Prusa Mendel

From RepRapWiki

(Redirected from Prusa)

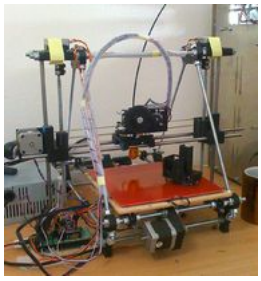
Also see SAE Prusa Mendel if you are building this machine using SAE (Imperial) Fasterers

The Prusa Mendel is a simpler remix of the original Mendel. I wanted to use bushings instead of regular bearings. The current version uses three 608 bearings in total, one for the X and two for the Y axis. The 624 bearings are gone altogether. I have the entire machine up and running, with my printed PLA bushings. It's pretty smooth.

Contents

Prusa Mendel

Release status: working



Description	Prusa Mendel is a simpler remix of normal Mendel.
License	GPL
Author	Prusajr (design), Kliment (maintenance and documentation)
Based-on	Mendel
Categories	Mendel Variations,
CAD Model(s)	none
External Link	none

Development

The development of the Prusa Mendel is hosted on github: http://github.com/prusajr/PrusaMendel

You can follow the changes on Changelog (https://github.com/prusajr/PrusaMendel/commits/master)

You can sign up for github for free and fork the project to begin working on it.

History

- http://blog.reprap.org/2010/10/story-of-simpler-mendel-pla-bushings.html

Bill of Materials

Printed Parts

```
2x coupling           RP
3x endstop-holder     RP
1x x-carriage         RP
1x x-end-idler        RP
1x x-end-motor        RP
1x y-motor-bracket    RP
2x z-motor-mount      RP
4x belt-clamp         RP
8x bar-clamp          RP
2x rod-clamp          RP
2x pulley             RP
```

AND EITHER

```
6x frame-vertex       RP
```

OR

```
4x frame-vertex with foot RP
2x frame-vertex      RP
```

Printed Bushings

```
12x pla-bushing        RP-PLA (check your build file, the file makes either 4 or 12.)
```

Non-Printed Parts ("vitamins")

(necessary)

```
83x M8 nut            Fastener (buy a 100-pack to be on the safe side. These are useful)
93x M8 washer         Fastener (again, buy a 100-pack.)
2x M4x20 bolt        Fastener
2x M4 nut            Fastener
2x M4 washer         Fastener
22x M3x10 bolt        Fastener
16x M3x25 bolt        Fastener
4x M3x40 bolt         Fastener
70x M3 washer         Fastener
40x M3 nut (8 optionally nyloc) Fastener
2x M3 grub screw (or M3x10 bolt)      Fastener
6x M8x30 Mudguard/fender washers Fastener
3x 608 Bearing        Bearings
4x Ballpoint pen springs        Spring
6x M8x370mm side       Threaded rod
4x M8x294mm front/rear       Threaded rod
3x M8x440mm top/bottom       Threaded rod
2x M8x210mm Z-leadscrew      Threaded rod
1x M8x50mm threaded rod or bolt for X idler    Threaded rod
2x 8mmx495mm X-bar           Smooth rod
2x 8mmx406mm Y-bar           Smooth rod
2x 8mmx350mm Z-bar           Smooth rod
1x 225mmx225mm print top plate     Thick Sheet
1x 140mmx225mm print bottom plate.   Thick Sheet
1x 840mmx5mm T5 pitch timing belt    Belt
1x 1380mmx5mm T5 pitch timing belt   Belt
5x Nema 17 bipolar           NEMA Stepper
50x Small cable binder/ziptie       Misc.
1x Wade's Geared Extruder (or any other compatible extruder)
1x Electronics + endstops. This can be RAMPS,Pololu Electronics,Gen6,Gen3,or anything else compatibl
```

(optional)

```
3x 30mmx10mm Optoflags (if using opto endstops)          Thin, stiff, opaque sheet
2x 8mm ID spring           Spring
1x piece of threaded rod or wood or any other material with precisely 290mm length.
1x piece of threaded rod or wood or any other material with precisely 234mm length.
```

(You can combine the latter two by having a piece of thick sheet with dimensions 290x234. Make sure to mark which side is which.)

When cutting the threaded rods from 1m lengths, you will need 6x 1m pieces (or 5x 1m pieces and 1x 50cm piece). Cut them as follows:

```
Rod 1: 370mm, 370mm, 210mm, ~50mm (the last piece will turn up somewhat shorter than 50mm. Use it f
Rod 2: 370mm, 370mm, 210mm, ~50mm
Rod 3: 370mm, 294mm, 294mm, ~42mm
Rod 4: 370mm, 294mm, 294mm, ~42mm
Rod 5: 440mm, 440mm, ~120mm
```

```
Rod 6: 440mm
```

(The Prusa Mendel uses the 4 drivers in the standard Mendel electronics package to drive 5 motors by using "two steppers wired in parallel to one driver"[1] (http://blog.reprap.org/2010/10/story-of-simpler-mendel-y-and-z-axes.html)).

Printing the Parts

Printing a Prusa on a Mendel


A printed set of Prusa Mendel parts

An easier option then individually printing each part if you are printing Prusa on a RepRap Mendel is the pre-assembled build file containing the Prusa parts. With this option you only need to print the Mendel plate and the PLA bushings to get a complete Prusa Mendel:

- Mendel Plate (http://github.com/prusajr/PrusaMendel/raw/master/stl/mendelplate.stl) (contains all printed parts except the PLA Bushings)
- PLA Bushing (http://github.com/prusajr/PrusaMendel/raw/master/stl/pla-bushing.stl)

SAE versions:

- SAE Mendel Plate (http://github.com/prusajr/PrusaMendel/raw/master/stl-sae/mendelplate.stl) (contains all printed parts except the PLA Bushings)
- SAE PLA Bushing (http://github.com/prusajr/PrusaMendel/raw/master/stl-sae/pla-bushing.stl)

Printing a Prusa on a CupCake CNC

There are also pre-assembled build files available to fit your CupCake CNC's build area (download using right click => save as)

Note:

- These plates are 85x95mm in size.

Plates for the MakerBot (The plates have changed, these print times are no longer accurate):

- Makerbot Plate 1 (http://github.com/prusajr/PrusaMendel/raw/master/stl/mbotplate1.stl) => 6 hrs 30 min
- Makerbot Plate 2 (http://github.com/prusajr/PrusaMendel/raw/master/stl/mbotplate2.stl) => ~2 hrs 30 min (needs retesting)
- Makerbot Plate 3 (http://github.com/prusajr/PrusaMendel/raw/master/stl/mbotplate3.stl) => 5 hrs 40 min
- Makerbot Plate 4 (http://github.com/prusajr/PrusaMendel/raw/master/stl/mbotplate4.stl) => 2 hrs 30 min
- Makerbot Plate 5 (http://github.com/prusajr/PrusaMendel/raw/master/stl/mbotplate5.stl) => 1 hr 50 min

SAE versions: (The plates have changed, these print times are no longer accurate):

- SAE Makerbot Plate 1 (http://github.com/prusajr/PrusaMendel/raw/master/stl-sae/mbotplate1.stl) => 6 hrs 30 min
- SAE Makerbot Plate 2 (http://github.com/prusajr/PrusaMendel/raw/master/stl-sae/mbotplate2.stl) => ~2 hrs 30 min (needs retesting)
- SAE Makerbot Plate 3 (http://github.com/prusajr/PrusaMendel/raw/master/stl-sae/mbotplate3.stl) => 5 hrs 40 min
- SAE Makerbot Plate 4 (http://github.com/prusajr/PrusaMendel/raw/master/stl-sae/mbotplate4.stl) => 2 hrs 30 min
- SAE Makerbot Plate 5 (http://github.com/prusajr/PrusaMendel/raw/master/stl-sae/mbotplate5.stl) => 1 hr 50 min

Printing a Prusa on anything else

Last but not least, if you have a machine that doesn't fit into any of the previous options all the .stl files necessary to print a Prusa Mendel are available on the PrusaMendel Github (http://github.com/prusajr/PrusaMendel) where you can download them and print them individually.

Buy the printed parts

Support the community by buying printed parts from one of your fellow RepRap developers: Nice_People_Who_Upload_Files_And_Are_Quite_Keen_On_Selling_You_A_Set_Of_Printed_Parts.

You can also ask on IRC (irc://chat.freenode.net/#reprap) , or try the RepRap User Groups

Assembly

For the visually oriented, have a look at this photo gallery (http://picasaweb.google.com/bokowski/PrusaMendel) of an ongoing Mendel Prusa build.

Assembling the frame vertex triangles (2x)

This part takes 15 minutes per triangle to assemble, for a total of 30 minutes.

There is a triangle on each side of the Prusa RepRap, you will need to make 2 of these and then connect them together (see next step) to form the Prusa frame. Each side is an equilateral triangle with a frame vertex on each corner. You can use either footed or non-footed vertices to build this (the footed ones look better, but are not critical.) The instructions assume you are using footed vertices.

Parts Required (per triangle)

- 2 RP footed frame vertices

- 1 RP frame vertex (non-footed)

- 1 RP bar clamp

- 3 370mm M8 threaded rods
- 14 M8 nuts
- 14 M8 washers
- (optional but recommended)A piece of threaded rod or wood or any other material with precisely 290mm length. This is your frame jig J1.

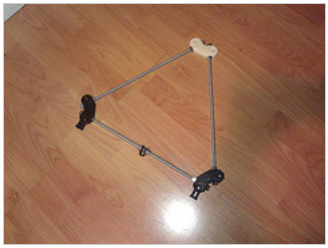
Instructions

1. Take one of the 370mm threaded rods, and slip an M8 washer onto the middle of it.
2. Take the RP bar clamp (the U-shaped bit with the two holes) and slide the threaded rod through the two holes until the clamp sits next to the washer.
3. Slide another washer onto the rod from the other side.
4. Thread two M8 nuts onto either side of the clamp, until they are next to the washer, but do not tighten them yet.
5. Thread another two nuts on each side of the rod, followed by washers. See the picture for what it should look like.
6. Slide the rod through the long bottom (footed) side of two vertices. Make sure the feet point in the same direction. Also make sure the bulge on the non-footed side of the vertex points outwards.
7. Measure the distance. The distance between the two vertices should be 290mm (along the rod). Get it approximately right now, we will check this again later. If you have a frame jig, place it between the two vertices and adjust the nuts until you can just barely fit the jig J1 between them.
8. Place another washer and nut on the other side of the vertex. Tighten, but not too much. We'll need a bit of flexibility here still.
9. Take another 370mm M8 threaded rod and place a nut followed by a washer at each end.

The bar clamp on the threaded rod.

10. Place one end of the threaded rod into the one of the two footed frame vertices. It should be in the same plane as the first threaded rod. fix it in place with a washer and nut. You should now have two sides of the equilateral triangle.
11. Take the third piece of threaded rod and put a nut and washer on each end. Place it in the other footed vertex and fix it in place with a washer and nut. You should now have a triangle of threaded rods with two footed vertices on two of the corners, nothing in the third corner, and a bar clamp between the two vertices.
12. Take the third vertex (non-footed) and slide it onto the threaded rods in the final corner of the triangle. Measure the lenghts of the three sides to make sure they are all 290mm long (along the rod from plastic part to plastic part). Adjust the nuts to make sure this is so. Use the frame jig J1 if you have one. Once done, place a washer and nut on the top of the vertex. Tighten all the outer nuts.

1. You should now have a sturdy triangle with equal-length sides, two feet on the bottom, and a bar clamp between the feet. Adjust the nuts around the bar clamp (but do not crush the bar clamp together yet) until it's approximately in the middle of the rod. Leave the nuts there loose. See photo for what you should have at this point.
2. That's it, that's one of the triangles done. Repeat the entire procedure for the second triangle. It is exactly identical to the first.


The finished frame triangle

Now we need to connect the 2 frame triangles to form the Prusa RepRap frame.

The easiest way to do this is to thread everything onto the front and rear threaded rods and attach those to the triangles first, and then thread the top rods through. That's what the instructions below assume you are doing.

Assembling the front threaded rods

This step takes about 30 minutes.

These 2 threaded rods are used to connect the front/bottom vertex of each triangle as well as the y-stage bars and y motor mount to the frame.

Parts Required

- 2 assembled frame vertex triangles
- 2 RP bar clamps

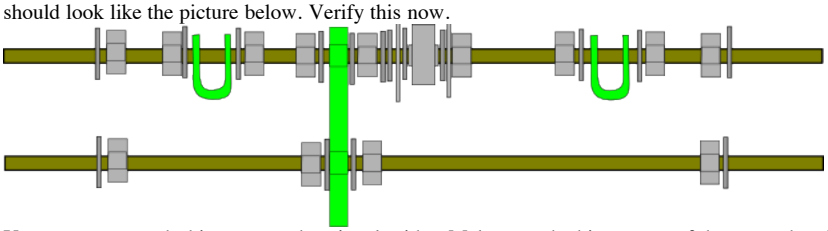
- 1 RP y motor bracket

- 18 M8 nuts
- 20 M8 washers
- 2 M8x30 fender/mudguard washers
- 1 608 bearing
- 2 294mm threaded rods.

Instructions

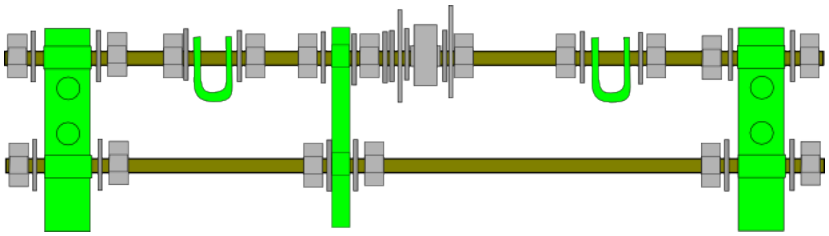
1. Thread the bottom rod first. Thread an M8 nut onto the middle of the rod. Slide an M8 washer next to it.
2. Thread the rod through the bottom hole of the RP y-motor-bracket. The bottom hole of the bracket is the long, straight side.
3. Slide another washer onto the other side of the rod and add another M8 nut to hold it in place.
4. Add a nut and washer to each end of the rod.
5. Now thread the top rod. This is a complicated one, so make sure you get it all done in the right order. From left to right, the rod should have: 1 washer, 2 nuts, 1 washer, 1 bar clamp (threaded through the holes), 1 washer, 2 nuts, 1 washer, the y-motor-bracket (with the pointy bit pointed towards you),1 washer, 1 nut, 2 washers, 1 fender/mudguard washer, 1 washer, 1 608 bearing, 1 washer,1 fender/mudguard washer, 2 nuts, 1 washer, 1 bar clamp (threaded through the holes), 1 washer, 2 nuts, 1 washer.

6. When you hold it with the bigger part (with the circular hole) of the motor bracket *towards you*, it should look like the picture below. Verify this now.



7. You can now attach this setup to the triangle sides. Make sure the bigger part of the motor bracket points **OUT** of the triangle. Thread the ends of the rods through two of the footed vertices. Put a washer and nut on the end of each threaded rod.

It should now look like this:



Assembling the rear threaded rods

This step takes about 20 minutes.

These 2 threaded rods are used to connect the back/bottom vertex of the 2 triangles together as well as the y-stage bars and belt pulley.

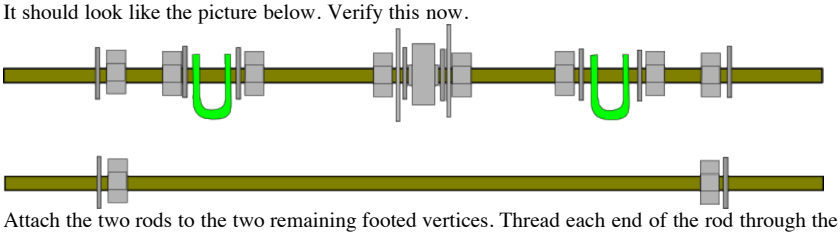
Parts Required

- 2 assembled frame vertex triangles
- 2 RP bar clamps

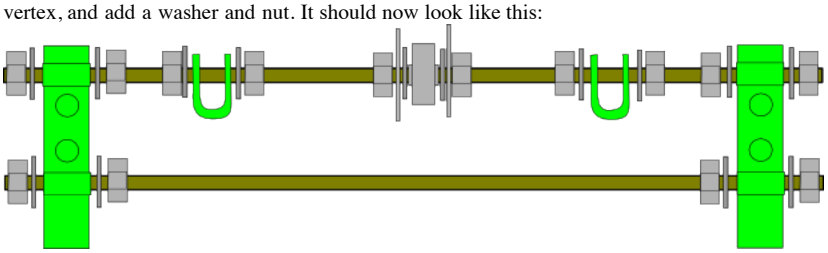
- 14 M8 nuts
- 14 M8 washers
- 2 M8x30 fender/mudguard washers
- 1 608 bearing
- 2 294mm threaded rods

Instructions

1. Thread the bottom rod first. Add a nut and washer to each end of the rod.
2. Now thread the top rod. This is again a complicated one, so make sure you get it all done in the right order. From left to right, the rod should have: 1 washer, 2 nuts, 1 washer, 1 bar clamp (threaded through the holes), 1 washer, 2 nuts, 1 fender/mudguard washer, 1 washer, 1 608 bearing, 1 washer,1 fender/mudguard washer, 2 nuts, 1 washer, 1 bar clamp (threaded through the holes), 1 washer, 2 nuts, 1 washer.
3. It should look like the picture below. Verify this now.



4. Attach the two rods to the two remaining footed vertices. Thread each end of the rod through the vertex, and add a washer and nut. It should now look like this:



Your frame should now be standing on its own feet without support, but the tops sides of the triangles will still be wobbly. We'll fix that next.

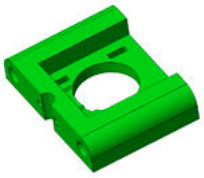
Assembling the top threaded rods

This step takes about 10 minutes.

These connect the 2 frame triangles at their tops as well as providing mounts for the z-axis motors.

Parts Required

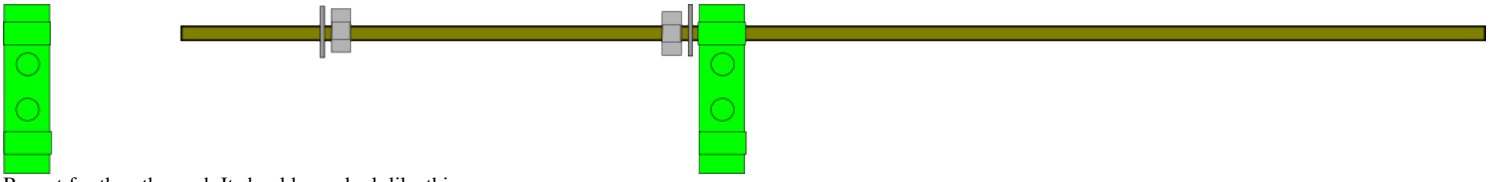
- 2 assembled and connected frame vertex triangles
- 2 RP z motor mounts



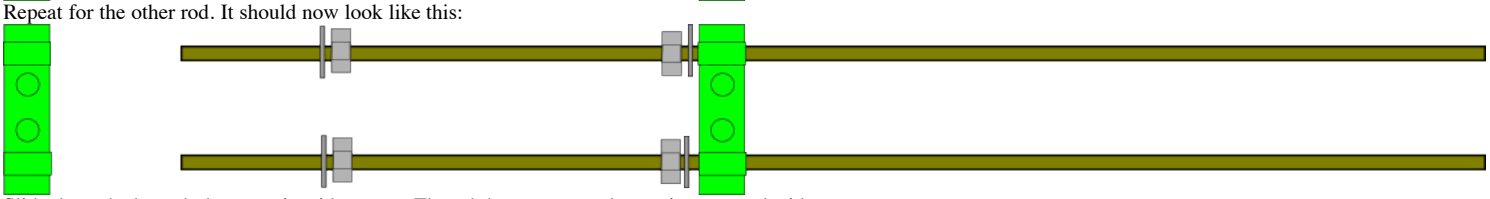
- 12 M8 nuts
- 16 M8 washers
- 2 440mm threaded rods

Instructions

1. Slide one of the threaded rods through one side of one of the top vertices. Put a washer, two nuts, and another washer on the part of the rod between the top vertices. This is what it should look like when seen from above:

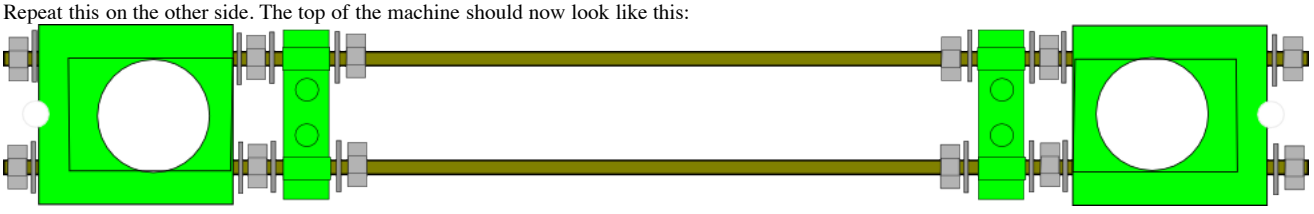


2. Repeat for the other rod. It should now look like this:



3. Slide the rods through the opposite side vertex. Thread the nuts up to the vertices on each side.
4. To each of the four ends of the threaded rod, add a washer, a nut and another washer. Your setup should now look like this:

5. Take one of the RP z motor mounts and attach it to the ends of the threaded rod. The side with the two holes and the indentation should point towards the *outside*. Add a washer and nut to the end of each rod.
6. Repeat this on the other side. The top of the machine should now look like this:



Tightening the frame

This step takes about 10 minutes.

Now that the frame is fully assembled we can adjust and tighten each of its threaded rods. You will need your frame jigs if you have them, or a reasonably precise length measurement tool.

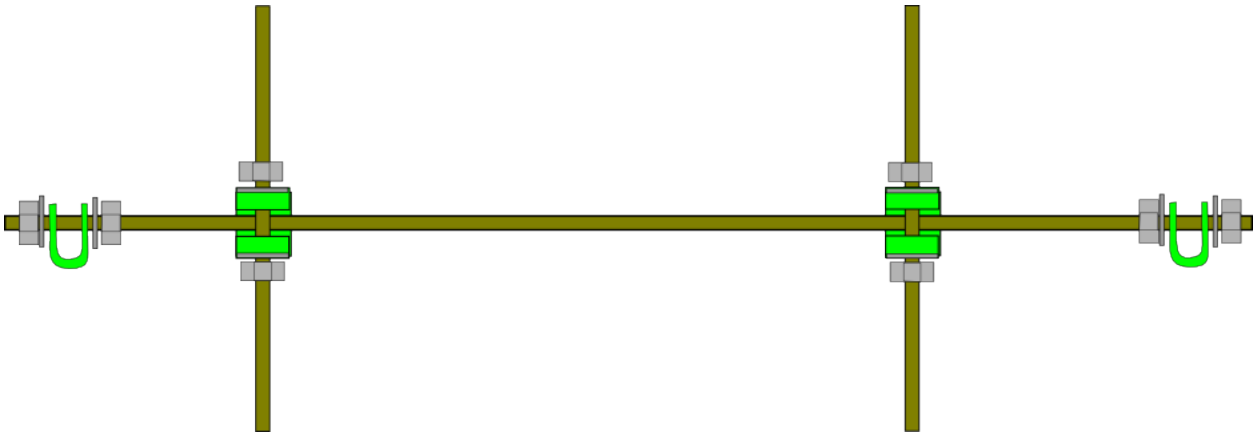
Parts Required

- 2 RP bar clamps

- 4 M8 nuts
- 4 M8 washers
- 1 440mm threaded rod
- (optional but recommended)A piece of threaded rod or wood or any other material with precisely 290mm length. This is your frame jig J1.
- (optional but recommended)A piece of threaded rod or wood or any other material with precisely 234mm length. This is your frame jig J2.

Instructions

1. Verify that the triangle vertices have distance J1 (290mm) from plastic to plastic along each of the three sides. Once you are sure of this, tighten the outer vertex nuts until they are firmly attached and unable to move, but do not crush the plastic parts.
2. Adjust each of the bottom rods until it has distance J2 (234mm) between the inside ends of the vertices. Use frame jig J2 to check this if you have it. Once you are sure this is true, tighten the outer vertex nuts until they are firm, but do not crush the plastic.
3. Adjust the top of the frame so that the distance between the inside ends of the vertices is precisely J2 (234mm) and the length of rod outside the vertex on one side is the same as the length outside the vertex on the other side. Double-check the distances before tightening the nut on the outside of the vertex.
4. The frame should now be fairly stable. Using a plumb line or similar (for example a nut hanging on a length of yarn), adjust the bar clamps on the bottom side of each triangle until they are directly below the middle of the top vertices. Do not tighten the nuts either side of the bar clamps yet.
5. Insert the 440mm threaded rod through the two bar clamps on the bottom of the frame. make sure the new rod is on *top* of the triangle bottom rod. Adjust it so that the same length sticks out on each side.
6. On each side, place a nut, washer, bar clamp (threaded through the holes), washer, and another nut. The setup should look like this when seen from below:



Assembling the y axis

Parts Required

- 4 PLA bushings

- 2 belt clamps

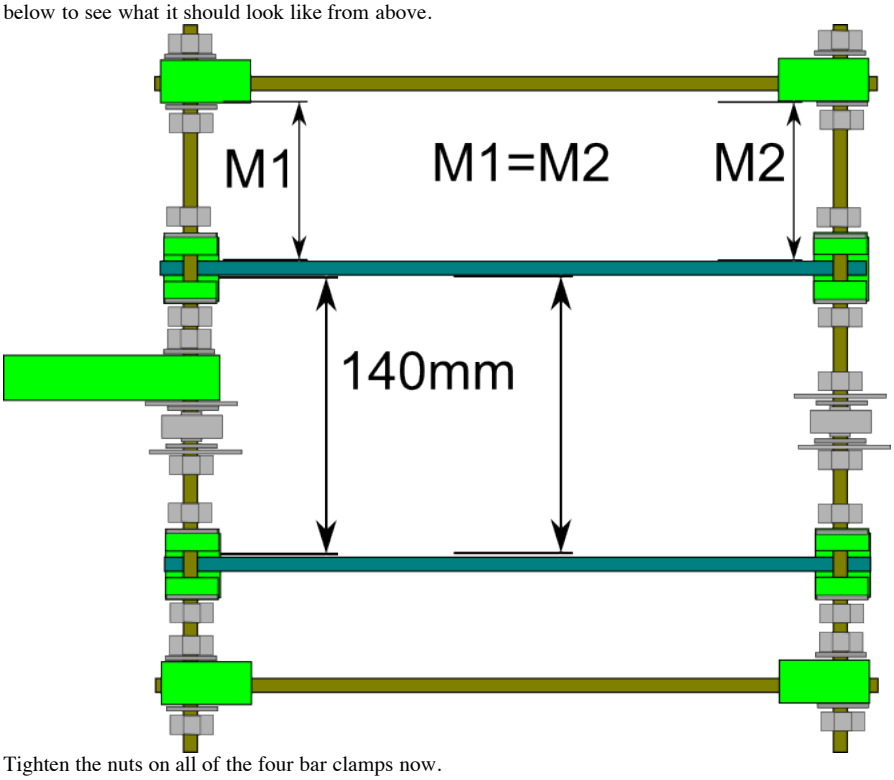
- 1 225x140mm print bottom plate
- 1 225x225mm print top plate
- 2 406mm smooth rods
- 1 y timing belt
- 1 NEMA 17 stepper motor
- 1 pulley
- 3 M3x10 bolts
- 4 M3x25 bolts
- 8 M3 washers
- 4 M3 nuts
- 1 M3 grub screw

Instructions

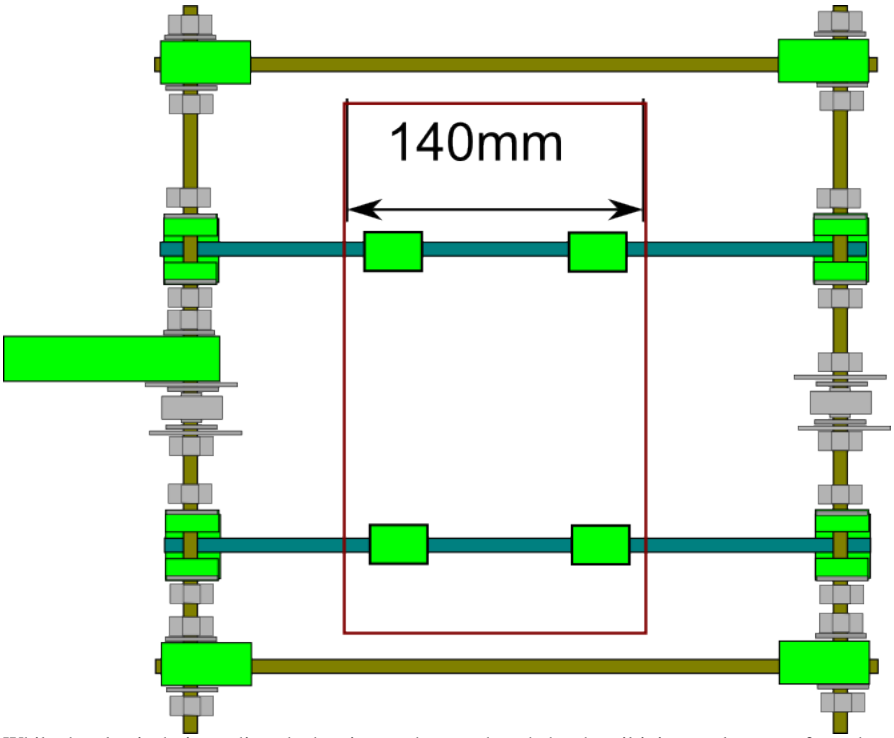
1. Mark each of the four corners of the print bottom plate 8mm from each side with the marker.
2. Carefully drill a 3mm hole in each of the four corners.
3. Clamp the print bottom plate and the print top plate together, so that the bottom plate is equally far from each edge of the top plate. Drill 3mm holes into the top plate through the corner holes in the bottom plate so that they match on both plates.
4. Slide the two 406mm smooth rods through the bar clamps on the front and rear threaded rods. They should fit

snugly and be approximately parallel.

1. Place the narrow side of the "print bottom" plate between the rods. This ensures they are exactly 140mm apart from each other. Adjust the nuts on the front side bar clamps until the print bottom plate just barely fits between the rods. Try to get them at an approximately equal distance from the middle of the rod.
2. Tighten the front nuts just enough that they do not move on their own, but no further.
3. Measure the distance from the left front vertex to the left smooth rod. Adjust the distance from the left rear vertex to the left smooth rod to match it. This ensures the left rod is parallel to the frame. Tighten the nuts on the left clamp just enough that they do not move around.
4. Place the print bottom plate next to the left smooth rod on the rear side. Adjust the right rear bar clamp's nuts until the narrow side of the bottom plate barely fits between the rods.
5. Recheck the distances from the left vertex to the left rod are the same at the front and rear and that the short side of the print bottom plate fits snugly between the smooth rods both at the front and at the rear. This should ensure that the rods are parallel to each other and to the frame. Use the diagram below to see what it should look like from above.



6. Tighten the nuts on all of the four bar clamps now.
7. Snap 2 PLA bushings onto each of the two smooth rods. Place them about 120cm apart on each rod. Make sure they slide freely on the rods. Put a dab of glue on the top side of the bushings (the side opposite the open side). Carefully place the print bottom plate on top of the bushings, so that it's equally far apart from each of the two triangles (see diagram below). Wait for the glue to dry.



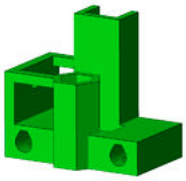
8. While the glue is drying, adjust the bearing on the rear threaded rod until it is exactly across from the front threaded rod. Tighten the nuts on the y motor bracket and the bearings at this point. All nuts on the front and rear rods should now be tight.
9. Also while the glue is drying, ensure that the hole in the center of the pulley matches your motor shaft (it should slide on and fit very snugly). If it is too tight to fit, drill it out.
10. Insert an M3 nut into the rectangular slot on the pulley bottom. You may need to widen the slot slightly to do this. Make sure that the center of the nut is aligned with the channel in the pulley that goes to the center hole.
11. Once you are satisfied with the position of the nut, insert an M3 grub screw into the channel on the rim of the hub. Tighten it until you see the end of the screw inside the center hole. Then unscrew it enough to slide the pulley onto the motor shaft.
12. Place the motor with the pulley on it next to the mounting holes in the y motor bracket. Position the motor the left, so that the pulley ends up on the side of the bearing.
13. Adjust the pulley position on the shaft so that when the motor is flush with the bracket, the teeth on the pulley are approximately at the position of the bearing.
14. Fasten the motor with 3 M3x10 bolts. Put a washer between each bolt and the y motor bracket.
15. Tighten the grub screw so that the pulley cannot move along the shaft.
16. Position the y belt on top of the print bottom plate and through both of the bearings. Pull lightly on both ends so that it is straight. If the belt is not straight, adjust the position of the rear bearing until it is. Use a marker to mark out the position of the belt on the print bottom plate. Also mark which side of the plate is on the left.
17. *After the glue has dried,* carefully pop the print bottom plate with the PLA bushings off the rails. Place the two belt clamps perpendicular to the marked position of the belt, several centimeters apart. Make sure the belt position is between the two holes on each clamp. Use a marker to mark where the holes of the belt clamps would be on the plate.
18. Carefully drill a 3mm hole through each of the four marked belt clamp holes.
19. Place the print bottom plate back on the smooth rods, paying attention to the marking to make sure the correct side is on the left.
20. Place one end of the belt, toothed side down, where the holes for the front belt clamp are. Put a washer onto each of two M3x25 bolts, and thread them through the holes in one of the belt clamps. Then attach the clamp to the top of the plate, clamping down the belt. Leave several centimeters of the belt behind the clamp.
21. Put two M3 nuts underneath the plate and thread them onto the bolts. Tighten both nuts so that the end of the belt is firmly attached to the plate, toothed side down.
22. Pass the belt over the front bearing, around the motor pulley, and then up underneath the plate to the other bearing. Pull it tight, then lay it on top of the plate, toothed side down.
23. Put a washer onto each of two M3x25 bolts, and thread them through the holes in the second belt clamp. Then attach the clamp to the top of the plate, clamping down the belt.
24. Attach an M3 nut to each of the two bolts, and pull the belt tight before tightening the two nuts.
25. Turn the motor by hand. It should turn with little effort, and each slight rotation should be matched by a slight movement of the plate. Make sure it slides smoothly along the entire length of the rods. Pushing the plate should immediately make the motor turn. Make sure the belt is not too loose (plate and motor should not be able to move independently) or too tight (taking a lot of effort to move the plate). Once you are confident your belt tension is correct, tighten the clamps very firmly. You may now trim the belt, but leave several centimeters behind each clamp for future adjustment.

Assembling the x axis

Parts Required

- 1 RP x-end-motor

- 1 RP x-end-idler



- 2 495mm smooth rods
- 8 M3 nuts
- 8 M3x10 bolts
- 1 608 bearing
- 2 M8x30 fender/mudguard washers
- 1 50mm M8 threaded rod
- 3 M8 washers
- 2 M8 nuts

Instructions

1. Drill out the center hole in the hexagonal section of the x-end-idler and x-end-motor parts to 8mm.
2. Take the x-end-idler. Check the size of the hole on the flat, thin side surface. If it is 4mm in diameter, enlarge it using a file until it's 8mm in diameter.
3. Place 4 M3 nuts in the nut traps in the long channels on the bottom of the x-end-idler. You may find pulling them into the nut trap using an M3 bolt makes it easier. Thread M3x10 bolts through them, but just far enough that they do not fall out.
4. Place 4 M3 nuts in the nut traps of the x-end-motor part as well. Thread M3x10 bolts through those as above.
5. Place the x-end-motor and x-end-idler 50cm apart, so that the hexagonal parts are facing each other.
6. Slide the two 495mm smooth rods into the x-end idler. Make sure they go past the nut traps.
7. Slide the other ends of the rods into x-end-motor. Make sure they go past the nut traps. The hexagonal sections of the motor and idler should still be facing each other.
8. Tighten the M3 bolts on the x-end-idler. The x-end-motor should be able to move along the rods with minor effort. Do *not* tighten the x-end-motor bolts yet.
9. Thread an M8 nut onto one end of the 50mm threaded rod. (Alternatively, you can use an M8x50 bolt)
10. Put the following parts in this order onto the free end of the threaded rod (behind the nut): 1 fender washer, 1 M8 washer, 1 608 bearing, 1 M8 washer, 1 fender washer.
11. Thread the free end of the threaded rod into the side of the x-end-idler. The bearing should be on the outside. Put an M8 washer and an M8 nut on the inside and tighten both nuts.

Assembling the z axis

Parts Required

- 2 RP shaft couplers

- 2 RP rod-clamp

- 1 x axis assembly (from the previous step)
- 8 M3 nuts
- 20 M3 washers

- 8 M3x10 bolts
- 8 M3x25 bolts
- 4 PLA bushings
- 2 NEMA 17 stepper motors
- 2 210mm threaded rods
- 2 330mm smooth rods
- 4 M8 nuts (2 optional)
- 2 8.5mm ID springs (optional)

Instructions

1. Use a spirit level to make sure the two rods at the top of the frame are horizontal. If they are not, stack bits of paper under the vertices at the bottom until they are.
2. Drop a plumb line (or a nut tied to a length of yarn) directly down from the indentation on the side of the left z-motor-holder. Adjust the two bar clamps at the bottom of the frame on the left side until the nut falls into the U of the outer clamp. Repeat on the other side.
3. Put M3 nuts into the nut traps on both z-motor-holder ends.
4. Put an M3 washer on 2 M3x25 bolts and thread them into the flat (non-indented) end of a rod-clamp. Attach the rod-clamp to one of the z-motor-holders. Do not tighten.
5. Repeat for the other z-motor-holder and rod-clamp.
6. Insert a 330mm smooth rod into the space between each z-motor-holder and rod-clamp. Slide it in from the top. On the bottom, insert it into the U of the bottom bar clamp.
7. Using the plumb line, check that the smooth rods are vertical. If they are not, adjust the bottom bar clamp positions until they are. This is critical, so take as much time as you need.
8. Tighten the nuts on the bar clamps and the bolts on the rod clamps. Check again with the plumb line.
9. Place two PLA bushings on each of the smooth rods. Make sure they slide freely.
10. Position the x-axis assembly inside the frame so that the bushing channels on the x-axis-motor and x-axis-idler align with the bushings. The x-end-idler should be on the right, with the bearing on the rear side of the machine.
11. Put a blob of glue on the flat side of each bushing.
12. Push the rectangular channels of x-end-idler and x-end-motor against the flat of the bushings. Position the x-end-idler against the bushings on the right side of the machine and then slide the x-end-motor along the x-axis smooth rods until it makes contact with the bushings on the left side of the machine. Let the glue dry.
13. While the glue is drying, assemble the couplings. Insert an M3x25 bolt, with an M3 washer, through each of the two side holes on each coupling. Put an M3 washer and M3 nut on the other end. Do not tighten yet.
14. *Once the glue has dried*, slide the X axis to the top of the Z axis smooth rod, and place some kind of support underneath the x-axis smooth rods to hold it up in approximately the middle of the frame. Tighten the M3x10 screws on the bottom of the x-end-motor.
15. Slide X axis to the bottom of the Z axis smooth rod, if you feel the bushings binding, jog the bar clamps on both sides of the Z axis untill the bushings can travel the full length of the Z rod with no resistance.
16. Insert an M8 nut into the bottom of the hexagonal channel of x-end-motor. Repeat for x-end-idler.
17. *(optional)* Insert a spring into the top of the hexagonal channel of each x-end part. Insert an M8 nut on top of each spring.
18. Thread one end of the 210mm threaded rods into each hexagonal channel from above, compressing the top nut and spring if you have them. The threaded rod should turn freely in each channel, and the nuts should stay snugly in place. Turn the rods until about half their length sticks out from the bottom of the parts.
19. Place a NEMA 17 motor into each of the two z-motor-holder parts, shaft down. You may *optionally* fasten them from underneath with M3x10 bolts and M3 washers.
20. Attach the narrower end of a coupling to each of the motor shafts. Do not tighten the nuts on the coupling yet.
21. Turn the 210mm threaded rods so that they go upwards and enter the coupling. Screw them as far into the coupling as they will go, but do not use excessive force.
22. Carefully tighten the M3 nuts on both couplings.
23. Turn both threaded rods so that the x axis moves up. Make sure the couplings are supporting the weight.
24. Place a spirit level on the x-axis smooth rods. Turn the threaded rod on one side only until the x axis is level. Your Z axis is ready.

Installing the x carriage

Parts Required

- 1 RP x-carriage

- 1 RP pulley

- 2 RP belt clamps

- 1 x belt
- 2 M4 nuts
- 5 M3 nuts
- 1 M3 grub screw
- 4 M3x10 bolts
- 4 M3x25 bolts
- 8 M3 washers
- 1 Extruder
- 4 PLA bushings
- 1 NEMA17 stepper motor

Instructions

1. Ensure that the hole in the center of the pulley matches your motor shaft (it should slide on and fit very snugly). If it is too tight to fit, drill it out.
2. Insert an M3 nut into the rectangular slot on the pulley bottom. You may need to widen the slot slightly to do this. Make sure that the center of the nut is aligned with the channel on the side of the pulley rim.
3. Once you are satisfied with the position of the nut, insert an M3 grub screw into the channel on the rim of the hub. Tighten it until you see the end of the screw inside the center hole. Then unscrew it enough to slide the pulley onto the motor shaft.
4. Slide the pulley onto the motor shaft so that the rim comes onto the shaft last. Leave 1mm or so of shaft between the pulley and the motor body. Tighten the grub screw.
5. Insert the motor into the x-end-motor part so that the motor body is on the front of the machine and the pulley points towards the rear. The pulley teeth and the idler on the opposite side of the X axis should be aligned.
6. Fasten the motor using 4 M3x10 bolts and 4 M3 washers. The motor body should now be on top of the x-axis smooth rods.
7. Place 4 PLA bushings on the x-axis smooth rods. Make sure they slide freely.
8. Put a blob of glue on the flat side of each bushing.
9. Place the x-carriage on top of the bushings, making sure they fit into the channels. The protruding part of the x-carriage with the four nut traps should be on the side of the pulley and idler, pointing towards the rear of the machine.
10. Wait for the glue to dry.
11. *Once the glue has dried,* make sure the carriage can slide along the rods freely from end to end. Turn the entire frame around so that the rear of the machine faces towards you.
12. Put an M3 washer on each of two M3x25 bolts. Thread them through the holes of one belt-clamp. Repeat for the second belt-clamp.
13. Loosely attach one of the belt clamps to the carriage. Thread the two bolts through the holes in the carriage and attach nuts to them. Make sure there is enough space for the belt to slide between the clamp and the carriage. Repeat for the other clamp.
14. Slide one end of the belt through the left clamp, toothed side up. Pull several centimeters through, then tighten the clamp.
15. Run the belt over the 608 bearing and the motor pulley, then thread it through the other clamp, toothed side up. The belt should now form an elongated loop with the teeth on the inside of the loop. Pull the belt tight and tighten the second clamp.
16. Verify that the belt tension is right. Turning the motor pulley by hand should make the carriage move. The carriage should move freely along the entire length of the axis.
17. Use two M4x20 bolts and two M4 nuts to mount the extruder to the x-carriage.

Wiring the electronics

Parts Required

- 1 Electronics setup (Pololu, Ramps, Gen3, Gen6, or anything else compatible)
- 3 endstops
- 3 RP endstop holders
- 3 M3x25 bolts
- 6 M3 washers
- 3 M3 nuts
- A lot of cable ties

Instructions Electronics assembly.

1. There are various electronics configurations out there, but thay are mostly compatible. Regardless of what electronics you have, you should have at least three stepper drivers, ideally four. Those are either integrated on the board or separate modules. Identify the motor connections for X, Y, Z and the extruder stepper (E on some setups). Also identify the connections for the heated bed (if you have one), the extruder heater connection, the extruder and heated bed thermistors, and the X, Y and Z MIN endstop connections.
2. Screw or glue your endstops (opto or microswitch) to the long side of the three endstop holders.
3. If you are using opto endstops, you will need to make three opto flags. These are long, thin strips of some easily formable, opaque material, for example metal sheet from drink cans. If you are using microswitch endstops, you can skip this step. Take an empty drink can and cut three 10mmx30mm pieces from from it. These will be your optoflags.
4. Position your endstops on the smooth rods. Facing the front of the machine, place one on the left z smooth rod below where the x axis currently is. This is your Place one on the far left of the rear x axis smooth rod. Place the third one on the right y axis smooth rod behind the print bottom plate.
5. Put an M3 washer on an M3x25 bolt and thread it through each endstop holder, and put a washer and M3 nut on the other side. Do not tighten these nuts yet.
6. If you are using opto endstops, glue an optoflag onto the left side of the x-carriage, the bottom of the x-motor-bracket (pointing down) and the print bottom plate, so that they go through the gap in the optoswitch as the axis slides.
7. You now need to determine the limits of each axis. With the extruder/hotend installed, slide the X carriage left until the nozzle is 10mm to the right from the left edge of the print bottom plate. Reposition the endstop so that the opto/switch is engaged in this position. If your optoflag is too long, trim it until it just barely triggers the endstop when the nozzle is in this position. Tighten the nut on the X endstop, being careful not to move it.
8. Slide the print bottom plate backwards until the nozzle is about 42mm in front of the front edge of the print bottom plate. Reposition the endstop so that it engages when the print bottom plate is in this position. Tighten the Y endstop nut, being careful not to move it.
9. Adjust the Z endstop so that it is triggered when the Z axis moves downwards. Do not worry about the height yet. You will need to adjust the position of this endstop once the bed is installed and leveled.
10. Decide where your electronics will live. Mount these in place first, that will allow you to route cables easier.
11. Slide the X carriage as far away from the electronics as possible.
12. Route the cables from each of the endstops along the frame to the electronics board. Plug each one into the appropriate connector. For the X endstop, leave enough slack in the cable to allow the X axis to move along the Z all the way up and down the frame. Make sure none of the wires interfere with the movement of the axes. Use zipties to fix the wires to the frame.
13. Splice the Z motor wires together in parallel. If the motors are identical, join each wire with the wire of the same color, and then attach them to the connector that matches your electronics. Route the wires along the frame to your electronics board, and attach them to the Z-driver connector. Use cable ties to fix the wires to the frame.
14. Attach the Y motor wires to the connector that matches the electronics, route them along the frame (making sure they don't interfere with the Y-axis movement) and attach them to your electronics at the Y-driver connector. Fix the wires to the frame with zipties.
15. Attach the X motor wires to the connector that matches the electronics, route them along the frame and attach them to your electronics at the X-driver connector. Leave enough slack for the X-axis to move all the way up and down the Z axis without getting caught on the wires. Fix the wires to the frame with zipties.
16. Leaving enough slack so that the wires don't get stretched even when the X carriage is furthest away from the electronics, route the extruder motor, heater, and thermistor wires along the frame, to the electronics. Keep careful track of which wire is which. Color-coding is recommended. If your wires are not different colors, attach labels to the ends. Attach connectors to the wires to match your electronics and plug them into your electronics board. The stepper connection goes into the EXTRUDER/E connector. Tie the cables down to the frame with zipties.
17. Move the X and Y axes all the way in each direction, and check that no wires interfere with movement. Once done, slide each axis to approximately the middle of its range.
18. Get a piece of paper, and write "X, Y, Z, E" on it.
19. Plug in the power and USB connections to the electronics. *From this point on, if ANYTHING acts strange, switch off power first, and figure it out later. This is extremely important!*
20. Connect to the electronics from a computer using repsnapper, reprap host, or replicatorg.
21. Stand in front of the machine. In the software, tell the X axis to move forward (positive) by 10mm. If it moves to the RIGHT, write "OK" under X on your paper. If it moves to the LEFT, write "REV" under X. If it does not move write "NO" under it.
22. Tell the Y axis to move forward (positive) by 10mm. If it moves FORWARD (towards you), write "OK" under Y. If it moves BACKWARD (away from you), write "REV" under Y. If the axis does not move, write "NO" under Y on your paper.
23. Tell the Z axis to move forward (positive) by 10mm. If it moves UP, write "OK" under Z. If it moves DOWN, write "REV" under Z. If the axis does not move, write "NO" under Z on your paper.
24. Tell the extruder to move forward (positive). If it moves in the direction that would push filament into , the nozzle, write "OK" under Z. If it moves in the opposite direction, write "REV" under Z. If the axis does not move, write "NO" under Z on your paper.
25. Close the software and *switch off the power to the machine!*
26. For each axis that is labeled "REV", unplug its connector from the electronics, turn it by 180 degrees, and plug it in again. If the connector is polarized (can only be plugged in one way), you might need to reconnect the wires to the connector.
27. For each axis that is labeled "NO", make sure its connector is wired to the motor, and the connector is seated properly.
28. Repeat the test until all axes are labeled "OK". Now tell the X and Y axes to home. They should move until they reach their endstops, then stop.

Attaching the print bed

Parts Required

- 1 225x225mm print top plate
- 4 M3x40 bolts
- 4 ballpoint pen springs
- 8 M3 nuts (optionally nyloc)
- 16 M3 washers

Instructions

1. If you have a heated build platform, install it on the print top plate at this point. Cover your top plate or build platform with whatever your build surface material will be (Kapton, blue tape, etc.)
2. Put a washer on each of the four M3x40 bolts.
3. Thread each bolt through one of the holes in the print top plate.
4. Put an M3 washer, a ballpoint pen spring, and another M3 washer onto each bolt.
5. Thread a nut onto each bolt to fasten it to the print top plate. Do not tighten. This nut is only there to hold the springs in place.
6. Carefully place the print top plate on top of the print bottom plate. Make sure each bolt goes through one of the holes in the print bottom plate.
7. Put an M3 washer and nut on the end of each of the bolts.
8. Level the bed. To do this, put a spirit level on top of the bed and adjust the nuts of each of the M3 bolts until the spirit level shows the bed is level. Use the top nut to adjust the height and the bottom nut to fix it. If you have a heated build platform, put the spirit level on the platform. Once done, tighten all nuts.
9. Adjust the Z endstop so that it is triggered when the nozzle is just barely above the bed.
10. You are now ready to print. Enjoy!

Media

- Two printers simultaneously (http://www.youtube.com/watch?v=tyVM3-v84I0) - Prusa and shaper cube working side by side.
- Prusa homing using enstops (http://www.youtube.com/watch?v=kh3S9aOMRhU)
- Prusa development overview (http://www.youtube.com/watch?v=S8c5fB9Ozek)
- Prusa Y axis stress test (http://www.youtube.com/watch?v=0MvUD-tuOX0)
- Prusa Z axis stress test (http://www.youtube.com/watch?v=Y-pDYDnHYaQ)
- Early preview of the Prusa Mendel redesign (http://www.youtube.com/watch?v=DNRapg2gaPg)
- Fumon's Prusa build session 1 (http://www.flickr.com/photos/56020395@N06/sets/72157625420636778/show/) - D1plo1d building Fumon's Prusa Mendel at Hacklab.to. Should give a hint as to how the Prusa Mendel parts go together.

Prusa Improvements/Hacks

- Rob's Auto-centering shaft coupler - designed to reduce shaft/motor vibrations (print 2/replaces 2x coupler)

See Also

- PLA bushings

External Links

- Prusa's Blog (http://prusadjs.cz/)
- Prusa Builder Blog Feed (http://feeds.feedburner.com/Prusabuilders)
- assembly photo gallery (http://picasaweb.google.com/bokowski/PrusaMendel)

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