3D Printed Electronic Badminton Stringer

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1 License

2 Overview

Welcome to the KhordUino project, a mostly 3D printed and Arduino controlled badminton stringing machine.

In this guide, we'll walk you through building your own stringing machine for badminton rackets, combining your love for the sport with technology. Get ready to create a unique and functional piece of sports equipment using a 3D printer and basic electronics skills.

This DIY project will not only provide you with a functional stringing machine but also give you the satisfaction of building it from scratch. With the right materials, a 3D printer, and a bit of patience, you'll have a powerful and precise stringing machine that can help you maintain and improve your badminton equipment.

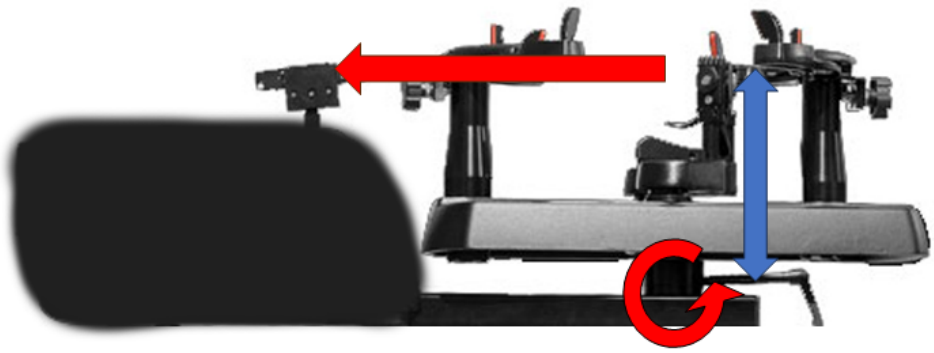
Before you begin, make sure you have access to the necessary tools, including a 3D printer, electronics components, and a basic understanding of electronics and 3D printing. With this guide, you'll be well on your way to constructing a fully functional electronic badminton stringing machine.

Let's dive in!

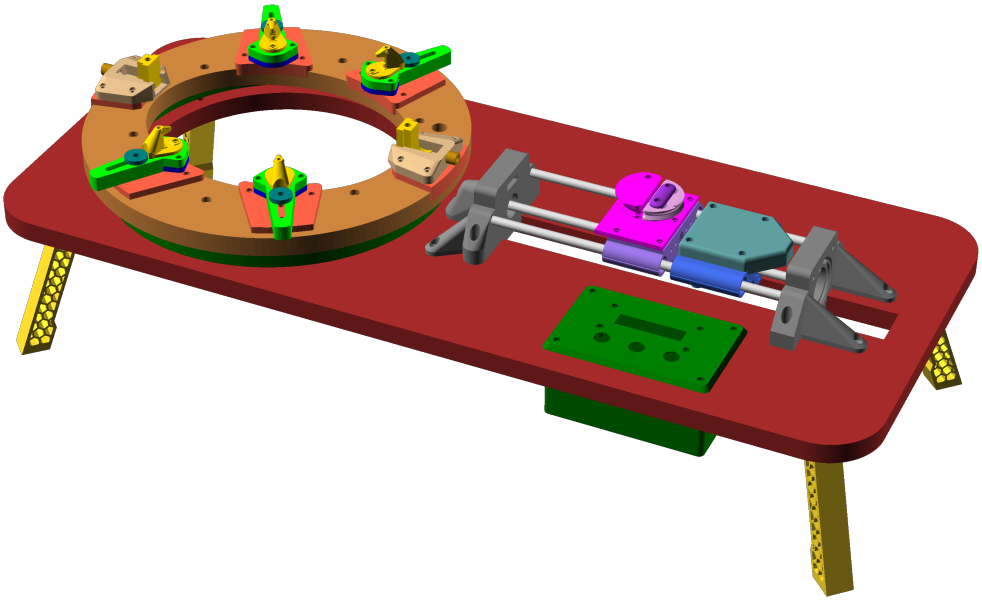
2.1 Mechanical design

A stringing machine usually comprises a stable frame, clamps to hold strings in place and a tensioning system to tighten strings. Electronic models have control panels for precision.

The KhordUino design is quite different from most metal frame stringing machines. In these machines (see below), the rotating joint for the frame is quite far from the tensioning plane.



In order to not require large metal components the rotating element (holding the racket) and the part pulling on the strings should be aligned as much as possible to minimise the moment (blue arrow). This is achieved by keeping the machine quite flat (which is also great for storage).



The rotation joint is kept very close to the racket face. This can only be achieved by using a large bearing “around” the racket rather than underneath it. As the rotating joint and the tensioning part of the machine are almost in the same plane the resulting Moment is greatly reduced.

2.2 Right or Left handed version.

If you are right-handed, it is best to have the racket head on your right when facing the control panel (and the opposite if left-handed).

The model shown in this document works best for left-handed people. If you would prefer a right-handed version, simply flip the base board and install the control panel on the other side.

You can also mirror the part name ‘GS_fixed_jaw.stl’ to place the string gripper closer or further away from the

operator.

2.3 Stringing technique

Since there is no base plate beneath the racket for fixed clamps, stringing necessitates the use of flying clamps. These flying clamps can be employed either from above, which is more convenient for cross strings, or from below, which is preferable for the main strings.

String tension is electronically regulated and adjustable, ranging from low tension (approximately 18 lbs) to extremely high tension (around 34 lbs). Moreover, it provides the option to easily pre-stretch the strings by an additional x% if desired.

Machine control is facilitated through a straightforward interface featuring three buttons and an LCD screen. This interface allows for setup adjustments, self-testing, and stringing functions.

It is highly recommended to perform a one-time calibration of the machine's load cell using a separate tension measuring device, such as a luggage scale, to ensure accurate tension readings.

3 Bill of Material

Below is a list of the materials needed to complete this project.

KhordUino Bill of Material (spreadsheet)

This build will also require the following tools:

- 3D printer
- Jigsaw, sander
- Drill (with 12mm, 9mm, 6mm and 4mm bits)
- Allen keys (M3 and M5)
- Spanner (for M3 and M5 nuts)
- Screwdrivers (Phillips and small flat head)
- Soldering iron
- Multimeter

4 3D printing

There are a lot of 3D printed parts in this project. Some of which will require to be quite strong while others are more cosmetic.

The STL file for each part present the best orientation for printing it.

In each section, the list of parts will be given with a quantity and some instructions about how to print it (supports or not, infill percentage).

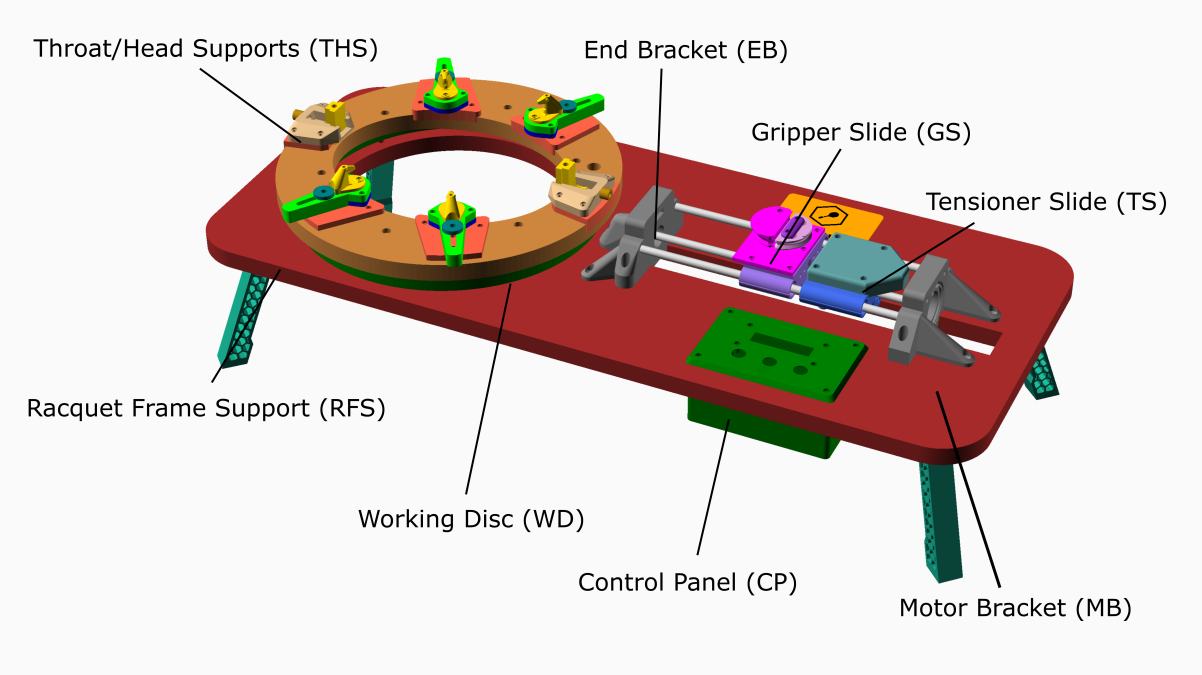
For each part there will be a list of recommended material (ABS,PETG or PLA) in order of suitability for the part, with a material in bold if it is strongly preferred.

All the parts will fit in a 150x150x150 print volume.

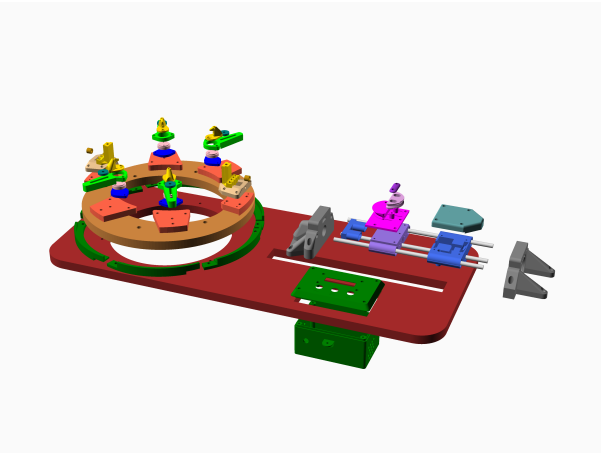
5 Main Components

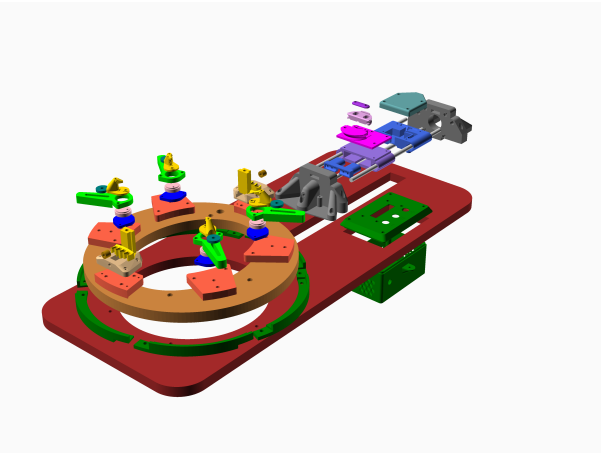
Below is a diagram illustrating the primary components of the machine:

- **Base Board (Plywood):** Provides support for all other components.
- **Working Disc (WD):** Rotates on a large-diameter bearing to spin the racket.
- **Throat/Head Supports (THS):** Hold the racket in place and prevent frame stretching.
- **Racket Frame Support (RFS):** Supports the sides of the racket.
- **Motor Bracket (MB):** Secures the stepper motor and linear rails.
- **End Bracket (EB):** Secures linear rails and acts as a fixed point for the lead screw.
- **Tensioner Slide (TS):** Pulled towards the MB by rotating the lead screw and contains the load cell.
- **Griper Slide (GS):** Where strings are 'attached' for tension measurement by the load cell between the GS and TS.
- **Control Panel (CP):** Houses the Arduino, LCD, and buttons.
- **PSU (Not Shown):** Provides 24V power.
- **Stepper Driver (Not Shown):** Controls the stepper motor responsible for turning the lead screw.



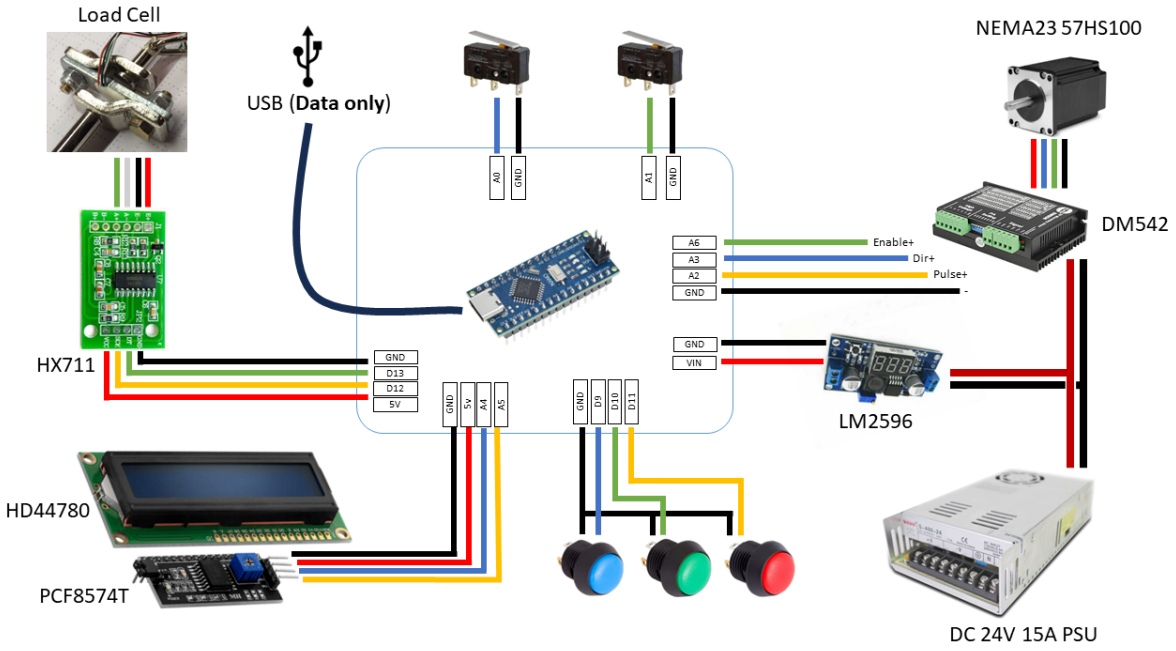
5.1 “Exploded” views





6 Electronic

Here is a diagram of all the electronic required for the project.



Please refer back to this when wiring the machine.

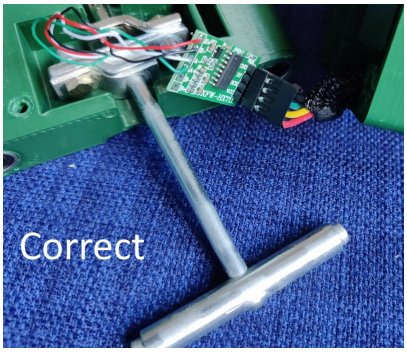
6.1 Load Cell & HX711

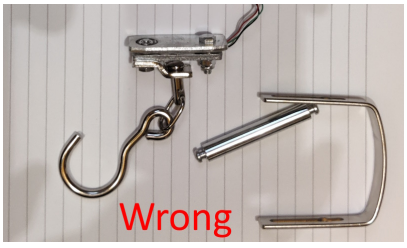
The load cell is extracted from a cheap luggage scale.

Your best bet is to pick one that looks like the one below, but I found out that there are (at least) two main designs for these cheap devices. The first one (the one we want) connects (internally) the top handle to the bottom hook via a metal rod. The other one (not suitable) connects the top handle to the bottom hook via the plastic casing only.

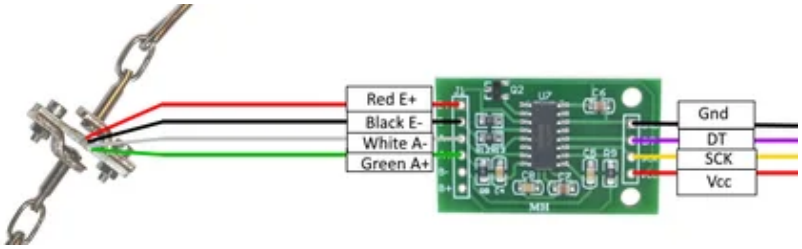
It seems that the luggage scale where the handle is secured via screws (see picture) are of the correct type for our use.

Here are some pictures of the internal part for two different types:





The reclaimed load cell must be soldered to the HX711 (that will be connected to the Arduino).



6.2 Limit switches

For the limit switches, use standard microswitches (~20x10x7mm).

They must be wired as Normally Open.

6.3 Stepper motor and driver

A NEMA 23 Stepper motor is required to provide enough torque for the machine (NEMA 17 isn't enough). A 2.5Nm (e.g. a 57hs100 is more than enough and it is likely a 57hs76 would be fine).

A 24V 4A capable stepper driver is recommended. The DM542 is a cheap option and will work fine but similar drivers (e.g. DM556, TB6600, ..) would work as well.

6.4 24V Power Supply

Any DC 24V 15A power supply should work fine.

The 3D printed parts provided will fit a PSU like this one:

6.5 24V to 5V DC converter

A DC to DC converter must be used to supply the required 5V to the arduino and there is plenty of choices for this. If you use a adjustable one, do remember to set it using your multimeter.

6.6 LCD

The LCD screen is a HD44780 1602 (16x2 Serial LCD Black Character Green Backlight) driven by a PCF8574T I2C adapter.

6.7 Buttons

The control panel is designed to receive 3 push buttons (Normally Open) and the hole diameter is 12mm.

6.8 Arduino

The firmware runs on a Arduino Nano.

I recommend using either a proto-board or a ready made breakout board to make the wiring easier.

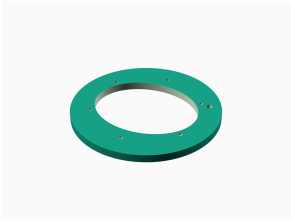
7 3D printed parts & assembly

7.1 Assembly

The recommended assembly order is as follows:

1. Cut and drill the base board and working disc out of 18mm plywood.
2. Attach the following to the underside of the base board (legs, PSU, Control Panel box, stepper driver).
3. Assemble and attach the THS and RFS parts to the Working Disc.
4. Mount the Working Disc onto the bearing.
5. Attach the bearing to the base board.
6. Assemble the Tensioner Slide (TS)
7. Assemble the Gripper Slide (GS)
8. Assemble the TS, GS, lead screw and linear rails
9. Mount the End Bracket (EB) onto the base board
10. Install the TS+GS+screw+rail assembly into the End Bracket.
11. Mount the Motor Bracket onto the base board
12. Do the wiring.
13. Add the driver cover to the underside of the base board.

7.2 Plywood parts

1	2	3
		

#	Name (Quantity)	File	Notes
1	Base board (1)	board.(crv3d|dxf|pdf|svg)	Plywood
2	Working Disc (1)	board.(crv3d|dxf|pdf|svg)	Plywood
3	Corner tool (1)	tool2.stl	PLA, PTEG, ABS

7.2.1 Cutting

You can cut these two parts in a single sheet of 1220x606x18mm plywood.

A jigsaw should be enough for the cuts (use a guide for the straight line cuts) but I also provide a Vectric file in case you happen to have a CNC machine.

The best approach is to draw the template onto the wood, cut it with a jigsaw and sand down the edges.

Tip: 3D print and use ‘tool2’ to draw the rounded corners.

7.2.2 Drilling

Once the parts have been cut, you can use the large bearing to mark the position of its screw holes and drill all 12 of them (6 on the base board and 6 on the working disc) with a 5.5mm or 6mm drill bit (to receive 5mm bolts).

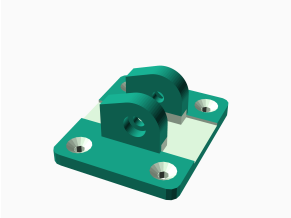
1. First you should enlarge the hole in the aluminium bearing so they can accept M5 bolts by re-drilling them with 6mm drill bit.
2. Position the bearing onto the base board and mark the 6 outer holes.
3. Drill all 6 using a 6mm drill bit.
4. Position the bearing onto the working disc and mark the 6 inner holes.
5. Position the bearing onto the working disc and mark one of the outer holes (this will be used to access the outer bolts).
6. Drill the one outer hole of the working disc using a 12mm drill bit.
7. Drill the 6 inner holes of the working disc using:
    - 6mm drill bit all the way through
    - 9mm drill bit but only 5mm deep (so that the head of the M5 screws will be sunk into the working disc)

Some more drilling will be required for wiring but it is best drill these later.

If you were planning to do it now is a good time to sand and paint the wooden parts.

7.3 Legs

In this step you will assemble the four legs and attach them to the underside of the base board.

1	2	3
		

#	Name (Quantity)	File	Notes
1	Leg (4)	BB_leg.stl	**PETG**, ABS, PLA, no supports, 100% infill
2	Leg hinge (4)	BB_leg_hinge.stl	**PETG**, ABS, PLA, no supports, 100% infill
3	Corner tool	tool2.stl	PLA, PTEG, ABS

You will need:

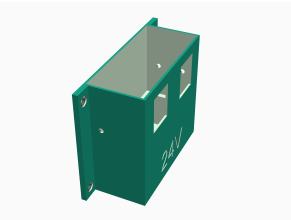
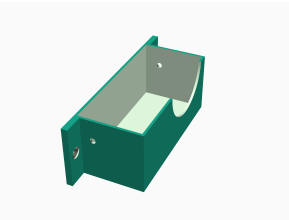
- M5x30 bolts (4)
- M5 locking nuts (4)
- 4mm x 16mm self tapping screws (16)

Steps:

1. Assemble the 4 legs + hinges with the M5 bolts + nuts.
2. Position the hinges on the underside of the base board using the ‘tool2’ part and screw them in place.

7.4 PSU, Control Panel Box and Stepper Driver

Next, you will wire and install the power supply and box for the electronic.

1	2	3	4
			

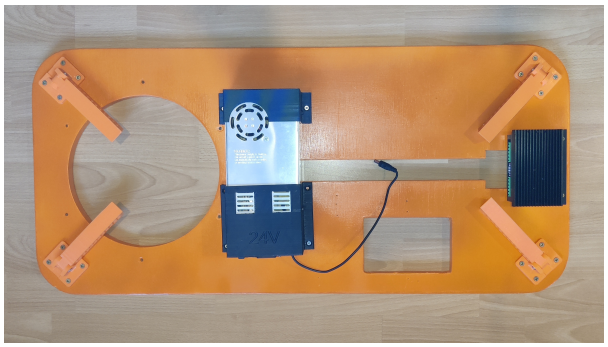
#	Name (Quantity)	File	Notes
1	PSU box 1 (1) P	SU_box_1.stl	PLA, ABS, PTEG, no support
2	PSU box 2 (1) P	SU_box_2.stl	PLA, ABS, PTEG, no support
3	Control Panel body (1) C	P_body.stl	PLA, ABS, PTEG, no support
4	Bracket for stepper driver (1) B	B_stepper_driver_bracket.stl	PLA, ABS, PTEG, no support

You will need:

- 4mm x 10mm self tapping screws (8)
- 4mm x 16mm self tapping screws (2)
- M3 nut (2)
- M3 washer (2)
- M3 10mm bolt (2)
- C14 inlet
- Rocker switch (for 12.5mmx19mm cutout)
- Wire for 24V

Steps:

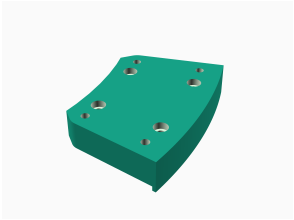
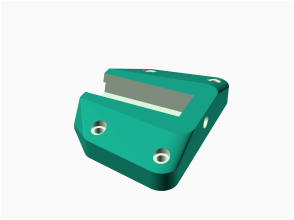
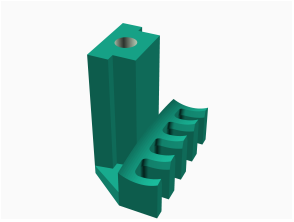
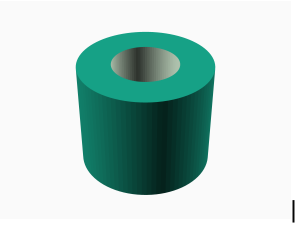
1. Wire the PSU (some soldering required for the C14 plug and switch).
2. Secure the PSU using the 10mm screws (see picture below).
3. Secure the control panel to the underside of the base board using the 16mm screws.
4. Add the M3 nuts to the driver bracket.
5. Attach the stepper driver to the bracket using M3 nuts, bolts and washers.
6. Secure the bracket to the underside of the base board using the 10mm screws (see picture below).



7.5 Throat/Head supports (THS)

Next, the THS supports are assembled and attached to the working disc.

Warning: the 'THS Base' part contains some embedded M3 nuts that must be added during 3D printing.

1	2	3	4
			

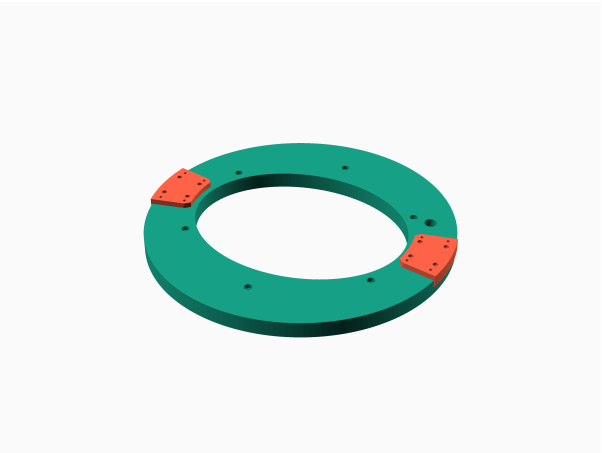
#	Name (Quantity)	File	Notes
1	THS base (2)	THS_base.stl	**ABS**, PLA, PETG, no support, 100% infill, embedded M3 nuts
2	THS body (2)	THS_body.stl	**ABS**, PLA, PETG, no support, 100% infill
3	THS gripper (2)	THS_gripper.stl	**PETG**, ABS, PLA, no support, 100% infill
4	THS spacer (2)	THS_spacer.stl	**ABS**, PETG, PLA, no support, 100% infill

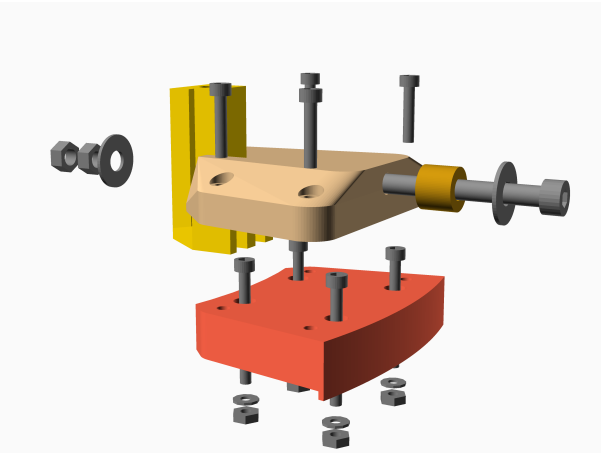
You will need:

- M3 x 30mm (8)
- M3 x 15mm (8)
- M3 nuts (16)
- M3 washer (8)
- M5 x 80mm (2)
- M5 nut (4)
- M5 large washer(4)

Steps:

1. Position the THS Bases at the narrowest points of the working disc (opposite each other).
2. Mark the position of the 4 holes in each part onto the wooden working disc.
3. Drill these holes at 4mm all the way through the working disc.
4. Secure the THS base (x2) to the working disc using the M3x30 bolts, nuts and washers.
5. Secure the THS body (x2) to the THS base using the M3x15 bolts.
6. Slide the THS gripper in the THS body and secure it with the M5 bolt, with 2 washers and 2 nuts and the THS spacer.

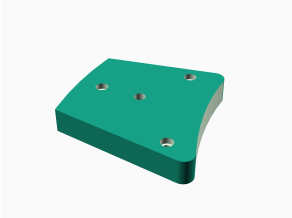




7.6 Racket frame support (RFS)

Next, the RFS supports are assembled and attached to the working disc.

Warning: the ‘RFS Base’ part contains some embedded M3 and M5 nuts that must be added during 3D printing.

1	2	3
		

4	5	6
		

#	Name (Quantity)	File	Notes
1	RFS base (2+2 mirrored)	RFS_base.stl	ABS, PLA, PETG, no support, 100% infill, embedded M5 nut
2	RFS arm (4)	RFS_arm.stl	**ABS**, PLA, PETG, no support, 100% infill
3	RFS bottom cap (4)	RFS_bottom_cap.stl	ABS, PLA, PETG, or PETG, no support, 100% infill
4	RFS rotating disc (4)	RFS_rotating_disc.stl	**ABS**, PLA, PETG, no support, 100% infill, embedded M3 nuts
5	RFS gripper (4)	RFS_gripper.stl	**ABS**, PTEG, no support, 100% infill
6	RFS washer (4)	RFS_washer.stl	ABS, PLA, PETG, no support, 100% infill

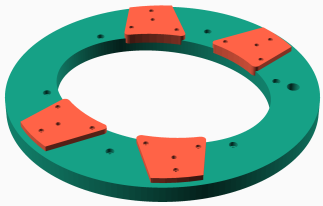
You will need:

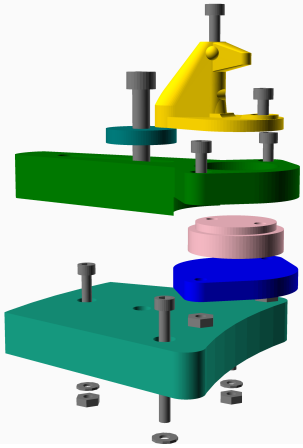
- M3 x 30mm (16)
- M3 x 8mm (4)
- M3 x 10mm (8)
- M3 nuts (28)
- M5 x 25mm (4)
- M5 nut (4)

Steps:

1. Position the RFS Bases as per the picture below on the working disc.
2. Mark the position of the 3 holes in each part onto the wooden working disc.
3. Drill these holes at 4mm all the way through the working disc.

4. Secure the RFS base (x4) to the working disc using the M3x30 bolts, nuts and washers.
5. Assemble the RFS arm, rotating disc and bottom cap using the M3x10 bolts.
6. Attach the grippers onto the RFS rotating discs with one M3x30 and one M3x8 each.
7. Secure the RFS arms (x4) to the RFS bases using the M5x25 bolts and the RFS washer.



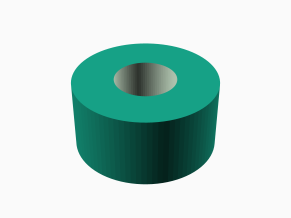


7.7 Working Disc on Base Board

Next, the working disc and base board are connected via the large bearing.

1

2



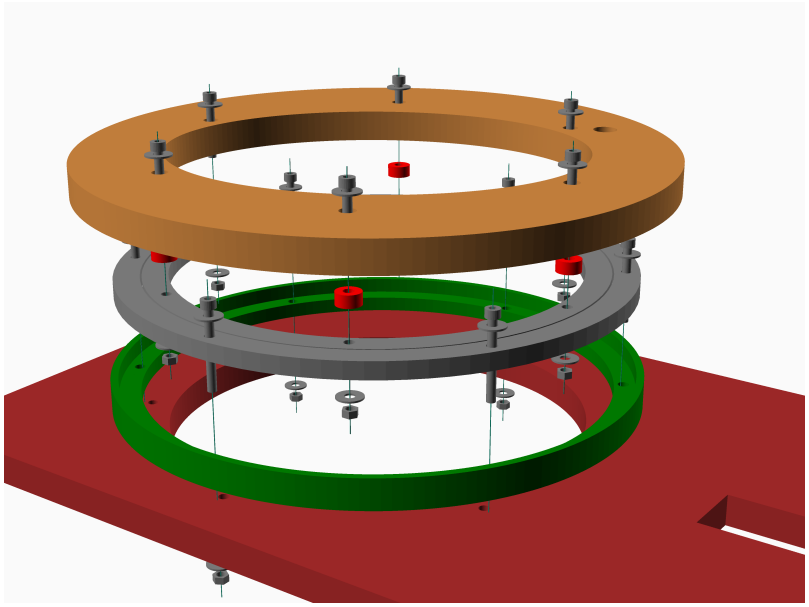
#	Name (Quantity)	File	Notes
1	WD segment (6)	WD_base_segment.stl	PLA, PTEG, ABS, supports on build plate
2	WD spacer (6)	WD_spacer.stl	PLA, PTEG, ABS, no support, 100% infill

You will need:

- M5 x 35mm (6)
- M5 x 45mm (6)
- M5 locking nuts (12)
- M5 normal washer (24)

Steps:

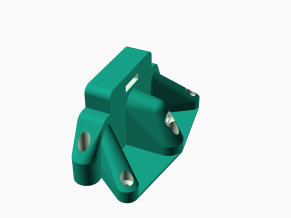
1. Attach the inner ring of the large bearing to the WD (with the spacers between the bearing and the WD) using the 6 M5x35 bolts (1 washer at each end) and nuts.
2. Using the access hole in the WD, place the 6 M5x45 (with washer) in the outer holes of the bearing.
3. Add the 6 base segments to the underside of the bearing (the M5x45 will go through the holes in the segment).
4. Plate the WD+Bearing+segments assembly onto the base board and push the M5x45 through the holes drilled in the base board.
5. Secure the M5x45 using the washers and locking nuts.



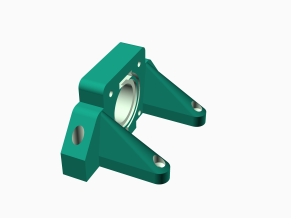
7.8 The Motor and End Brackets

Next, we'll assemble the end brackets, threaded rod and linear guide.

1



2



#	Name (Quantity)	File	Notes
1	End Bracket (1)	EB.stl	**ABS**, PLA, PTEG, 100% infill, supports on build plate
2	Motor Bracker (1)	MB.stl	ABS, PLA, PETG, supports on build plate

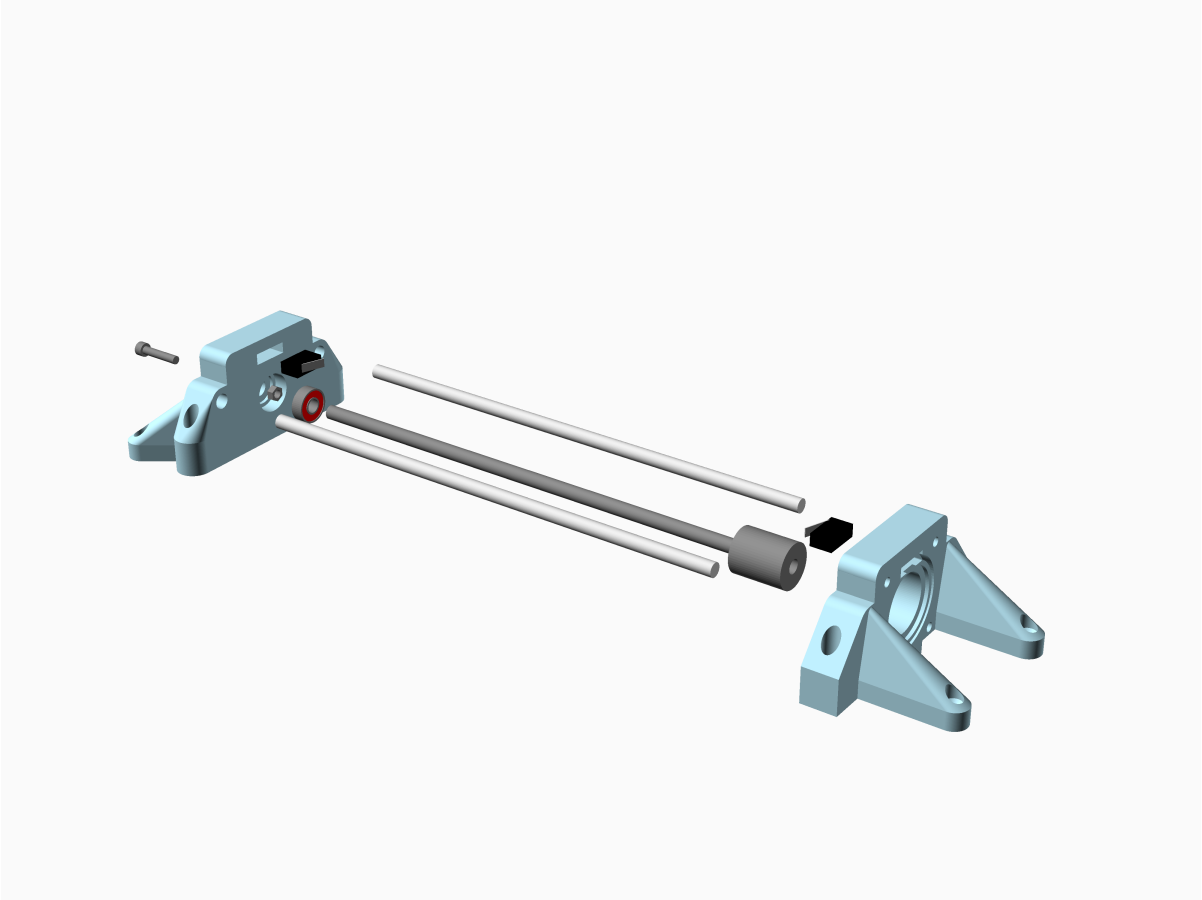
You will need:

- M5 x 25mm (5)
- M5 nuts (5)
- 8mmx300mm linear rails (2)
- T8 300mm lead screw (1)
- Ball Bearing 8x22x7mm (1)
- Micro-switch 19x7mm (2)
- Wires (black, blue, green)
- Heat shrink tubing
- 8-8mm CNC flexible shaft coupler (L=30mm, D=25mm) (1)
- NEMA 23 Stepper motor

Steps:

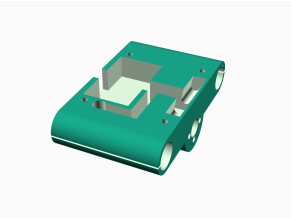
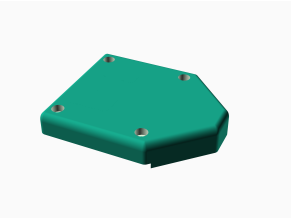
1. Solder some wires (blue/black) and (green/black) (50cm long for now) to the two microswitches (it is best to insulate the terminal once soldered).
2. Install the blue/black switch in the EB part.
3. Install the green/black switch in the MB part (note that there is a channel in that part to run the wire).
4. Use the shaft coupler to connect (tight) the stepper motor and the T8 thread rod.
5. Separate the two parts of the coupler.
6. Attach the stepper motor to the MB part with 4 M5x25 bolts and nuts (make sure the motor wires are facing down towards the BB and than the microswitch wires are not pinched by the motor face).
7. Install a M5x25 with nut in the EB part. This will serve as a adjustable stopper for the T8 lead screw.
8. Install the bearing in the EB part. This will serve as a guide for the T8 lead screw.
9. Install the linear rails and lead screw on the MB end.
10. Add the EB part at the other end of the lead screw and linear rails.
11. Place the assembled parts onto the based board and mark where drilling will be required to accomodate the motor and switches wires (all of then must traveser to the other side of the BB).
12. Remove the assembled parts and drill/cut the BB as required.

13. Separate the EB and MB parts (we need to add more parts on the rails).



7.9 Tensioner Slide

Next, we'll assemble the tensioner slide (TS). This is the part containing the load cell and the HX711.

1	2
	

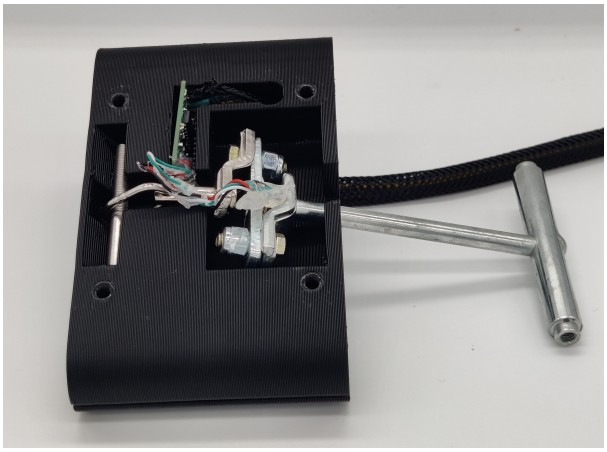
#	Name (Quantity)	File	Notes
1	Tensioner body (1)	TS_body.stl	**ABS**, PLA, PETG 100% infill, supports everywhere
2	Tensioner top (1)	TS_top.stl	ABS, PLA, PETG, no supports

You will need:

- M3 x 25mm (4)
- M3 x 30mm (4)
- M3 nuts (7)
- LM8UU linear bearing (4)
- T8 lead screw nut (1)
- Load cell (1)
- HX711 (1)
- Wires (red, black,green,yellow)
- Braided wrapping cable sleeve 8mm

Steps:

1. Install the LM8UU linear bearings in the body (this will be a tight fit, use a flat screwdriver to open the slot a bit).
2. Add 4 M3 nuts in the hexagonal holes on the underside of the TS body.
3. Secure the T8 lead screw nut (see picture below) using three M3x30 and nuts.
4. Install the 4 linear bearings.
5. Solder the thin load cell wires to the HX711 (E+,E-,A+,A-) as per the wiring diagram. Warning: these wire are fragile (it may help to use some hot glue to secure them to the HX711 after soldering).
6. Solder 4 wires to the other side of the HX711 as per the wiring diagram.
7. Add the braided wrapping cable sleeve and thread the wires through the hole in the TS body.
8. Install the load cell and HX711 in the TS body (see picture below).
9. Use a M3x30mm as 'anchor' point in the TS body for the load cell (see picture below).
10. Being careful not to pinch the load cell wires, add the TS body top and secure it with four M3x25.



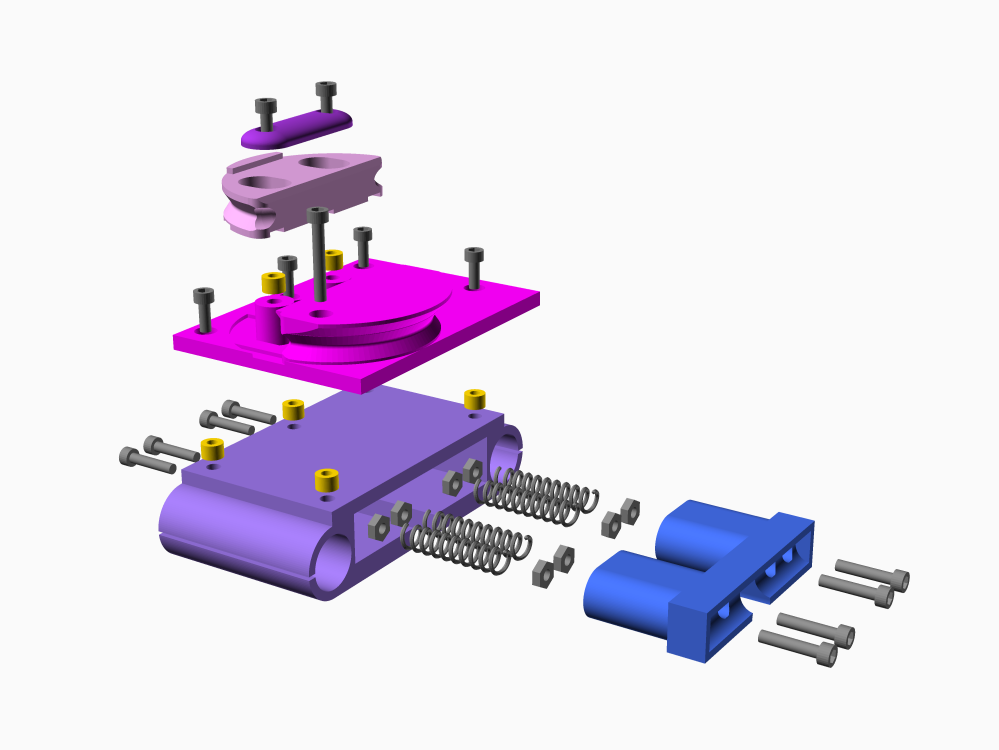
7.10 Gripper Slide

The Gripper Slide (GS) is made of 3 sub-components:

- The GS body
- The springs housing
- The GS plate

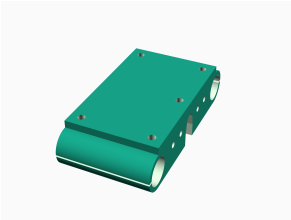
The GS body contains a moving part: the springs hosing. The Tensioner slide is connected to the spring housing via the metal bar of the load cell. When tension is applied, the spring housing slides in the TS body and the springs dampen the force applied by the stepper motor.

Note that the mobile and fixed jaws of the GS plate are kept apart by some opposing magnets embedded in the parts. Be careful to install this magnets so that the two parts repulse each other during the print.



7.10.1 GS body

1



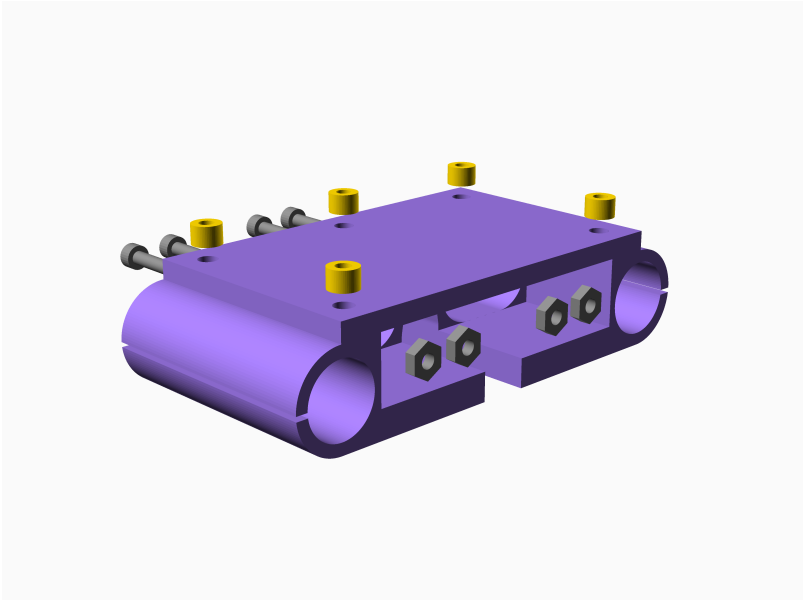
#	Name (Quantity)	File	Notes
1	Gripper body (1)	GS_body.stl	**ABS**, PLA, PETG, 100% infill, no supports

You will need:

- M3 x 10mm (4)
- M3 nuts (4)
- M3 heat inserts (5)
- LM8UU linear bearings (4)

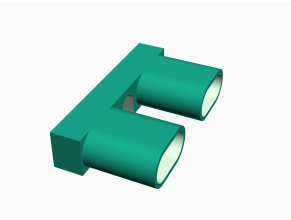
Steps:

1. Install the LM8UU linear bearings in the body (this will be a tight fit, use a flat screwdriver to open the slot a bit).
2. Install the 4 M3x10 bolts so that the bolts face inside the part (the bolts are used to limit the springs lateral movements).
3. Secure the bolts with the nuts using the 3D printed tool to reach inside the body.
4. Insert the 5 threaded heat insert on the top face of the part (using a soldering iron or you prefered method on installing inserts).



7.10.2 Spring housing

1



2

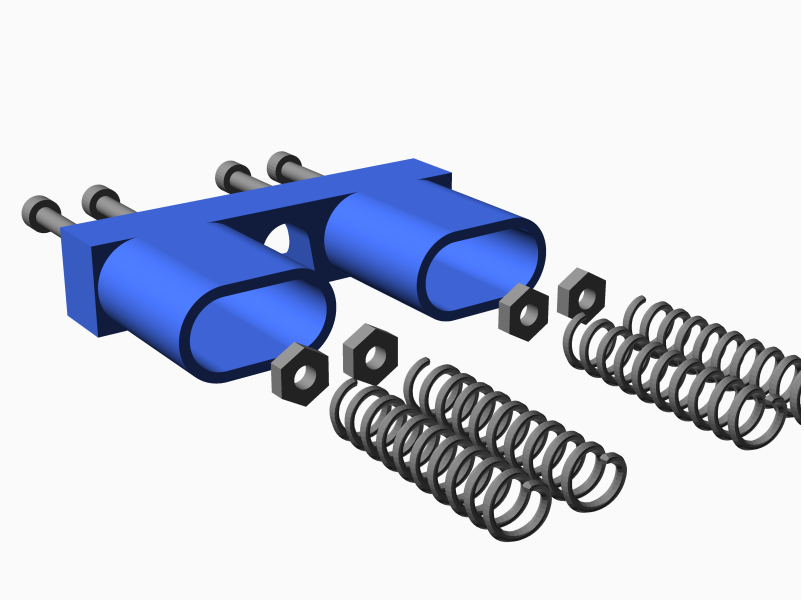
#	Name (Quantity)	File	Notes
1	Spring housing (1)	GS_springs_housing.stl	ABS, PLA, PETG, 100% infill, supports on build plate
2	Tool (1)	tool1.stl	PLA, PETG, ABS

You will need:

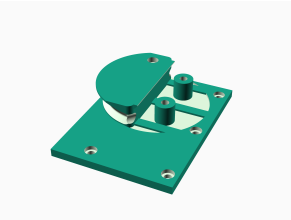
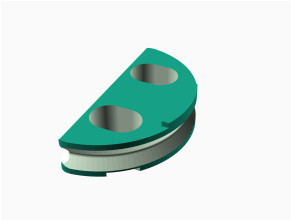
- M3 x 10mm (4)
- M3 nuts (7)
- Springs (4)

Steps:

1. Install the 4 M3x10 bolts so that the screws face inside the part (the screws are used to limit the springs lateral movements).
2. Secure the bolts with the nuts using the 3D printed tool to reach inside the housing.
3. Slide the springs in the part.



7.10.3 Gripper plate

1	2	3
		

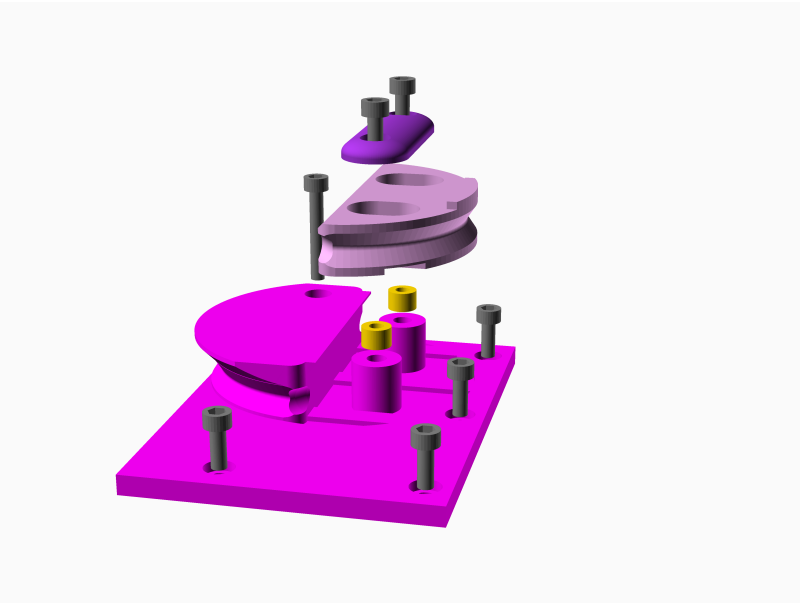
#	Name (Quantity)	File	Notes
1	Fixed jaw (1)	GS_fixed_jaw.stl	**ABS**, PLA 100% infill, no supports, embedded magnets
2	Mobile jaw (1)	GS_mobile_jaw.stl	**ABS**, PLA, 100% infill, no supports, embedded magnets
3	Retainer (1)	GS_mobile_jaw_retainer.stl	PLA, PETG, ABS, no support

You will need:

- M3 x 8mm (6)
- M3 x 15mm (1)
- M3 x washer (2)
- M3 heat inserts (2)
- Magnets 6mm diameter, 3mm thick (6)

Steps:

1. Install the fixed jaw onto the GS body and secure it in the inserts using 4 M3x8 and one M3x15.
2. Install the mobile jaw onto the plate and secure with 2 M3x8 bolts. Use 2 washers underneath the retainer.



7.11 Control Panel & LCD screen

In this step, you will secure the box for the control panel to the underside of the base board.

1

#	Name (Quantity)	File	Notes
1	Control Panel cover (1)	CP_cover.stl	PLA, ABS, PETG, no supports

You will need:

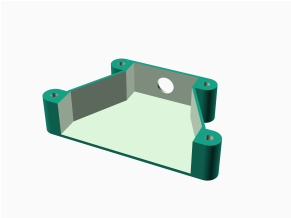
- M3 x 10mm (4)
- M3 x 25mm (4)
- M3 nuts (4)
- Buttons (3)
- LCD HD44780 (1)
- LCD driver PCF8574T (1)
- Wires (red, black, yellow, blue, green)
- Heat shrink tubing

Steps:

1. Solder some wires to the buttons (see wiring diagram).
2. Solder some wires to the PCF8574T (yellow for SCL, blue for SDA and red/black for VCC/GND).
3. Solder the PCF8574T and the HD44780 together using a row of 16 pins.
4. Attach the LCD via it’s mounting holes to the inside of the CP cover with the M3x10 bolts and nuts.
5. Insert the buttons in the holes of the CP cover and secure them with the provided rings.
6. Insert the M3x25 bolts in the corner holes (you will use them to close the CP once the wiring is done).

7.12 Final assembly

1



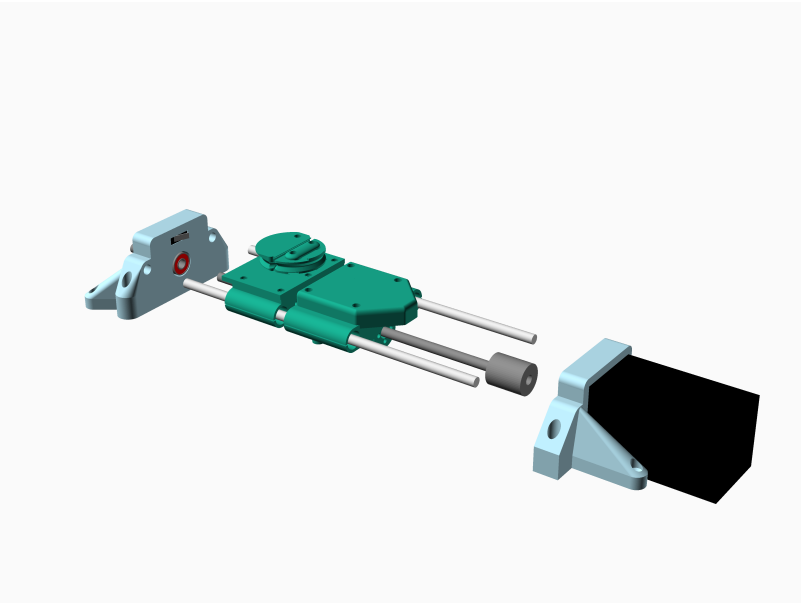
#	Name (Quantity)	File	Notes
1	Stepper driver cover(1)	BB_stepper_driver_cover.stl	PLA, PETG, ABS, no supports

You will need:

- 4x25mm wood screws (4)
- 4x35mm wood screws (8)
- Wires (black, yellow, blue, green, red)
- Braided wrapping cable sleeve 8mm

Steps:

1. “Connect” the GS and TS together via the load cell hook (place the T bar on the GS spring housing).
2. Slide the linear rails through the GS and TS bearings.
3. Thread the T8 lead screw through the TS part.
4. Add the EB and MB brackets at each end (making sure the T8 lead screw is coupled to the motor).
5. Place the entire assembly on the based board and thread the wires and cables through the holes drilled earlier.
6. Secure the EB and MB to the base board using the wood screws (Two 4x25mm and 4x35mm per end).
7. Flip the machine upside down and connect the stepper motor wires to the stepper driver.
8. Connect some wires (see wiring diagram) to the stepper driver (24V, GND, Enable+,Dir+,Pulse+) and wrap them.
9. Thread this bundle of wires throuhg the hole in the 3D printed Stepper driver cover and secure the cover using four 4x35mm screws into the baseboard.

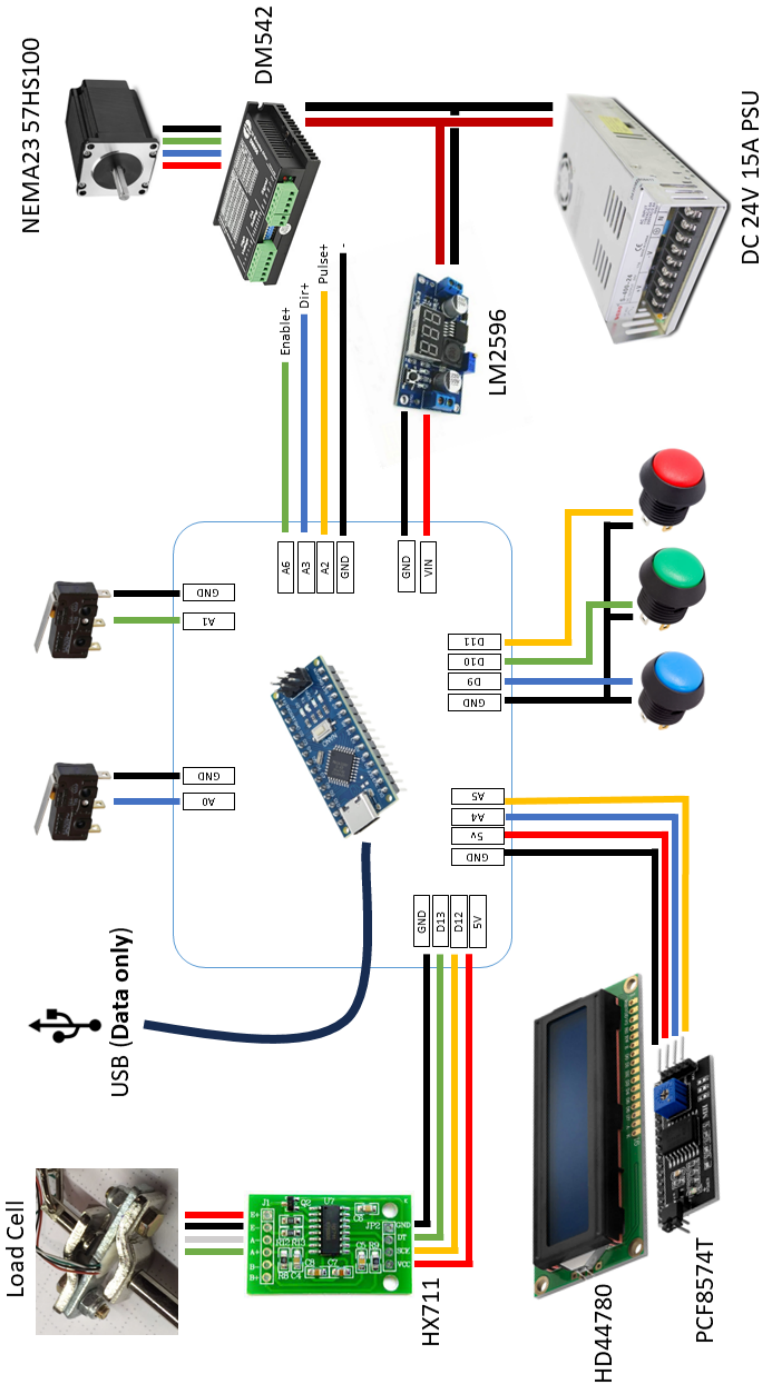


7.13 Wiring

For the wiring, follow the diagram below and do your best to fit everything in the box (there is plenty of space for the extra length of wires so do feel you need to cut them too short).

You can use the provided cable clips (BB_cable_retainers.stl) to secure the wires to the underside of the base board.

7.13.1 Wiring diagram



7.13.2 Data only USB

To avoid any issue it is best (in my experience) to not power the Arduino nano via USB at the same time as via the power supply. In order to program the Arduino (and debug the firmware) you can leave a ‘data only’ USB cable plugged in the Arduino.

To make a ‘data only’ USB cable:

1. Take a standard USB cable (that works for you arduino) and cut it in the middle.
2. Reconnect (soldering + heat shrink tubing) the data and ground wires of the cable (usually the white, green and black) and isolate the red one.

8 Firmware

The firmware is provided as an Arduino skech (see *firmware/KhordUino_v1.ino*).

You should program the Ardunio before closing the control panel unless you are planning to leave a USB cable connected.

8.1 Setup and test

From the main screen you can navigate the menu to choose:

- **Start**: to start stringing.
- **Setup**:
  - **Test**: For testing all the buttons (3 on CP and limit switches).
  - **Calibrate**: For calibrating the load cell (see next section).
  - **Set param A**: For setting the calibration value ‘A’.
  - **Set param B**: For setting the calibration value ‘B’.
- **Info**:
  - **Version**: Show the firmware version
  - **EEPROM**: Show the saved strining tension, and the calibration values.

8.1.1 Calibration

TODO (software not finished yet)

9 Using KhordUino

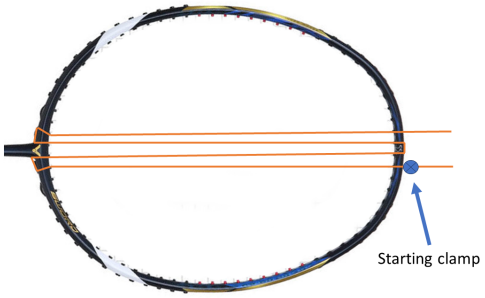
9.1 Setting up the machine

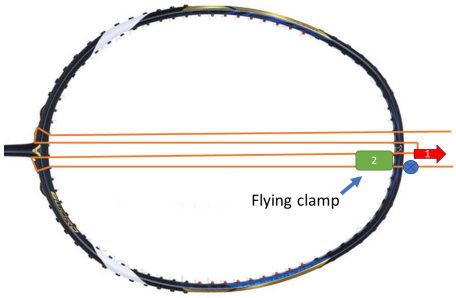
From a stored position you should:

1. Unfold the legs.
2. Install the KhordUino on a table or counter top.
3. Connect the 24V power supply to the main and switch in on.
4. Once the KhordUino controller is ready press the middle button to select ‘Start’.
5. Select the desired tension with the ‘+’ and ‘-’ buttons then press the ‘OK’ button.

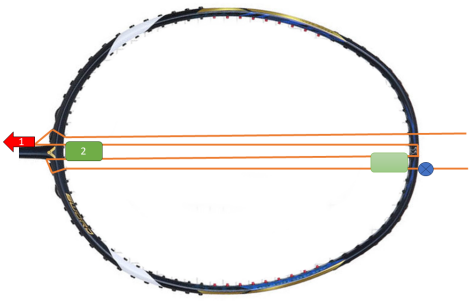
9.2 Starting the main strings using flying clamps

Start by placing the starting clamp as shown. | Apply some tension, place a flying clamp then release.

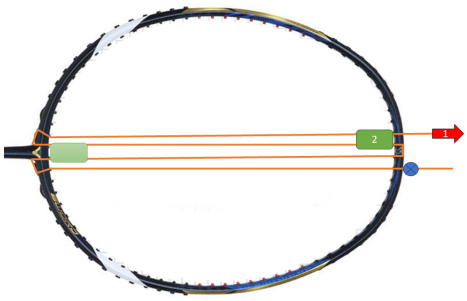




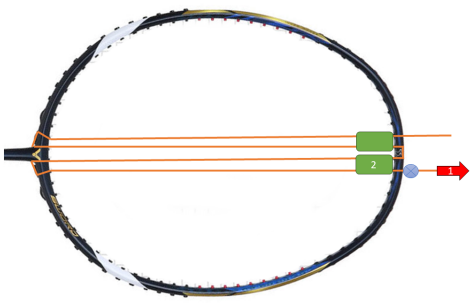
Pull at the throat, move the flying clamp and release.



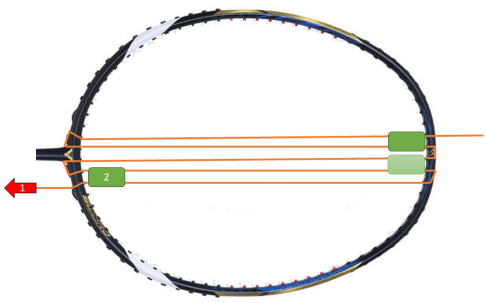
Pull at the head, move the flying clamp and release.



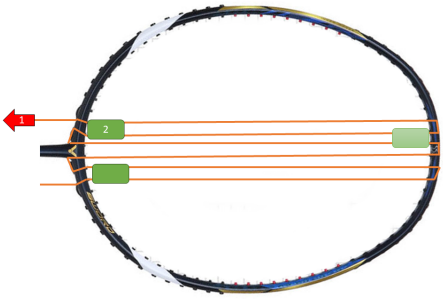
Pull at the head, place a 2nd flying clamp and release.

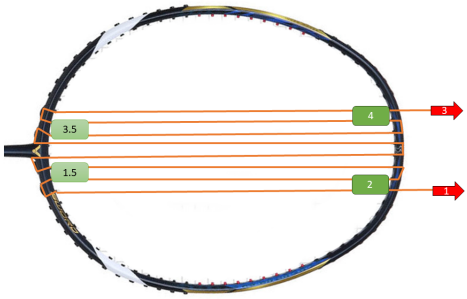


Remove the starting clamp, pull and move the flying clamp.

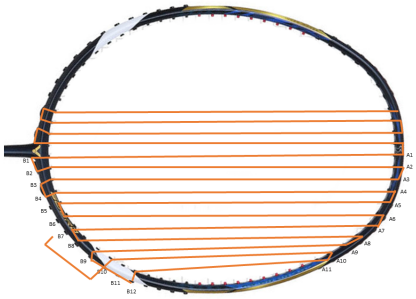


From this point, alternate tensionning side to side.

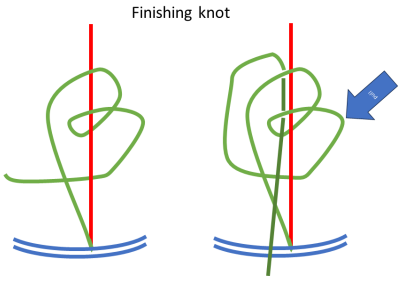




Be sure to follow the stringing pattern for you racket.



Use the finishing knot to tie off the string ends.



Use a starting knot for the cross string.