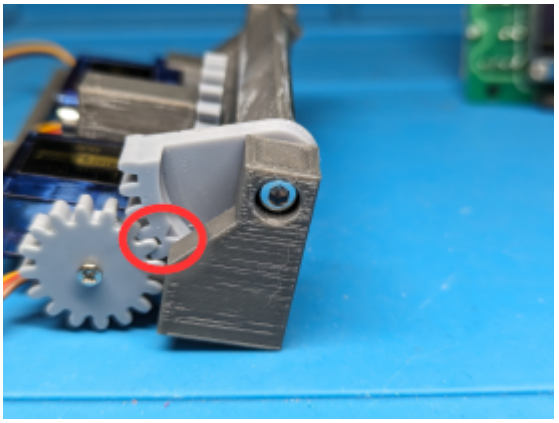
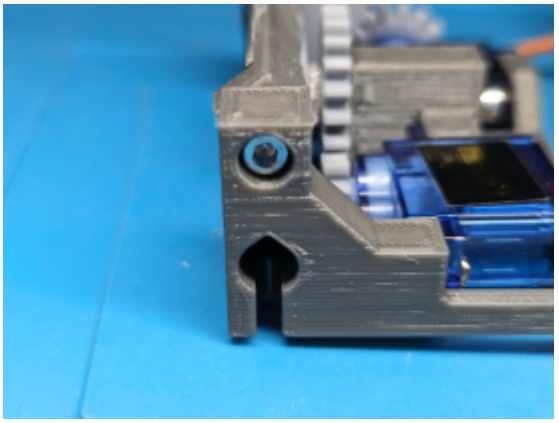
Installing the mirror axis



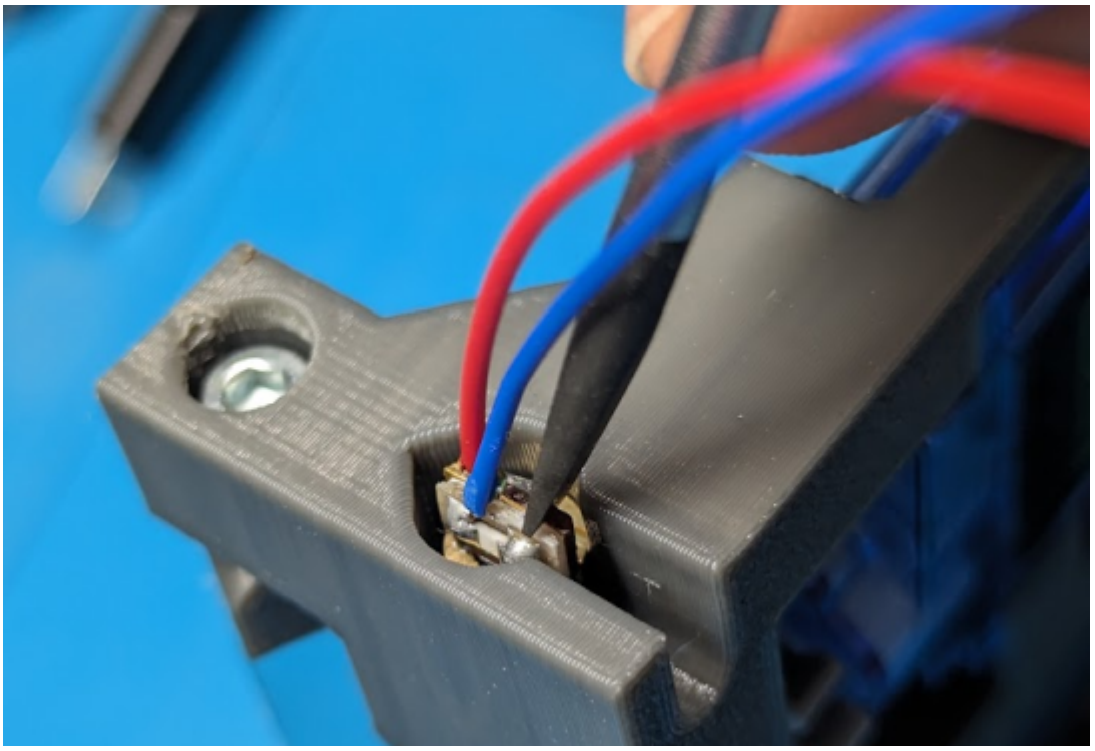
Both mirror axes need to be mated with their respective gear first (see images below). The half gear belongs to the large axis, the round gear to the small one. Both axes have to be movable still after installation. The printed parts are designed so that screws should bottom out before the axis becomes immovably tight. Nonetheless it is a good idea to double check and possibly turn the screw counter clockwise for about a quarter turn.

The small mirror axis needs to be mounted with the M3x25mm screw. The mirror needs to have a 45° angle as its initial center position. Try to be as close to 45° as you can. Again this is not rocket science, it doesn't need to be perfect.

The half gear of the large axis needs to be mounted with the two little triangles facing each other. The axis is then brought into position with the other triangle (the one facing the teeth) pointing to the servo gear tooth closest to the half gear. The axis is then fastened (NOT tightened until stuck) with two M3x10 screws. Hold the axis on its end blocks while turning the screw, not the mirror, to avoid breaking it.

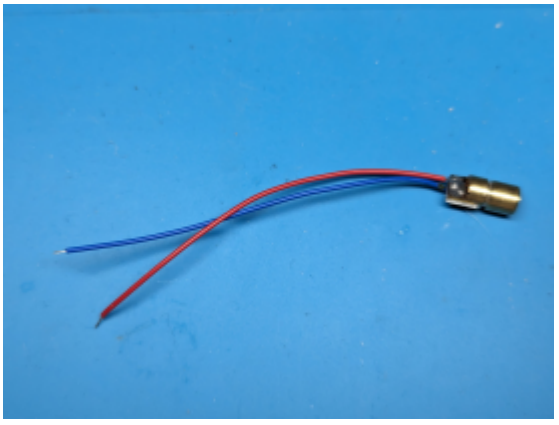







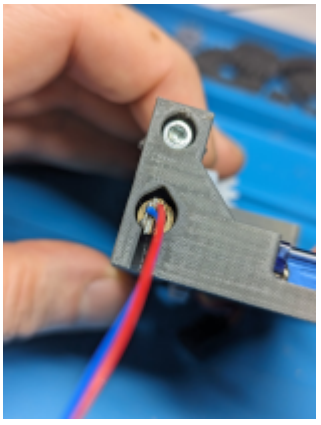
Installing the laser diode

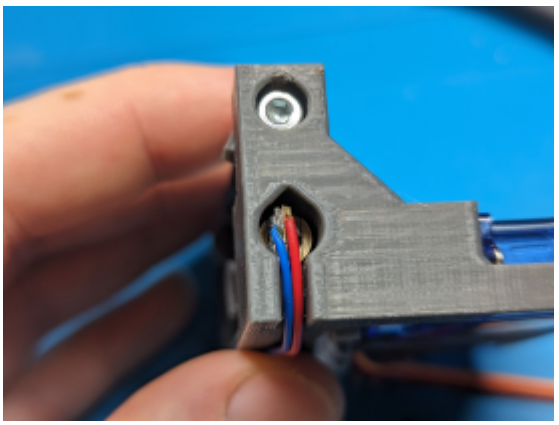


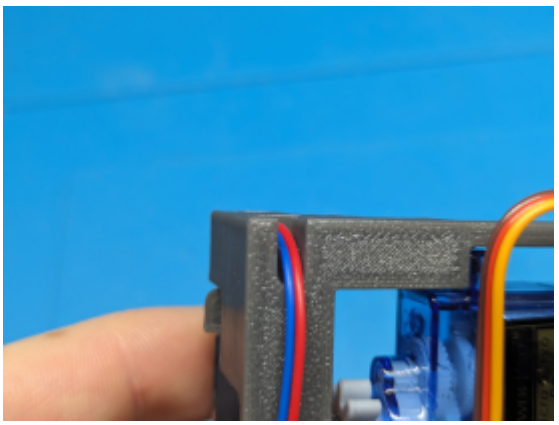
The laser diode can now be inserted into its mounting hole. It needs to be deep enough so that the wires are below the printed parts surface. This is necessary in order for them not to be squashed between the case lid later.

A flathead screwdriver is ideal to push the diode in deep enough. Don’t be too rough here to not break anything.The wires are therefore routed through the channel below the diode as shown in the images.

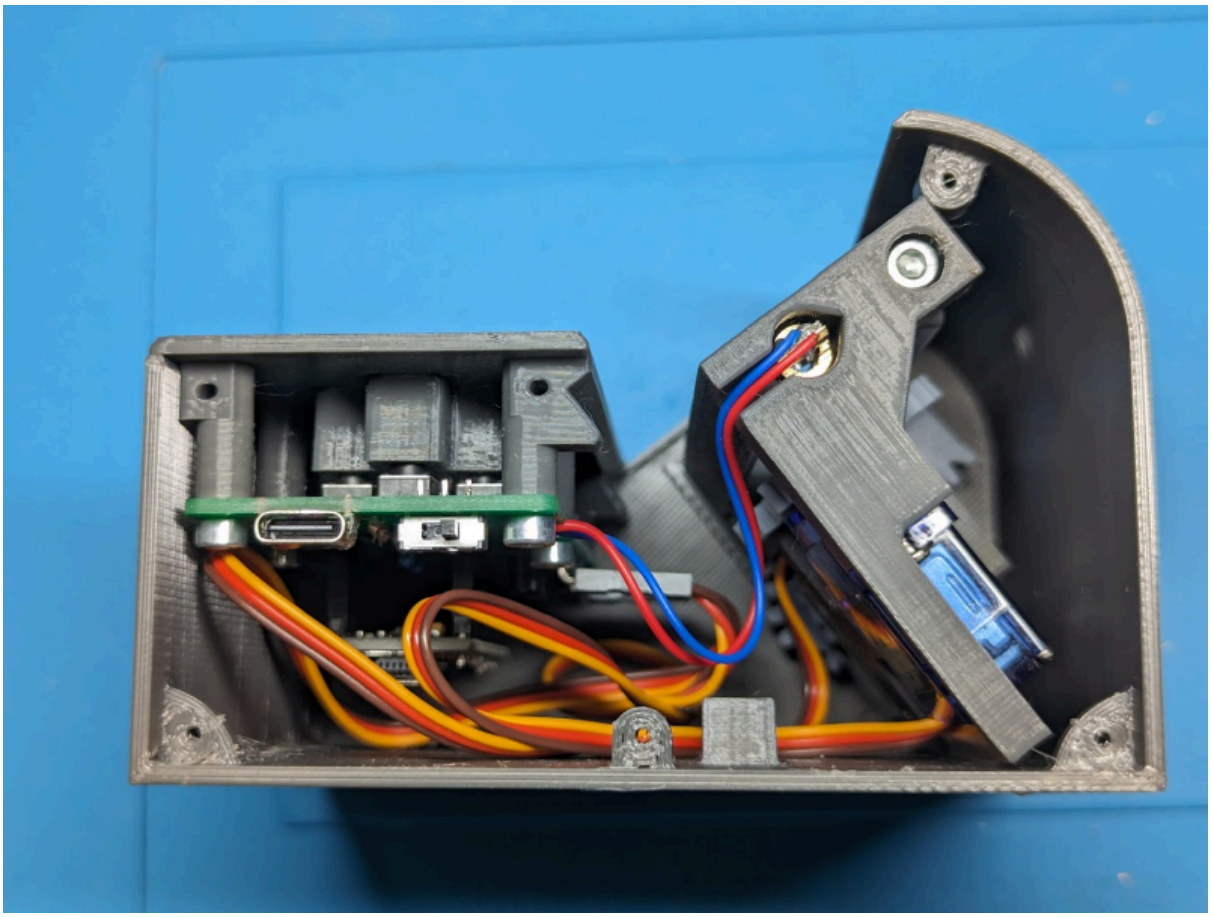






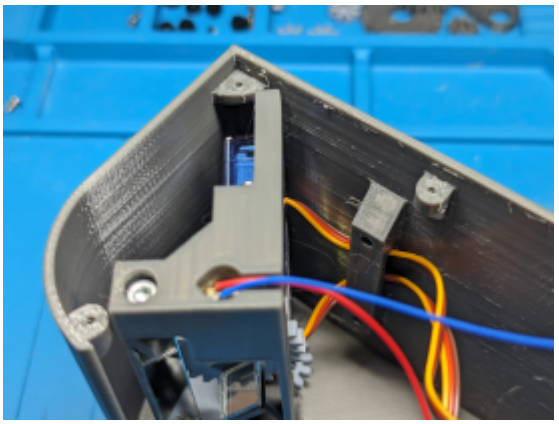


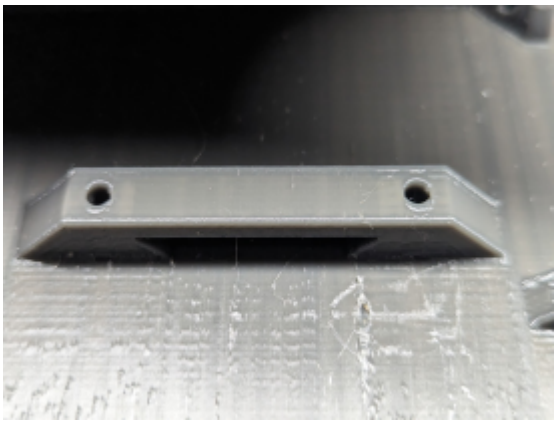
Mounting the laser cage and electronics panel

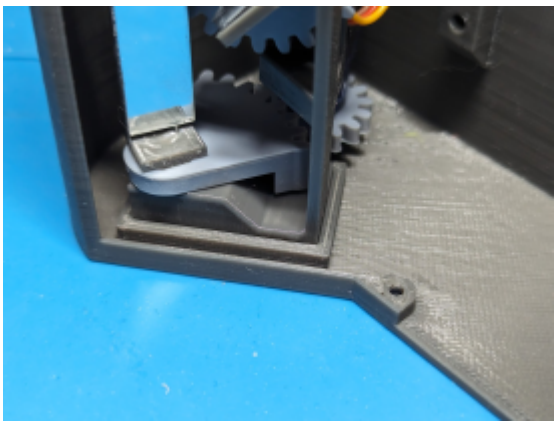


The backside of the case features a “bridge” which is meant to route the serve cables through. This is to prevent them from contact with the moving gears. Route those two cables from top to bottom first (connectors in direction of the case bottom).

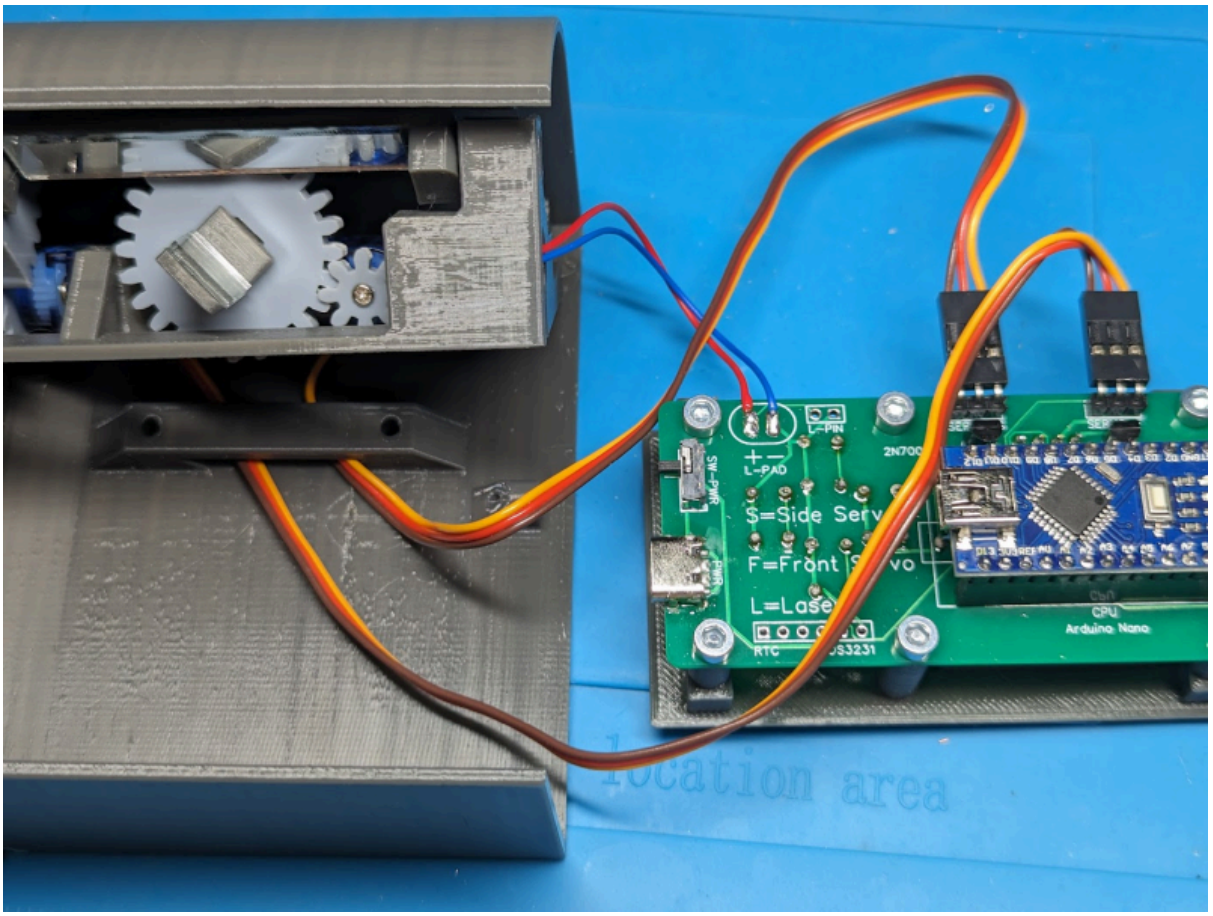
The cage is then plugged into the case as shown. It will later be held in position by the frame at the case left side and the lid on the right side. The front control panel will be installed afterwards







Attaching the wires

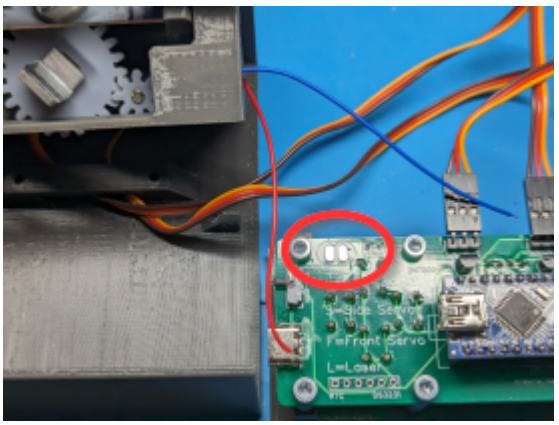


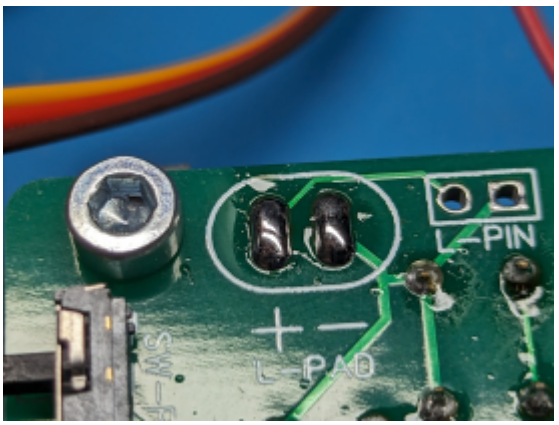
The laser is meant to be soldered directly to the board. Since they usually don't come with any kind of connector this is the easiest way to attach it. There are also two holes besides the laser solder pads (L-Pad) marked "L-Pin" where you can solder in a male 2-pin header and attach a Dupont plug to the laser wires if you have the necessary tools available. This is total overkill though, but you're free to do so if you want.

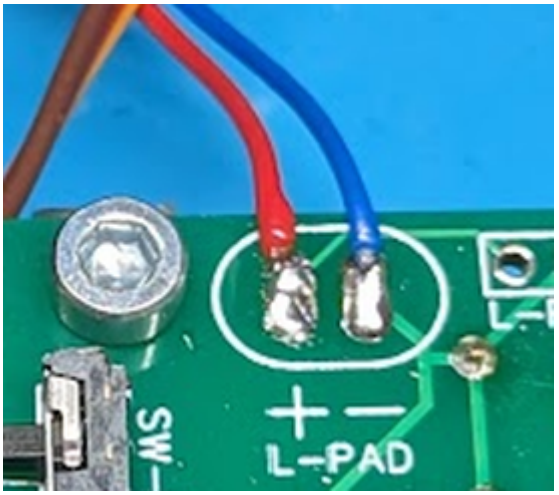
To attach the laser wires we first apply some solder to the laser pad connectors. You can be rather generous here, a small hill is what we're aiming for (see images below).

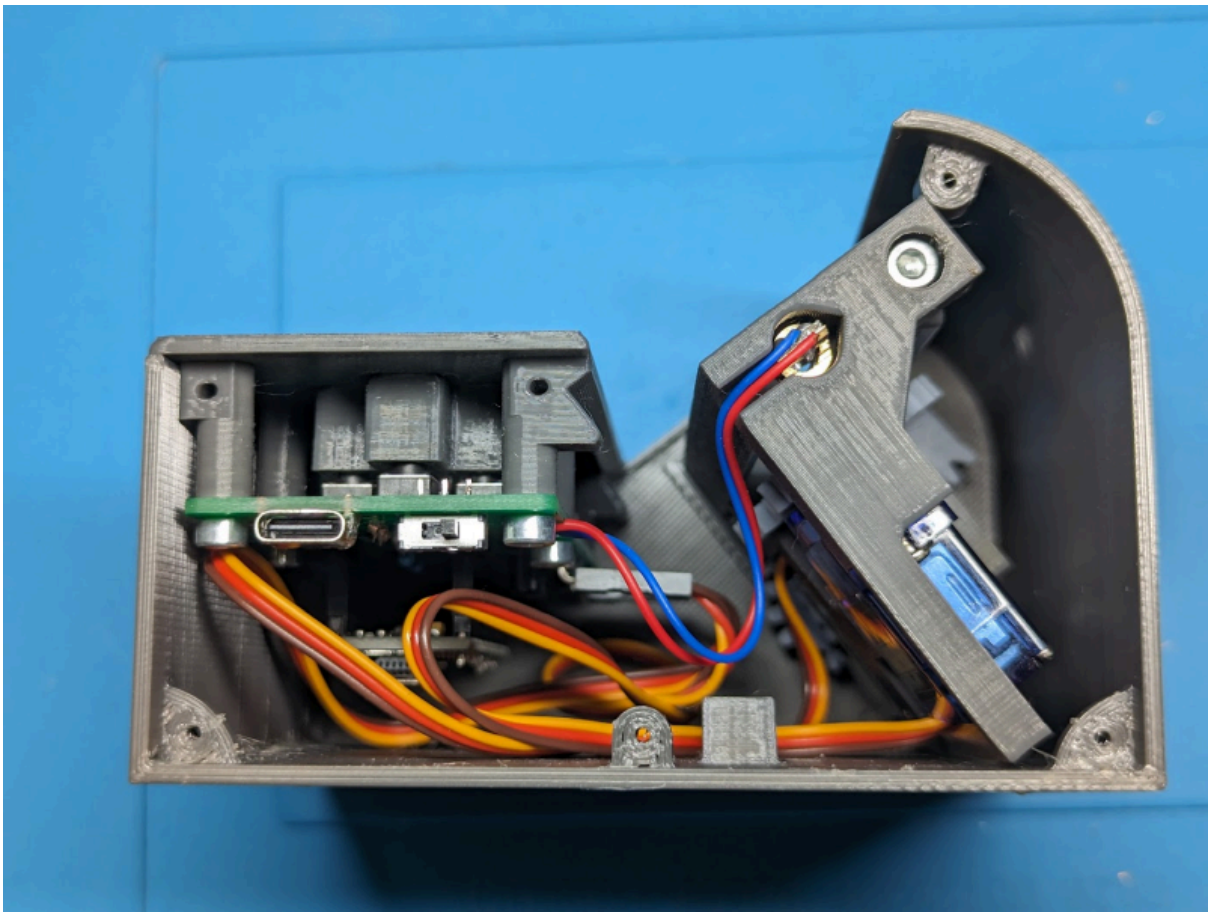
Mind the polarity, red is "+" and blue is "-". After that it's easy to quickly heat up the solder and stick the laser wires into the molten puddle until it cools down again.

The servos are plugged in with the brown wire (ground) facing left and the yellow (signal) facing right. The board is marked "servo front" and "servo side". The front servo is the one on the left, moving the large axis with the half gear. The one on the right is the "side servo".



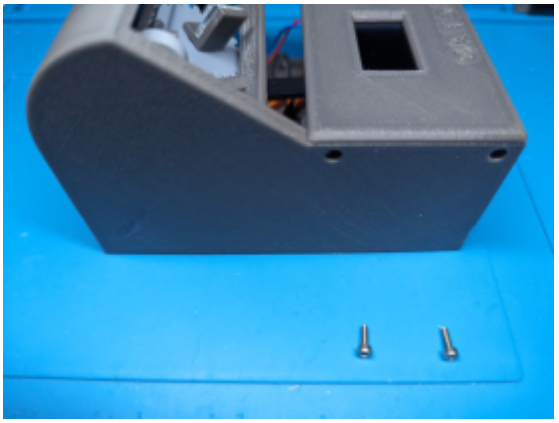

L-PIN
L-PAD


L-PAD

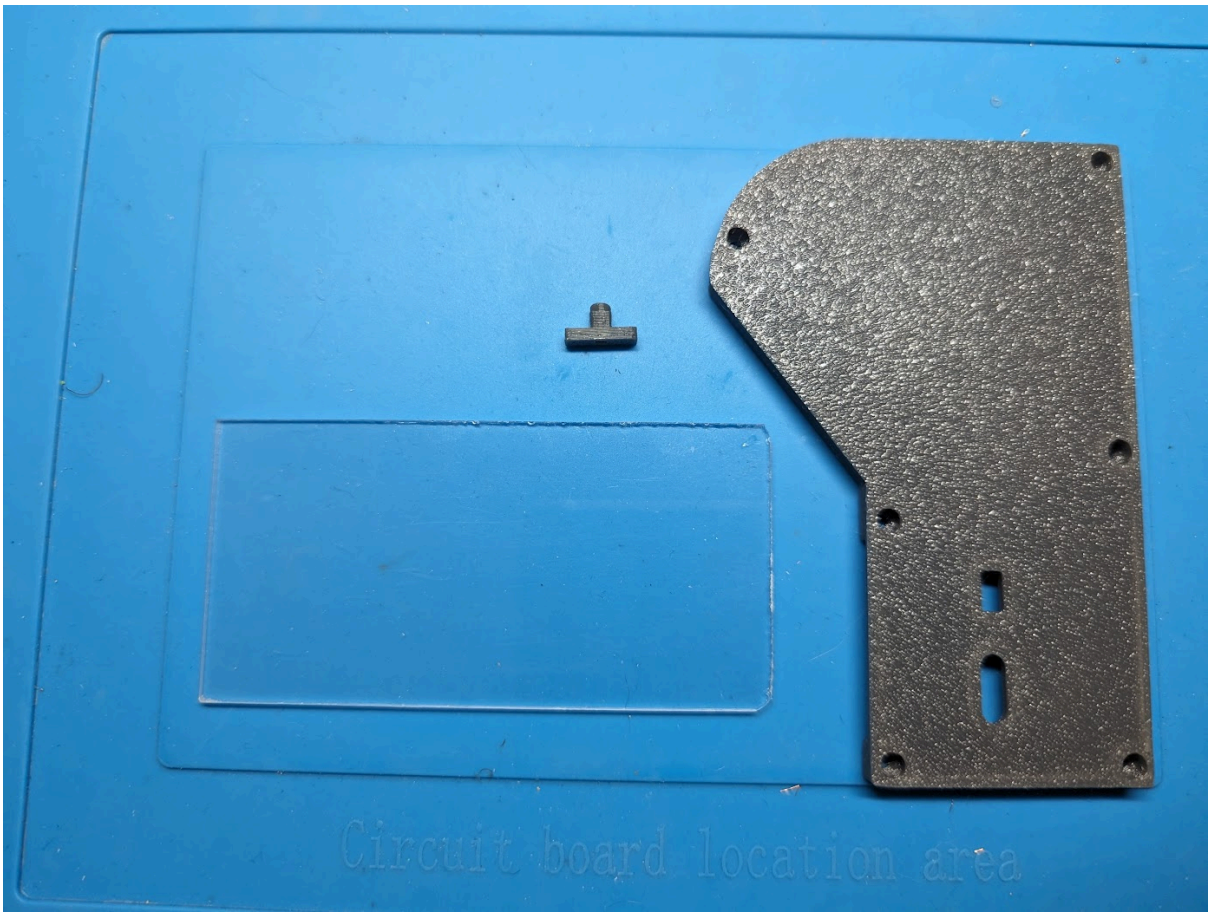


Now it’s time to install the front control panel. Make sure the servo cables are tucked in the bottom half of the case. Pull them a bit through the cases routing bridge if necessary. They don’t need to be pulled tight, just enough so they can’t touch the gears.

The control panel can now be screwed to the left side of the case. Use the M2x6mm screws for that.



Closing the case



These are the last steps. The case will now be closed. This is where the acrylic window is inserted. Slide it between the control panel and upper curvature of the case. There is a slot between the laser cage frame and the opening of the case for it to be plugged in. A similar slot is on the lid as well. You also need to put the power switch slider on top of the power switch.

You can now put the lid on top. Make sure the laser wires are still in the channel of the cage. The lid is easiest to close if you put it at an angle, fitting the windows partly into its slot again. with that it can’t move around anymore and everything should come together nicely. If not, make sure the laser cage sits firmly in the bottom part of the case. You might need to move it around a little bit.

Finally use 6 M2x6mm screws to tighten the lid. Your very own Gatoino is now finished and ready for action!