

RPieces - TableTopXYZ

User and Assembly Manual



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Feel free to use: no strings attached (text content only / images respectfully referenced)

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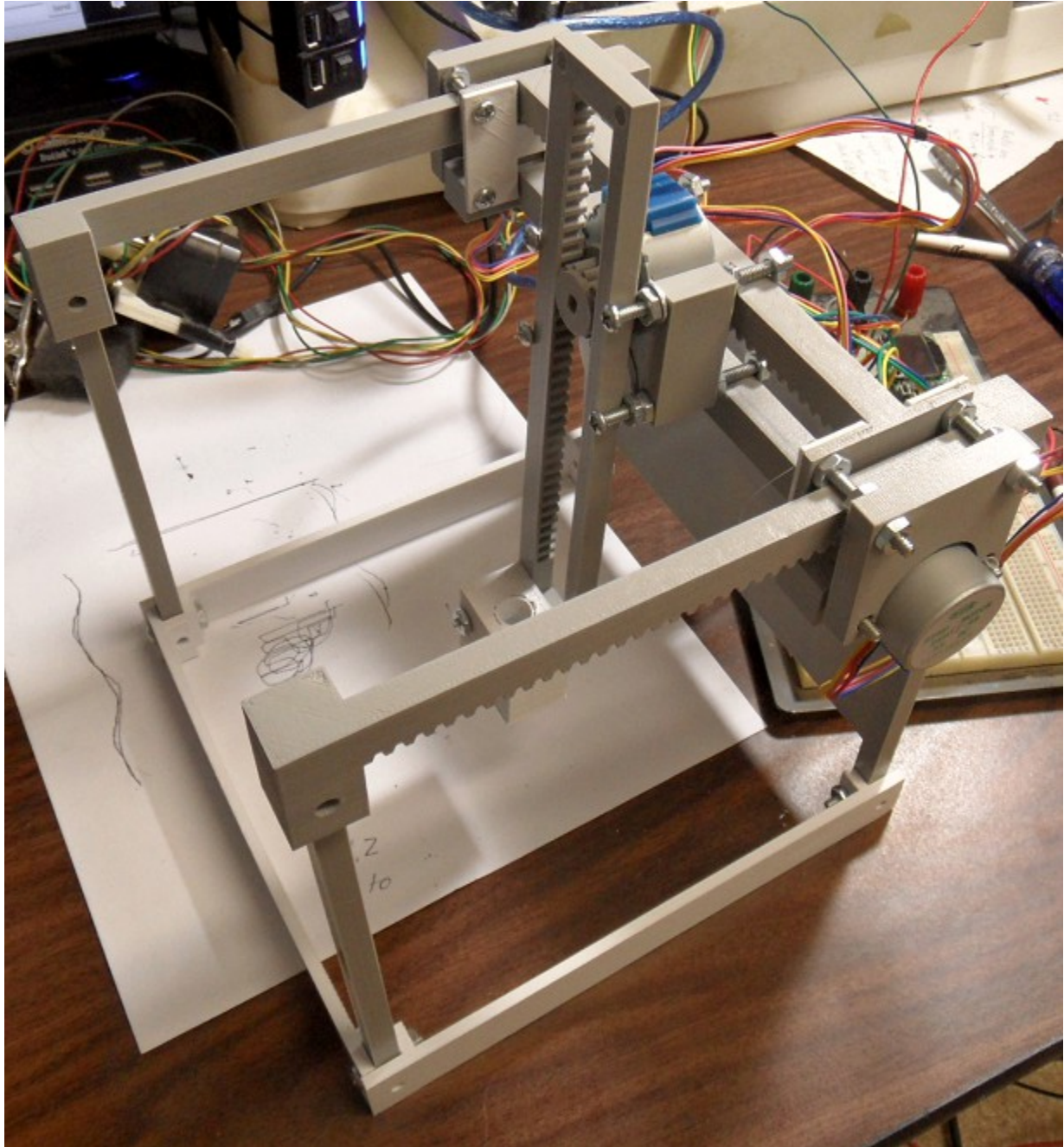
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1. INTRODUCTION

The "**RPieces – TableTopXYZ**" project's goal is to provide a simple and almost entirely printable motion frame for various usages. Including 3d printing, plotting and minor milling. The platform can also be used in testing software, firmware or just testing a model creation on a physical unit before sending it to a much larger commercial unit.

The project is Open Source and Resides at: <https://github.com/tgit23/RPieces-TableTopXYZ>

This documentation resides at: <https://github.com/tgit23/RPieces-TableTopXYZ/docs>



2. BILL OF MATERIALS - \$28.07

2.1 Tools (N/A)

The following tools are required to build the project components

- ✓ 3D-Printer (With a 190mm x 190mm XY Build Envelope or Larger)
- ✓ Phillips head screw driver and nut driver

2.2 3D – Prints

- ✓ (1) BackSide.stl
- ✓ (1) Base-Front.stl
- ✓ (1) Base-Left.stl
- ✓ (1) Base-Right.stl
- ✓ (2) Leg.stl
- ✓ (4) MotorGear.stl
- ✓ (1) X-Guide.stl
- ✓ (1) X-Rack.stl
- ✓ (1) XZ-MotorTie.stl
- ✓ (2) Y-MotorMount.stl
- ✓ (1) Y-Rack-Left.stl
- ✓ (1) Y-Rack-Right.stl
- ✓ (1) Z-Rack.stl

2.3 Power Supply (\$3.10)



Illustration 1: 5VDC Adapter

- ✓ (1) 5Vdc Adapter around 2A maybe less (\$3.10)
 - www.banggood.com/3-Way-Port-Audio-Video-AV-RCA-Switch-Selector-Box-Splitter-p-964652.html

2.4 Electronic Control (\$22.73)

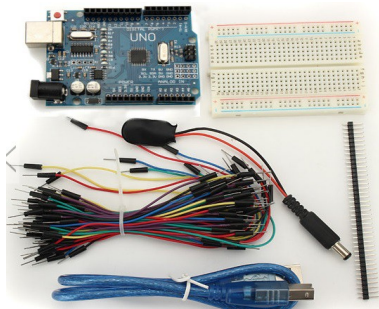


Illustration 2: (2) Arduino UNO R3



Illustration 3: LCD Keypad Shield



Illustration 4: M-F 20cm Dupont

- ✓ (1) UNO R3 Atmega328P Module, Mini Breadboard & Jumpers (\$10.19/ea)
 - <http://www.banggood.com/UNO-R3-Module-Mini-Breadboard-Jumper-Starter-Kit-For-Basic-Arduino-p-1065051.html>
- ✓ (4) 28BYJ-48 5V DC Step Motor with ULN2003 Driver Board (\$10.34/per5)
 - <http://www.banggood.com/5Pcs-DC-5V-4-Phase-5-Wire-Stepper-Motor-With-ULN2003-Driver-Board-p-951162.html>
 - Resources

- 28BYJ Data-sheet <http://www.sensors.co.nz/datasheet/28BYJ-48%20Stepper%20Motor.pdf>
- ULN2003 Data-sheet <http://www.ti.com/lit/ds/symlink/uln2003a.pdf>

- ✓ (~40) 20 to 30cm Male to Female DuPont Jumpers (\$2.20)
 - <http://www.banggood.com/40-x-30cm-Male-To-Female-DuPont-Breadboard-Jumper-Wire-Cable-p-89708.html>

2.5 Machine Screws (\$2.24)

✓ Complete List

- (4) #6-32 x 2" Machine Screws (\$0.06/ea = \$0.24)
- (8) #6-32 x 1-1/4" Machine Screws (\$0.05/ea = \$0.40)
- (4) #6-32 x 3/4" Machine Screws (\$0.05/ea = \$0.20)
- (2) #6 Flat Washers (\$0.05/ea = \$0.10)
- (26) #6-32 Hex Nuts (\$0.05/ea = \$1.30)

✓ Itemized List

- X Gantry
 - (4) #6-32 x 2" Machine Screws
 - (12) #6-32 Hex Nuts
 - (2) #6 Flat Washers
- Y – Gantry
 - (8) #6-32 x 1-1/4" Machine Screws
 - (10) #6-32 Hex Nuts
- Frame
 - (4) #6-32 x 3/4" Machine Screws
 - (4) #6-32 Hex Nuts

✓ Online Price Reference

- Machine Screws @ https://www.boltdepot.com/Machine_screws_Phillips_pan_head_Zinc_plated_steel_6-32.aspx
- Washers @ https://www.boltdepot.com/Product-Details.aspx?Units=US&Category=Washers&Subcategory=SAE_flat_washers&Material=Steel&Plating=Zinc
- Hex Nuts @ https://www.boltdepot.com/Product-Details.aspx?Units=US&Category=Nuts&Subcategory=Hex_machine_screw_nuts&Dimensional_standard=&Material=Steel&Plating=Zinc

Minor variances in size shouldn't be a problem; but the (4) 2" Long machine screws are required. Other screws must be the listed length or longer. All except for the Frame screws need to fit inside the metal bolt holes of the 28BYJ Stepper Motor.

3. HARDWARE ASSEMBLY

Below is the list of the Parts that needed to be printed by a 3D-Printer along with any significant notes about the print. They can be printed with ABS or PLA but PLA is highly suggested over ABS for it's non-curling and non-flexible (brittle) attributes.

- ✓ Models that require precision (Slower Printing - Printed at a 0.1 Layer Height)
 - (4) MotorGear.stl
 - (1) X-Rack.stl
 - (2) Y-Rack.stl
 - (1) Z-Rack.stl
- ✓ Models that can be a little sloppy (Fast Printing – Can be Printed at a 0.3 Layer Height)
 - (1) BackSide.stl - (175mm x 170mm x 7.5mm)
 - (1) Base-Front.stl
 - (1) Base-Left.stl
 - (1) Base-Right.stl
 - (2) Leg.stl
 - (1) X-Guide.stl - (190mm x 45mm x 13mm)
 - (1) XZ-MotorTie.stl
 - (2) Y-MotorMount.stl

Items can be printed at any resolution desired; The sloppier the print the looser the screws will need to be for motion and the looser the completed unit will function (Low Prints = Low Precision).

3.1 Backside & Electronics

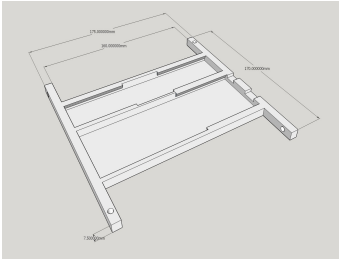


Illustration 5: (1) Backside

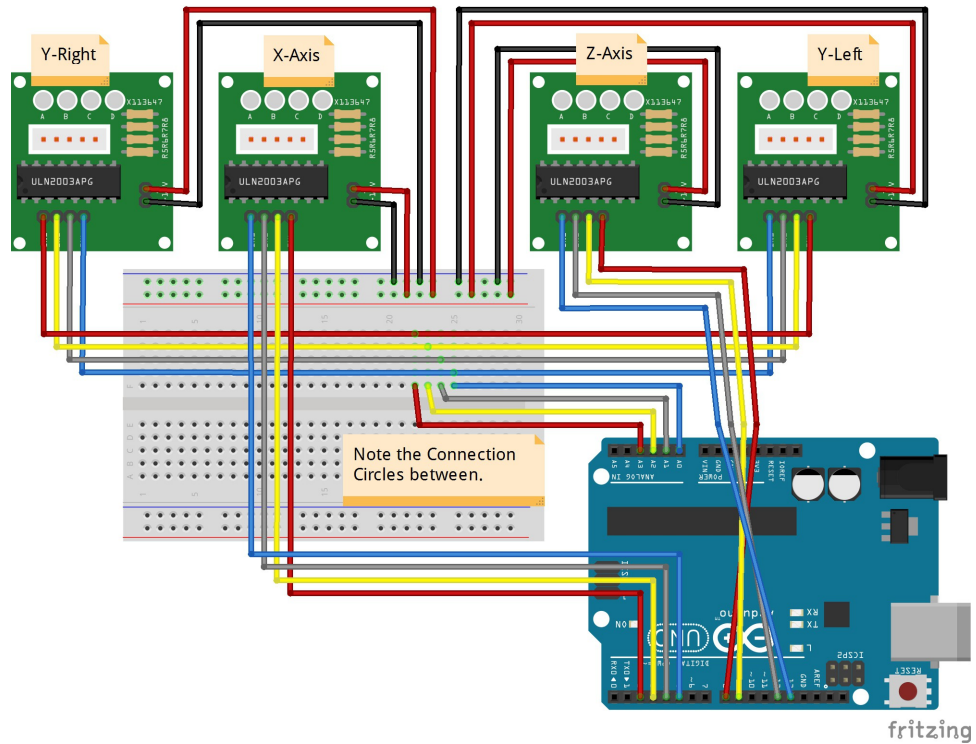


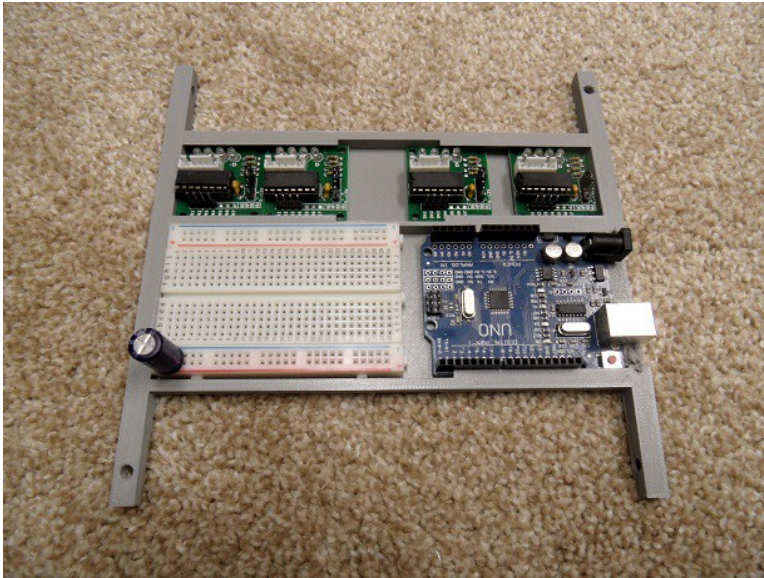
Illustration 6: Wiring Diagram

3.1.1 Print Backside

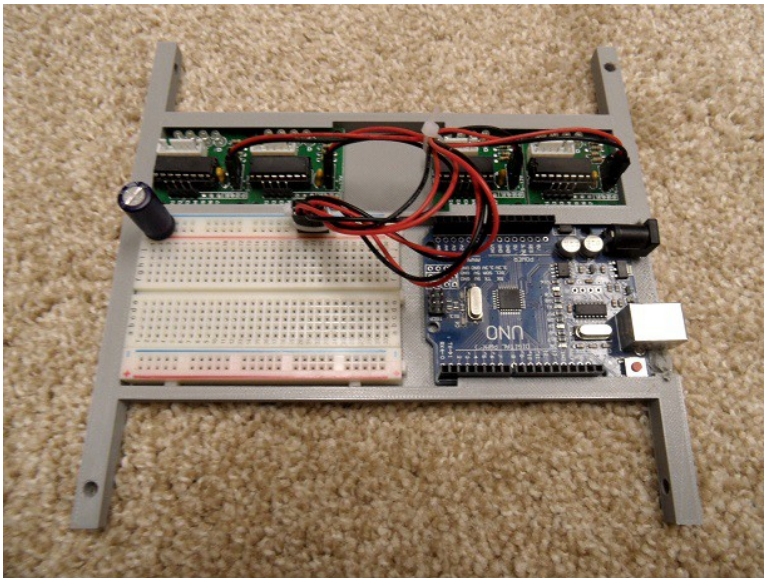
1. Print [BACKSIDE.STL](#) file on 3d printer.
2. Once finished continue printing models (Used in Section 4.2)
 - a) (2) [Y-RACK.STL](#)
 - b) (2) [LEGS.STL](#)
 - c) (2) [BASE-SIDE.STL](#)
 - d) (1) [BASE-FRONT.STL](#)

3.1.2 Electronics Assembly

1. Place electronic assemblies inside the Backside Panel
 - a) Place (4) ULN2003 driver boards - inserting them into the center and slidding them to the edge
 - b) Place (1) Arduino UNO - inserting on the left and slidding to the right
 - c) Place a half-size bread board on the left.

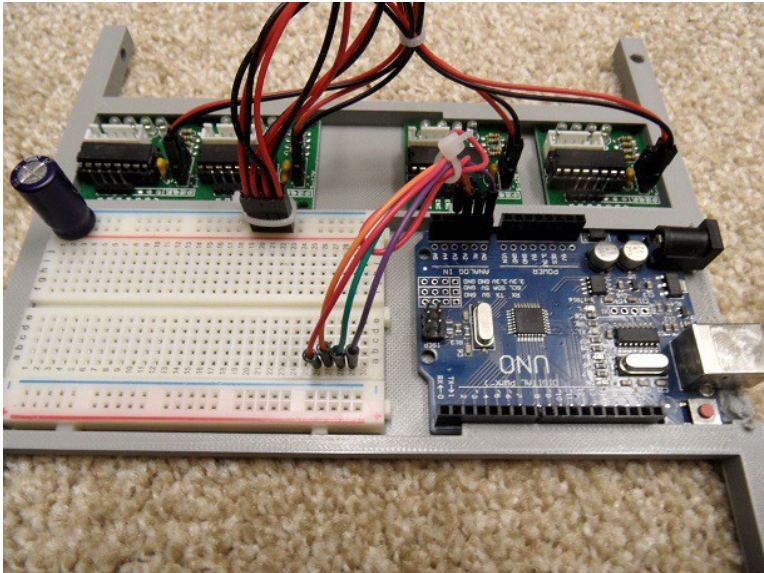


2. Wire power to the ULN2003 driver boards
 - a) Use Dupont Male to Female jumpers to wire the Positive (+) and Negative (-) pins on ALL the ULN2003 boards together on the BB power rail



3. Wire the Y-Axis Motor Control pins for splitting to BOTH Y-Axis motors (A0 → A3)

- a) Use breadboard jumper wires to route from the Arduino UNO → Breadboard or common point
- b) Diagram coloring order is:
 - A0 = Blue/Purple
 - A1 = Grey/Green
 - A2 = Yellow
 - A3 = Red



4. Connect control wires for the X, Y, and Z ULN2003 Control Boards

a) Right Side Y-Axis ULN2003

- A0 (Blue) → Breadboard → IN1
- A1 (Grey) → Breadboard → IN2
- A2 (Yellow) → Breadboard → IN3
- A3 (Red) → Breadboard → IN4

b) Left Side Y-Axis ULN2003 (**REVERSED WIRING**)

- A0 (Blue) → Breadboard → IN4
- A1 (Grey) → Breadboard → IN3
- A2 (Yellow) → Breadboard → IN2
- A3 (Red) → Breadboard → IN1

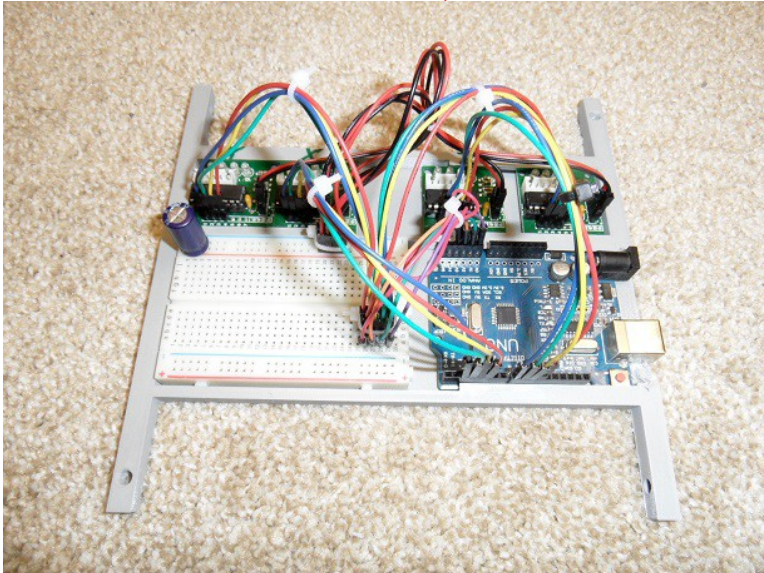
c) X-Axis ULN2003

- D5 (Blue) → IN1
- D4 (Grey) → IN2
- D3 (Yellow) → IN3
- D2 (Red) → IN4

Picture Has Errors!!! Following the Wiring Diagram or Text above.

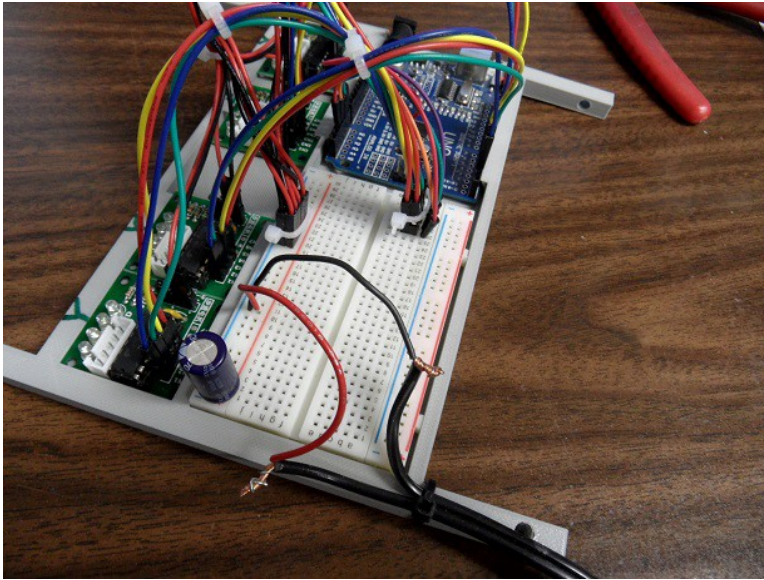
--- D2...D5 are backwards on the Arduino in the picture!!!

--- Y-Axis left ULN2003 are backwards in the picture!!!



5. Wire Power Supply Adapter

- a) Cut and strip the ends of the 5Vdc Wall Power Adapter
- b) Wire-tie the end to the Backside leg
- c) Check the polarity of the power (+ / -)
- d) Attach power to the power rail wired in step #2 above
- e) OPTIONALLY an appropriate capacitor can be placed on this power rail.



3.2 Y-Rail / Frame

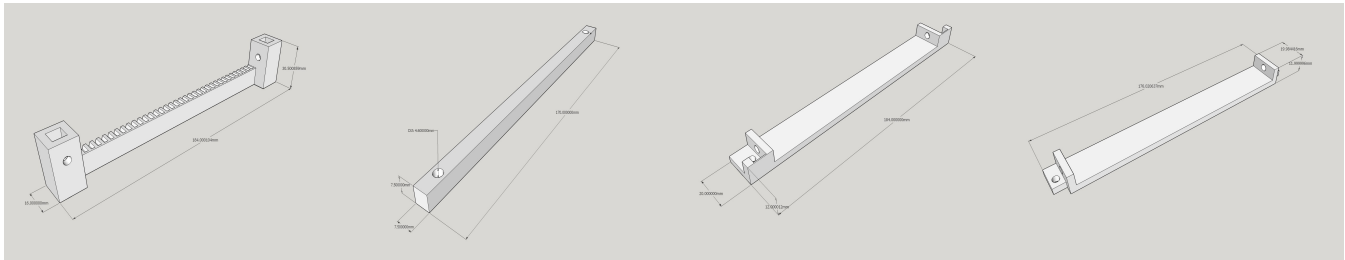


Illustration 7: (2) Y-Rack

Illustration 8: (2) Leg

Illustration 9: (2) Base-Side

Illustration 10: (1) Base-Front

1. Insert Legs into Y-Racks

- The racks rail (gearing part) will always be at the farthest from the center of the machine
- Insert (2) [LEG.STL](#) into the front side of (2) [Y-RACK.STL](#) positioning them so the holes align

2. Insert Backside Panel into Racks

- Insert the top Legs of the [BACKSIDE.STL](#) Panel; Flat side facing forward (towards Y-Racks hang) - into the (2) Y-Rails

3. Attach Leg Bases

- Slide (2) [BASE-SIDE.STL](#) Bases under the legs aligned with the Y-Rack and long side vertical
- Attach (1) [BASE-FRONT.STL](#) Base to across the front (where the two separate legs exist) of the unit.

4. Bolt the standing model

- Use (4) #6-32 x 3/4" long machine screws to attach and tighten the 4-corners of the Bases
- Use (4) #6-32 x 3/4" long machine screws to attach and tighten the Y-Racks to the Legs and Back-Side Panel



3.3 X-Rail / Gantry Frame

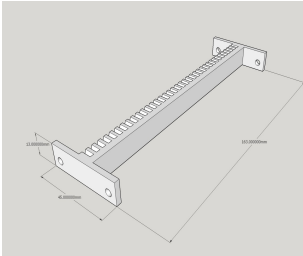


Illustration 11: X-Rack

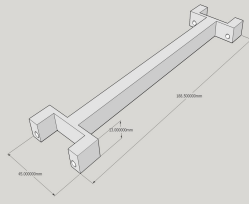


Illustration 12: X-Guide

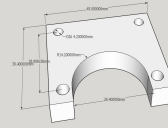


Illustration 13: Y-Motor Mounts

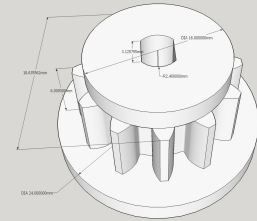


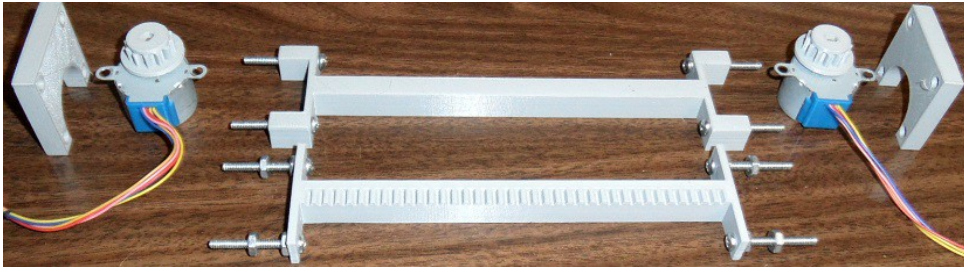
Illustration 14: Motor Gear

1. 3D Print the following files

- [X-RACK.STL](#)
- [X-GUIDE.STL](#)
- (2) [Y-MOTORMOUNT.STL](#)
- (2) [MOTORGEAR.STL](#)

2. Prepare the [X-RACK](#) and [X-GUIDE](#)

- Attach a [MOTOR-GEAR](#) to each of (2) 28BYJ-48 Stepper Motors (*Tap lightly with small hammer if needed*)
- Place (4) 1-1/4" long Machine screws through the four holes in the [X-RACK](#); threaded ends pointing outward.
- Place (4) 1-1/4" long Machine screws through the four holes in the [X-GUIDE](#); threaded ends pointing outward.
- Put on (8) Machine screws nuts on the [X-RACK](#) machine screws – but no need to tighten them just yet.
- Roll on (4) more Machine screws to the [X-RACK](#) screws leaving them ~ 7 to 8mm from the tightened nuts

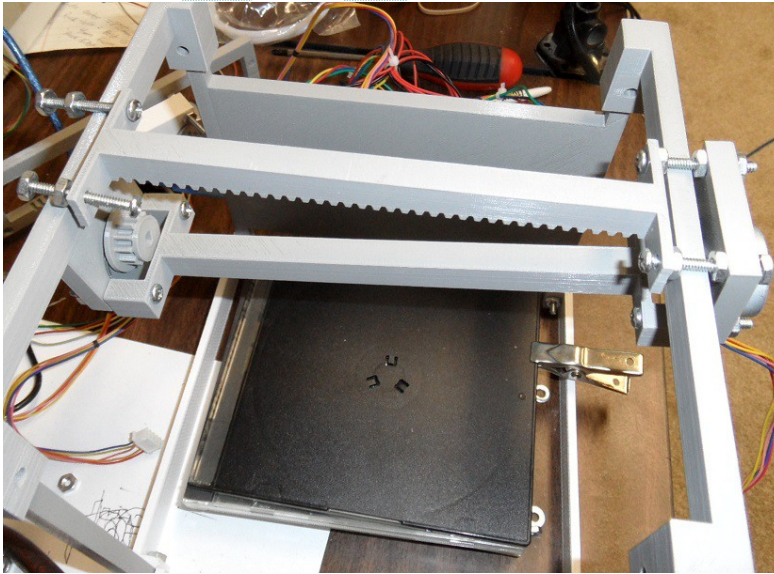


3. Bolt motors to the [X-GUIDE](#) using [Y-MOTOR-MOUNTS](#).

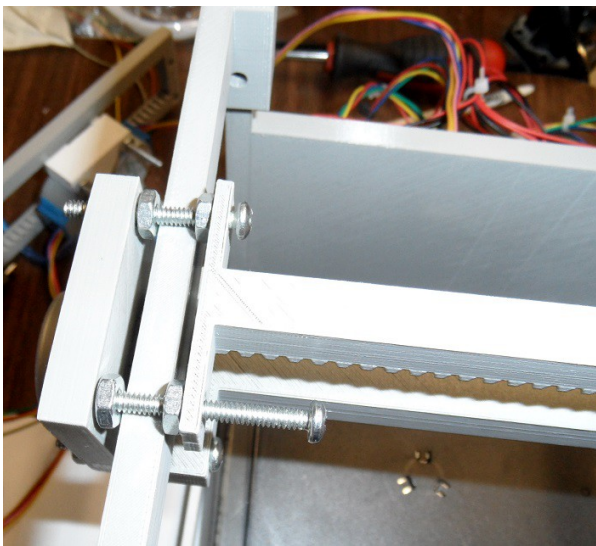
- Position the [X-GUIDE](#); Fat Side of Bolt hole with Wire side of Stepper Motors
- Run machine screw through the metal casings motor bolt holes
- Then slide the [Y-MOTOR-MOUNTS](#) onto both ends of the machine screws
- Attach nuts and tighten fairly snug (*Will need to adjust them later on*)



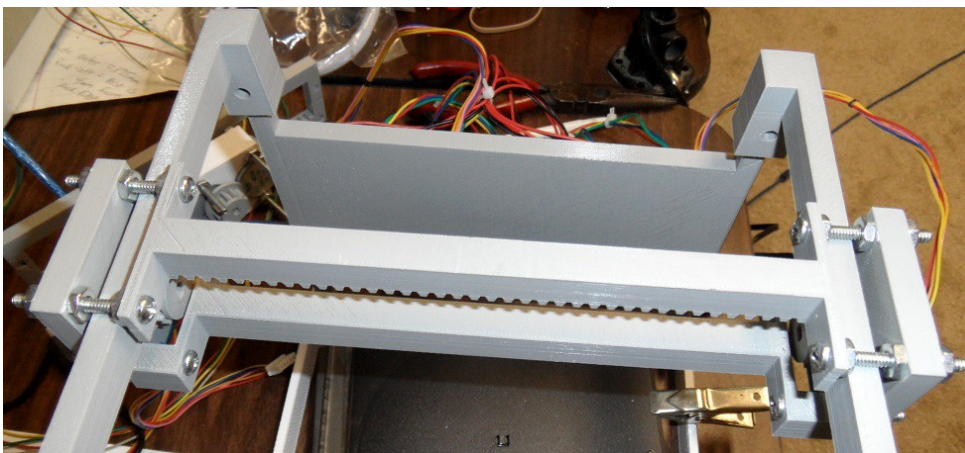
4. Place the [X-RACK](#) on top of the [Y-RACKS](#) and attach the [X-GUIDE](#) with attached Motors
- a) Position the [X-RACK](#) so the Gearing end faces forward and down.
 - b) Slide one end of the [X-GUIDE](#) onto the [X-RACK](#) machine screws and attach nuts to hold it.



5. Lift the [X-GUIDE](#) and Thread the [X-RACK](#) machine Screws through the [Y-MOTOR-MOUNT](#) on the other end.



6. Attach nuts – Final assembly should look like the picture.



3.4 X & Z-Rail / Tool-head

Note: The Z-Rail has been changed to fit on the other side of the machine XZ Motor Mount screws (It'll be apparent when assembling) so pictures of the Z-Rail won't be quit correct.

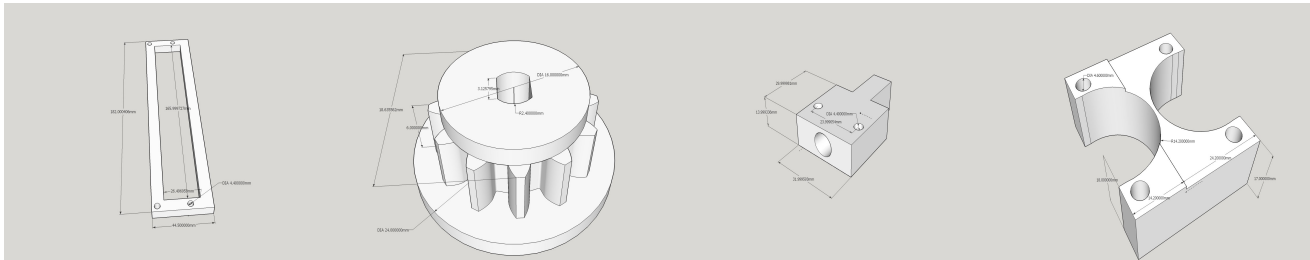


Illustration 15: Z-Rail

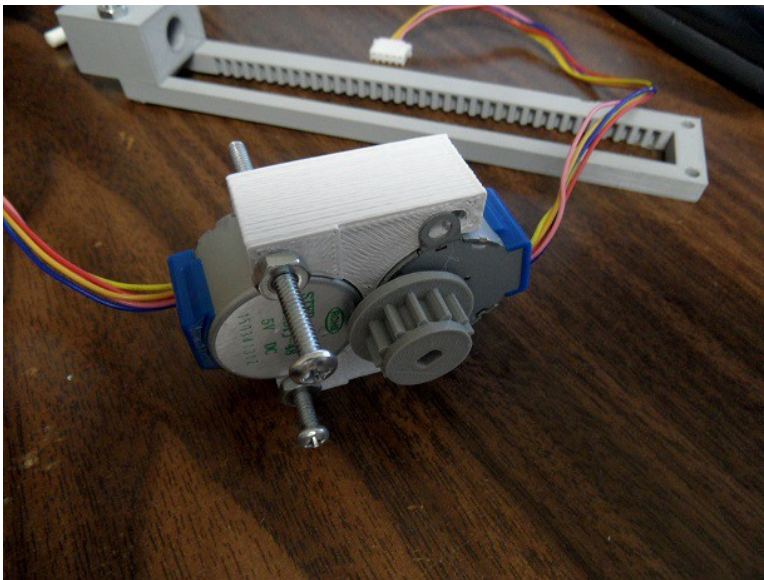
Illustration 16: Motor Gear

Illustration 17: Pen Tool-head

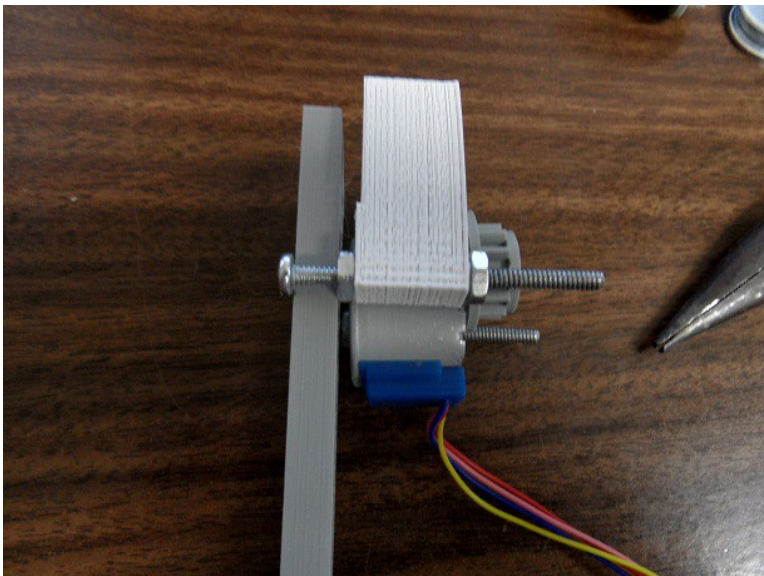
Illustration 18: X & Z Motor Mounts

1. Install Motors into [XZ-MOTOR-TIE](#)

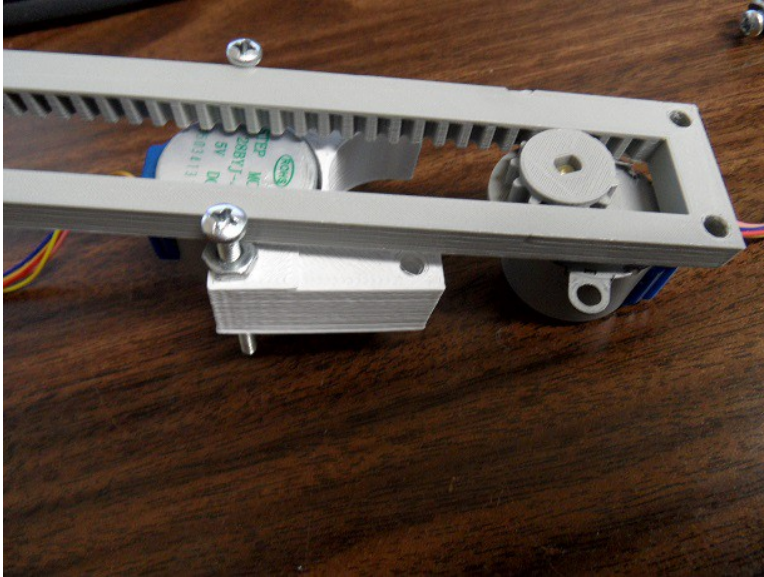
- a) Attach a [MOTOR-GEAR](#) to each of (2) 28BYJ-48 Stepper Motors (*Tap lightly with small hammer if needed*)
- b) Place the two motors inside [XZ-MOTOR-TIE](#) Block and insert a 2" long machine screw with nut through the holes as shown.



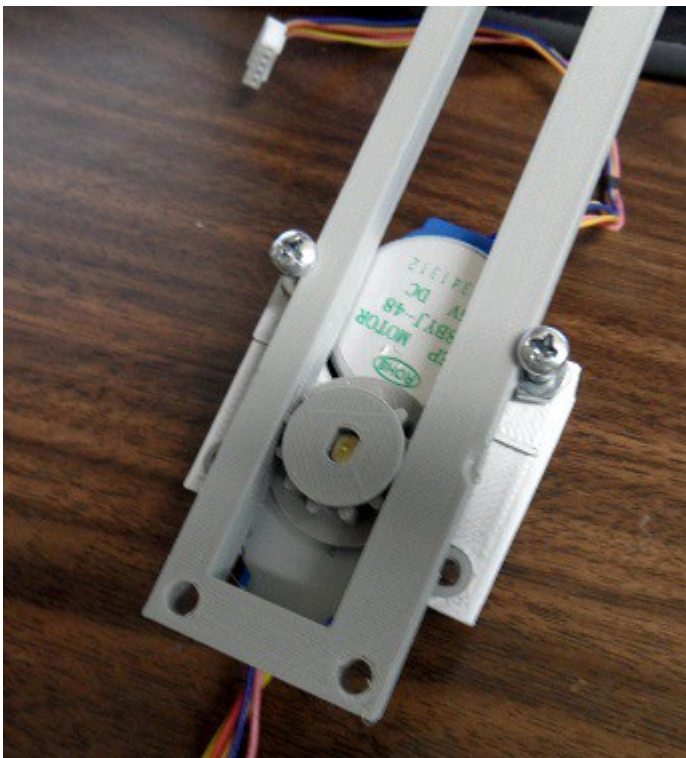
2. Using the [Z-RACK](#) for spacing – Tighten the two Machine Screws to the [XZ-MOTOR-TIE](#) Block as shown



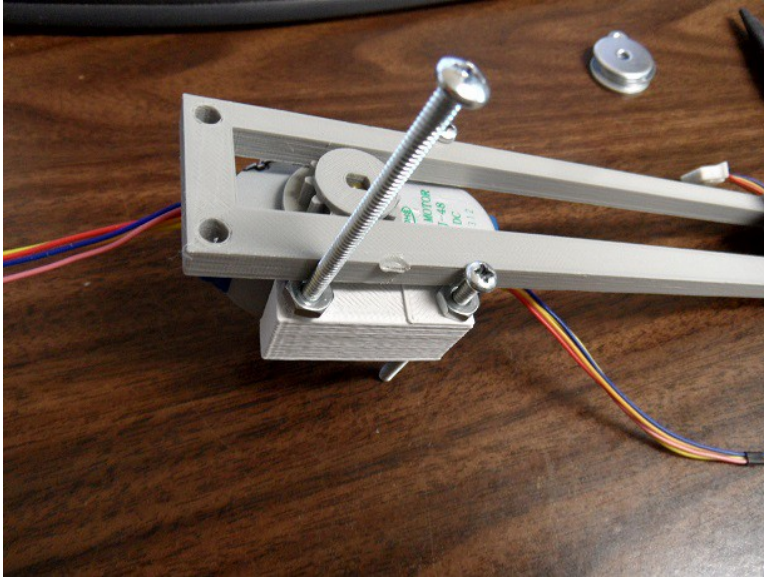
- Slide the [Z-RACK](#) forward and insert the second 28BYJ stepper motor into the [Z-RACK](#) gearing as shown.



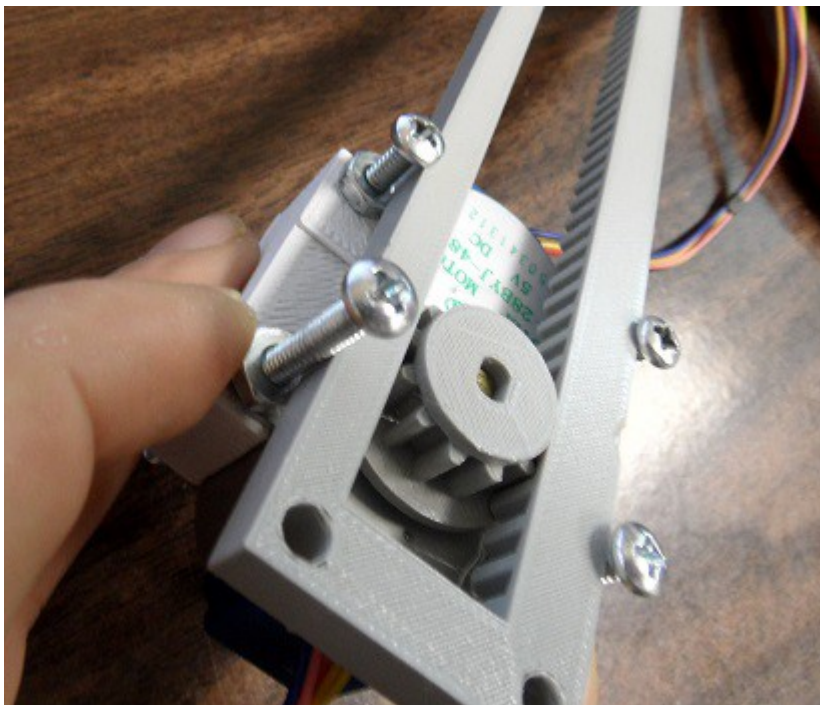
- Slide the [Z-RACK](#) down until the inserted motor slides into place with its motor mount holes



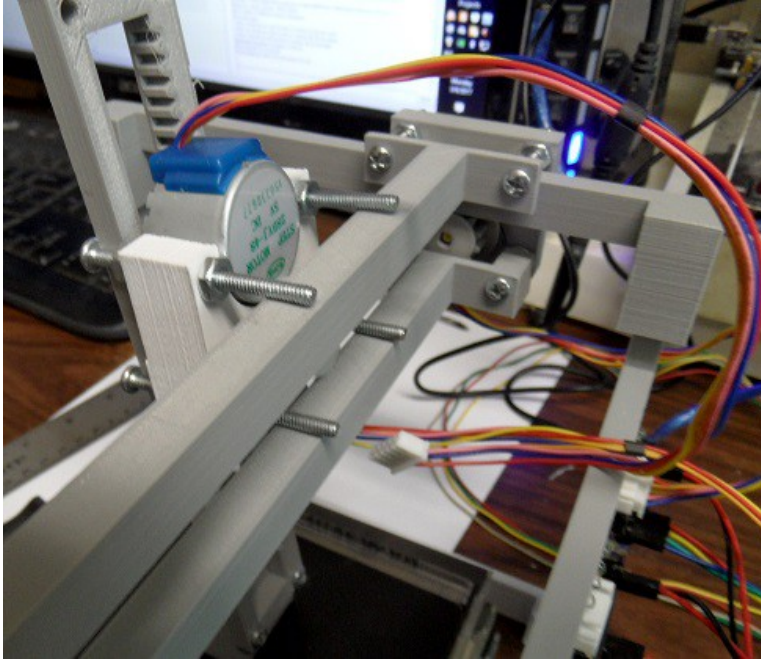
5. Obtain (2) more 2" machine screws. Start a nut on the very end of each.



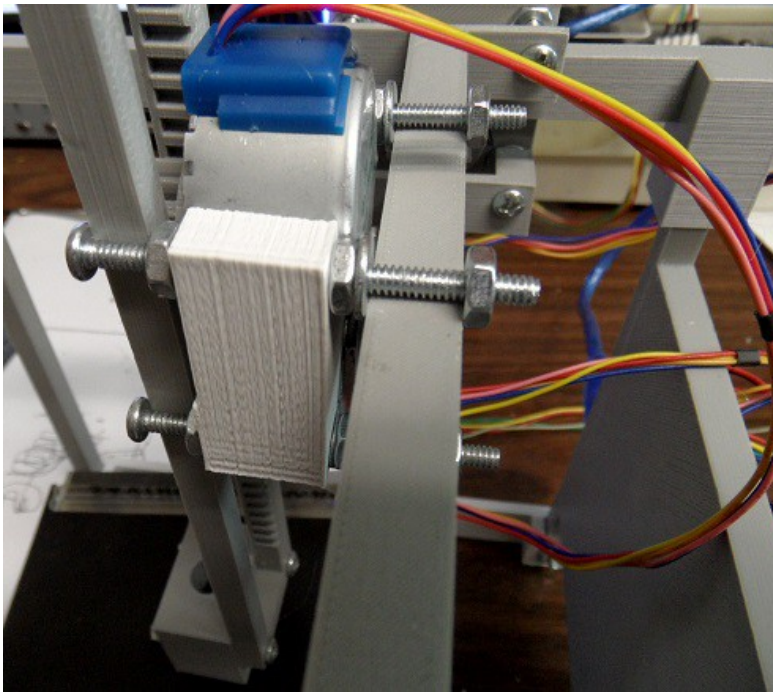
6. Using a finger to hold the end-nut from turning; twist the screw down into the [XZ-MOTOR](#) Hole. Once set into proper alignment with the [Z-RACK](#) put (2) more nuts on the back side and tighten these (2) machine screws to the [XZ-MOTOR](#) block.



7. The [XZ-MOTORIE](#) assembly (i.e. center carriage) is now ready to be mounted to the [X-RACK](#) as shown.



8. Use (2) flat washer on the top bolts to keep the carriage aligned with the [X-RACK/GUIDE](#). Then use nuts to lock the carriage to the [X-RACK](#). Keep the screws fairly loose to allow motor to move across the [X-RAIL](#).
- a) Now adjust the X-Guide bolts on both ends to make a snug fit against the lower machine screws.



4. SOFTWARE / FIRMWARE

4.1 Firmware Upload

1. Install Arduino Sketch IDE <https://www.arduino.cc/en/Main/Software>
2. Install the modified [GRB-28BYJ-48](#) Firmware
 - a) In a web-browser; go to <https://github.com/tgit23/GRBL-28byj-48>
 - b) Click on the file [GRBL.ZIP](#)
 - c) Click on the [DOWNLOAD](#) button on the lower-right next to "History" and Save to a place you'll remember – like Documents or Desktop
 - d) Run the Arduino Sketch IDE
 - e) Choose Menu Item [SKETCH](#) → [INCLUDE LIBRARY](#) → [ADD .ZIP LIBRARY](#)
 - f) Select the [GRBL.ZIP](#) Library file saved in step 'c' above
3. Upload the Firmware
 - a) Inside any running Arduino Sketch IDE
 - b) Choose [FILE](#) → [EXAMPLES](#) → [GRBL](#) → [GRBLUPLOAD](#)
 - c) Select the Port the Arduino UNO is connected to; in Sketch menu [TOOLS](#) → [PORT](#)
 - d) Select the Board; Sketch menu [TOOLS](#) → [BOARD](#) → [ARDUINO/GENUINO UNO](#)
 - e) Press the Up-Arrow in the Top-Left Corner to upload the firmware onto the Arduino UNO board
4. Now the unit is ready for operation.

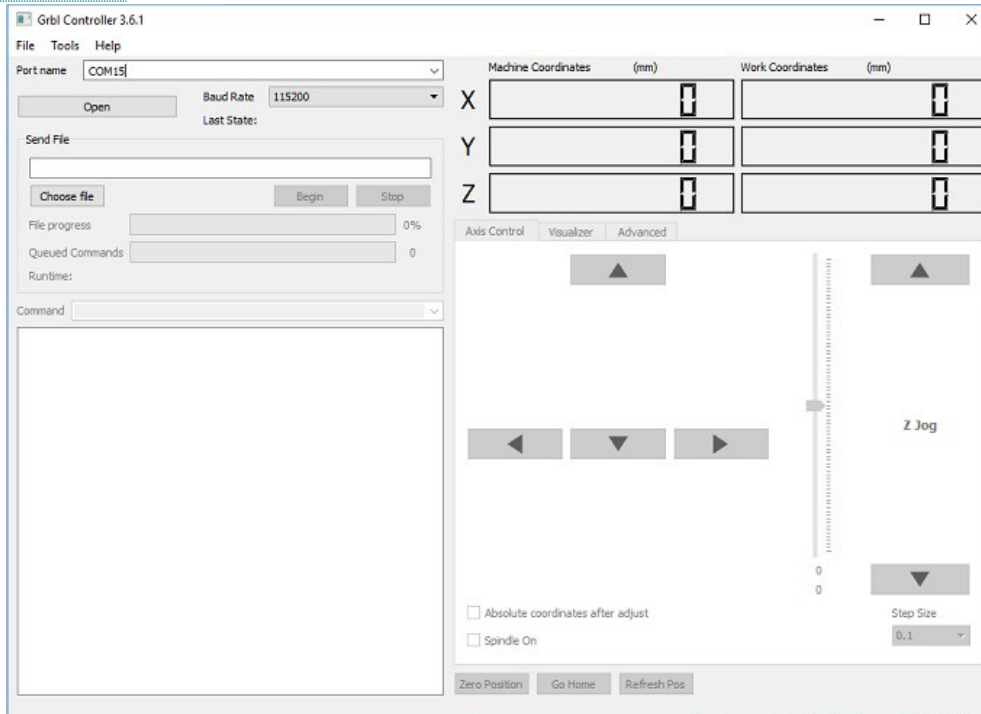
✓ More Information

○ [GRBL](#) Wiki @ <https://github.com/gnea/grbl/wiki>

○

4.2 Controller Install / Initial Settings

1. Download and install [GRBL CONTROLLER](http://zapmaker.org/projects/grbl-controller-3-0/) located @ <http://zapmaker.org/projects/grbl-controller-3-0/>
2. Run [GRBL CONTROLLER](http://zapmaker.org/projects/grbl-controller-3-0/)



3. Pick the Port on which the Arduino UNO is connected and click 'Open'
4. Enter [GRBL](http://zapmaker.org/projects/grbl-controller-3-0/) Settings for the Machine (**First Time Only**)
 - a) \$0=3 ; Step pulse, microseconds
 - b) \$1=1 ; Step idle delay, microseconds (shuts off motors)
 - c) \$100=100 ; X steps/mm
 - d) \$101=100 ; Y steps/mm
 - e) \$102=100 ; Z steps/mm
 - f) \$110=550 ; Max rate X, mm/min
 - g) \$111=550 ; Max rate Y, mm/min
 - h) \$112=550 ; Max rate Z, mm/min
 - i) \$120=100 ; X Acceleration, mm/sec²
 - j) \$121=100 ; Y Acceleration, mm/sec²
 - k) \$122=100 ; Z Acceleration, mm/sec²

[GRBL](http://zapmaker.org/projects/grbl-controller-3-0/) will store these values in the Arduino UNO EEPROM thus retain them during during power off and uploads.

- ✓ In 3d printer terms the GUI Controller example would be 'pronterface'.

4.3 Running a design file

1. Run [GRBL CONTROLLER](http://zapmaker.org/projects/grbl-controller-3-0/)
2. Pick the Port on which the Arduino UNO (Machine) is connected and click 'Open'
3. On Tab 'Axis Control' select 'Step Size' 10 and then click the up-arrow on Z-Jog.
4. Using the 'Axis Control' to operate the machine motion; position the 'head' at a point that will be represented as coordinate 0,0
5. Click 'Zero Position'
6. Under 'Send File' click 'Choose File' and select the design file (.nc) to run

a) Example files can be gotten @ <https://github.com/tgit23/RPieces-TableTopXYZ/tree/master/nc-examples>

7. Click 'Begin' to start executing.

4.4 Design Software

Design Software for GRBL often includes the G-Code generator (In 3d printer terms – slic3r).

- ✓ Common free GRBL design software (the signifying difference being CAM or CAD)
 - FreeMill w/ VisualCAM (also free)
 - SketchUCam plug-in for Google Sketchup
 - pyCam
- ✓ Milling or drilling PCB
 - KiCad
 - FlatCAM

5. TOOL-HEADS

5.1 Pilot-Razor-Point-Pen

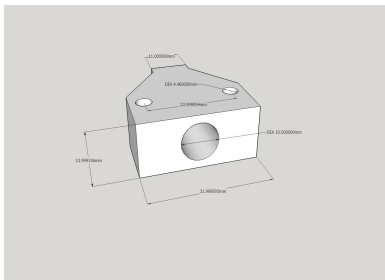


Illustration 19: ToolHead-PilotRazorPointPen.STL

- ✓ Example of the Pen @ http://www.staples.com/Pilot-Razor-Point-Pens/product_SS110064
- ✓ Mounting Hardware Required
 - (2) #6-32 x 1-1/4" (or Longer) Machine Screws
 - (2) Hex Nuts

5.2 Mini-Drill

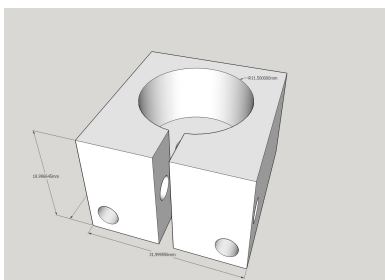


Illustration 20: ToolHead-PilotRazorPointPen.STL

- ✓ Example of Mini-Drill @ https://www.amazon.com/Lemonbest-Micro-Electric-Drill-1-5mm/dp/B01301L2L6/ref=pd_sim_60_3
 - Full Description Line Mini DIY Micro Electric Hand Drill for PCB 0.7 to 1.5mm Craft Drill Chuck Tools with US Plug
 - Item Weight 2.7 ounces
 - Product Dimensions 5.1 x 1 x 1 inches
 - Wattage 18 watts
- ✓ Mounting Hardware Required
 - (3) #6-32 x 1-1/2" (or Longer) Machine Screws
 - (3) #6 Hex Nuts

