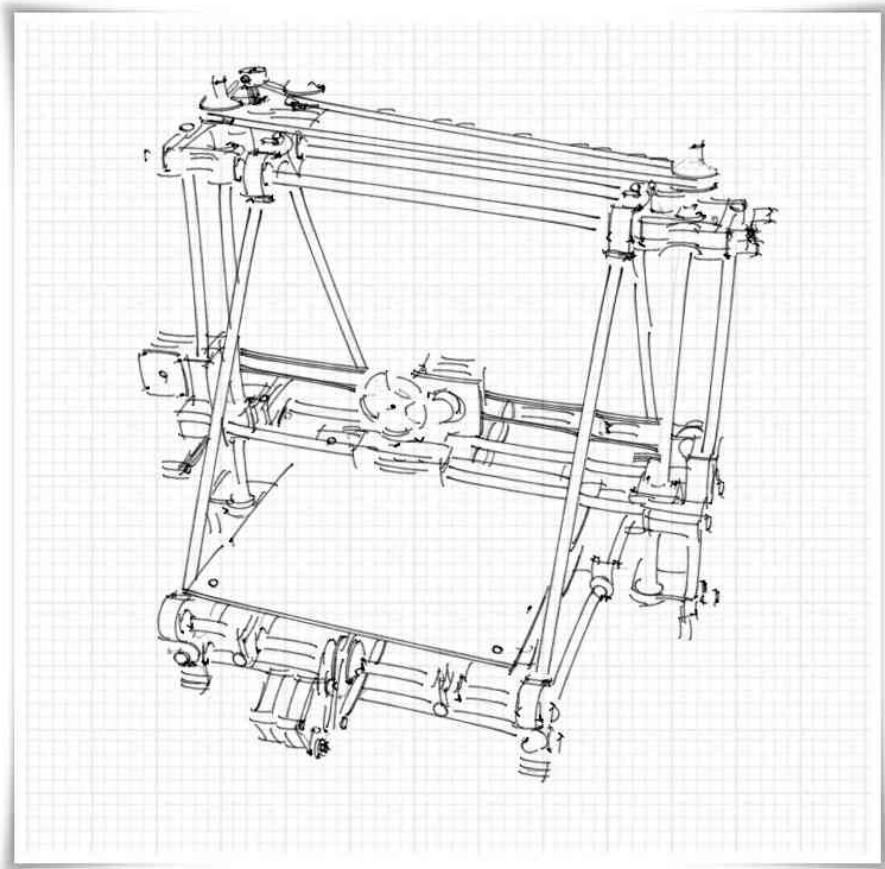


Durbie Prusa Mendel



Assembly Instructions



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Introduction

Document Version & Date: V1.1 Dec 2011

Goal:

Provide a visual guide of the steps needed to construct a Durbie Prusa Mendel 3D Printer.

The instructions contained within are based on, and modified where necessary, from:

1) the reprap.org wiki:

<http://reprap.org/wiki/Prusa>

2) Gary Hodgson's Prusa Mendel Visual Instructions

<http://garyhodgson.com/reprap/prusa-mendel-visual-instructions/>

Original Authors:

Prusajr (design for the original Prusa Mendel)

Kliment (maintenance and documentation for the original Prusa Mendel)

Gary Hodgson (author of work from which this document was inspired and derived from)

Author of this Document:

Md Noh

Mendel STL Model Files:

Prusa Mendel: <https://github.com/prusajr/PrusaMendel>

Durbie Prusa Mendel: <https://github.com/romscraj/durbie>

Sketchup Model Credits:

Below are the Credits for the Sketchup models from 3D Warehouse

(sketchup.google.com/3dwarehouse/), modified for use in this documentation where necessary, and are used in accordance to the Google 3D Warehouse Terms of Service as of December 2011 under Section 11.1, Subsection (a):

- 'stepper motor - nema 17' by russ_anderson
<http://sketchup.google.com/3dwarehouse/details?mid=7b5ee9e35f85c343757b961dad12f52>
- 'Straight dashed line and arrow, ground' by Google
<http://sketchup.google.com/3dwarehouse/details?mid=f352190b5a788ecff788b21b3d1cd437>
- 'Spirit Level' by COL 1
<http://sketchup.google.com/3dwarehouse/details?mid=2b43e78280d32d13c9de7b195ccfa970>
- 'Chicken leg', 'Cicipopo Chocolate Chip Cookies', 'Cicipopo Bread' by cicipopo
<http://sketchup.google.com/3dwarehouse/details?mid=f0a9637c4d041e4628badf849e167308>
<http://sketchup.google.com/3dwarehouse/details?mid=3594a9a674ca8d82c99e160a4c94582>
<http://sketchup.google.com/3dwarehouse/details?mid=38fe68125fb895ba5898f9335ccc83b>
- 'CHIAVE FISSA' by FRANCESCOM.
<http://sketchup.google.com/3dwarehouse/details?mid=aa46baba5f812190fcc0b9c5b716d443>
- 'Engineering Tools' by Mike
<http://sketchup.google.com/3dwarehouse/details?mid=20624d6ea2b53ef4d3f6d823f04dd65>
- 'ANT' by qbanruben
<http://sketchup.google.com/3dwarehouse/details?mid=f16f37317eac2e37b21d2748b9ce78f4>
- 'Coffee Cup' by Brian
<http://sketchup.google.com/3dwarehouse/details?mid=9ff8400080c77feac2ad6fd1941624c3>
- 'microswitch' by Area 51
<http://sketchup.google.com/3dwarehouse/details?mid=4044fa57fba51ab2eccea76358162c51>

Licensing:

Prusa Mendel: GPL (<http://reprap.org/wiki/GPL>)

Durbie Prusa Mendel: GPL (<http://reprap.org/wiki/GPL>)

This Document: GFDL (<http://www.gnu.org/licenses/fdl.html>)

The source files for this document are available at:

<https://github.com/romscraj/durbie>

Issues with this document can be submitted to:

romscraj@orangeknob.com

Bill of Materials (1/3)

Printed Parts

Note: **Extruder parts are not included in this BOM.** Part drawings not shown to scale.

4x frame-vertex-with-foot



2x frame-vertex-without-foot



1x y-motor-bracket



6x bar-clamp



1x bottom-right-bearing-holder



1x bottom-left-bearing-holder

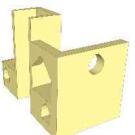


3x endstop-holder

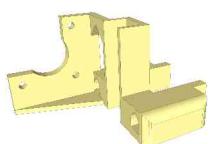
(2x additional required if mounting electronics as shown in Step 10.8)



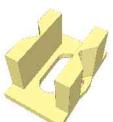
1x x-end-idler



1x x-end-motor



2x slide-coupling-base



2x slide-coupling-block



2x slide-coupling-cover



1x top-right-bearing-holder



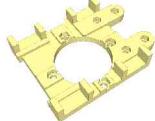
1x top-left-bearing-holder



1x z-motor-bracket



1x x-carriage



2x rod-clamp



4x belt-clamp



2x belt-riser



12x PLA-bushings



3x motor-pulley

(Or 3 x Custom Aluminium Pulleys)



2x z-pulley



Bill of Materials (2/3)

Non-Printed Parts

Note: **Extruder parts are not included in this BOM.** Quantities stated are absolute minimum requirements – it is recommended to procure extra quantities of common parts to be on the safe side.

Quantity	Description	Type	Remarks
90	M8 hex nut	Fastener	
94	M8 flat washer	Fastener	
12	M8 fender washer / large washer	Fastener	Outer diameter must be at least 28mm, typically 30mm.
2	M8x30 <u>hex head</u> bolt	Fastener	Can be substituted with 2x M8x50 Threaded Rod and 2x M8 Nut
2	M4 hex nut	Fastener	For mounting the extruder
2	M4 flat washer	Fastener	For mounting the extruder
2	M4x20 bolt	Fastener	For mounting the extruder. Socket Cap head recommended
61	M3 hex nut	Fastener	
64	M3 flat washer	Fastener	
14	M3 nylon washer (1mm thick)	Fastener	Used as insulating washers. Can be substituted with regular M3 washers while losing insulation benefit.
25	M3x10 bolt	Fastener	Socket Cap head recommended
3	M3x10 set screw / grub screw	Fastener	
20	M3x25 bolt	Fastener	Socket Cap head recommended
4	M3x40 bolt	Fastener	Socket Cap head recommended
4	294mm M8 threaded rod	Threaded Rod	Frame Front & Rear
8	370mm M8 threaded rod	Threaded Rod	Frame Vertex Triangle & Z-leadscrew
3	440mm M8 threaded rod	Threaded Rod	Frame Top & Bottom
2	350 mm smooth rod	Smooth Rod	Z axis smooth rods
2	406 mm smooth rod	Smooth Rod	Y axis smooth rods
2	420 mm smooth rod	Smooth Rod	X axis smooth rods
4	3mm ID spring x 30mm length	Spring	Can be substituted with ballpoint pen springs
8	608 Bearing (Roller skate / In-line skate / skateboard bearings)	Ball Bearing	
3	NEMA 17 Bipolar Stepper Motor + cable	Stepper Motor	Extruder Stepper is not included – 3x quantity is for printer only
2	840mm x 5mm T5 Pitch Timing Belt	Belt	Y & Z axis belt. Z belt <i>must</i> be a continuous / closed belt
1	1380mm x 5mm T5 Pitch Timing Belt	Belt	X axis belt

Bill of Materials (3/3)

Non-Printed Parts (continued)

Note: **Extruder parts are not included in this BOM.** Quantities stated are absolute minimum requirements – it is recommended to procure extra quantities of common parts to be on the safe side.

Quantity	Description	Type	Remarks
1	140mm x 235mm Print-Bottom-Plate	Plate / Board	5mm thick recommended – material may be wood (eg. Plywood or MDF), acrylic sheet etc.
1	235mm x 235mm Print-Top-Plate	Plate / Board	3mm thick aluminium recommended
1	Electronics + Endstops + associated cables + compatible Power Supply	Electronics	This can be RAMPS, Gen3, Gen6, or anything else compatible. Additional items may be required if you are using opto type endstops – refer to the instructions at the RepRap wiki at " http://reprap.org/wiki/Prusa_Mendel_Assembly " under the "Wiring the electronics" section
1	Extruder + motor		Any compatible Extruder of your choice.
1	Glue	Misc.	Araldite Rapid is recommended and widely available in most regions.
50	Small cable binder / zip tie	Misc.	Used to affix cables and wires to frame
50cm	Velcro strap	Misc.	May be substituted with strong string or shoelace etc.
1	Blue tape / masking tape / Kapton tape	Misc.	Used to cover the build platform. For printing PLA plastic on non-heated build platforms, blue tape or just regular masking tape will work for a start.

Recommended Essential Tools

1	Spirit level	Tool	15cm length or shorter would be ideal
2	13mm Spanner – combination wrench	Tool	Very highly recommended for ease of assembly – for use with M8 nuts
1	2.5mm Allen key	Tool	For use with M3 socket cap head
1	3mm Allen key	Tool	For use with M4 socket cap head
1	Steel rule / measuring tape	Tool	30cm/12" steel rule with zero at the edge is recommended
1	12" Engineer's try square	Tool	Optional – ideal tool for marking out hole centres on print top and bottom plates
1	Hand drill / drill press + 3mm drill bit (and other sizes)	Tool	3mm bit for drilling the holes on the print top and bottom plates. Hand drill + centre punch + pilot hole + step drilling method + proper clamping works, but a bench drill press is highly recommended
1	Needle Nose / Snipe Nose Pliers	Tool	Useful for gripping M3 & M4 nuts in tight spaces
1	Small wire cutter / diagonal pliers	Tool	Sharp blades for trimming belts, zipties etc.
2	File	Tool	Round / rat-tail, and flat bastard files

Part 1

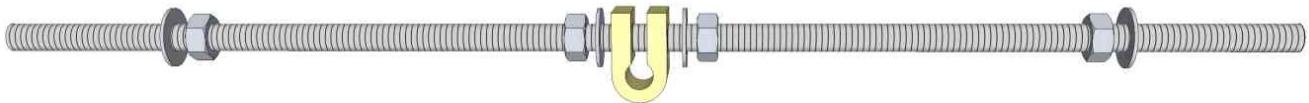
Assembling the frame vertex triangles

Note: In this section, you will need 6pcs of 370mm M8 threaded rods. Out of the total of 8 370mm threaded rods, select 2 of the straightest rods and put them aside - these will be used for the Z axis. You can roll the rods on a table and observe for wobbling (the straightest rods will roll with the least wobble). If the two straightest rods aren't very straight, that's ok - the printer has been designed to accomodate slightly bent rods.

1.1

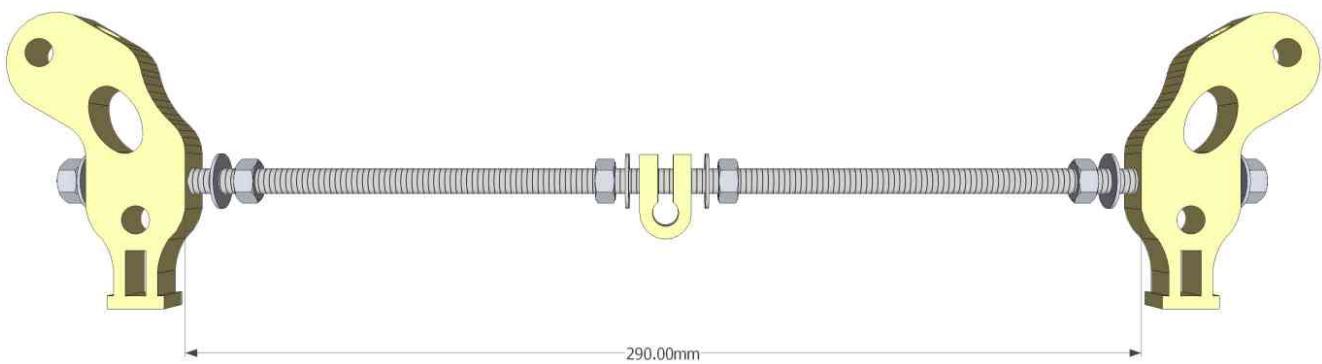
Start by inserting the following into one of the rods:

1 washer - 2 nuts – 1 washer – 1 bar-clamp – 1 washer - 2 nuts – 1 washer
Position them as per the photo below. Do not tighten the Bar Clamp yet.



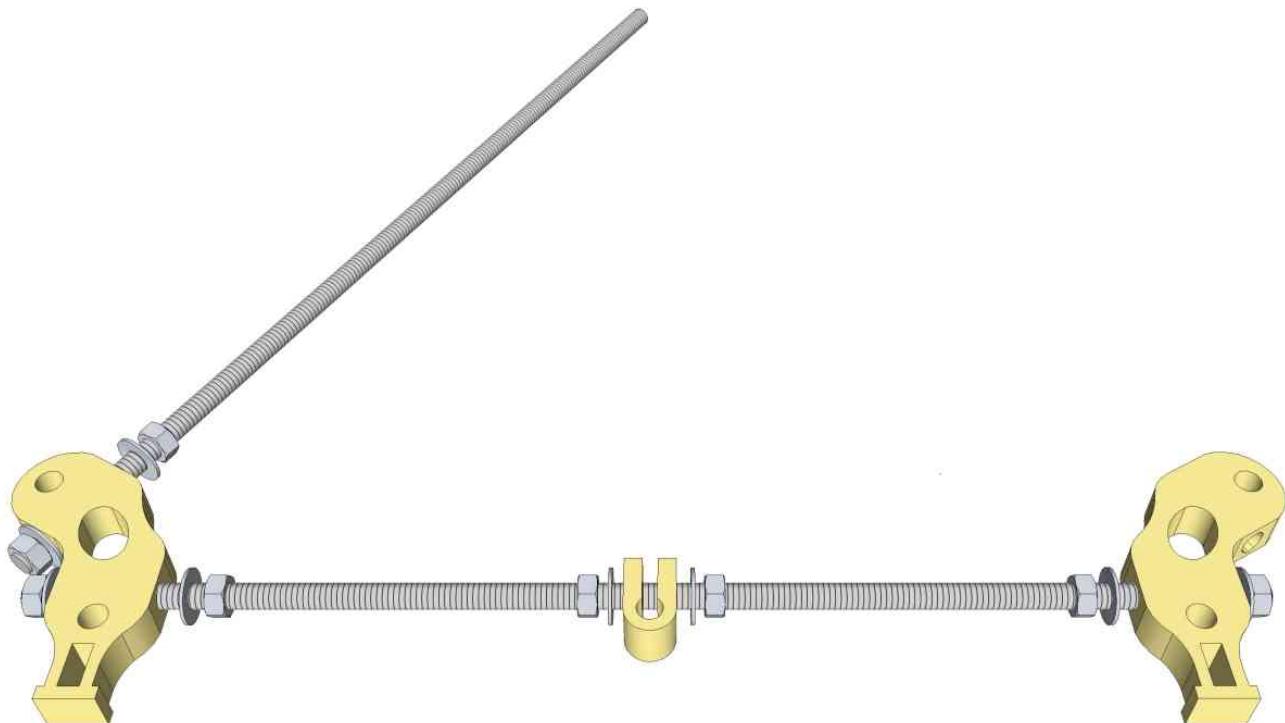
1.2

Slide in two frame-vertex-with-foot to the opposite ends of the rod. Observe the alignment as shown in the photo below. Measure distance D1 and adjust it to be approximately 290mm. Add a washer followed by a nut to each end. Tighten the two vertices by hand (without tools).

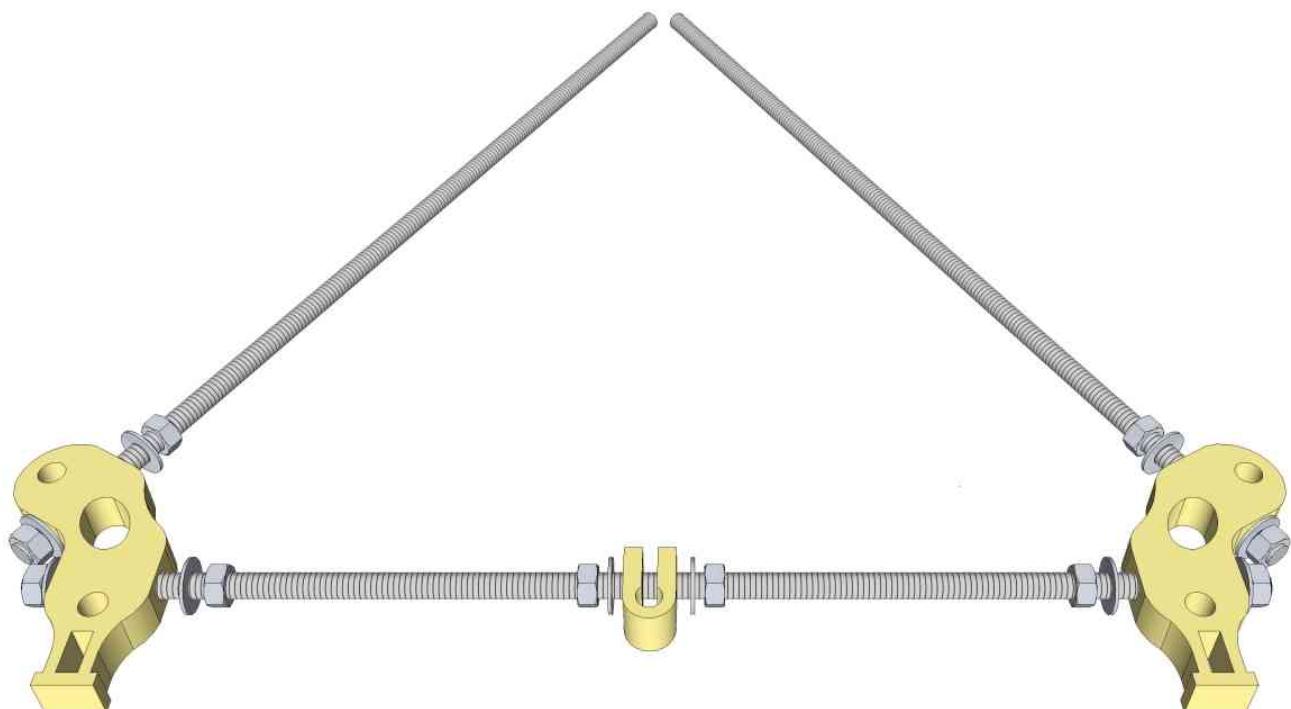


1.3

Take another 370mm threaded rod and insert a nut followed by a washer at one end. Insert one end into one of the vertices as shown below, and fix it in place with a washer and a nut.

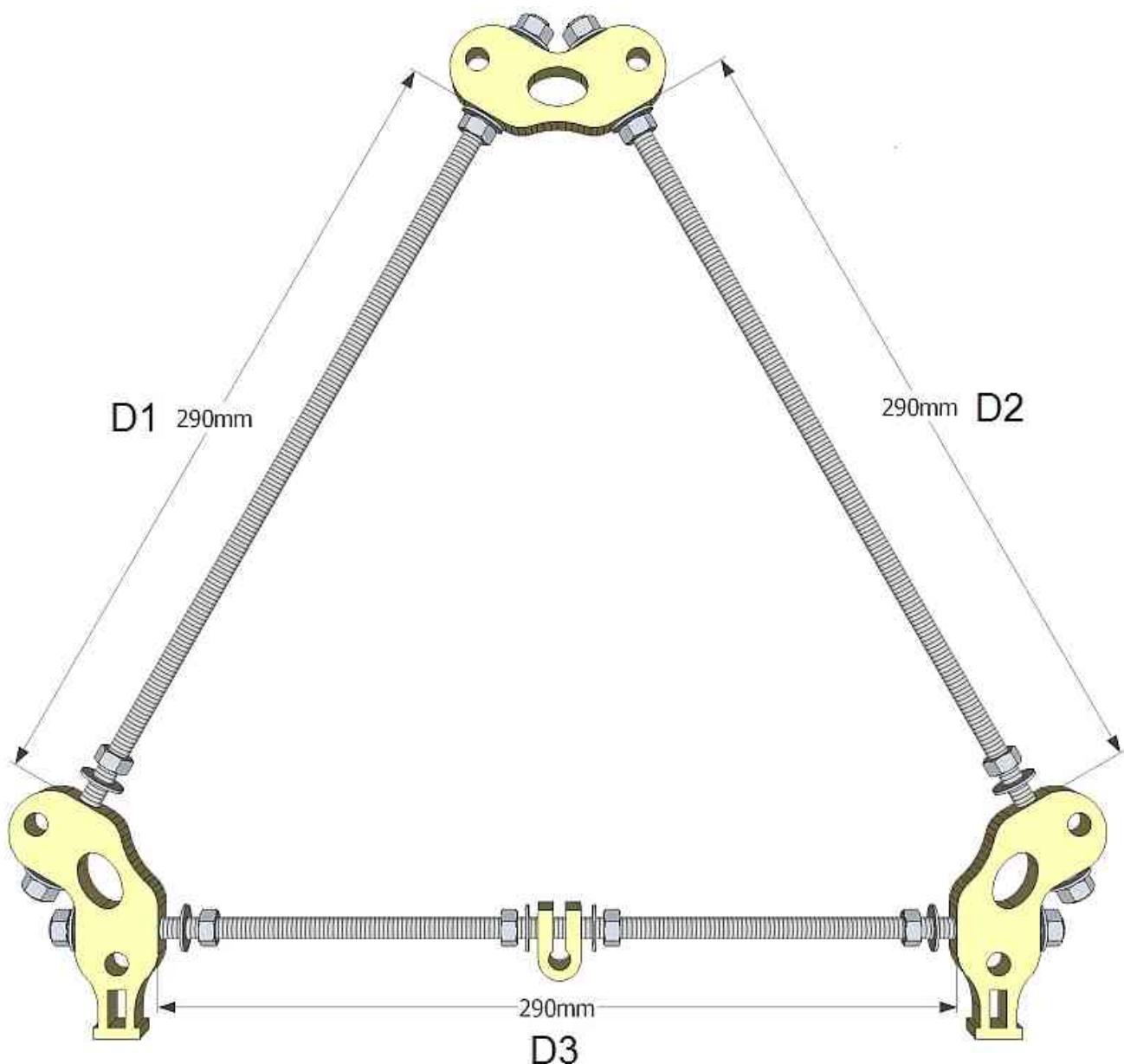


Repeat with the other vertex.

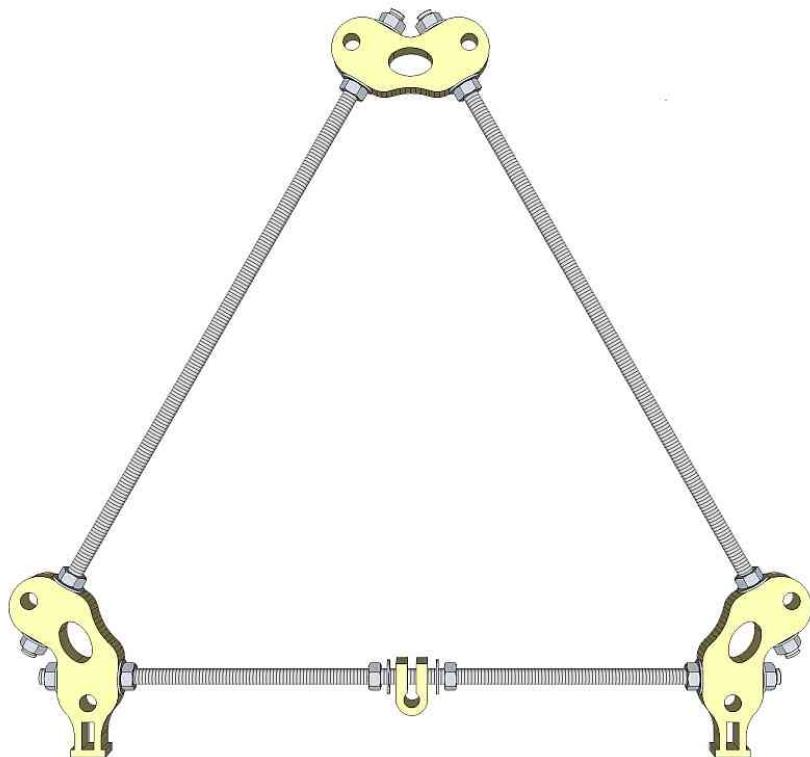


1.4

Insert one nut followed by one washer to the open end of the two threaded rods. Take one frame-vertex-without-foot and insert it into the final corner of the triangle. Insert a washer and a nut to the each of the ends of the two rods to hold the part in place. Measure distances D1, D2 and D3 and adjust them to precisely 290mm by adjusting the nuts if necessary. Once the measurements are correct, tighten all the nuts on the vertices (but not the bar-clamp).

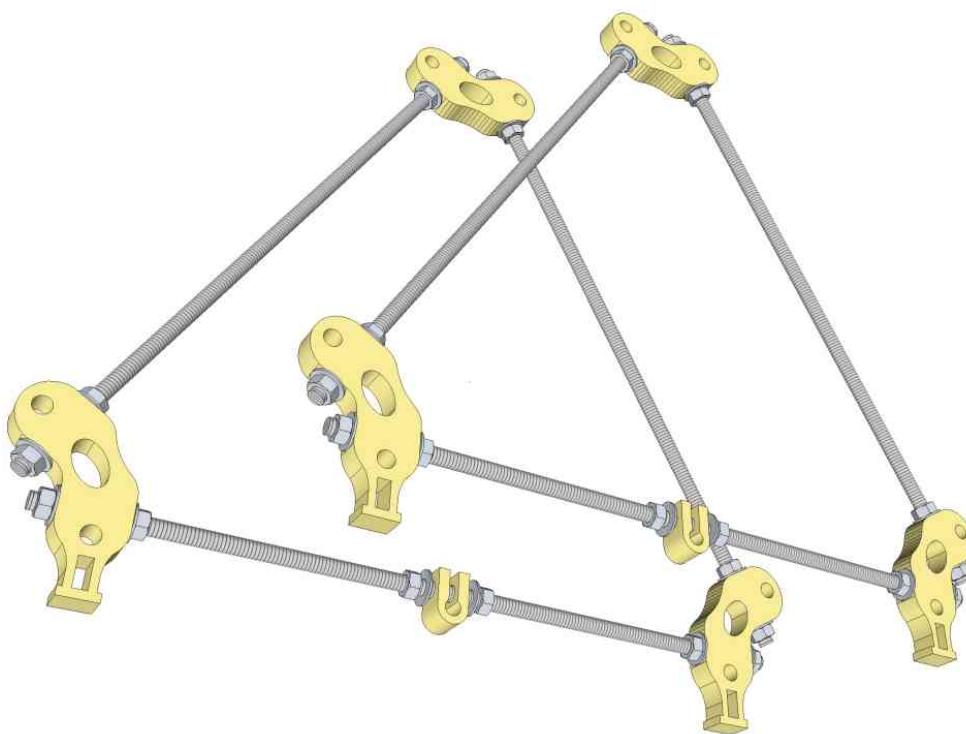


You should now have a sturdy triangle with equal length sides, two feet at the bottom, and a bar-clamp between the feet. All nuts should be tight except the ones on the bar-clamp. Compare your completed frame triangle with the picture below.



1.5

Repeat Steps 1.1 through 1.4 and assemble another frame triangle. The two frame triangles are exactly identical.



Part 2

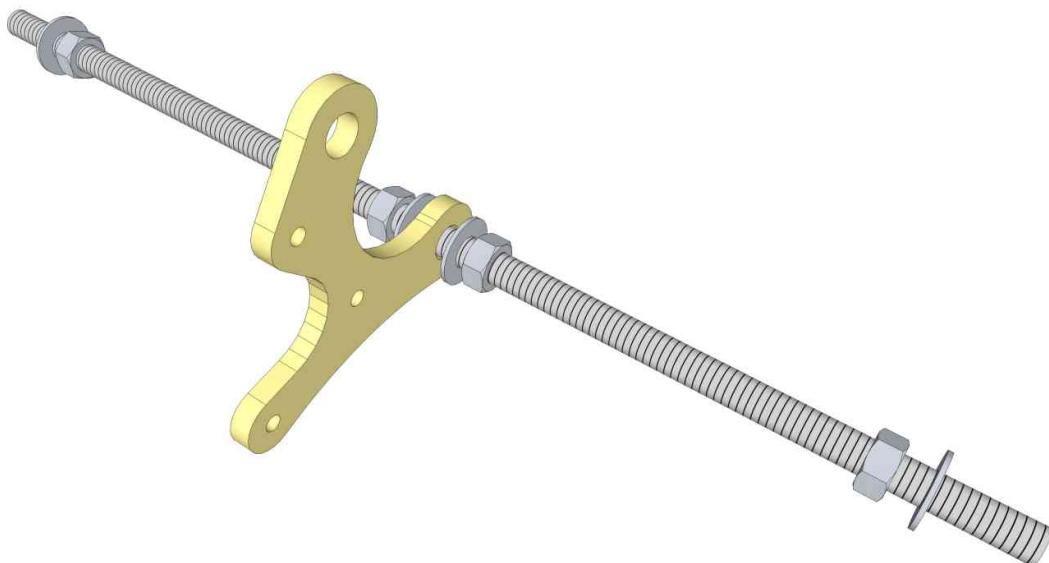
Assembling the front threaded rods

2.1

Take one 294mm M8 threaded rod and insert the following:

1 washer – 2 nuts – 1 washer – 1 y-motor-bracket – 1 washer – 2 nuts – 1 washer

Position them as per the photo below and make sure the y-motor-bracket is inserted in the correct orientation – the 'pointy' side should be pointing towards you. You may tighten the y-motor-bracket by hand to temporarily hold it in place.

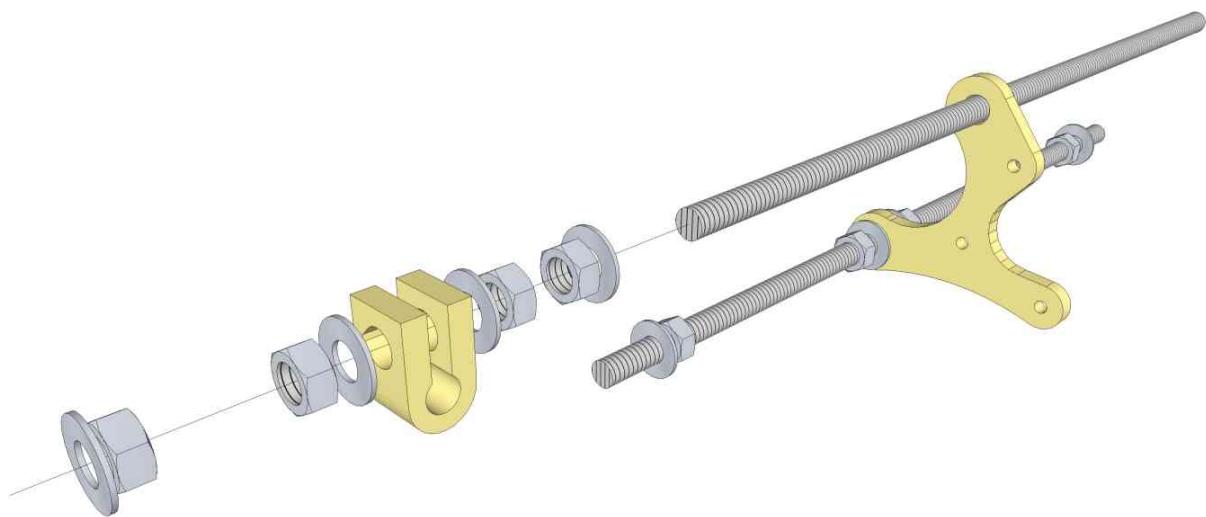


2.2

Insert another 294mm threaded rod into the top hole of the y-motor-bracket. The next step is a little complicated, so make sure you get it done in the correct order.

Insert the following in the order given into the left end of the rod:

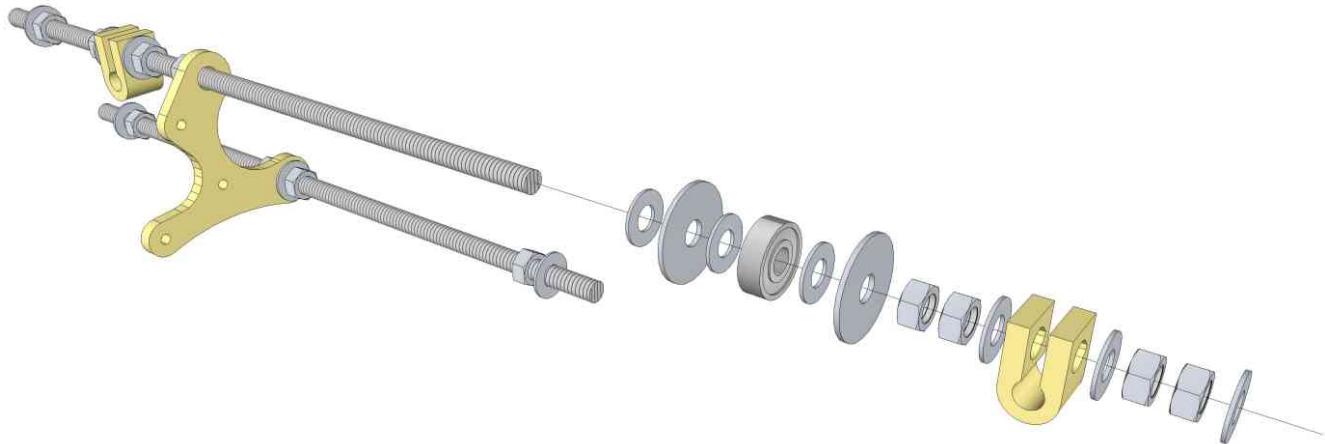
1 washer – 2 nuts – 1 washer – 1 bar-clamp – 1 washer – 2 nuts – 1 washer



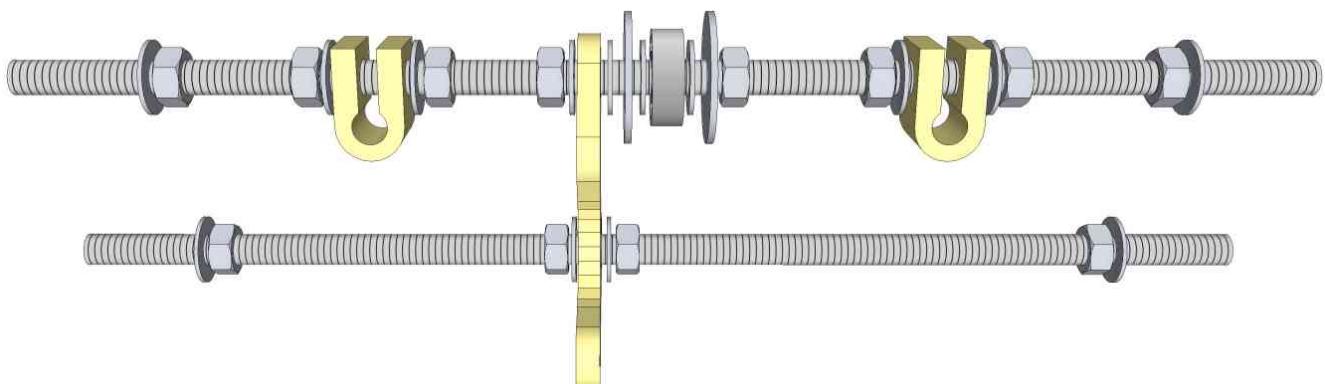
2.3

Next, insert the following into the right end of the rod:

1 washer – 1 large washer – 1 washer – 1 608 Bearing – 1 washer – 1 large washer – 2 nuts – 1 washer – 1 bar-clamp – 1 washer – 2 nuts – 1 washer

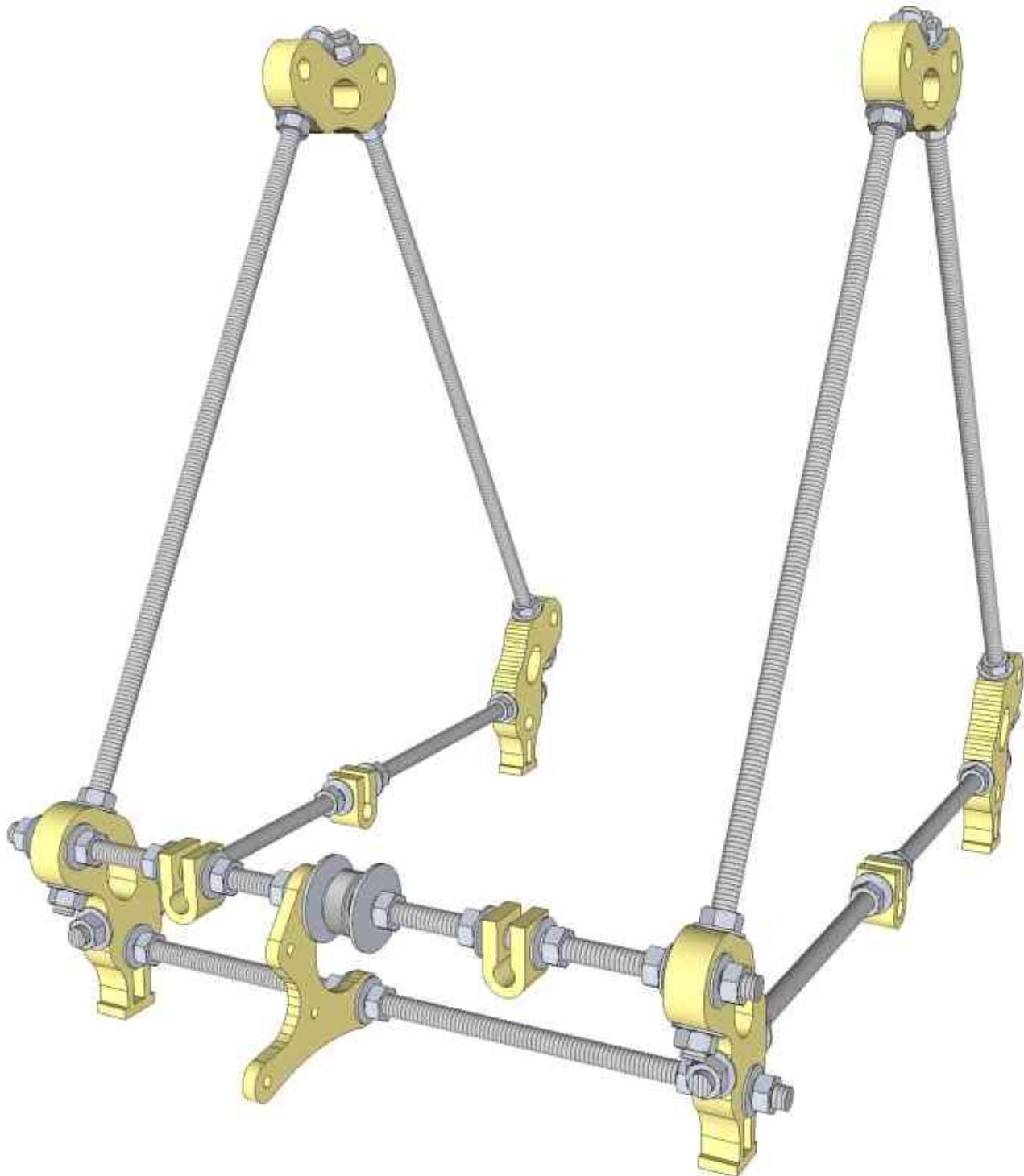


Verify that your assembled parts are correct by referring to the picture below:



2.4

With the y-motor-bracket pointing out towards you, insert the two rods through the two holes in each of the frame-vertex-with-foot. Put a washer followed by a nut to both ends of both threaded rods. This is what you should have so far:

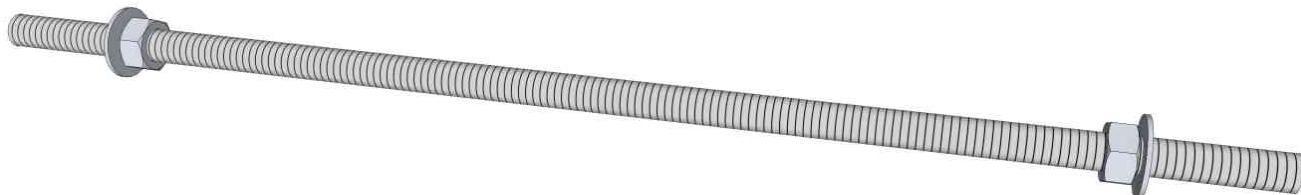


Part 3

Assembling the rear threaded rods

3.1

Take one 294mm M8 threaded rod and insert a nut followed by a washer to each end. This is the rear bottom rod.



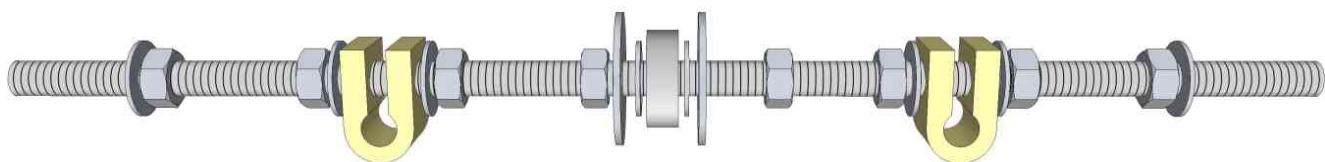
3.2

Now for the rear top rod. Once again, the next step is a little complicated so make sure you get it all in the correct order.

Insert the following into another 294mm M8 threaded rod:

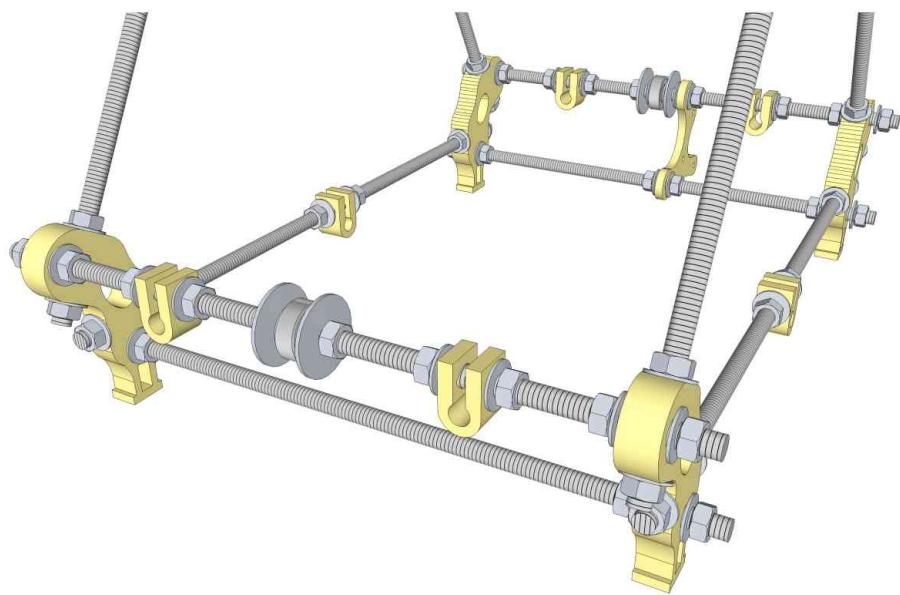
1 washer – 2 nuts – 1 washer – 1 bar-clamp – 1 washer – 2 nuts – 1 large washer – 1 washer – 1 608 bearing – 1 washer – 1 large washer – 2 nuts – 1 washer – 1 bar-clamp – 1 washer – 2 nuts – 1 washer

Verify that your assembled parts are correct by referring to the picture below:

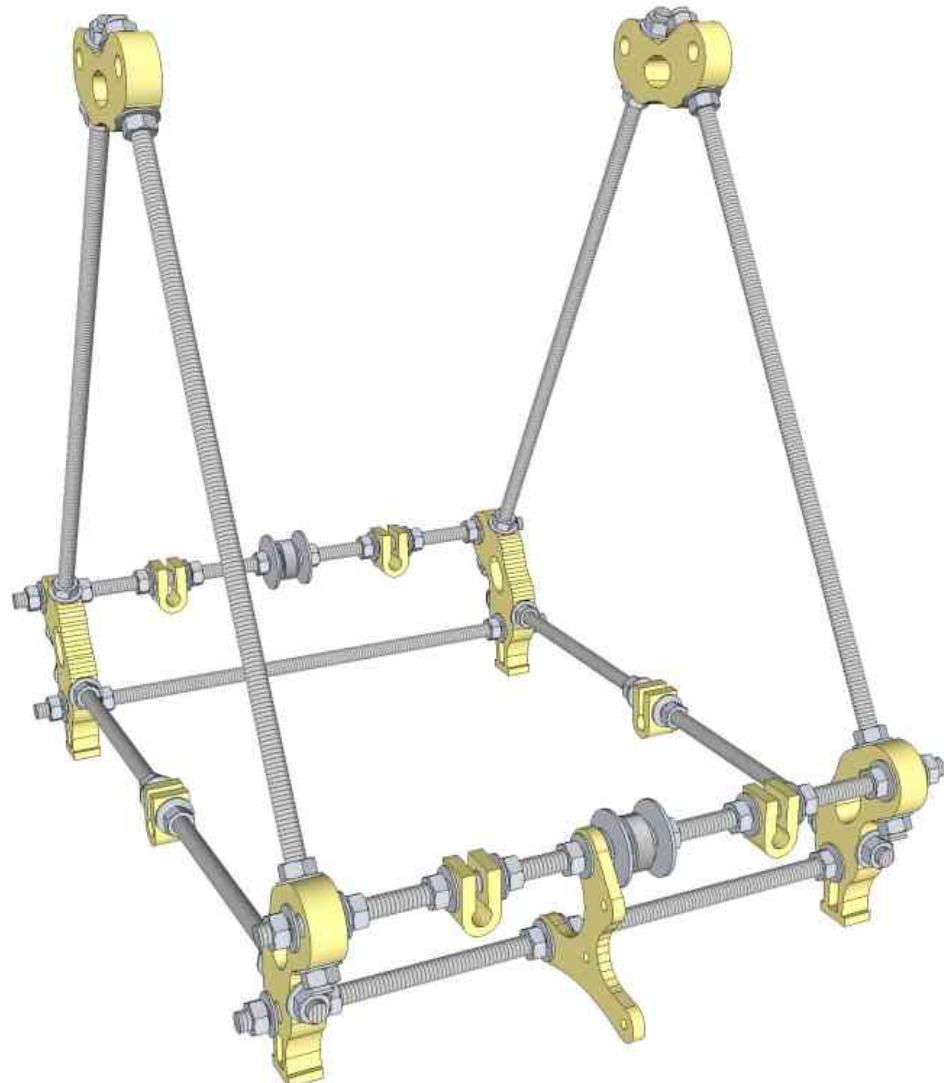


3.3

Attach the two rods to the remaining two vertices, and add a washer followed by a nut to both ends of both threaded rods.



Your frame should now look like this:

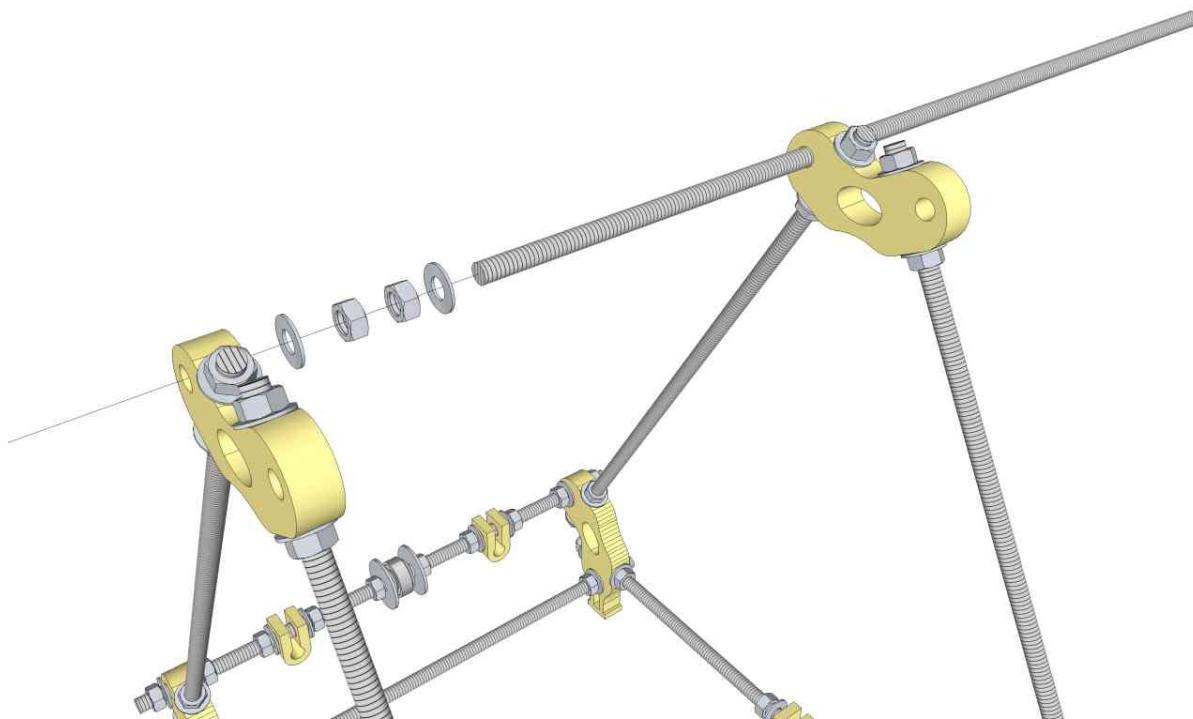


Part 4

Assembling the top threaded rods

4.1

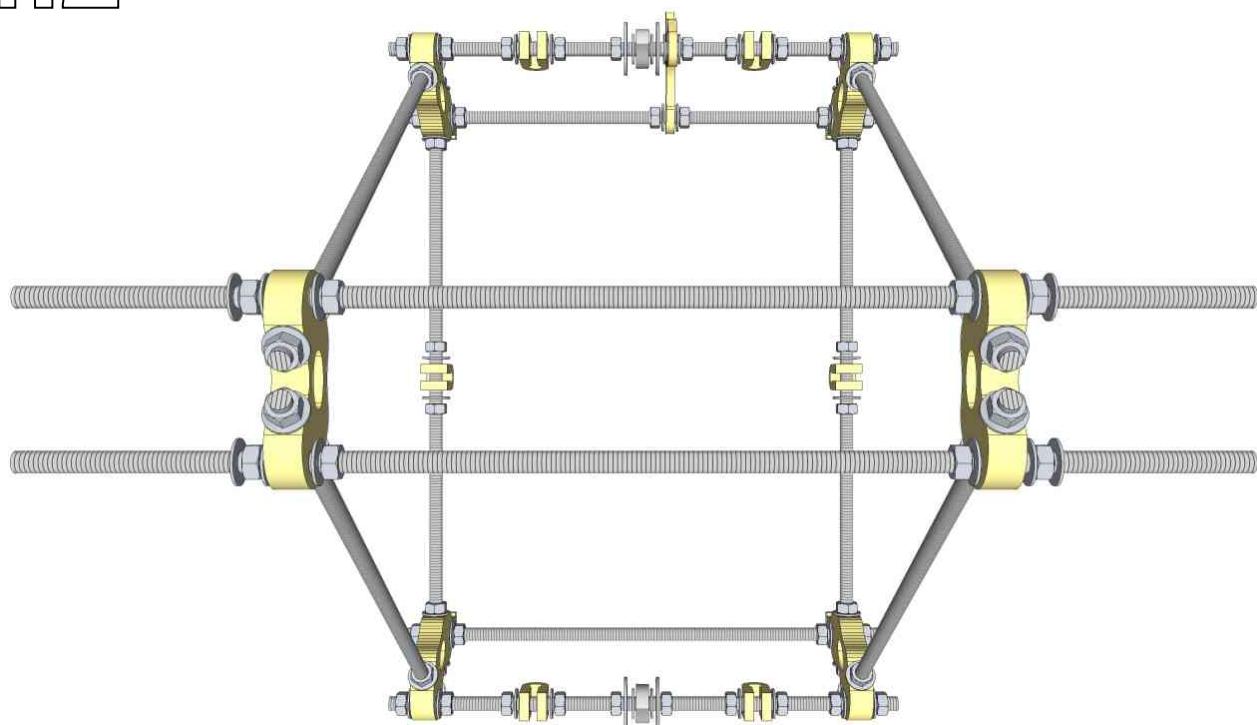
Slide one 440mm threaded rod through one of the top vertices. Halfway though, insert 1 washer - 2 nuts - 1 washer into the rod so that they are between the two top vertices.



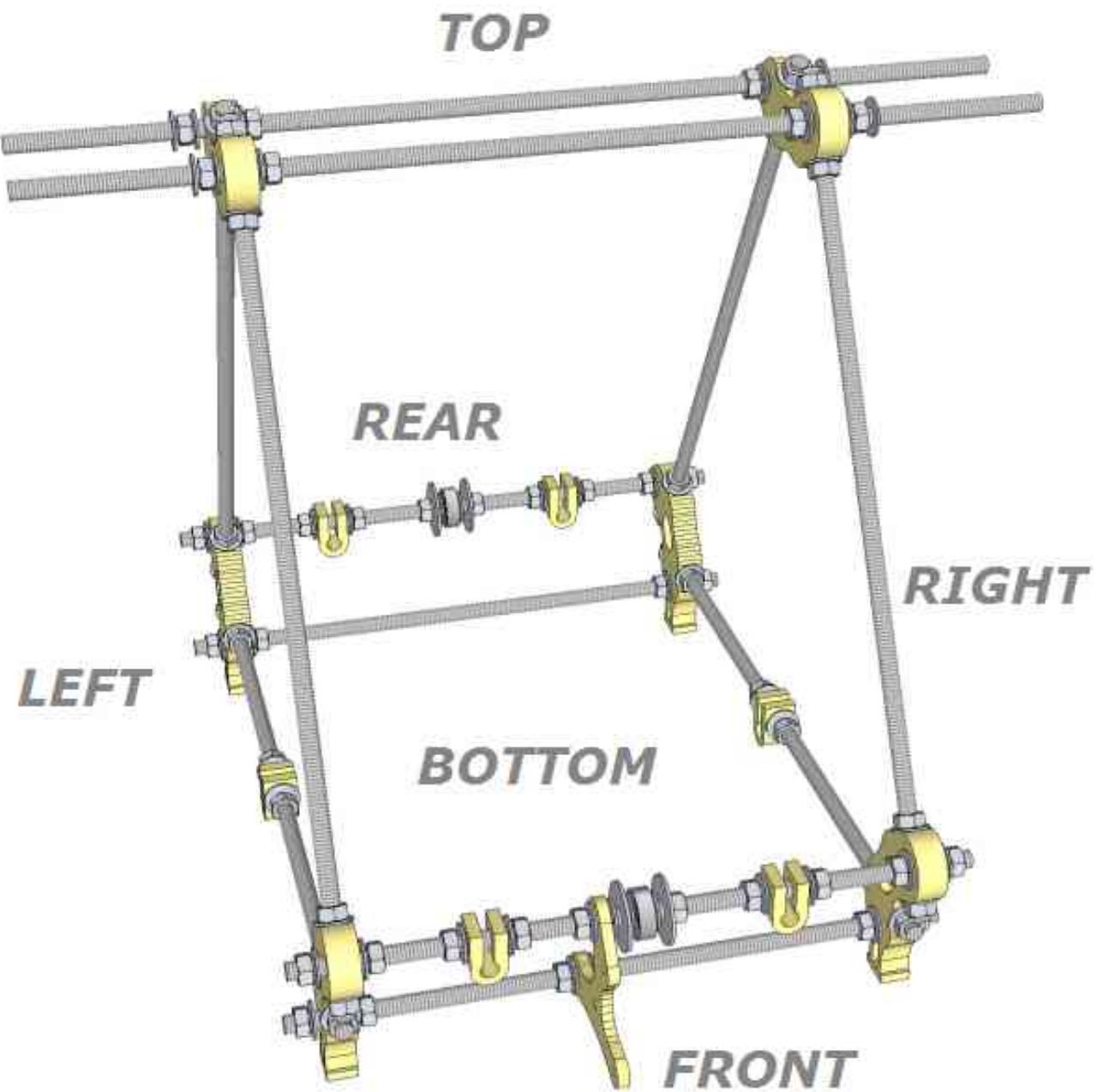
Slide the rod through to the vertex on the opposite side. Repeat from the beginning of this step for the other 440mm threaded rod. Position the washers and nuts to the insides of each of the vertices.

4.2

Insert 1 washer – 1 nut – 1 washer to both ends of both threaded rods. It should now look like this:

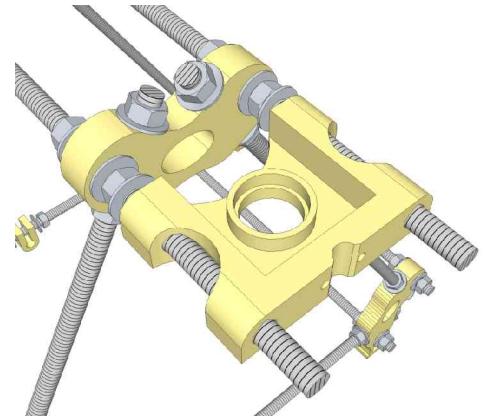
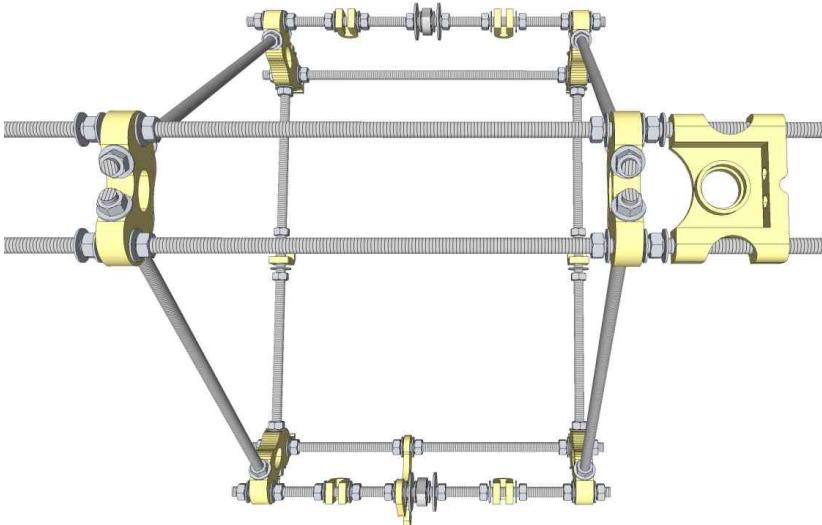


Refer to the picture below to familiarise yourself with the orientation of the build so far – you may need to refer back to this again if you are unsure in the steps that follow.



4.3

Insert the top-right-bearing-holder into the right side of the threaded rods. Observe the orientation: the flat surface should face the bottom, and the side with the two holes and the indentation should point towards the outside. Verify this with the photo below:

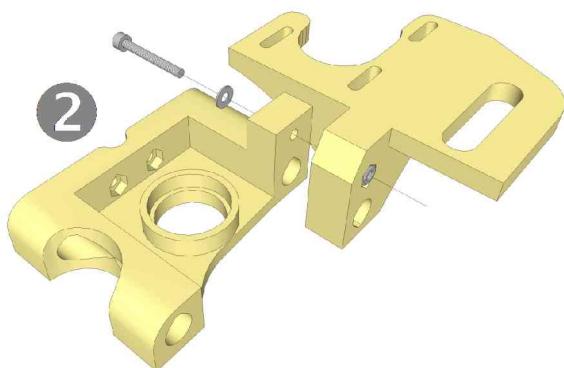
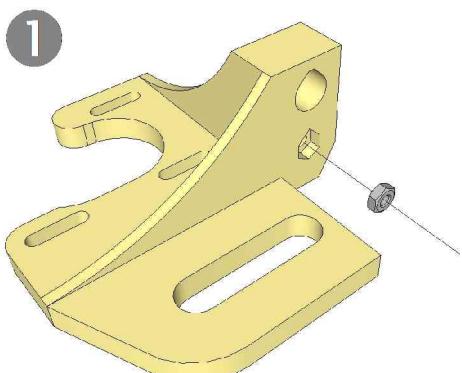


4.4

Take the z-motor-bracket and insert an M3 nut into the nut pocket. Take the top-left-bearing-holder and attach it to the z-motor-bracket using an M3 x 25 bolt and a washer. Do not tighten the bolt fully at this point. Note the orientation of the parts:

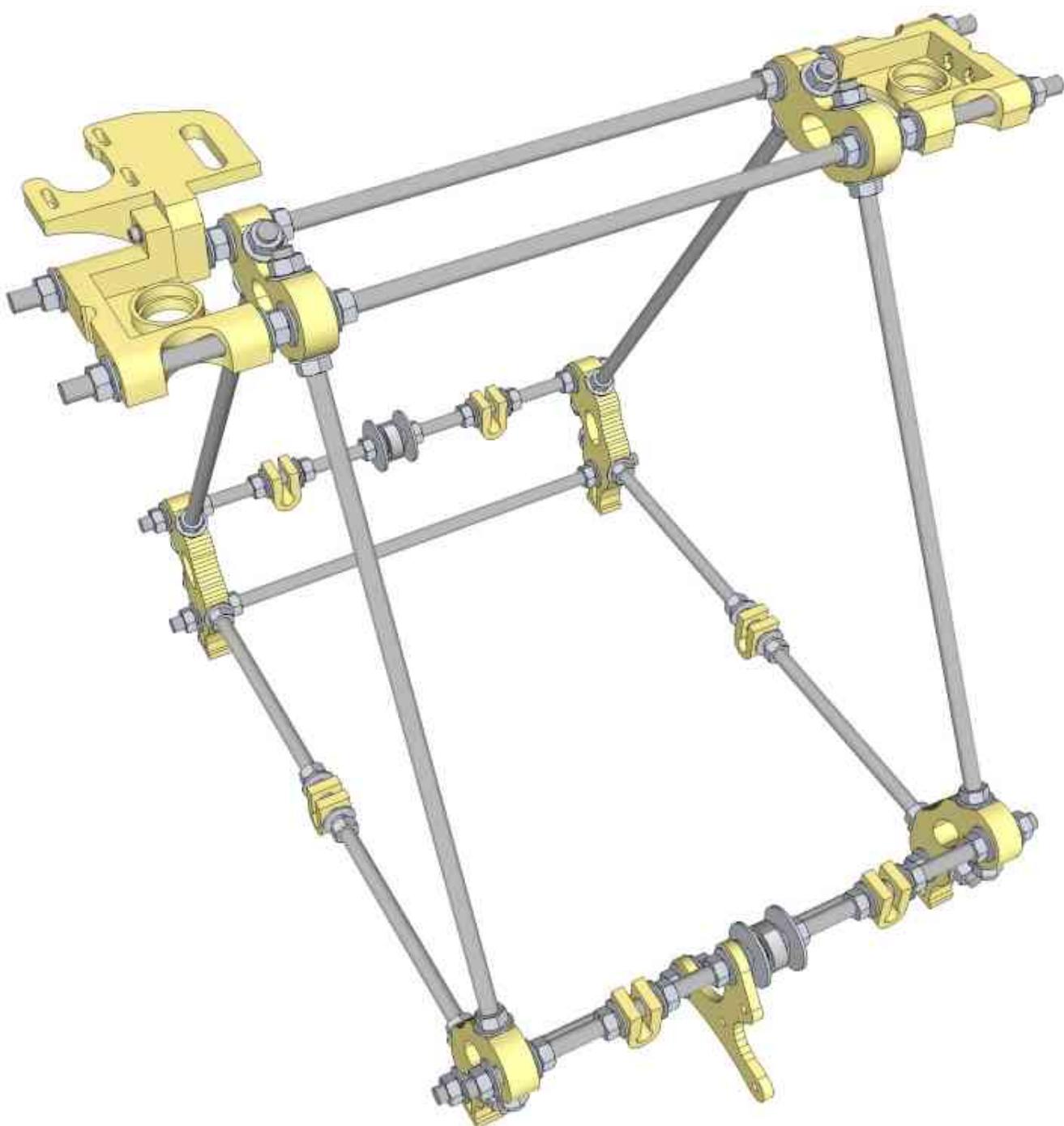
- the flat surface of the top-left-bearing-holder should face the bottom
- the side of the top-left-bearing-holder with the two holes and the indentation should face the left
- the flat surface of the z-motor-bracket should face the top
- the large oval hole on the z-motor-bracket should face the right

Verify that this is correct by referring to the photos below:



4.5

Insert the parts you have just assembled into the left side of the threaded rods. The z-motor-bracket should be facing the top-rear. Add a washer and a nut to both ends of both threaded rods. Verify your build with the photo below:

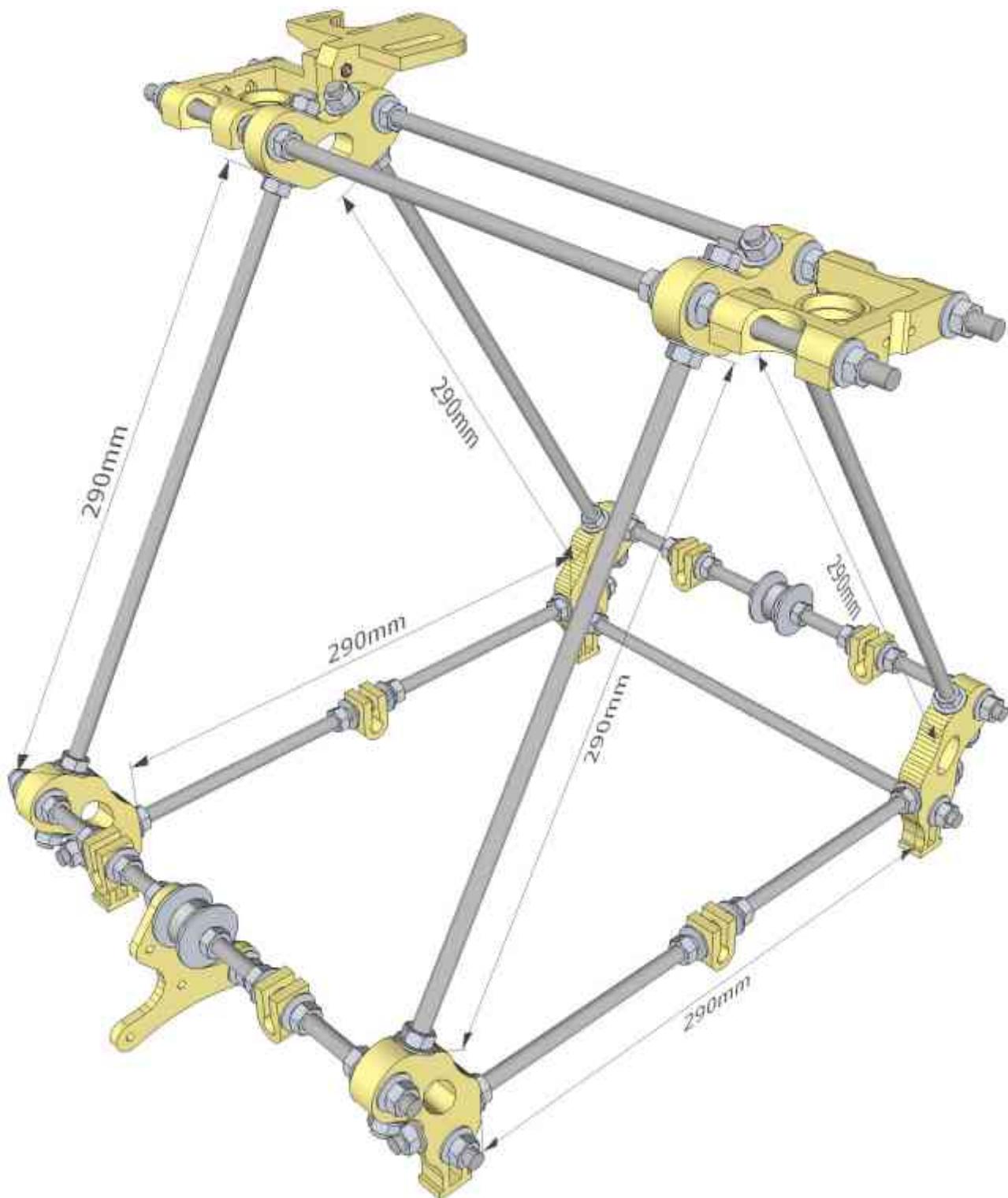


Part 5

Tightening the frame

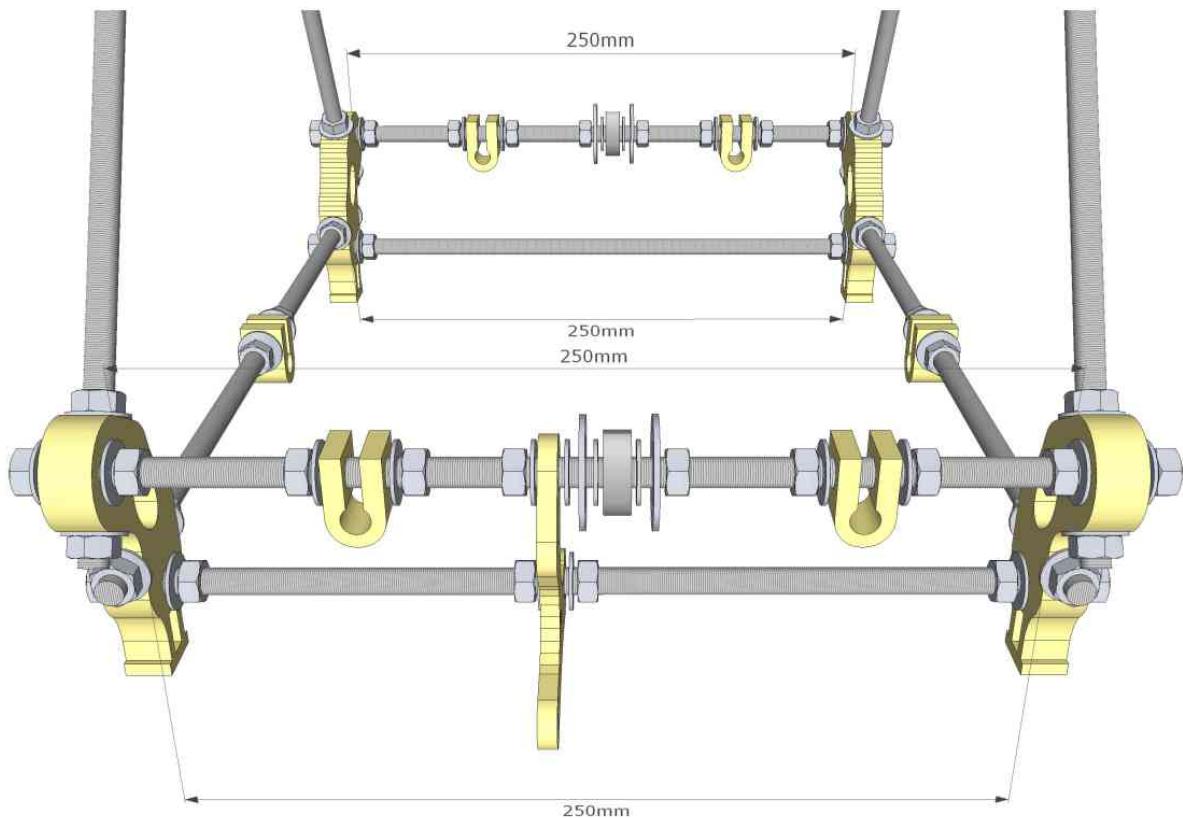
5.1

Measure and adjust the triangle vertices so that they are 290mm apart from plastic to plastic along the insides of each of the three sides. Once this has been verified, tighten the nuts firmly so that they are unable to move, however be careful not to overtighten and crush the plastic parts.



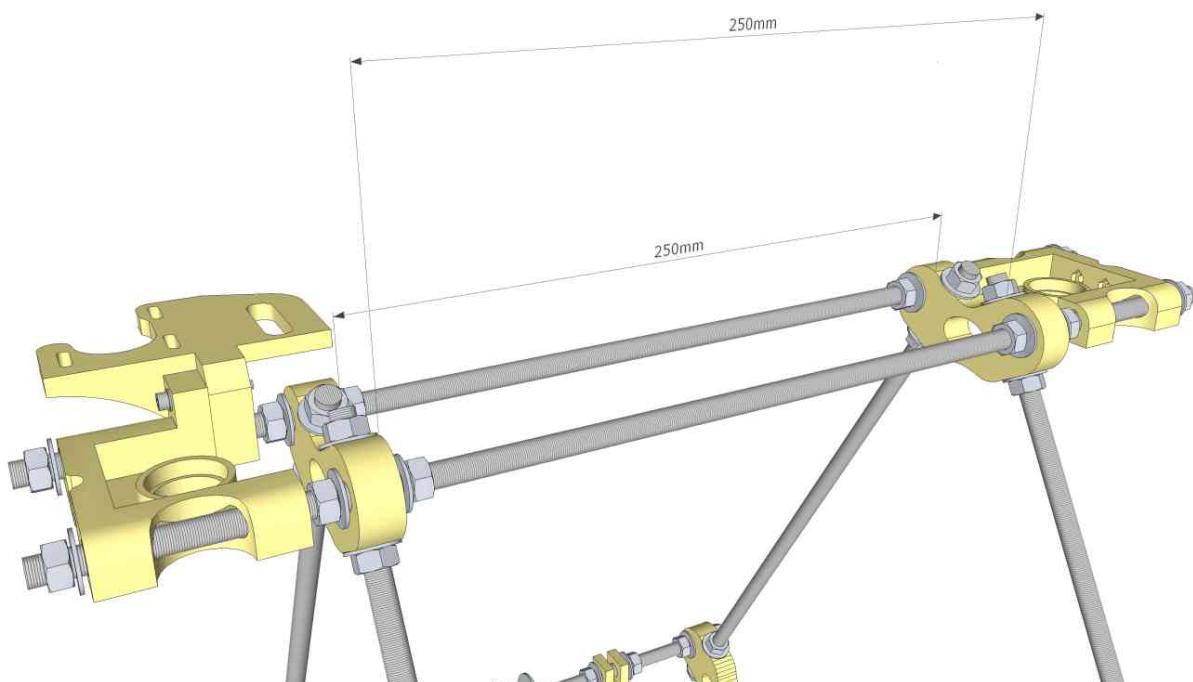
5.2

Measure and adjust the bottom rods so that they are 250mm apart from plastic to plastic along the insides of each of the rods against the vertices. Once this has been verified, tighten the nuts firmly so that they are unable to move, however be careful not to overtighten and crush the plastic parts.



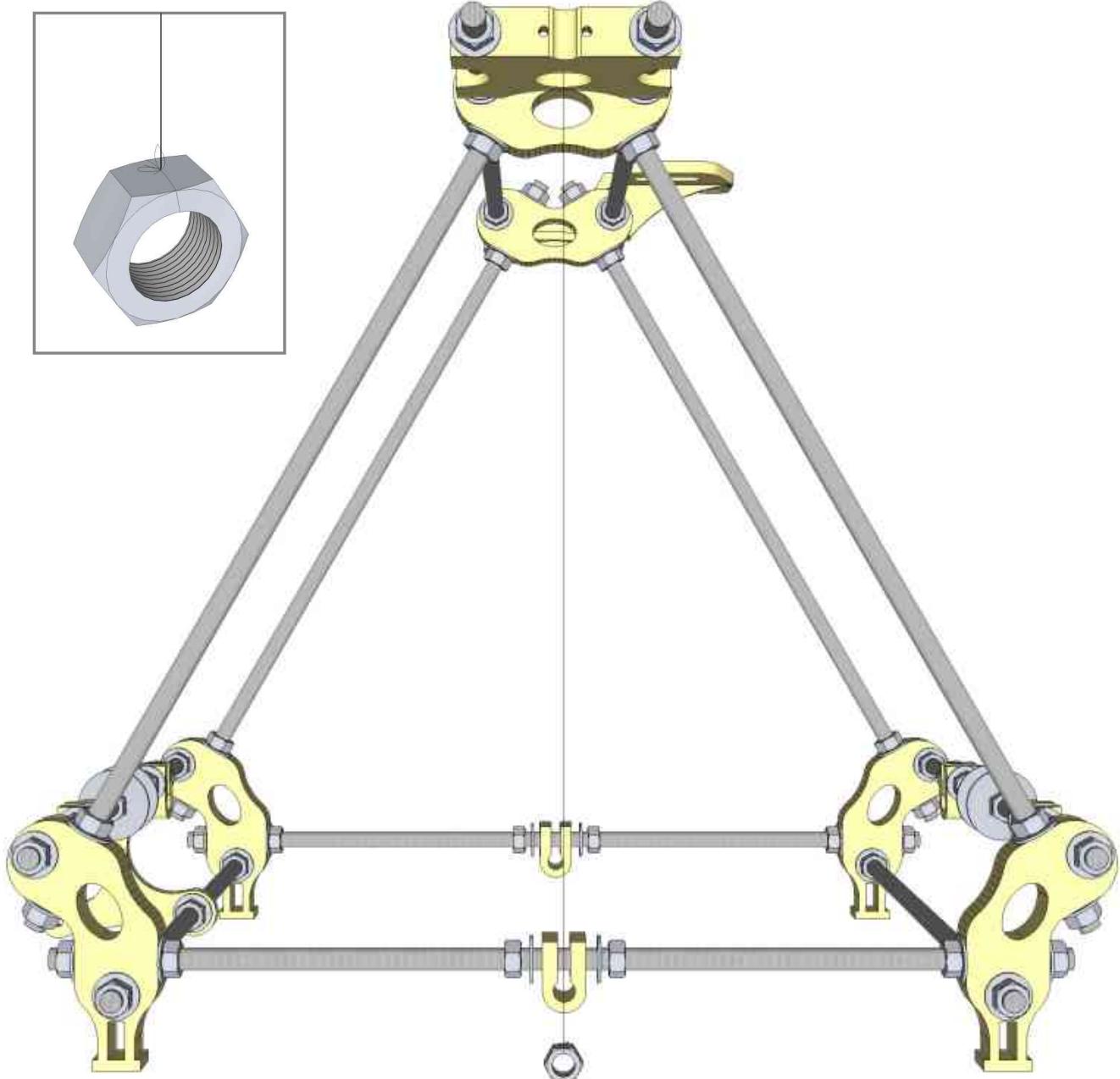
5.3

Measure and adjust the top rods so that they are 250mm apart from plastic to plastic along the insides of each of the rods against the vertices. Once this has been verified, tighten the nuts firmly on the vertices, followed by the top left and top right bearing holders so that they are unable to move, being careful not to crush the plastic parts. Tighten the M3x25 bolt on the Z-Motor Bracket as well.



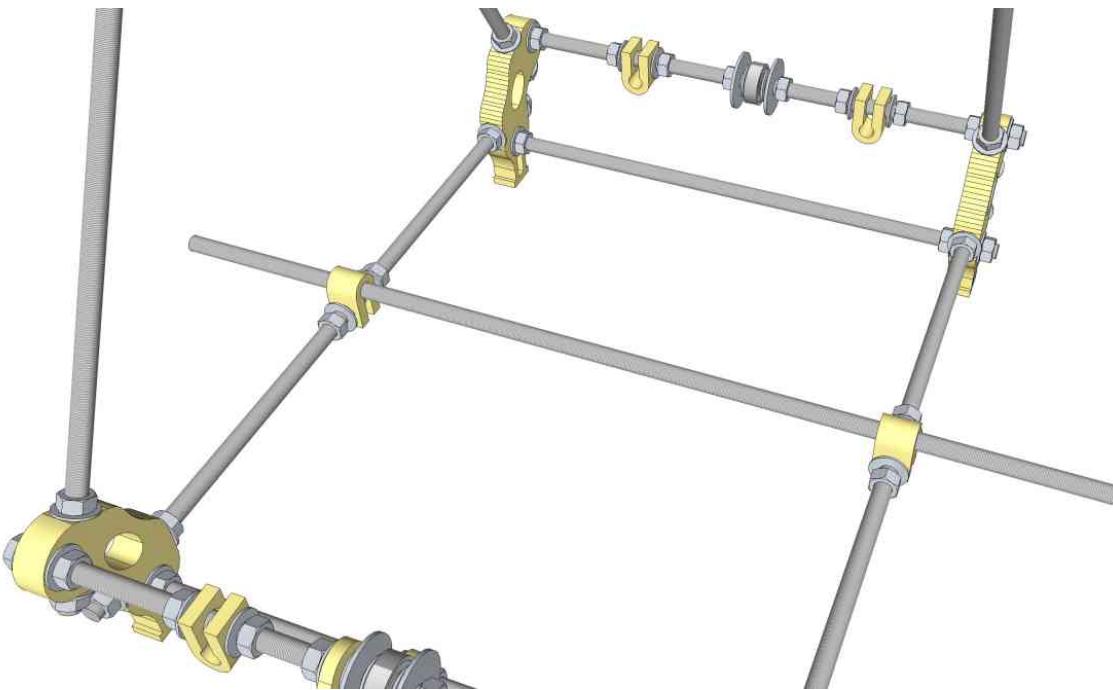
5.4

The frame should now be fairly stable. Using a plumb line or similar (for example a nut hanging from a string), adjust the bar clamps on the bottom side of each triangle until they are close to the top vertices. Do not tighten the bar clamps yet.



5.5

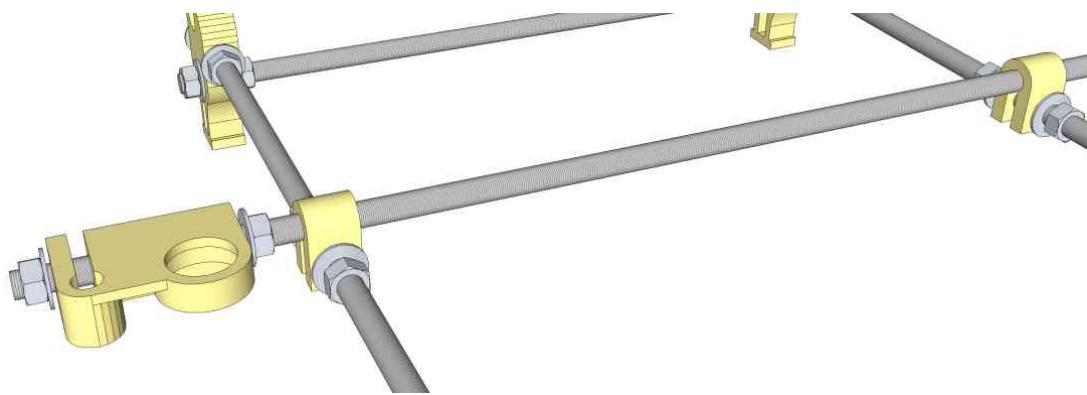
Insert a 440mm threaded rod through the two bar-clamps on the bottom of the frame. Make sure the rod is on top of the triangle bottom rods, and the same length extends out on each side. Do not tighten the bar clamps yet.



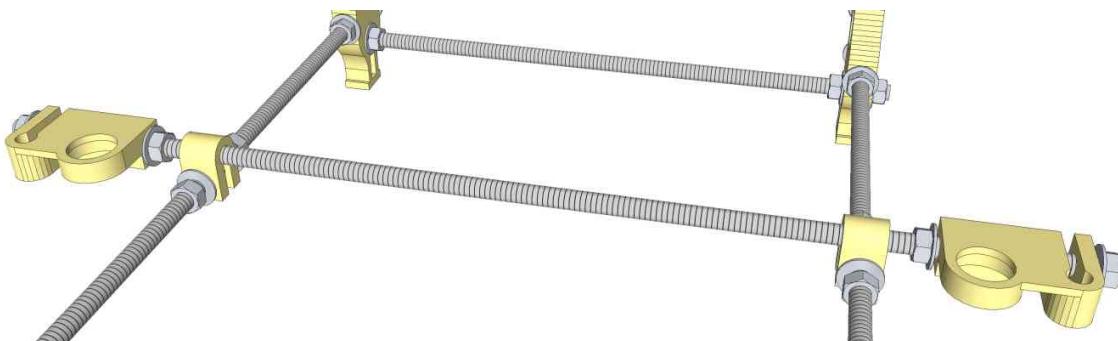
5.6

Insert the following into the left side of the threaded rod:
1 nut – 1 washer – Bottom Left Bearing Holder – 1 washer – 1 nut

Make sure of the orientation: the flat part of the Bottom Left Bearing Holder should face the top, and the side with the 'U-shaped' bar clamp should be on the outside.



Repeat with the right side, using the Bottom Right Bearing Holder.

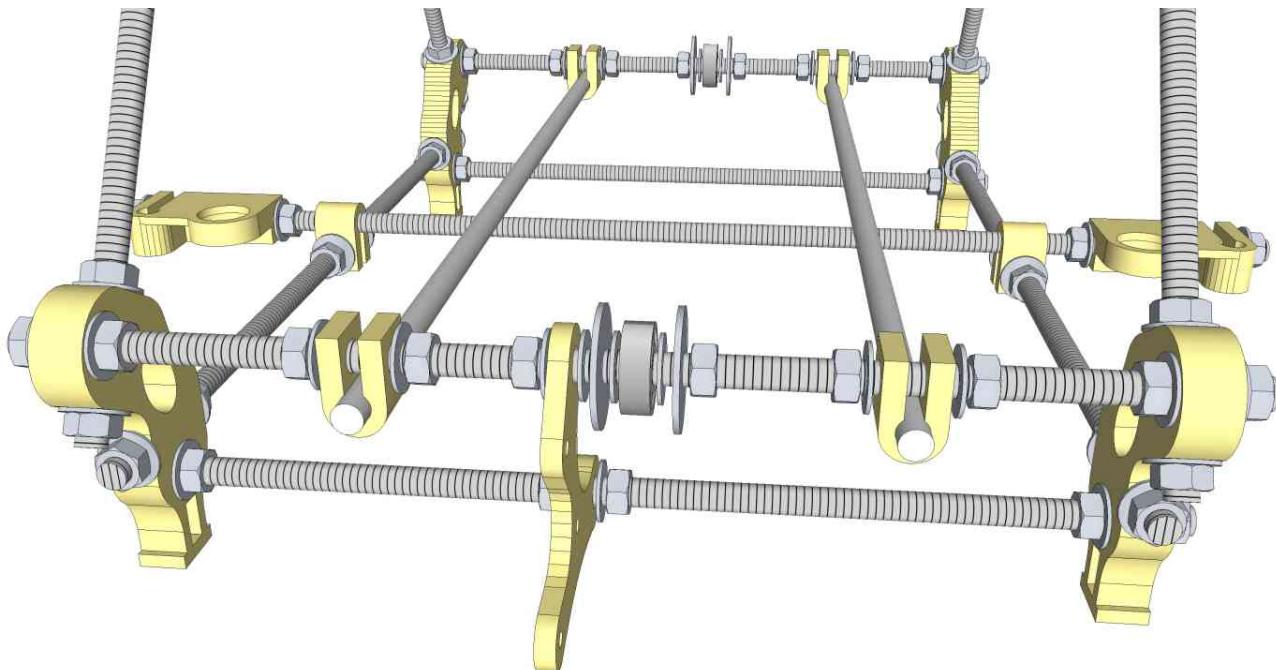


Part 6

Assembling the Y axis

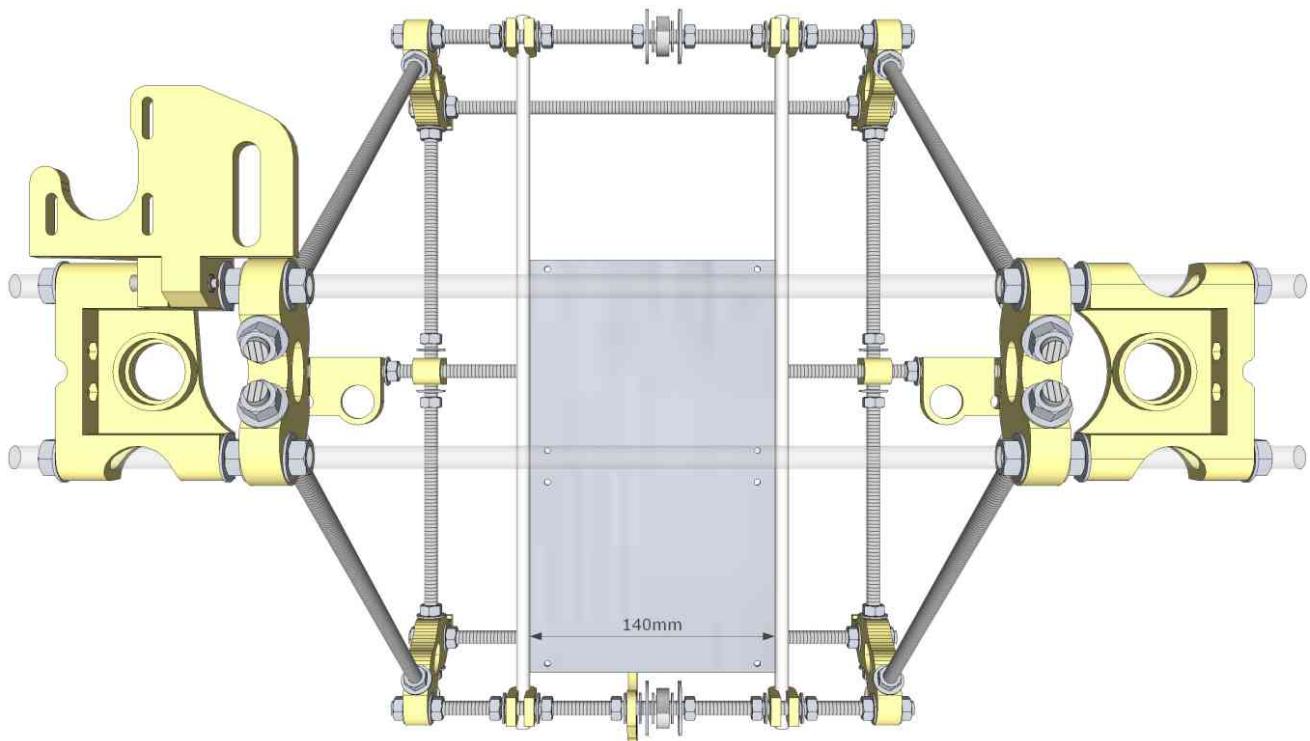
6.1

Slide the two 406mm rods through the bar-clamps on the front and rear threaded rods. They should fit snugly and be approximately parallel.



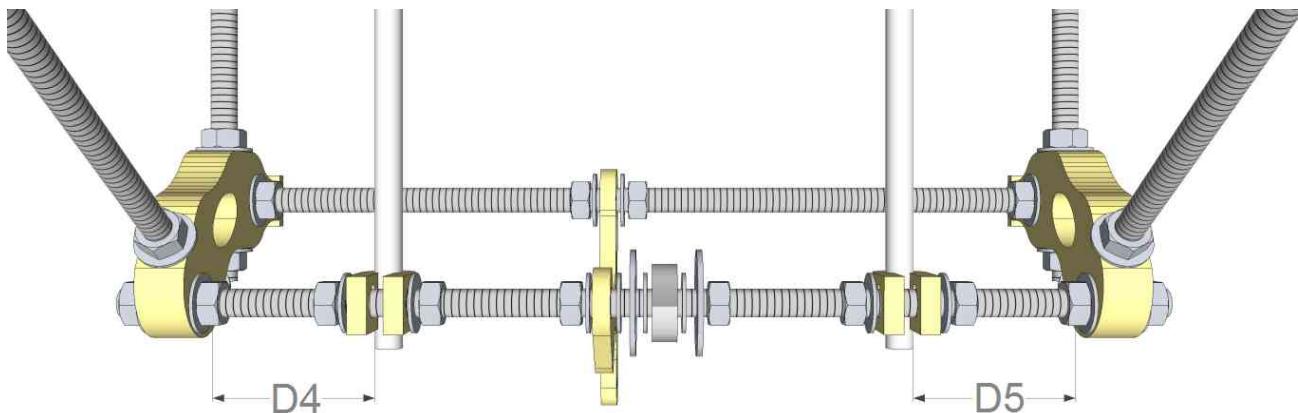
6.2

Place the narrow side of the “print bottom” plate between the rods. This ensures that they are exactly 140mm apart from each other by using the plate as a jig. Adjust the nuts on the front side bar clamps until the print bottom plate just barely fits between the rods.



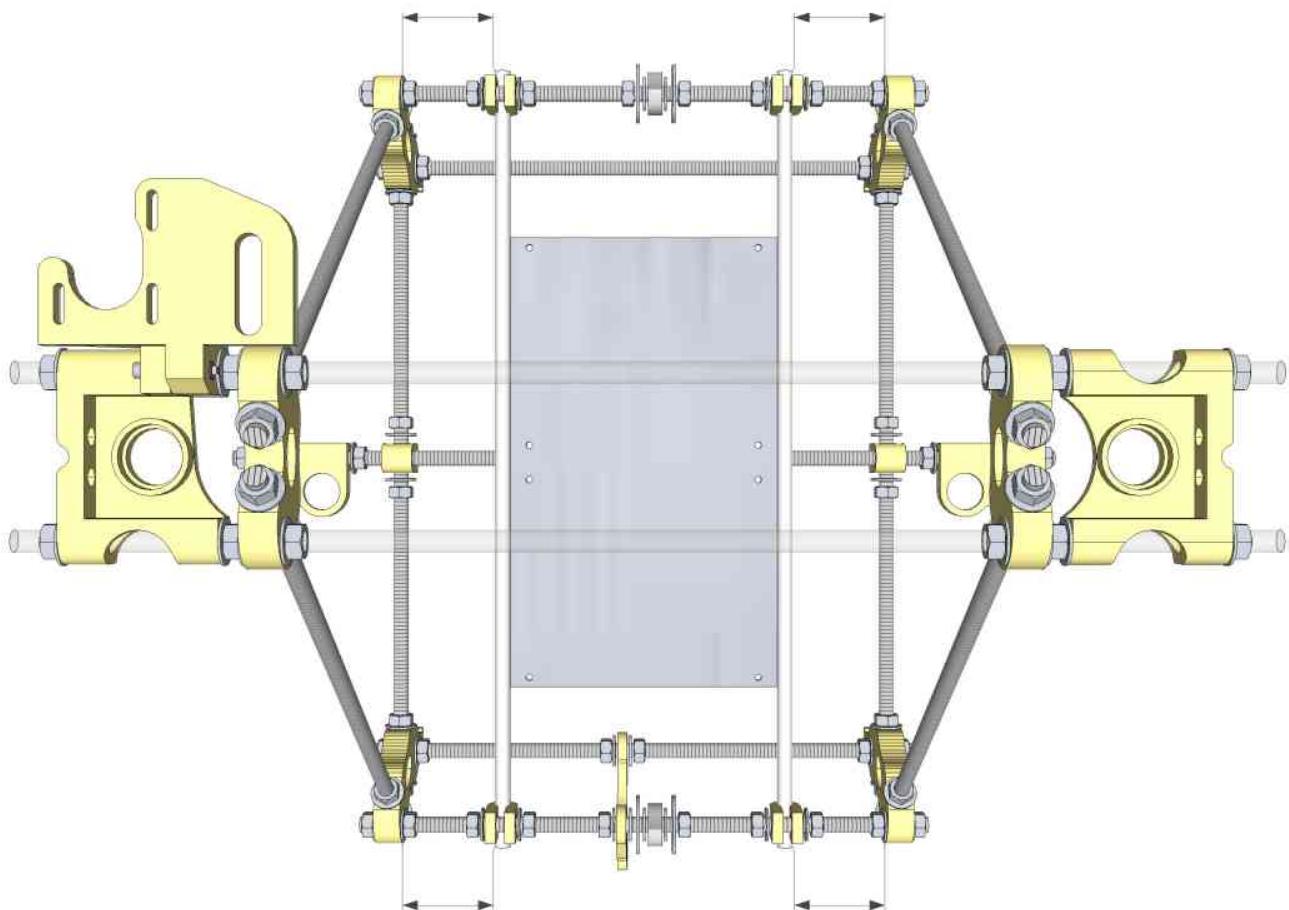
6.3

Next, ensure that the smooth rods are centered along the front threaded rod. You can easily do this by adding up the measurements of D4 and D5 before adjustment. When this sum is halved, use this value as the new value for D4 and D5. Tighten the nuts on the front bar-clamps by hand, just enough that they do not move on their own, but no further.



6.4

Adjust the rear bar clamps by using the new value for D4 and D5 that you have calculated earlier. Double check the distance between the smooth rods by using the print bottom plate to check the rear and front side again (the plate should barely fit between the rods). After you have done so, tighten the nuts on all the bar clamps, being careful not to overtighten.



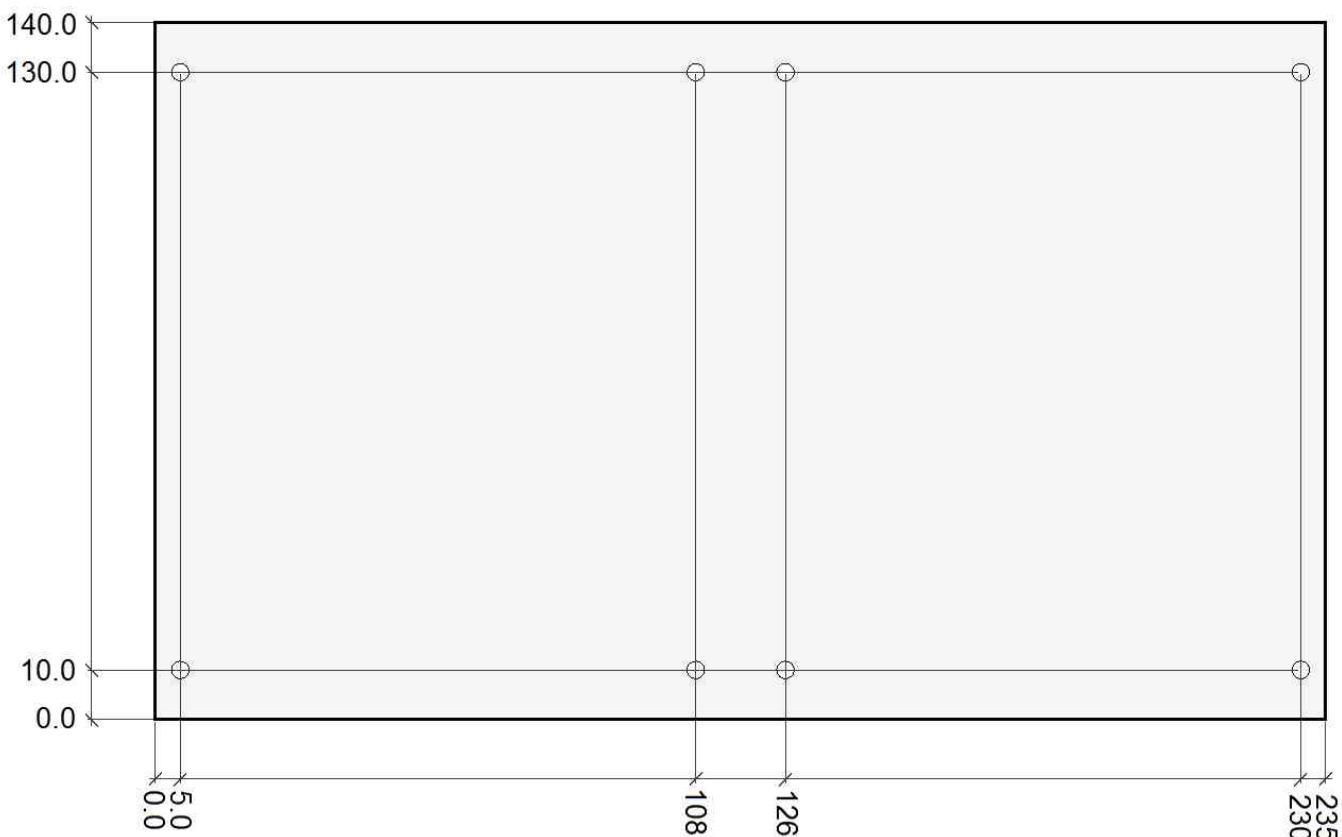
6.5

Drill the 3mm holes onto the print-bottom-plate as indicated in the drawing below. There are altogether 8 holes in total. At this point, you may choose to drill the holes that are required for the print-top-plate as well at the same time, or you may also choose to do it later. The print-top-plate has 4 holes to be drilled in total (a grand total of 12 holes for both plates). All markings for the holes should be measured based on a single datum point (or origin point) in order to minimise inaccuracies should the overall dimensions of the plate be not very precise.

If you are not familiar with datum dimensioning (as used in the drawings below), the datum point is taken to be the zero point from which all other measurements are referred from. In this case, the datum point is the bottom left corner of the print bottom plate (and print top plate). All dimensions given are measured starting from this point.

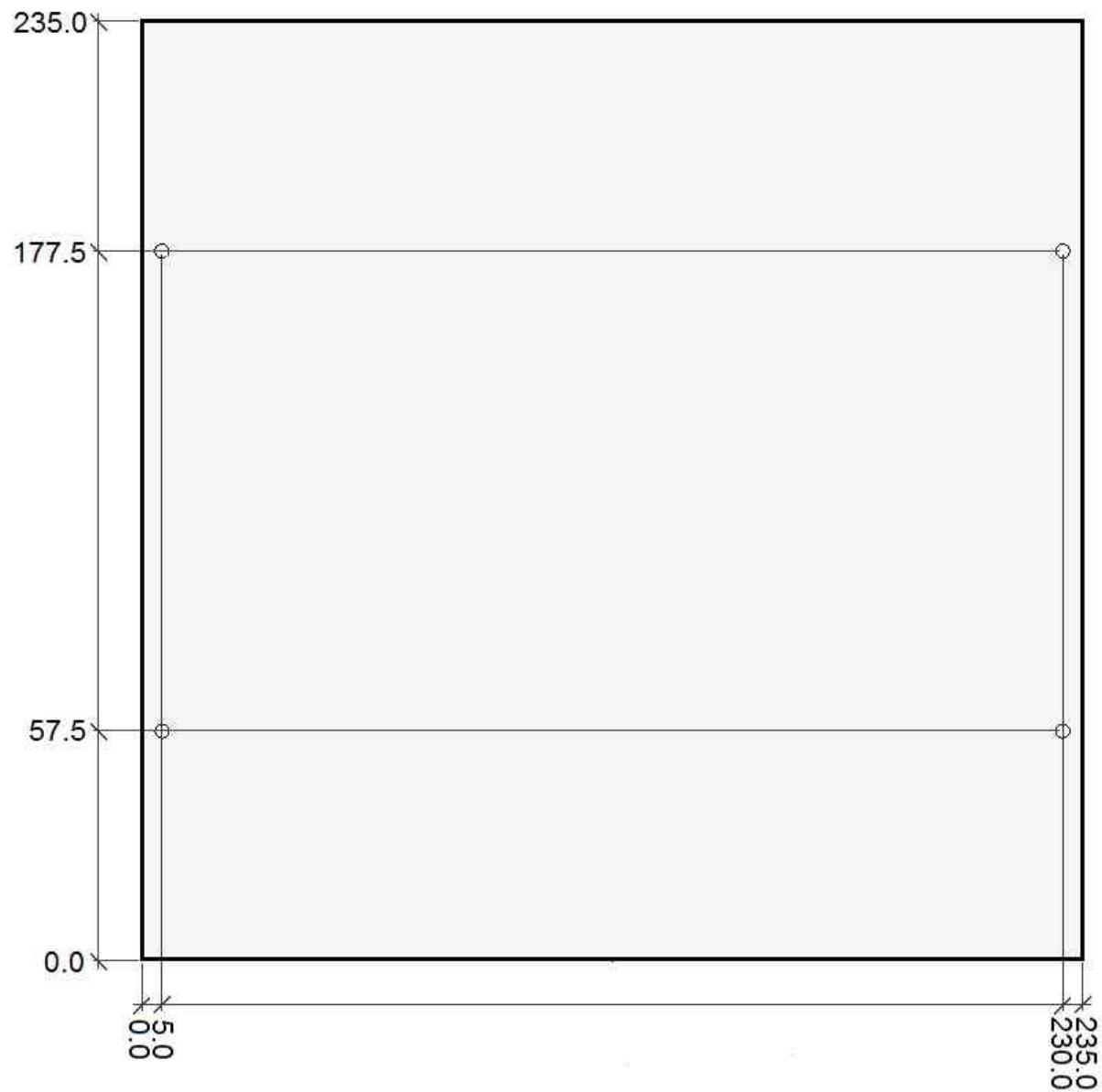
A long (12") engineer's try square is the ideal measuring tool to use.

Print-bottom-plate:



TOTAL 8 HOLES
ALL HOLES NOM. DIA. 3.0 THROUGH
ALL DIM. IN MM

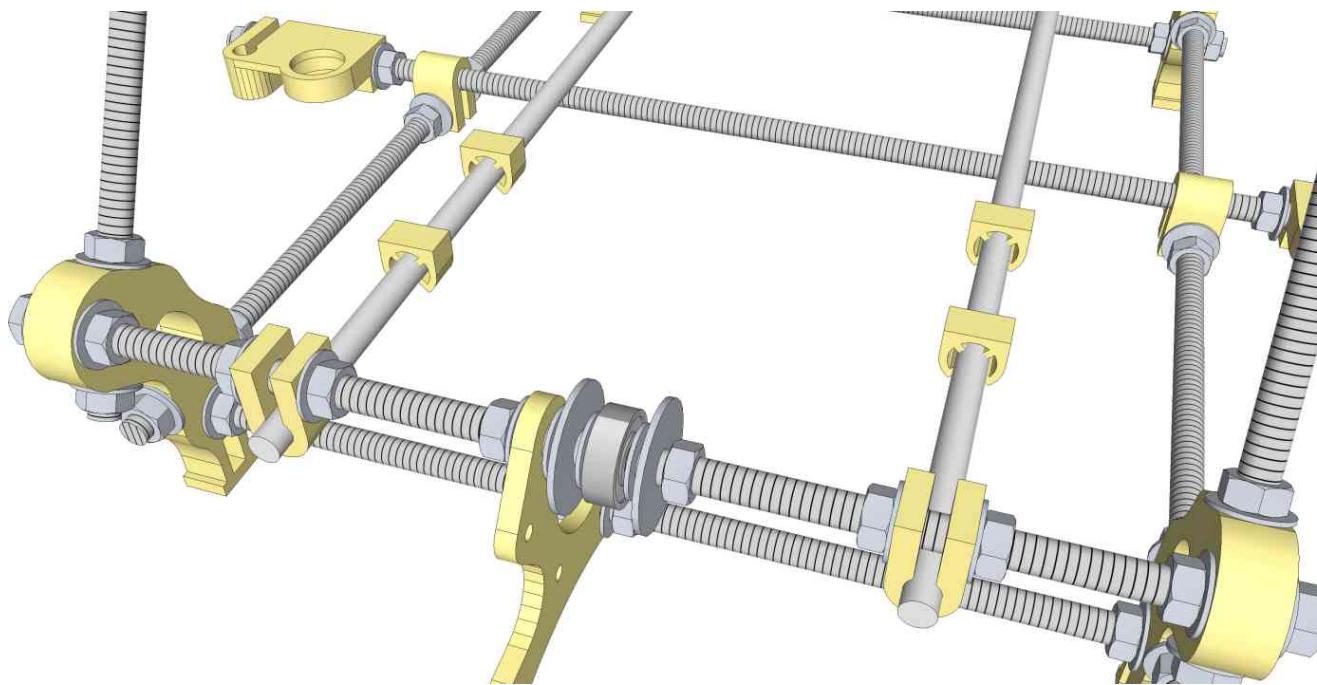
Print-top-plate:



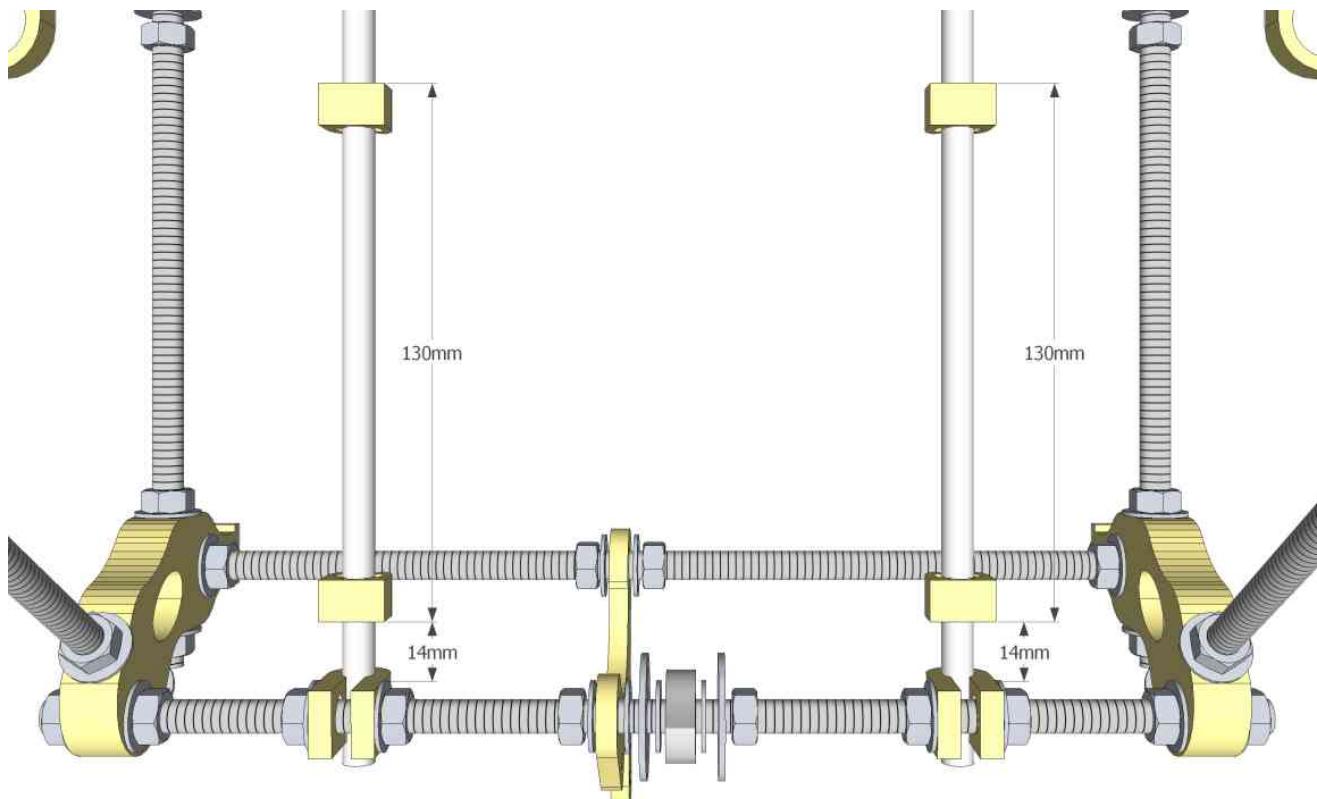
TOTAL 4 HOLES
ALL HOLES NOM. DIA. 3.0 THROUGH
ALL DIM. IN MM

6.6

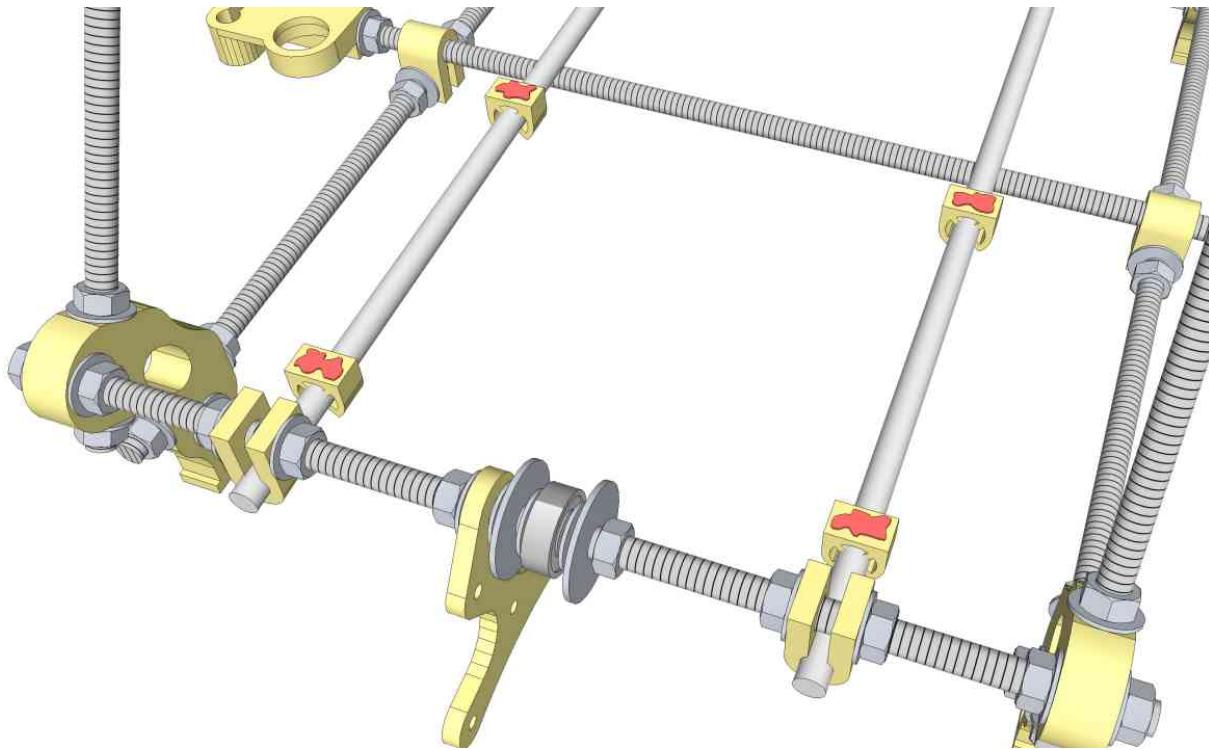
Snap 2 PLA-bushings onto each of the two smooth rods. Make sure they can slide freely on the rods.



Position the two front bushings to be 14mm away from the bar-clamp holding the smooth rod. The other two rear bushings should each be about 130mm apart from the front ones, measured from the outer edge of the bushings (refer to the drawing).

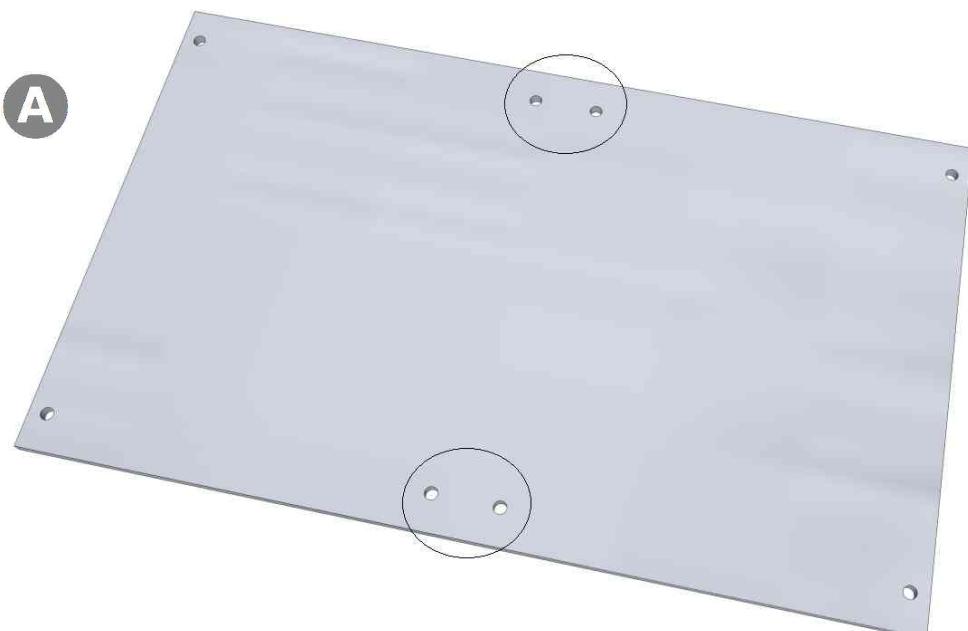


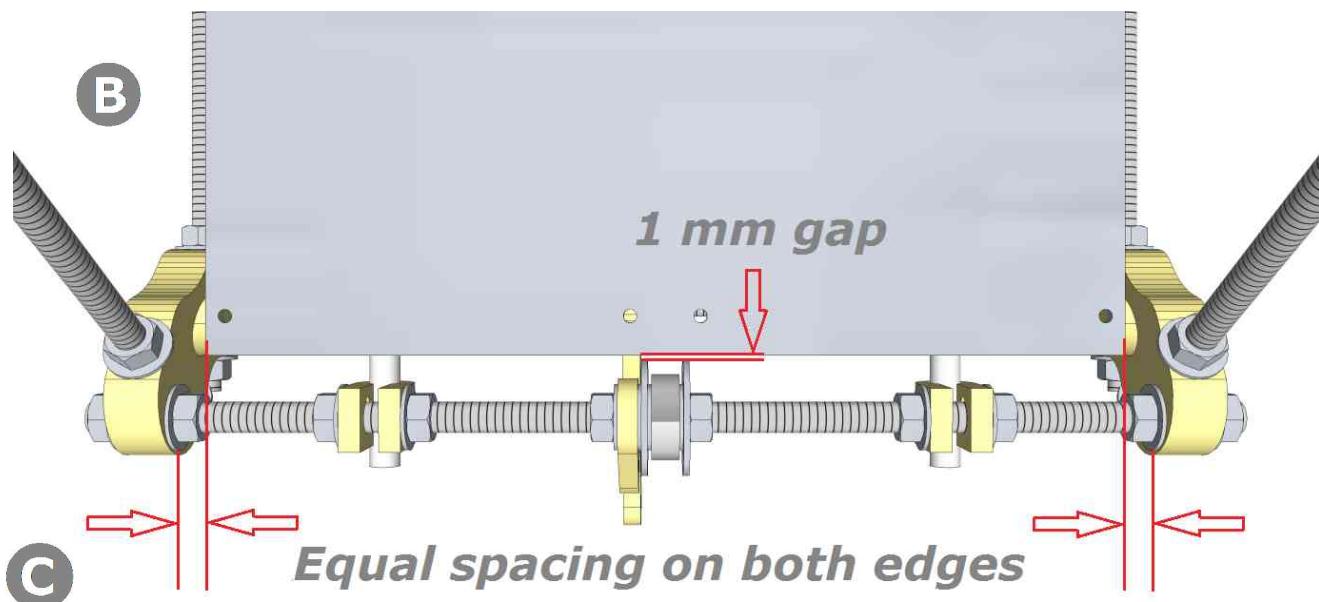
Put a dab of glue on the top side of the four bushings (the side opposite the open side).



Carefully place the print-bottom-plate on top of the bushings, taking note of the alignment:

- on the print-bottom-plate, there are two closely spaced holes located on the centre of each of the long sides near the edge – these holes are for the belt-clamps. Either one of these two sides must face the front. Refer to (A) below.
- the front edge of the print-bottom-plate should almost touch the two big washers on the front rod (but should not touch them – leave approximately 1mm gap) and should be parallel with the front rod. Refer to (B) on following page.
- the print-bottom-plate should be centred between the two front vertices. Refer to (C) on following page.

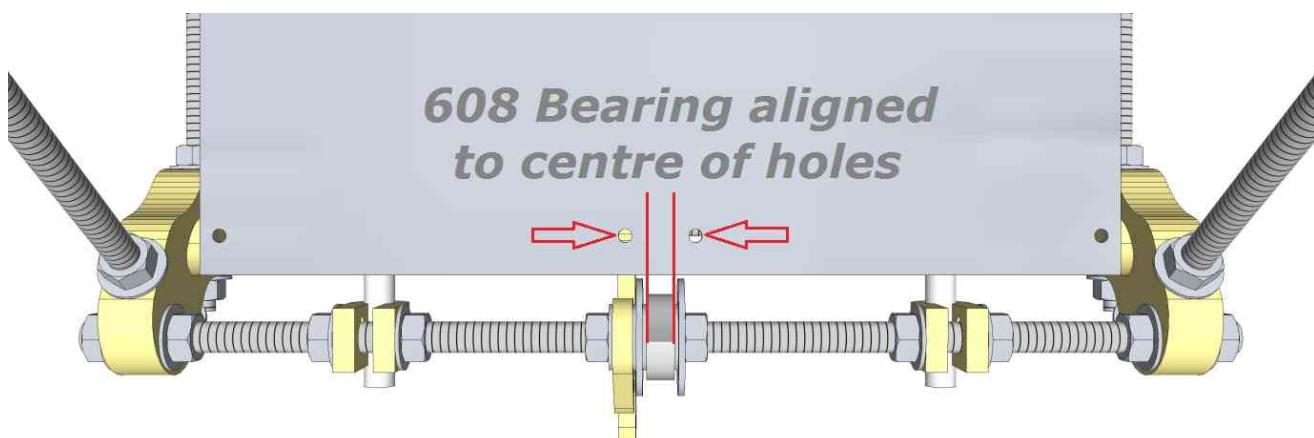




Take care not to move the print-bottom-plate before the glue has dried and hardened (refer to the usage instructions for the particular glue used).

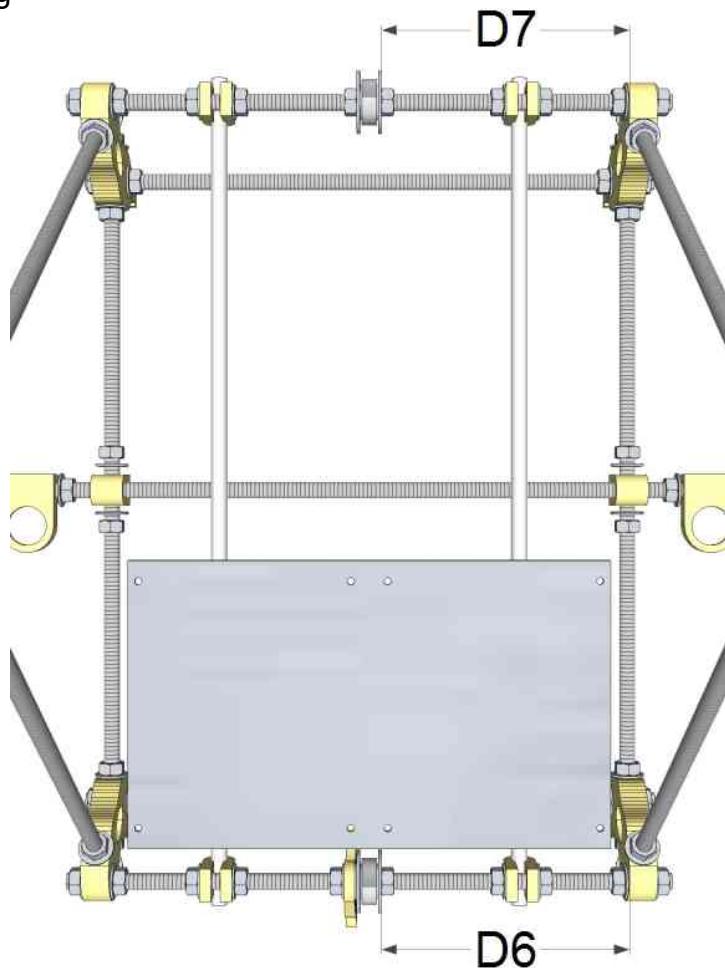
6.7

While the glue is drying, adjust the nuts that hold the y-motor-bracket and the 608 bearing so that the bearing is in the centre of the two smooth rods. You can do this by aligning the bearing to be in the centre in between the two closely spaced holes on the print bottom plate. Tighten the nuts holding the y-motor-bracket and the bearing.



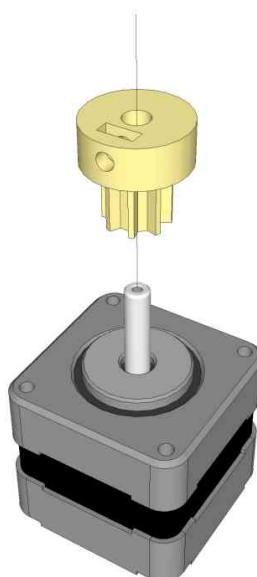
6.8

Adjust the bearing on the rear threaded rod until it is exactly across from the front threaded rod. You can measure distance D6 and use the measurement to adjust distance D7 so that they are equal. Tighten the nuts on the bearings. All the nuts on the front and rear threaded rods should now be tight



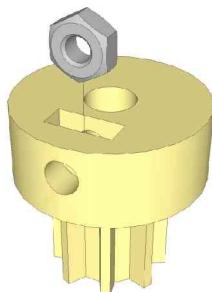
6.9

Ensure that the hole in the centre of the motor-pulley matches your motor shaft – it should slide on and fit very snugly. If it is too tight, carefully drill or file the hole. Repeat this with the two remaining pulleys, for use later.



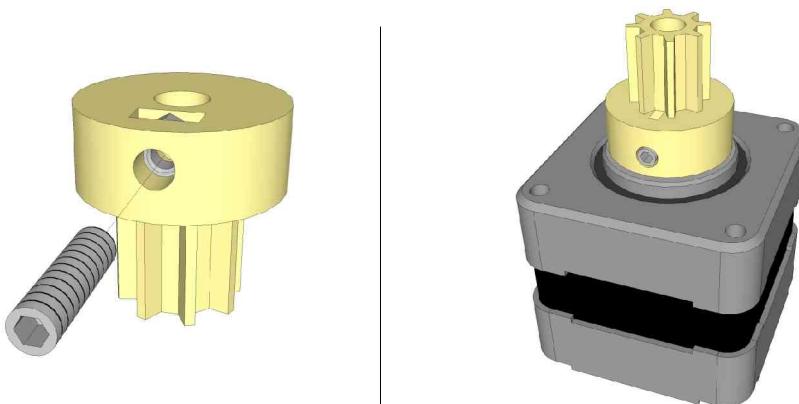
6.10

Insert an M3 nut into the rectangular slot on the bottom of the pulley. You may need to widen the slot slightly to do this. Make sure that the centre of the nut is aligned with the channel in the pulley that goes to the centre hole.



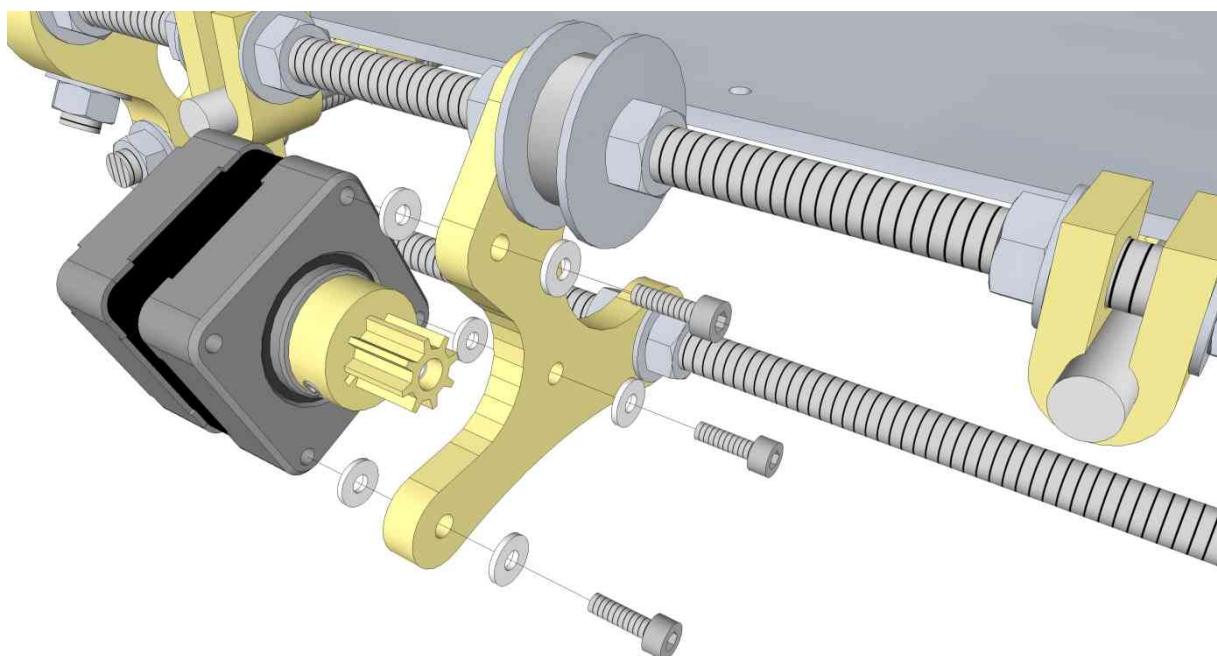
6.11

Insert an M3 grub screw into the channel on the rim of the hub, screwing it through the M3 nut until you see the end of the screw inside the centre hole. Then unscrew it enough to slide the pulley onto the motor shaft.



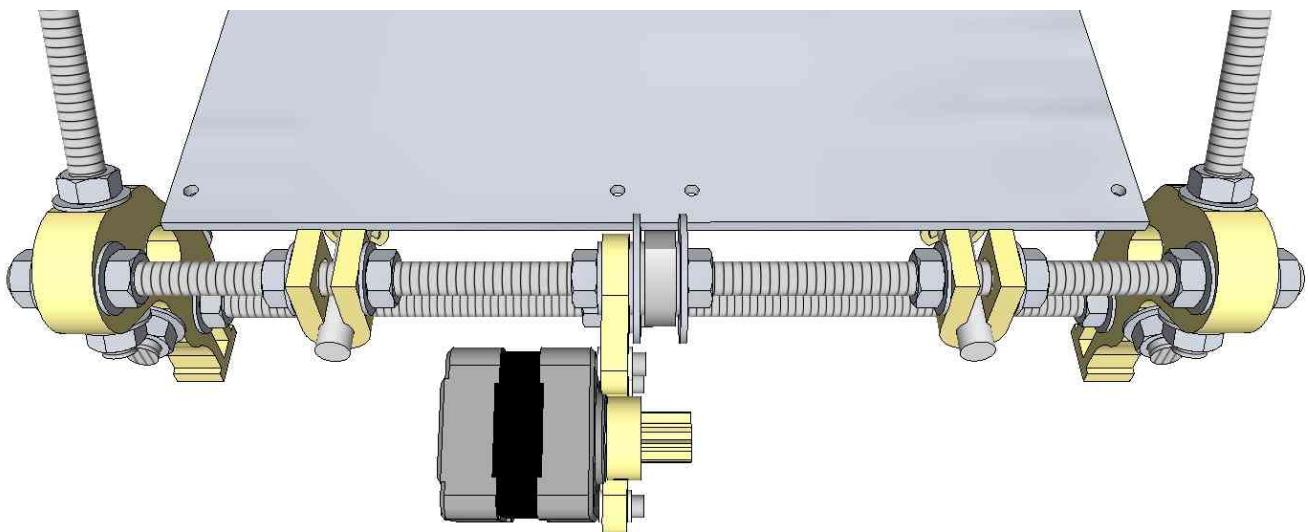
6.12

Fasten the motor with the pulley on it to the y-motor-bracket using three M3x10 bolts. Put a nylon washer between each bolt and the y-motor-bracket, as well as between the y-motor-bracket and the motor. Make sure of the orientation – the motor should be on the left, so that the pulley is on the right side of the y-motor-bracket where the bearing is.



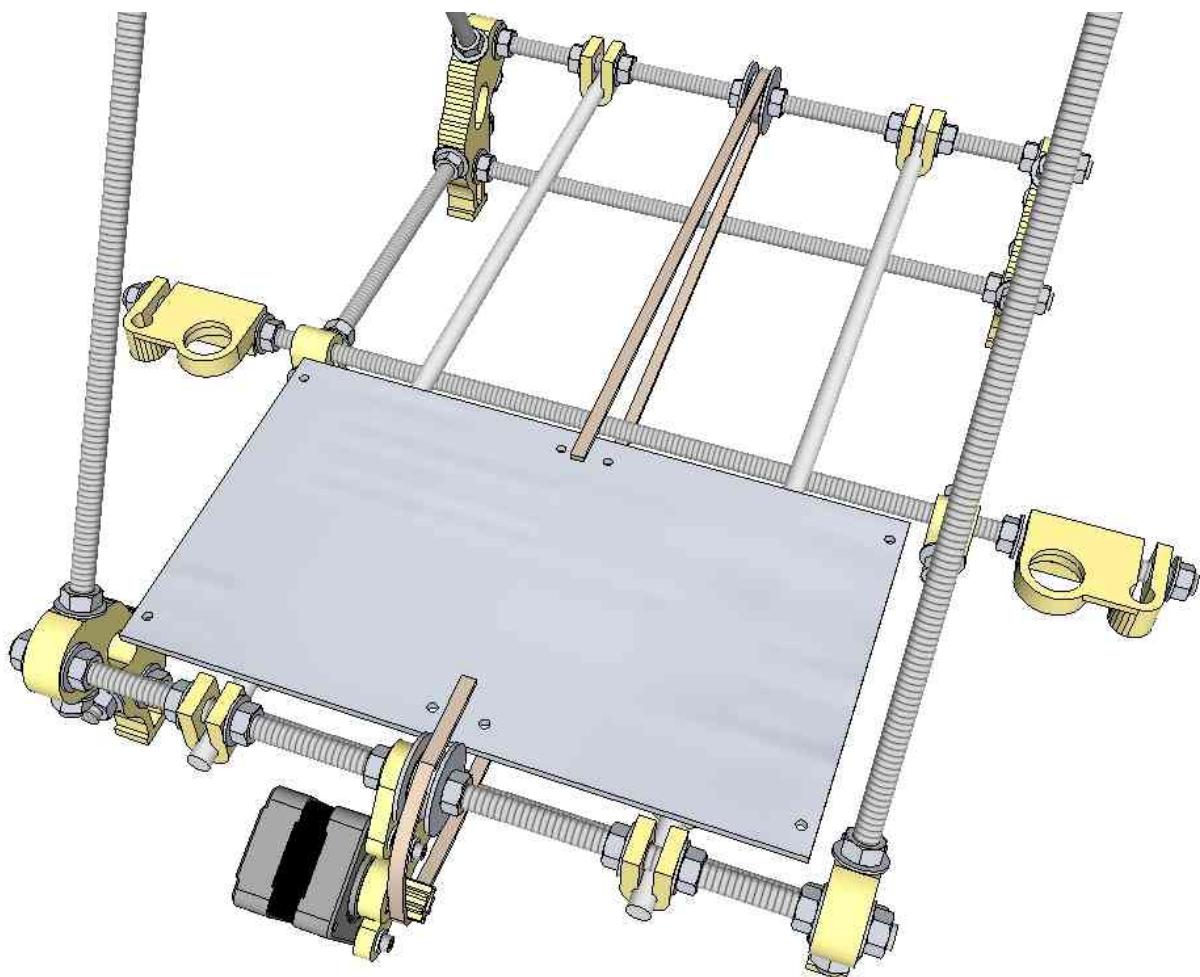
6.13

Adjust the pulley position on the shaft so that the teeth of the pulley are at the position of the bearing. Tighten the grub screw so that the pulley cannot move along the shaft.



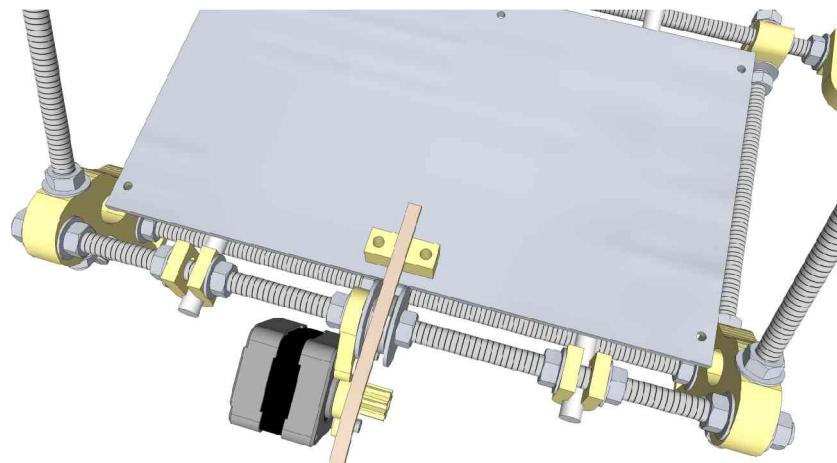
6.14

Position the y belt (840mm) on top of the print-bottom-plate through both the bearings. Pull lightly on both ends so that it is straight. If the position of the belt is not between the two belt-clamp holes on each respective edge of the print bottom plate, adjust the position of the bearings until it is.

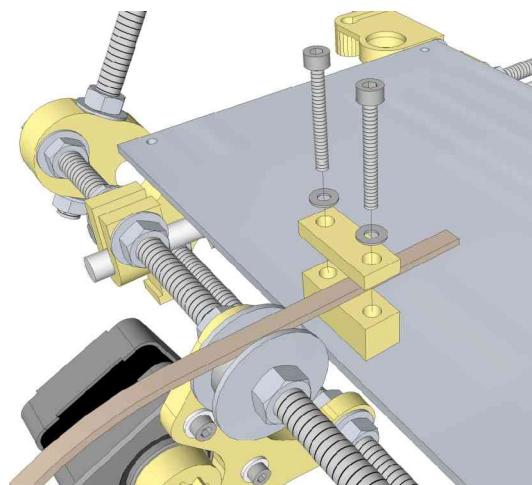


6.15

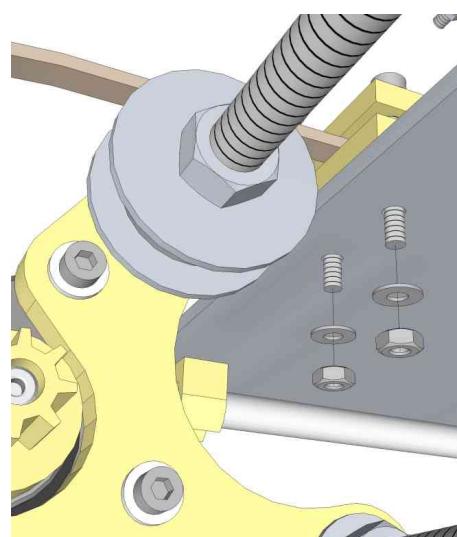
After the glue has dried and hardened, place a belt-riser where the holes for the front belt-clamp are. Place one end of the belt, toothed side down, on top of the belt-riser.



Put a washer onto each of two M3x25 bolts, and thread them through the two holes in one of the belt-clamps. Attach the clamp to the top of the belt-riser through to the underside of the print-bottom-plate, clamping down the belt. Leave several centimetres of the belt behind the clamp.

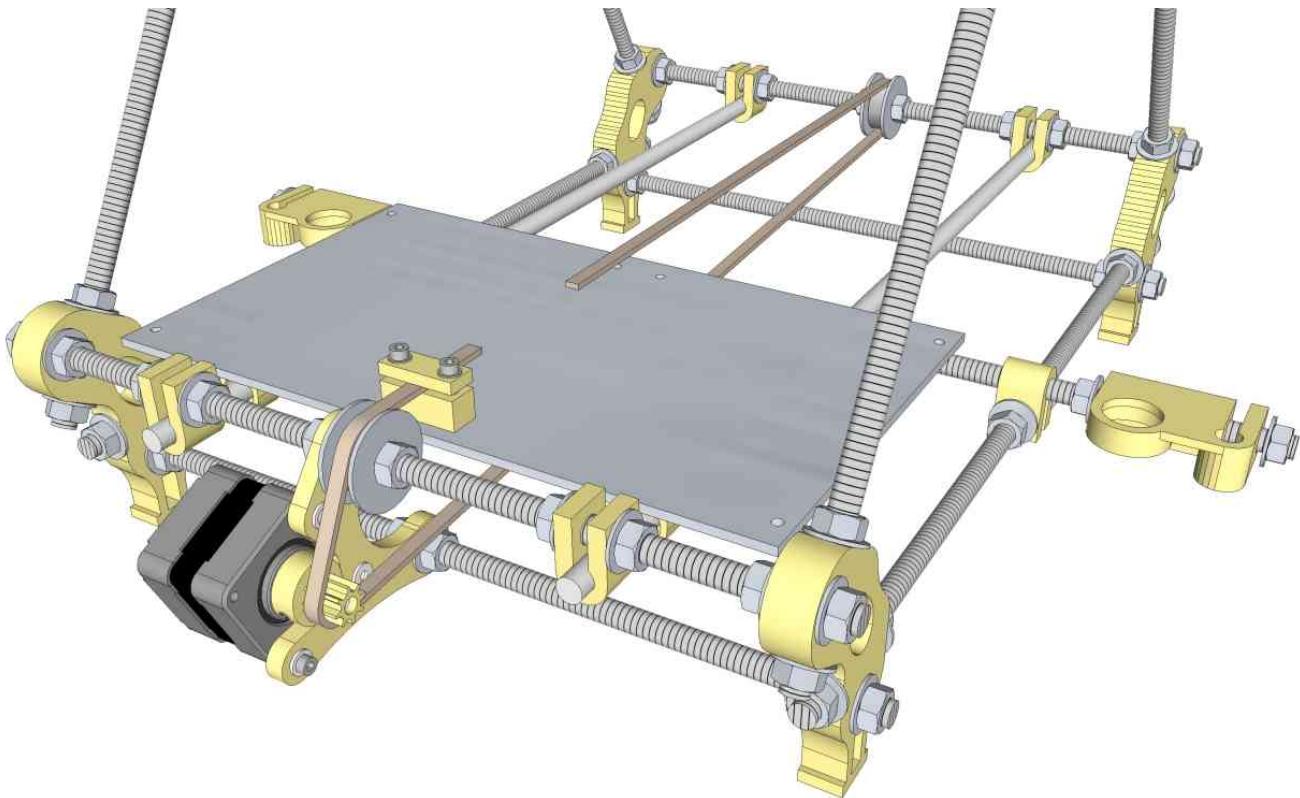


Put one M3 washer and one M3 nut onto each bolt from underneath the plate. Tighten both nuts so that the end of the belt is firmly attached, toothed side down.



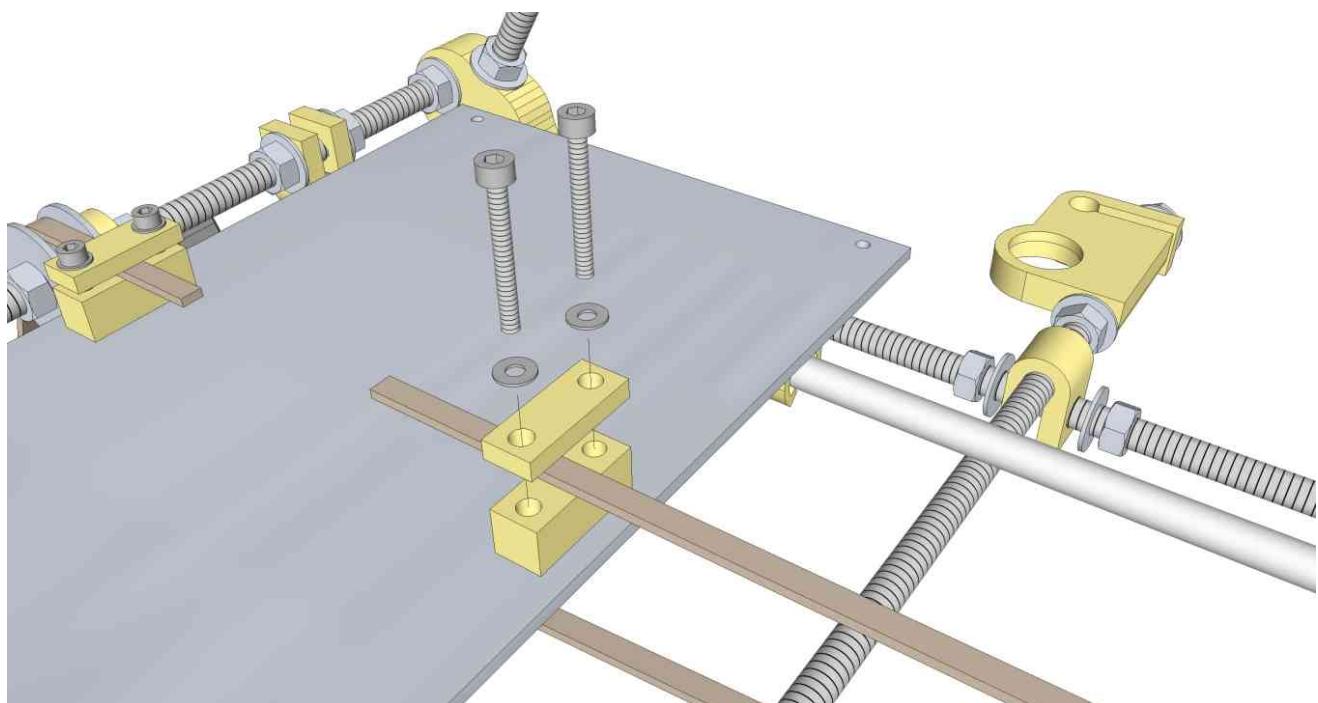
6.16

Pass the belt over the front bearing, around the motor-pulley, and then up underneath the plate over the rear bearing. Make sure that the belt is above the centre threaded rod when passing it through underneath the plate. Pull it tight, then lay it on top of the plate, toothed side down.



6.17

Place a belt-riser where the holes for the rear belt-clamp are. Put a washer onto each of two M3x25 bolts, and thread them through the two holes in the second belt-clamp. Attach the clamp to the top of the belt-riser through to the underside of the print-bottom-plate, clamping down the belt.



6.18

Put one M3 washer and one M3 nut onto each bolt from underneath the plate. Pull the belt tight, then tighten both nuts.

6.19

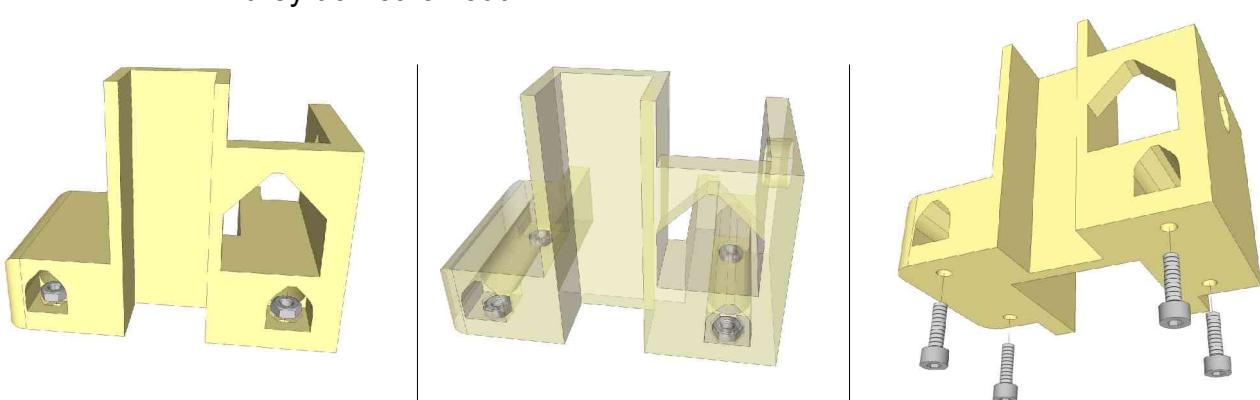
Turn the motor by hand. It should turn with little effort, and each slight rotation should be matched by a slight movement of the plate. Make sure it slides smoothly along the entire length of the rods. Pushing the plate should immediately make the motor turn. Make sure the belt is not too loose (plate 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 firmly. You may now trim the belt, but leave several centimeters behind each clamp for future adjustment.

Part 7

Assembling the X axis

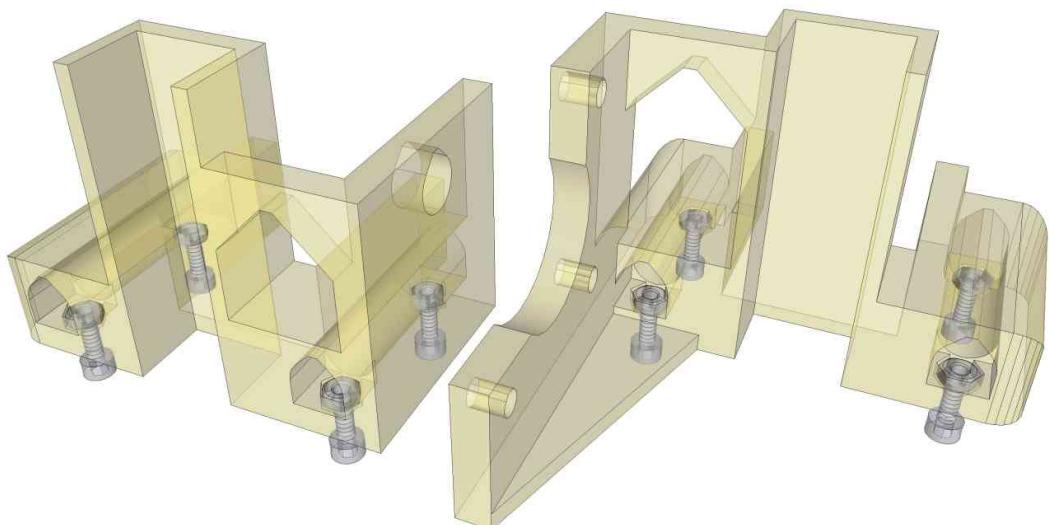
7.1

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.



7.2

Place 4 M3 nuts in the nut traps of the x-end-motor part as well. Thread M3x10 bolts through those as above.



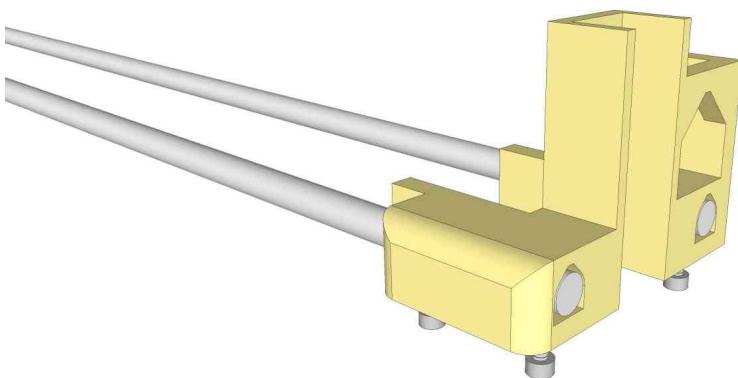
7.3

Place the x-end-motor and x-end-idler 50cm apart, so that the two “pointy” parts are facing each other.



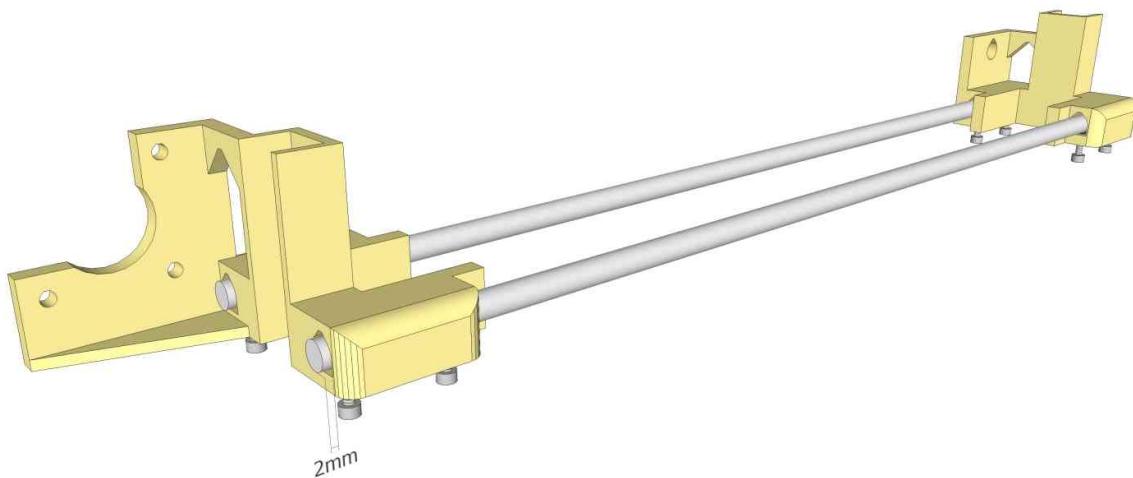
7.4

Slide the two 420mm smooth rods into the x-end-idler. Make sure they go past the nut traps.



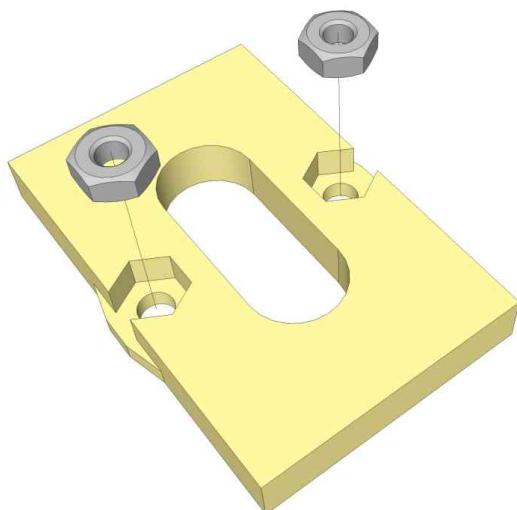
7.5

Slide the other ends of the rods into the x-end-motor. Make sure they go past the nut traps. Also ensure that they do not protrude more than 3mm beyond the outside holes. The “pointy” parts should still be facing each other. Tighten the M3 bolts on the x-end-motor and x-end-idler so that they are unable to slide along the smooth rods.



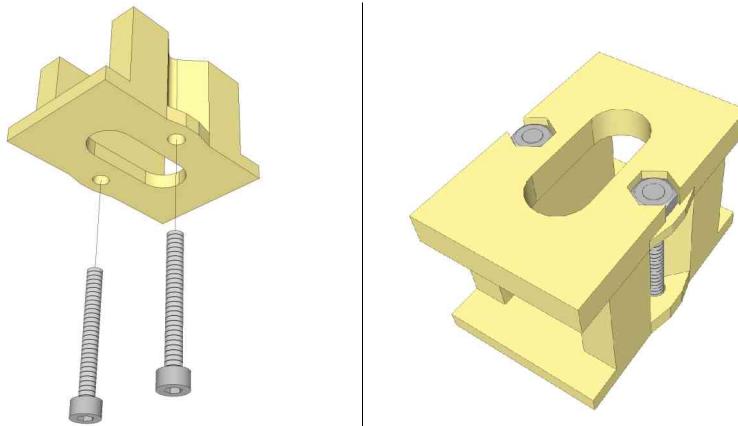
7.6

Take one slide-coupling-cover and insert two M3 nuts into the nut trap.



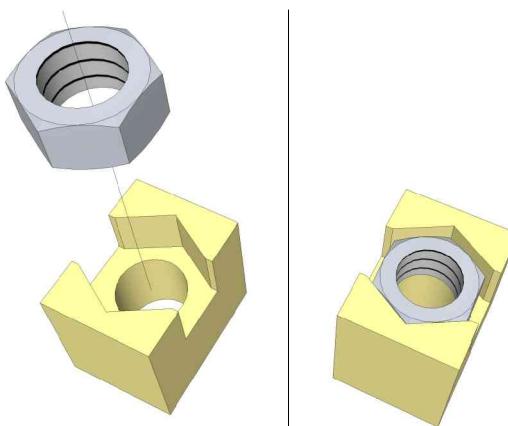
7.7

Take two M3x25 bolts and thread them through the two holes on the underside of one slide-coupling-base, then through the holes on the slide-coupling-cover and finally into the M3 nuts. Tighten both bolts.



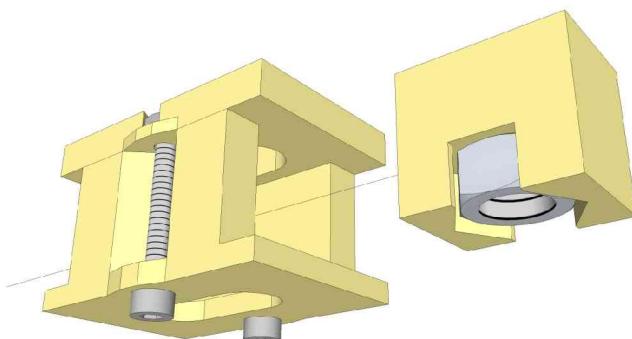
7.8

Take an M8 nut and insert it into the nut trap of one slide-coupling-block. The nut should fit snugly. You may need to clean out the inside faces of the nut trap if it is too tight to fit the nut in.



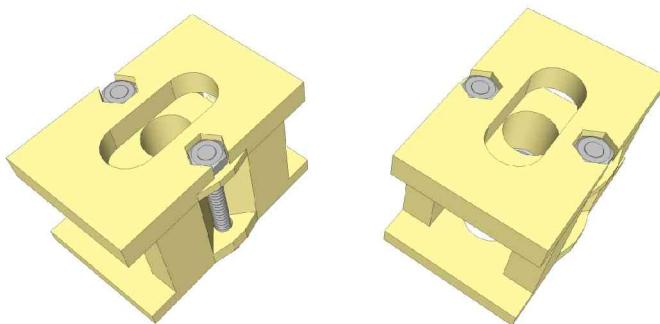
7.9

Slide the slide-coupling-block into the opening of either end of the slide-coupling-base. Note the orientation: the M8 nut should face the slide-coupling-base. It should be able to slide in and out very smoothly with no effort. You may need to clean out the internal mating faces of all the parts if it is too tight, but be careful not to remove too much plastic – the fit should not be too loose and there should not be excessive wobble/freeplay. This is important, so take as much time as you need.



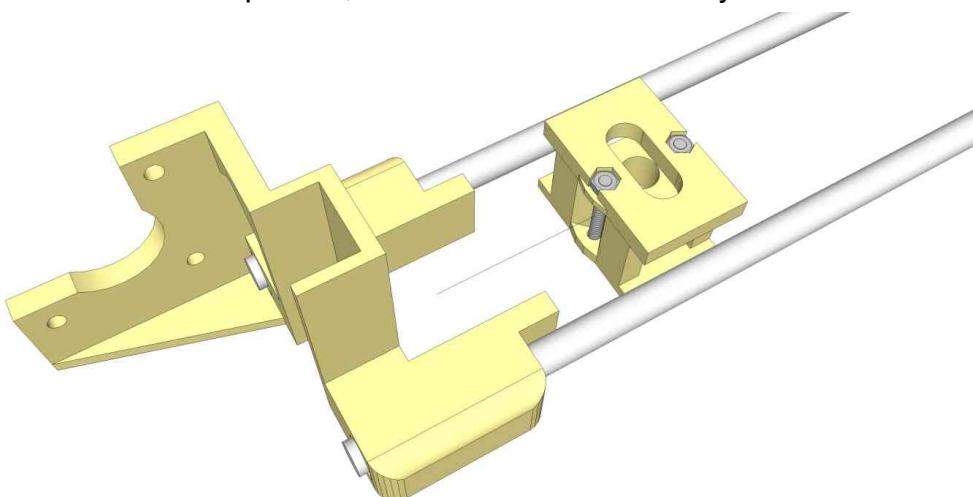
7.10

Repeat steps 7.6 through 7.9 with the other set of slide-coupling-base, slide-coupling-cover and slide-coupling-block.



7.11

Take one assembled slide coupling and slide it into the opening of the x-end motor between the smooth rods (the opening between the “pointy” ends). Note the orientation: the slide-coupling-cover should face the top. The assembled slide coupling should be able to slide in and out smoothly and without much wobble or freeplay. If it is not able to slide smoothly, carefully clean out the mating faces on all parts (including the x-end-motor). Be careful not to remove too much plastic – there should not be excessive wobble/freeplay when sliding the slide coupling in and out of the opening. This is important, so take as much time as you need.



7.12

Repeat the above step with the x-end-idler and the other assembled slide coupling. After that you can remove both the assembled slide couplings from the x-end-motor and x-end-idler for now.

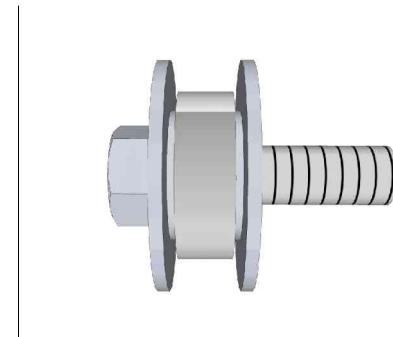
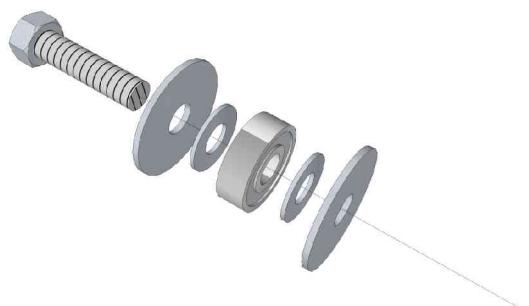


7.13

Loosen the four M3 bolts on the x-end-idler but do not remove them. The x-end-idler should be able slide freely on the smooth rods with minor effort. Do not loosen the bolts on the x-end-motor.

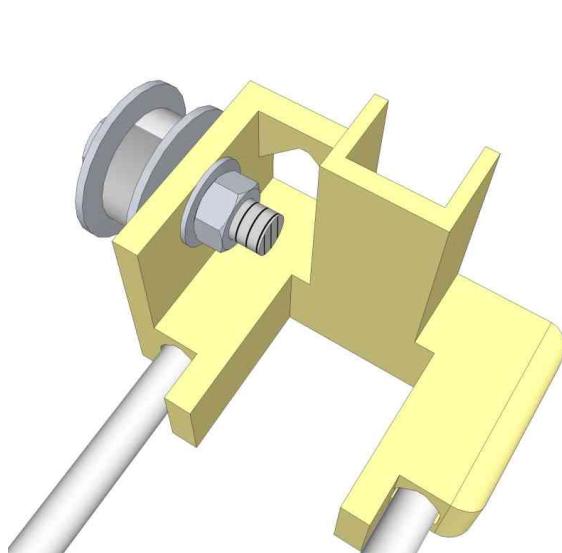
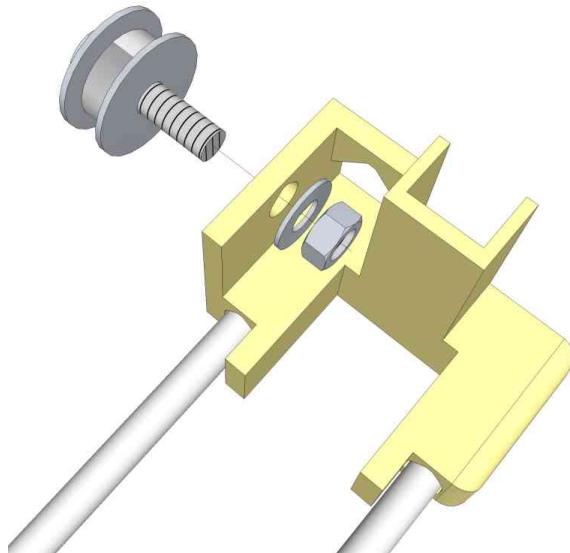
7.14

Take an M8x30 bolt and insert the following in this order:
1 large washer – 1 washer – 1 608 bearing – 1 washer – 1 large washer



7.15

Insert the free end of the bolt into the side of the x-end-idler. The bearing should be on the outside. Put an M8 washer followed by a nut on the inside and tighten everything together.

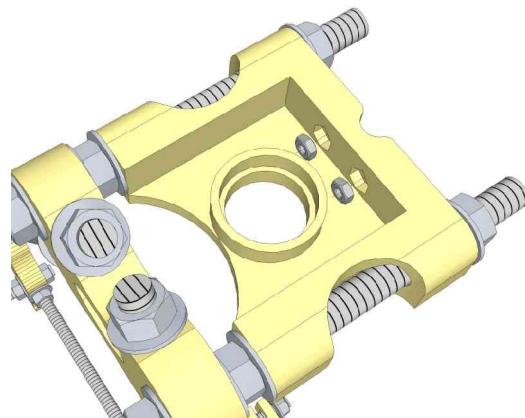
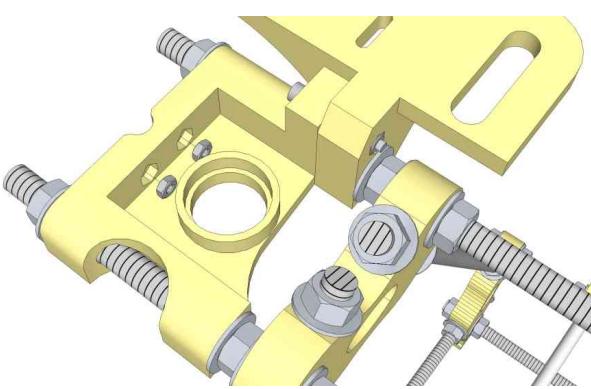


Part 8

Assembling the Z axis

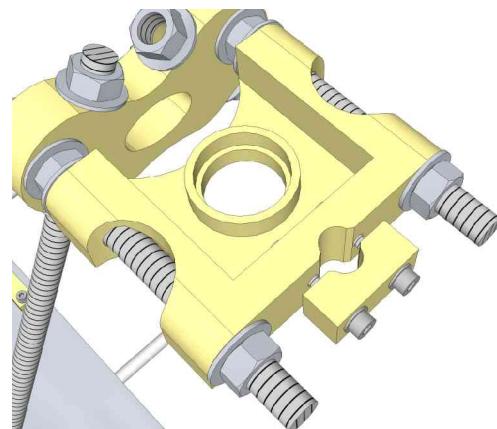
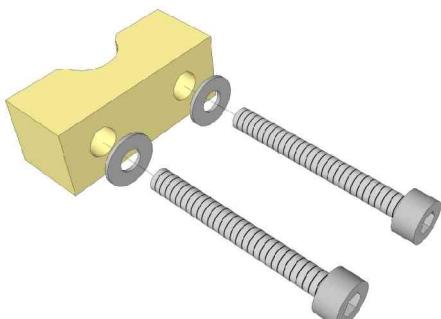
8.1

Put M3 nuts into the nut traps on both the top-left and top-right-bearing-holders. There are two nut traps on each of the parts.



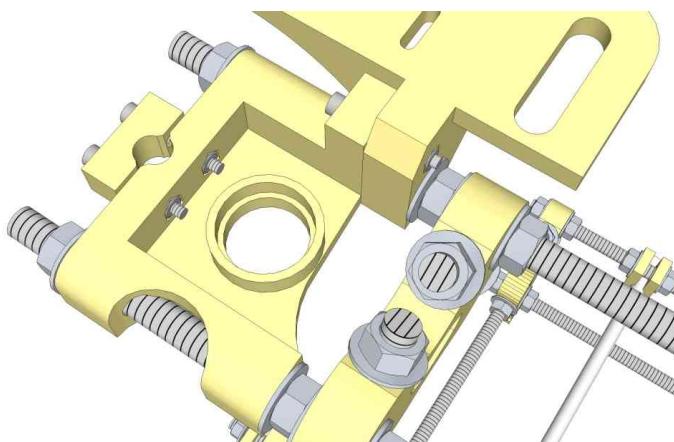
8.2

Put an M3 washer each on two M3x25 bolts and insert them through the flat (non-indented) end of a rod-clamp. Attach the rod-clamp to the top-right-bearing-holder. Do not tighten.



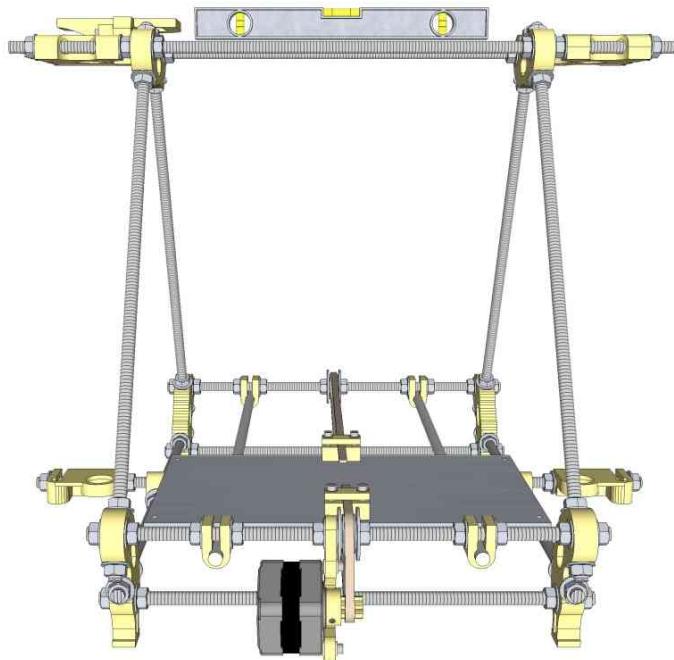
8.3

Repeat the step above for the other side.



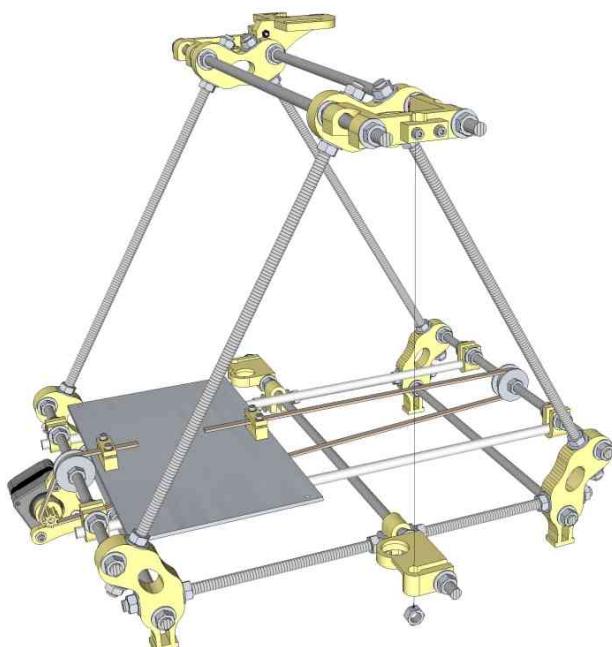
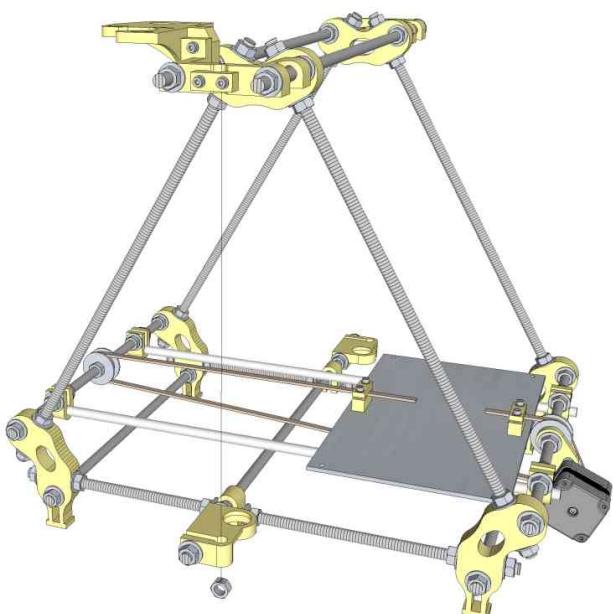
8.4

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. Once the frame has been levelled, do not move it until you have reached the end of Step 8.8 below, or you will have to redo the levelling.



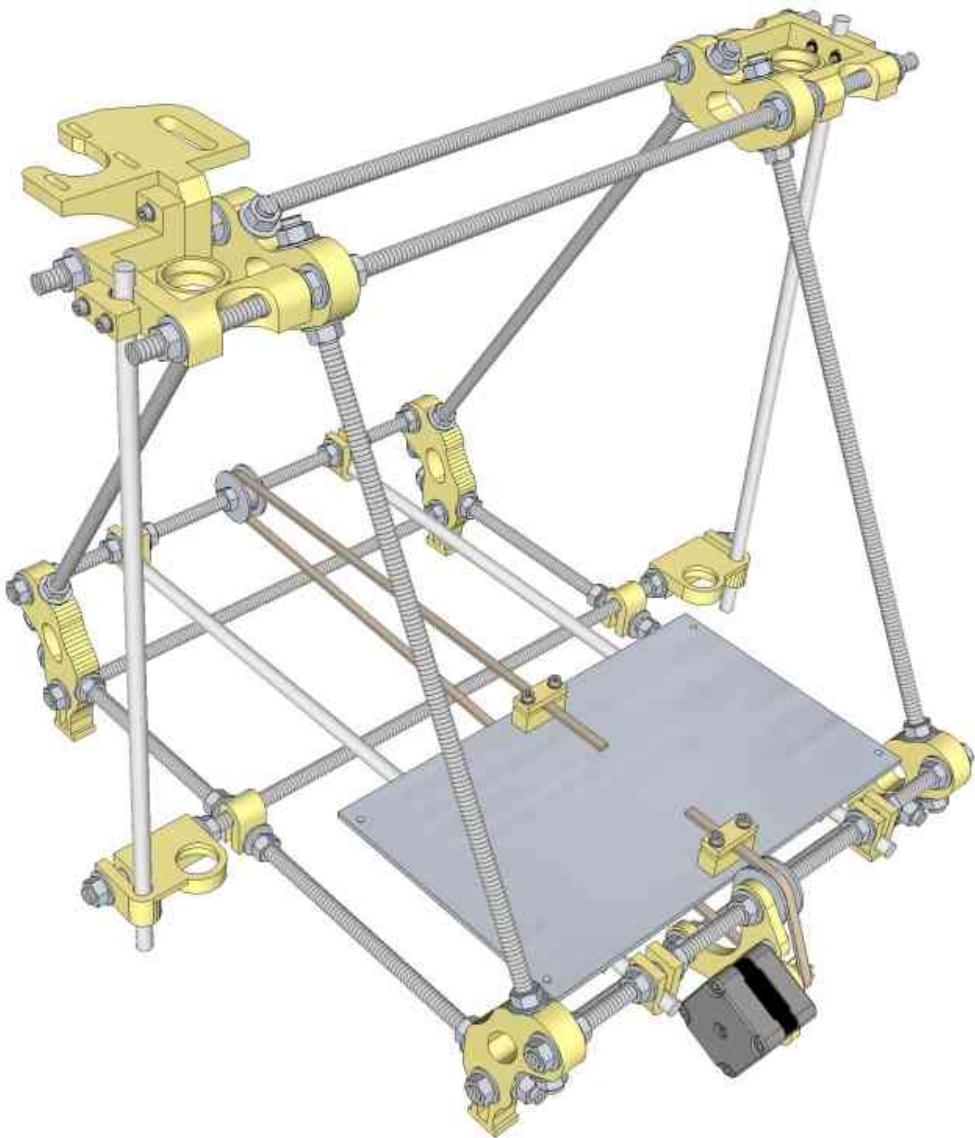
8.5

Drop a plumb line (or a nut tied to a string) directly down from the indentation on the side of the top-left-bearing-holder. Adjust the bar clamp and the bottom-left-bearing-holder at the bottom of the frame on the left side until the string is in the “U” of the bottom-left-bearing-holder. Remember not to move the frame, or you will have to redo the levelling by referring to the previous step. Repeat from the beginning of this step on the other side.



8.6

Insert a 350mm smooth rod into the space between each top-bearing-holder and rod-clamp. On the bottom, insert it into the “U” of each corresponding bottom-bearing-holder.



8.7

Using a plumb line (or a nut tied to a string), check that the smooth rods are perfectly vertical. If they are not, adjust the bottom bar-clamps until they are. This is critical, so take as much time as you need.

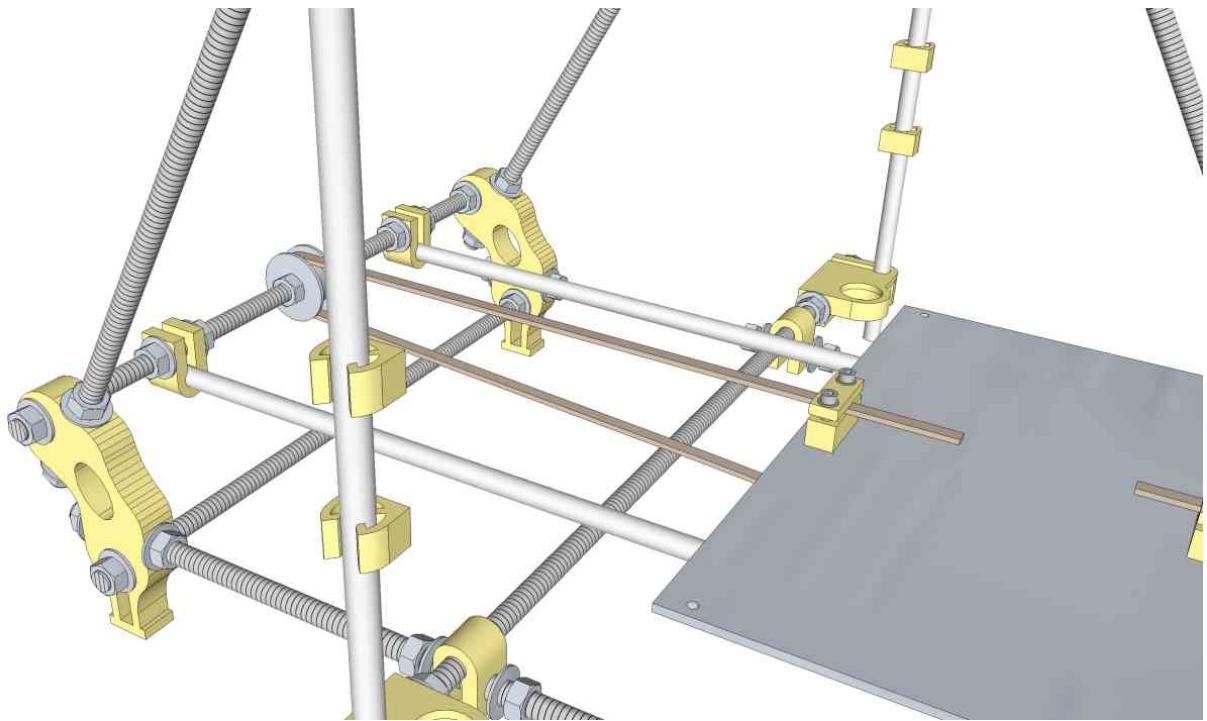
8.8

Tighten the nuts on the bar-clamps, both bottom-bearing-holders and both top rod-clamps. Be careful not to overtighten the nuts, especially on the bottom-bearing-holders – tighten so that the rod is unable to move but no further. Check again with the plumb line that the smooth rods are perfectly vertical.

After completing the steps above, you may now move the frame as required for the following steps.

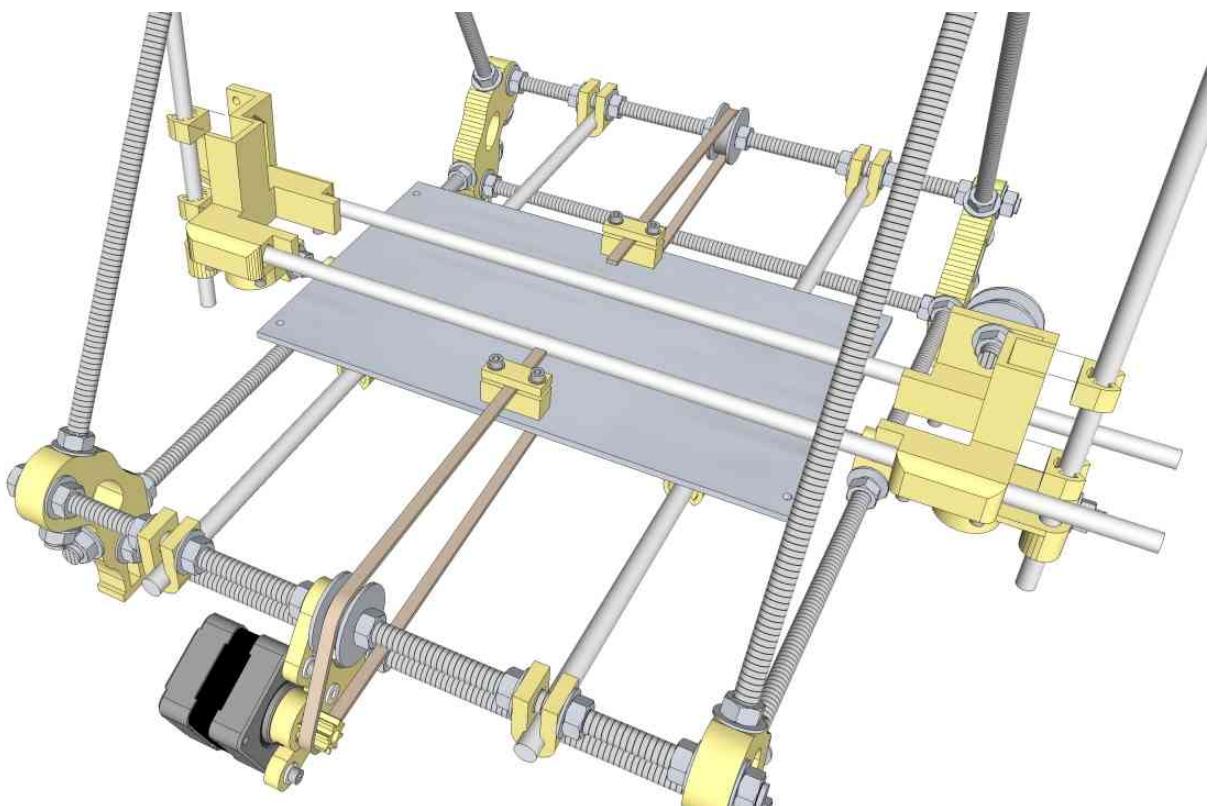
8.9

Place two PLA-bushings on each of the smooth rods. Make sure they slide freely.



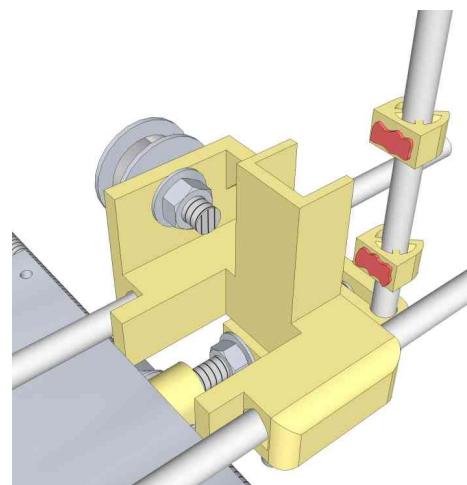
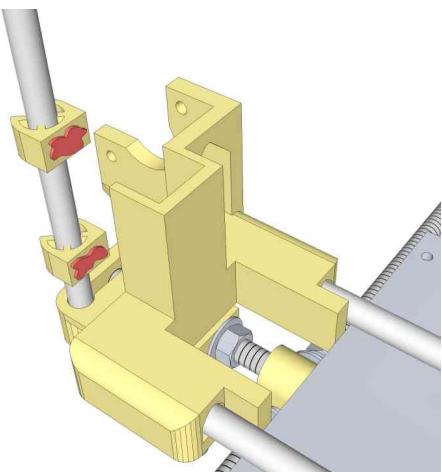
8.10

Position the assembled x axis (from Part 7) inside the frame so that the bushing channels on the x-end-motor and x-end-idler align with the bushings. The x-end-idler should be on the right, with the bearing on the rear side of the frame.



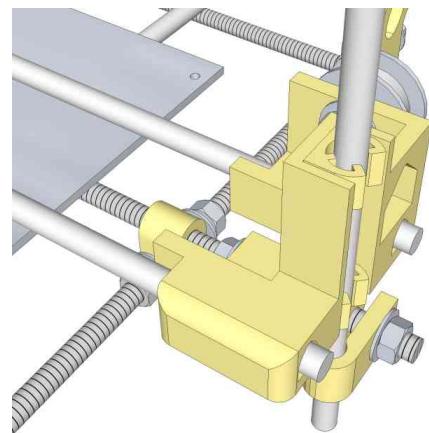
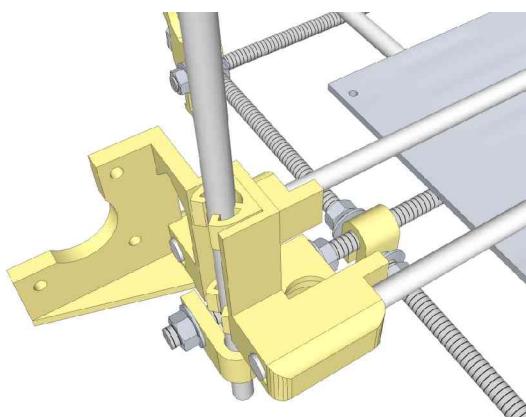
8.11

Put a dab of glue on the flat side of each bushing.



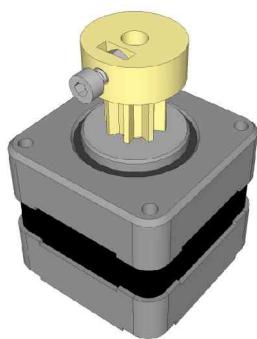
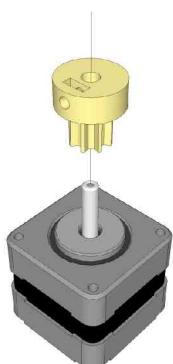
8.12

Push the rectangular channel of the x-end-motor and against the flat of the bushings on the left side. Slide the x-end-idler along the smooth rods until the rectangular channel meets the flat of the bushings on the right side. Check that the glue on the bushings have made good contact with both the x-end-motor and x-end-idler. Let the glue dry.



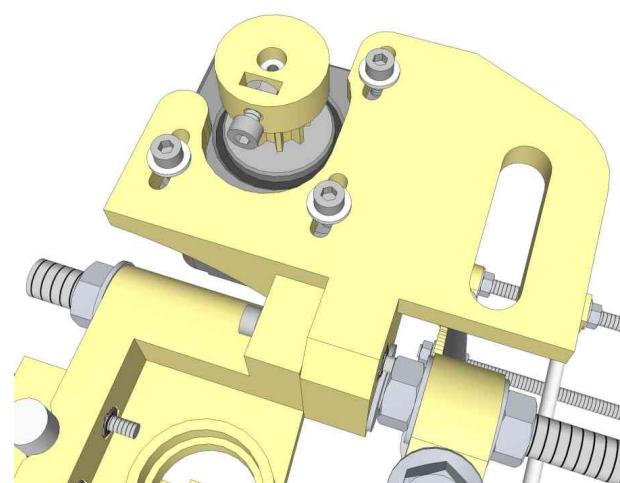
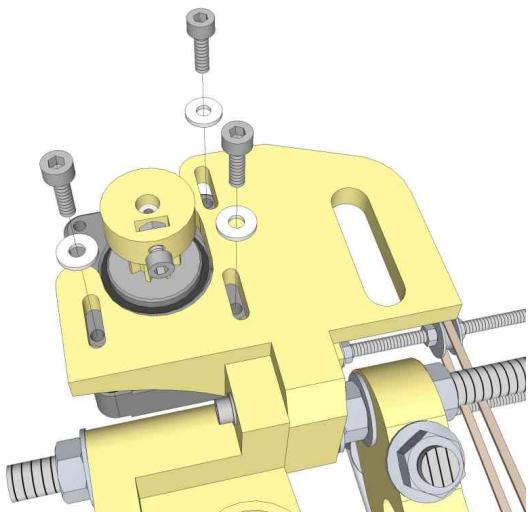
8.13

While the glue is drying, fasten a motor-pulley onto the motor that is to be used on the z axis. You can refer back to Part 6, steps 6.9 through 6.11, but this time, mount the pulley upside down – slide the pulley onto the motor shaft so that the pulley rim comes onto the shaft last. Leave a gap of about 1mm between the pulley and the motor body, then tighten the grub screw.



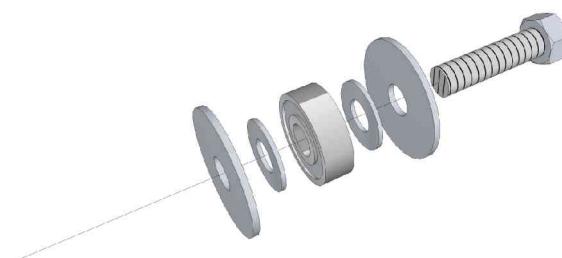
8.14

Fasten the motor with the pulley on it to the z-motor-bracket using three M3x10 bolts. Put an M3 (metal) washer between each bolt and the z-motor-bracket. Make sure of the orientation – the pulley should be facing upwards. Screw in the bolts so that the motor does not move, but do not tighten the bolts fully yet.



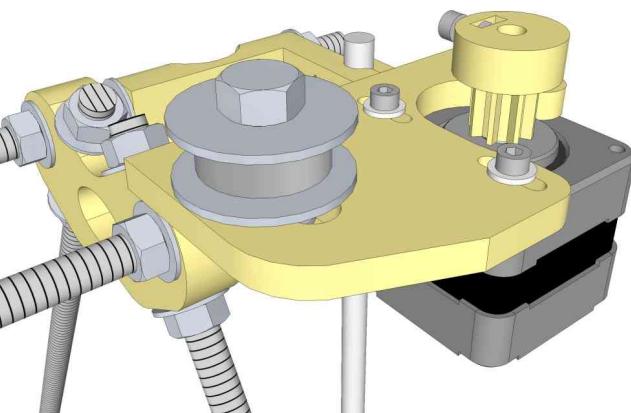
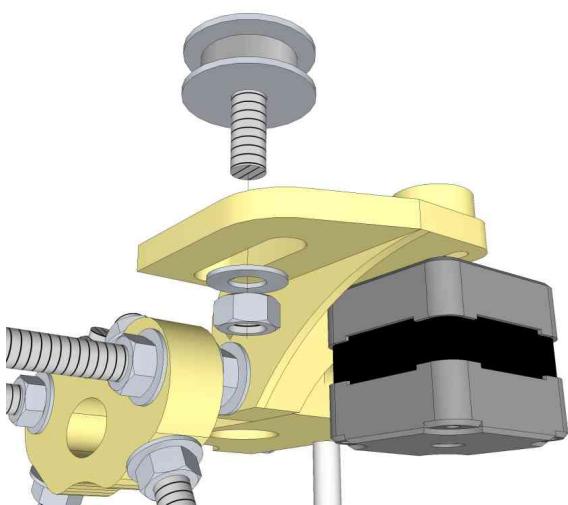
8.15

Take an M8x30 bolt and insert the following in this order:
1 large washer – 1 washer – 1 608 bearing – 1 washer – 1 large washer



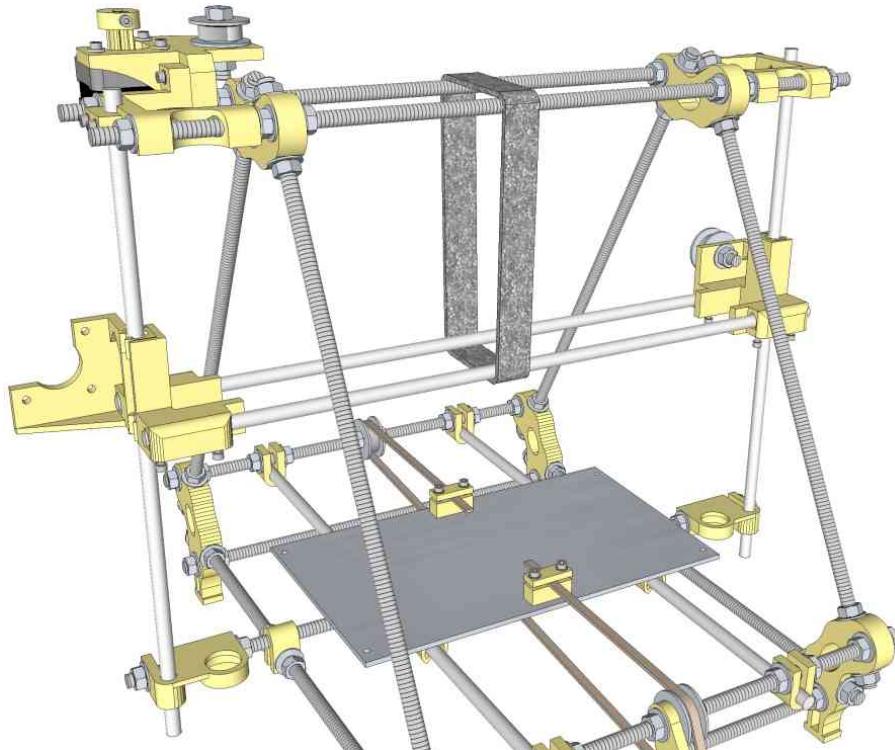
8.16

Insert the free end of the bolt into the large oval hole of the z-motor-bracket. The bearing should be on the top. Put an M8 washer followed by a nut on the underside and tighten by hand so that the bolt does not move, but do not tighten fully yet.



8.17

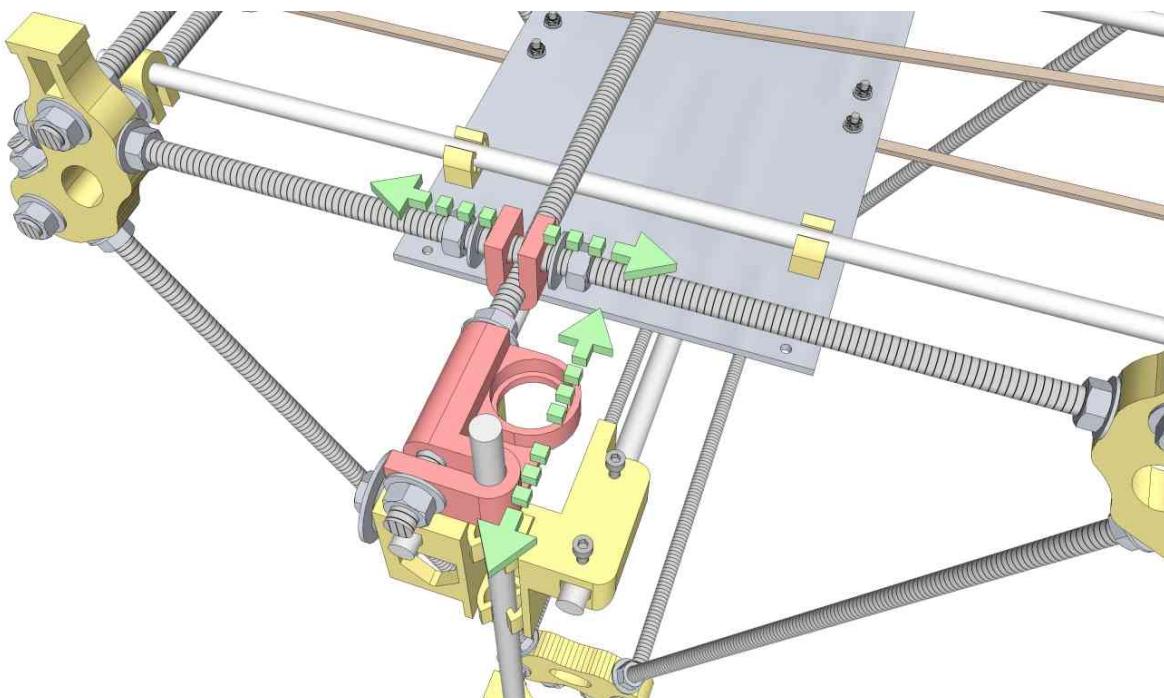
Once the glue has dried, slide the x axis to the top of the z axis smooth rods and use a length of velcro (or strong string, etc) to temporarily support the x axis onto the top threaded rods and hold it up to approximately the middle of the frame. Tighten the M3x10 bolts on the bottom of the x-end-idler.



8.18

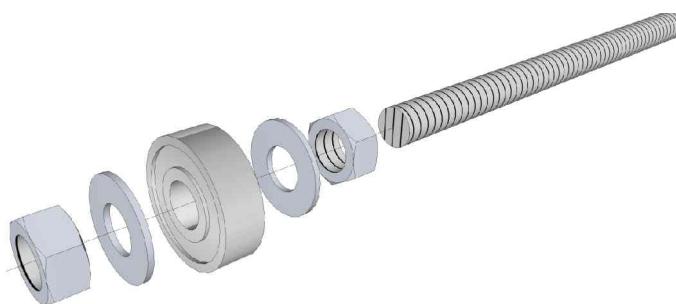
Slide the x axis to the bottom of the z axis smooth rods. If you feel the bushings binding, adjust the position of the bar-clamps and the bottom-bearing-holders in small amounts until the bushings can travel the full length of the z rods with no resistance.

(Note: Photo shows frame pictured from the underside for clarity. You do not need to flip the frame upside down for this step)



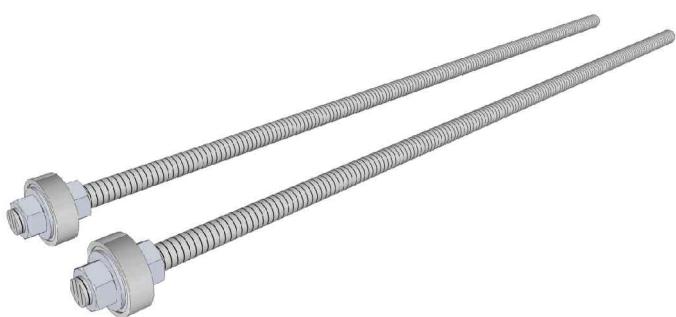
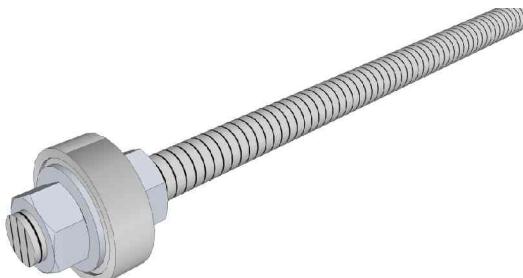
8.19

Take a 370mm threaded rod and insert the following:
1 nut – 1 washer – 1 608 bearing – 1 washer – 1 nut



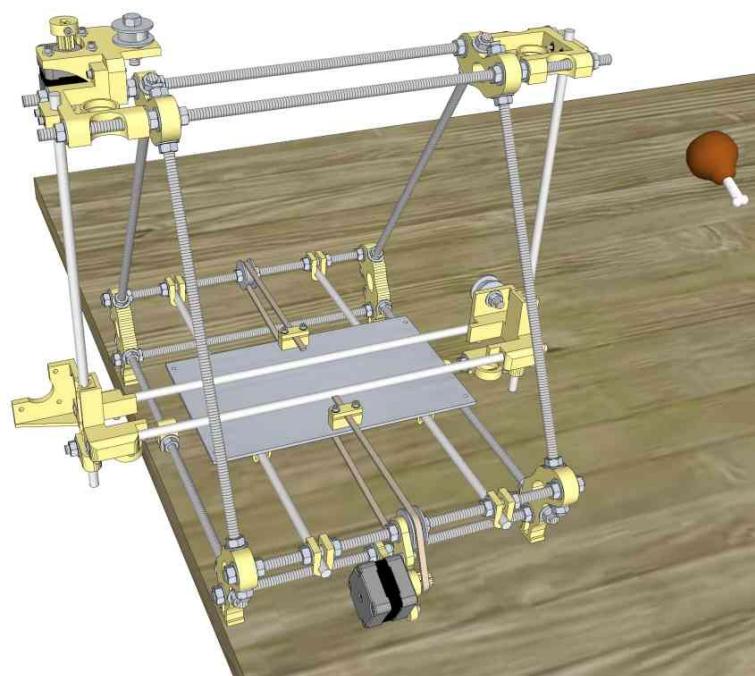
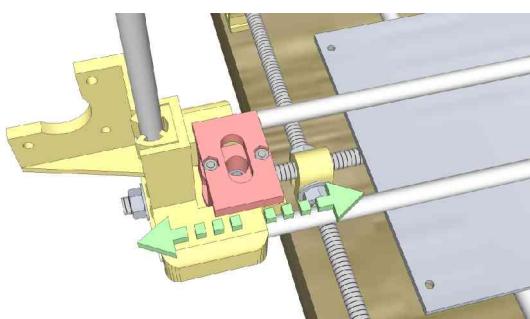
8.20

Position all the parts you have inserted at one end of the rod and leave less than 5mm of the threaded rod protruding out. Tighten the two nuts against the bearing tightly. Repeat from the above step for the other 370mm threaded rod.



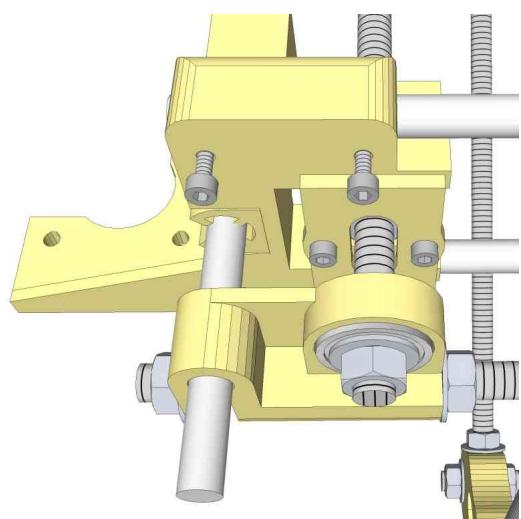
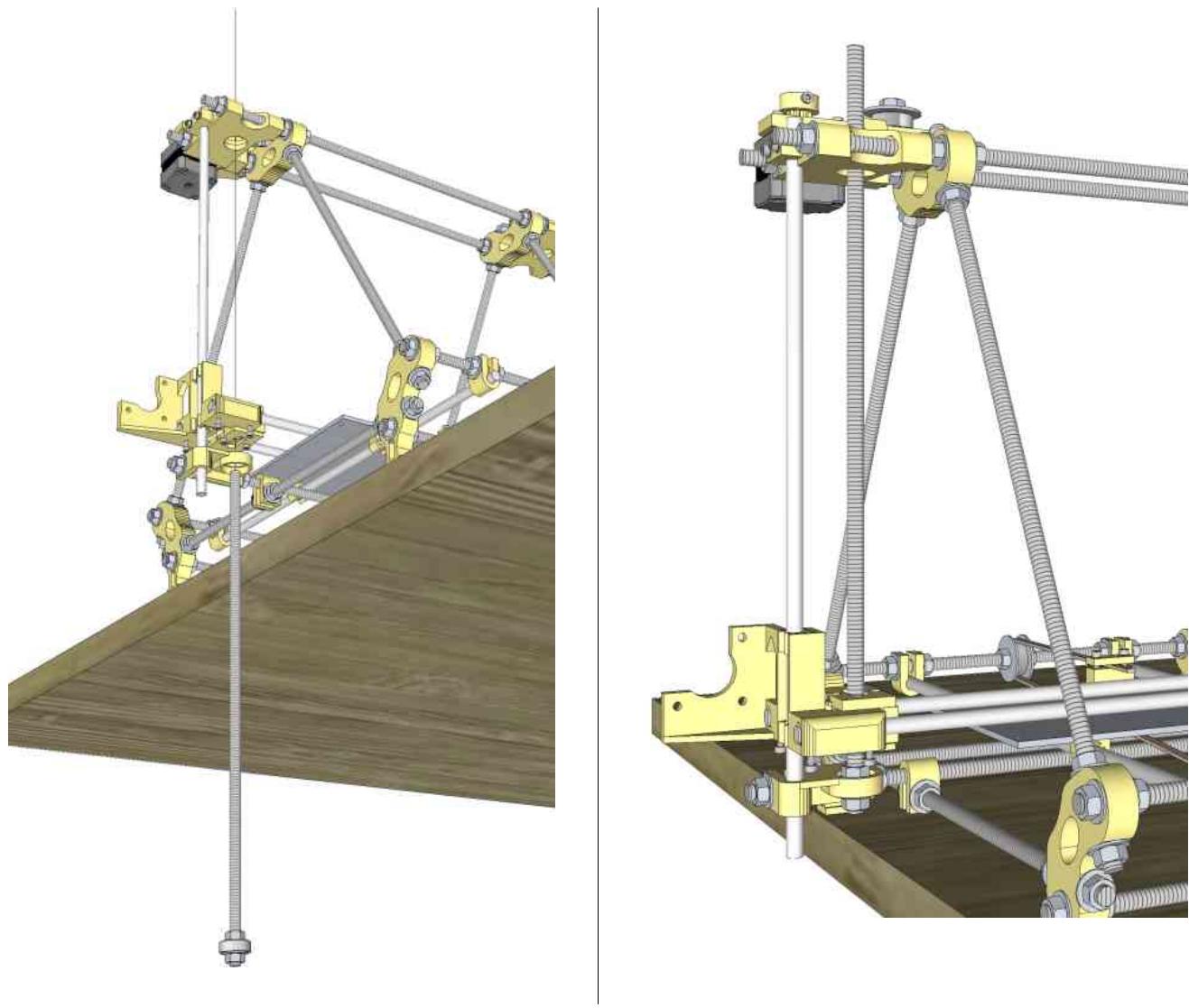
8.21

Position the frame on the edge of the table so that the bottom-left-bearing-holder is hanging over the edge of the table. Take one assembled slide coupling and insert it into the opening on the x-end-motor. Check again that it is able to slide in and out of the opening smoothly.



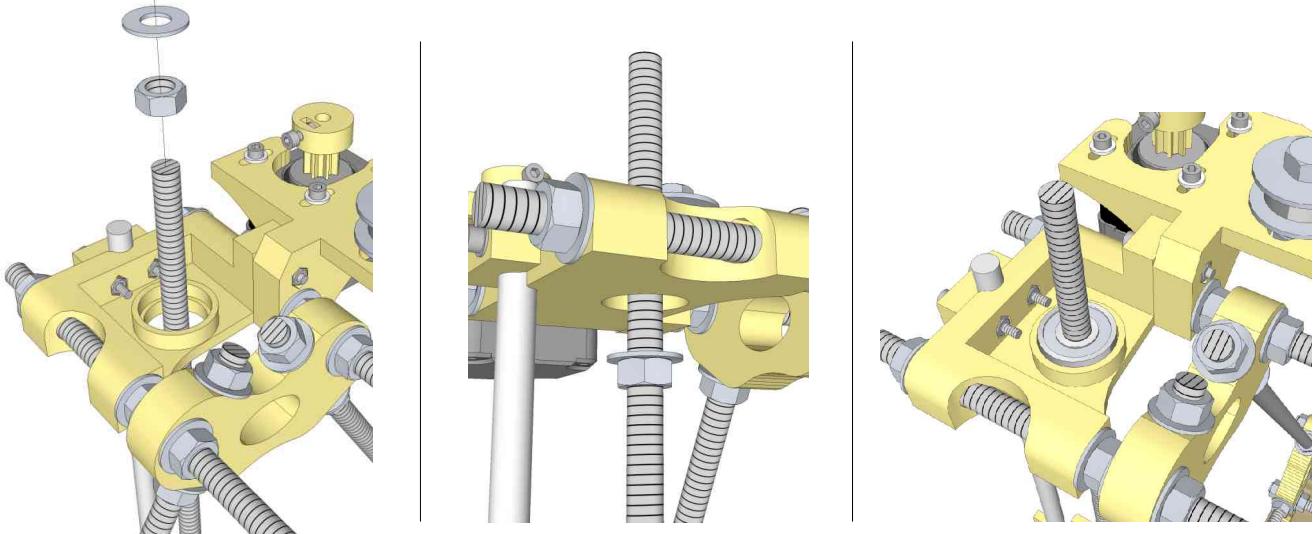
8.22

Insert the open end of one of the threaded rods through the big hole of the bottom-left-bearing-holder from the underside. Thread the rod through the M8 nut in the slide coupling until it reaches through the bearing hole of the top-left-bearing-holder, and the bearing on the bottom of the threaded rod has seated inside the bearing pocket of the bottom-left-bearing-holder.

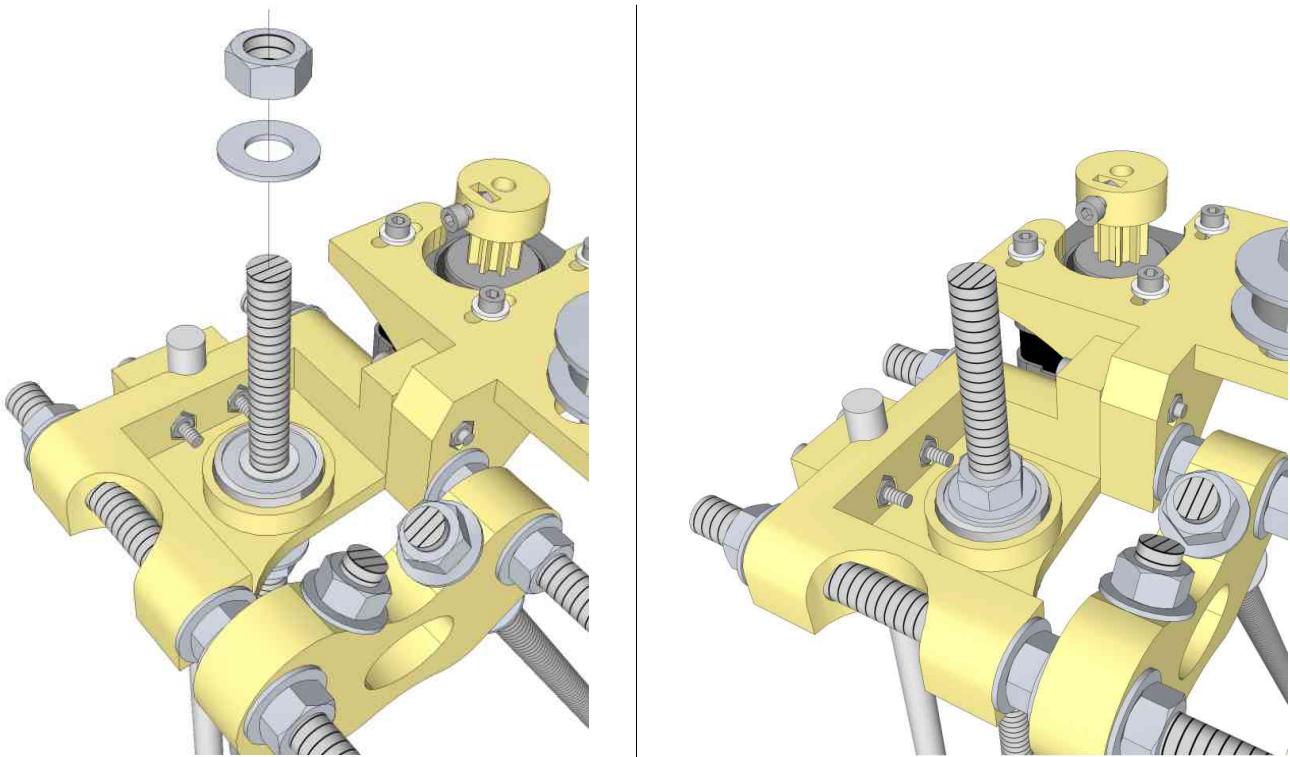


8.23

Insert an M8 nut followed by a washer into the open end of the threaded rod, threading them through the hole of the top-left-bearing-holder until it is lower than the underside of the part. Insert a 608 bearing and pop it into the bearing pocket of the top-left-bearing-holder.

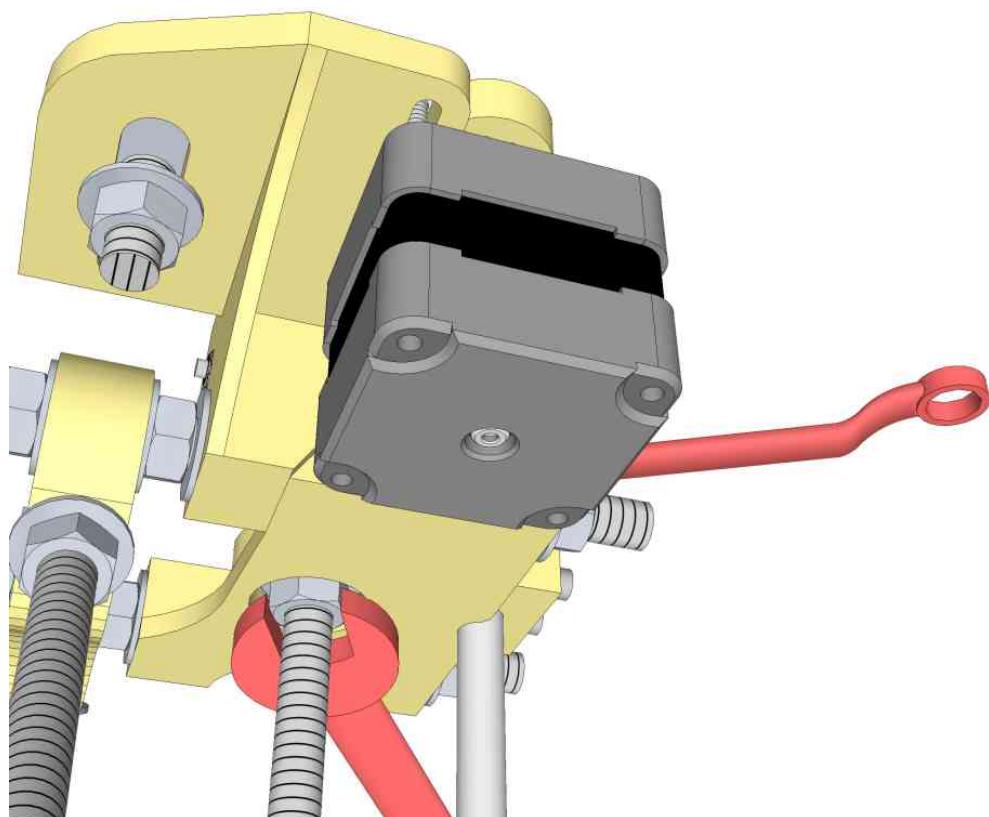
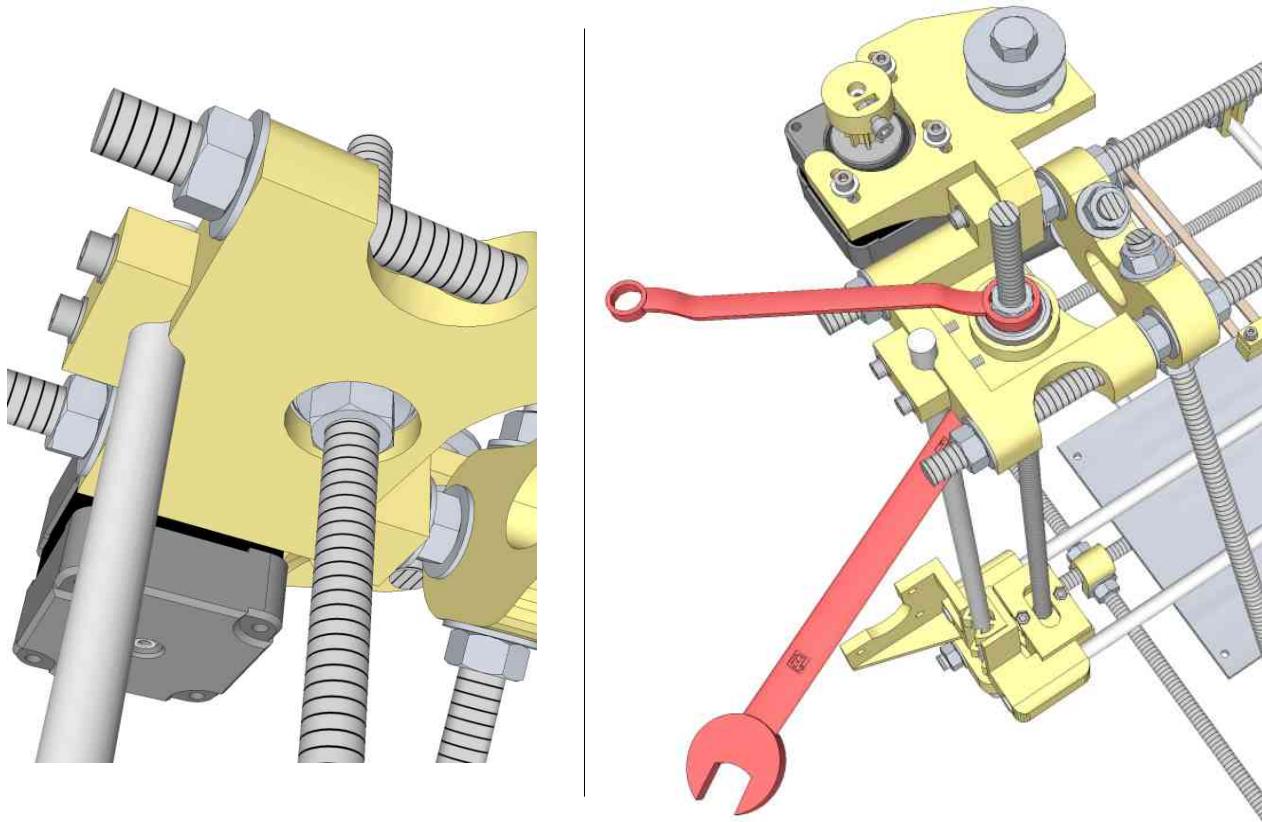
**8.24**

Insert one M8 washer followed by an M8 nut into the threaded rod. Thread them by hand until they reach the top 608 bearing, while ensuring that the bottom 608 bearing is seated snugly in its pocket. It is important to stop threading the nut and washer once they have reached the top bearing and that you do not use tools to do this. The threaded rod should now be unable to move vertically up or down, and the two 608 bearings at the top and bottom are seated snugly in their pockets.



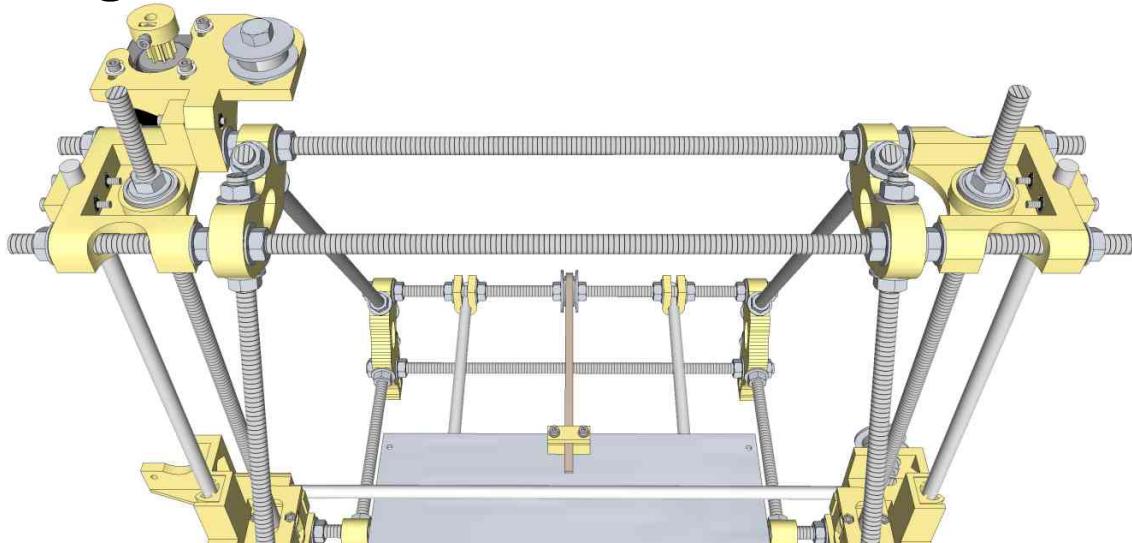
8.25

Thread the nut and washer that is underneath the top bearing until they reach the bearing. This next step is important: while holding the top-most nut with a suitable tool, tighten only the bottom nut onto the bearing. Do not turn the top nut while turning the bottom nut. Tighten them well.



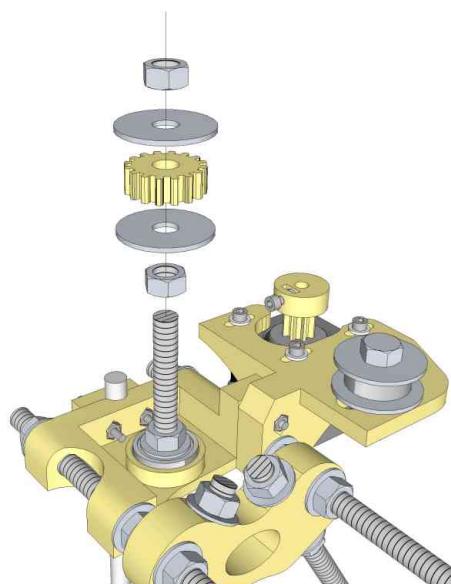
8.26

Repeat steps 8.21 through 8.25 for the other side.



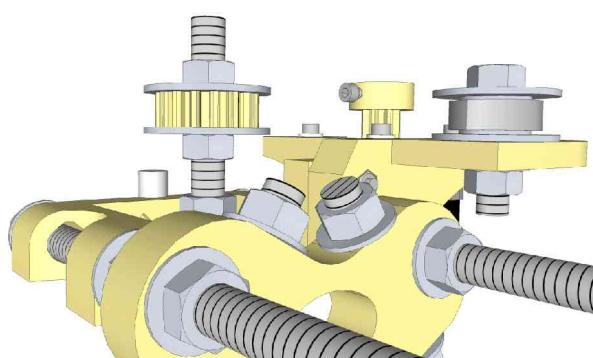
8.27

Insert the following into the top end of the left z threaded rod:
1 nut – 1 large washer – 1 z-pulley – 1 large washer – 1 nut



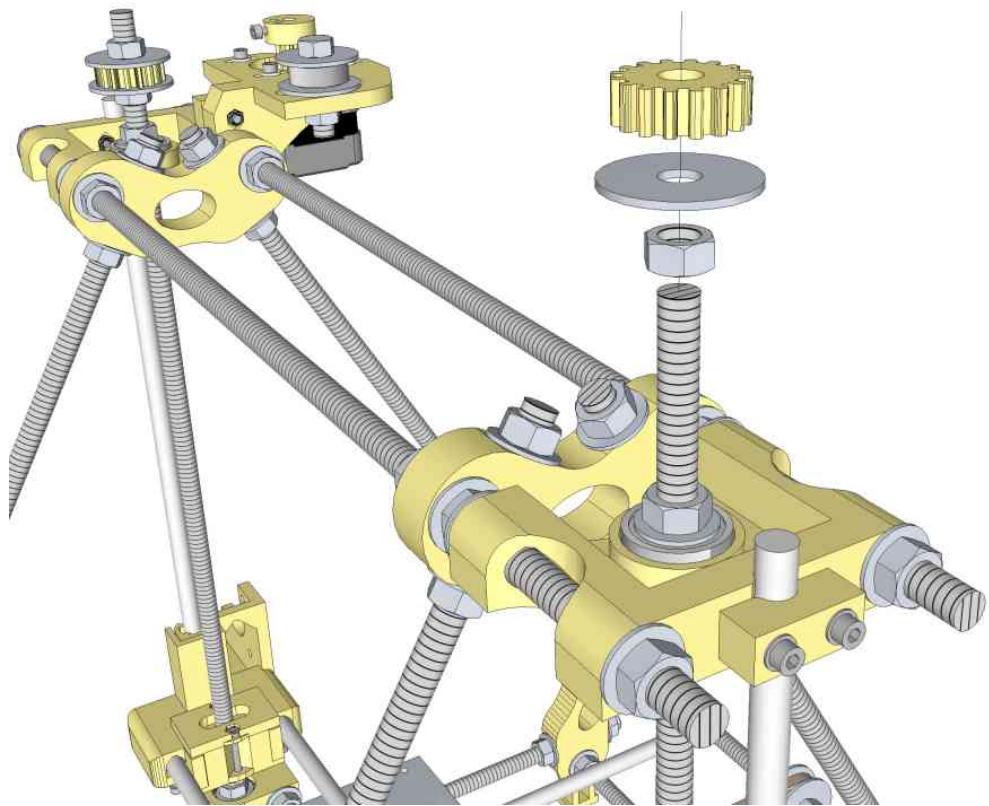
8.28

Adjust the position of the parts you have just inserted such that the z-pulley is aligned to the same height as the 608 bearing on the z-motor-bracket. Tighten both nuts against the z-pulley well so that it cannot turn on the threaded rod.



8.29

Insert the following into the top end of the right z threaded rod:
1 nut – 1 large washer – 1 z-pulley



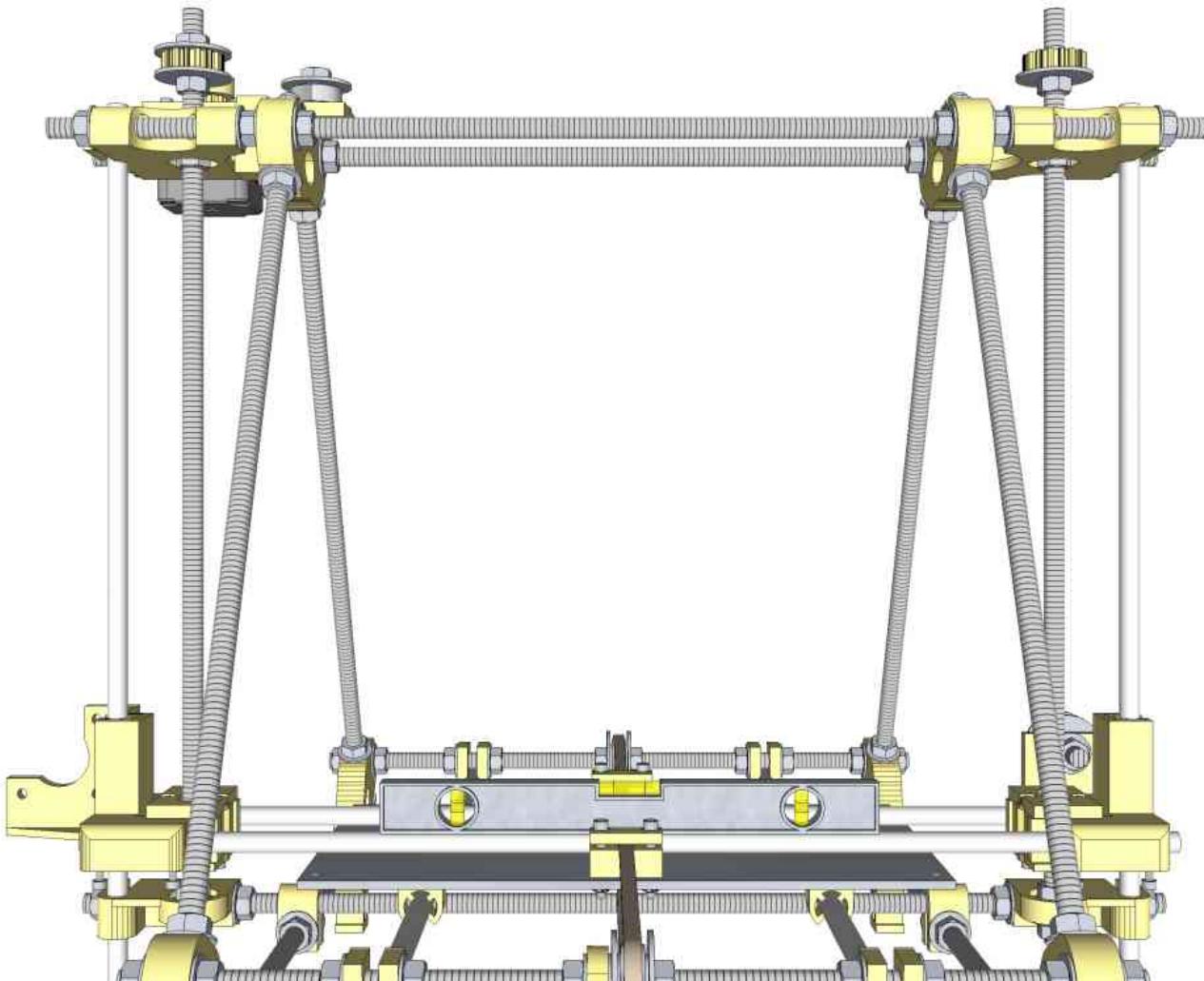
8.30

Adjust the position of the parts you have just inserted such that the right z-pulley is aligned to the same height as the left z-pulley.



8.31

Place a spirit level on the x axis smooth rods and turn the z threaded rods in small amounts by hand to raise or lower each side until the x axis is level.

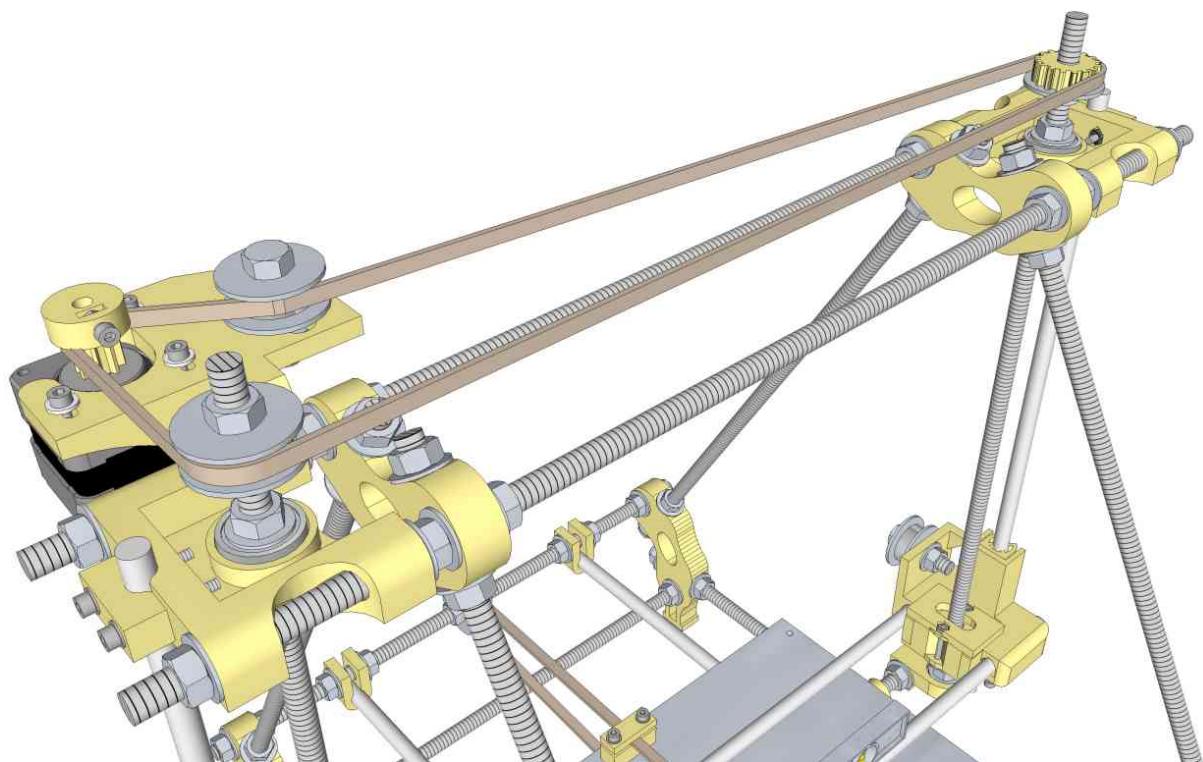
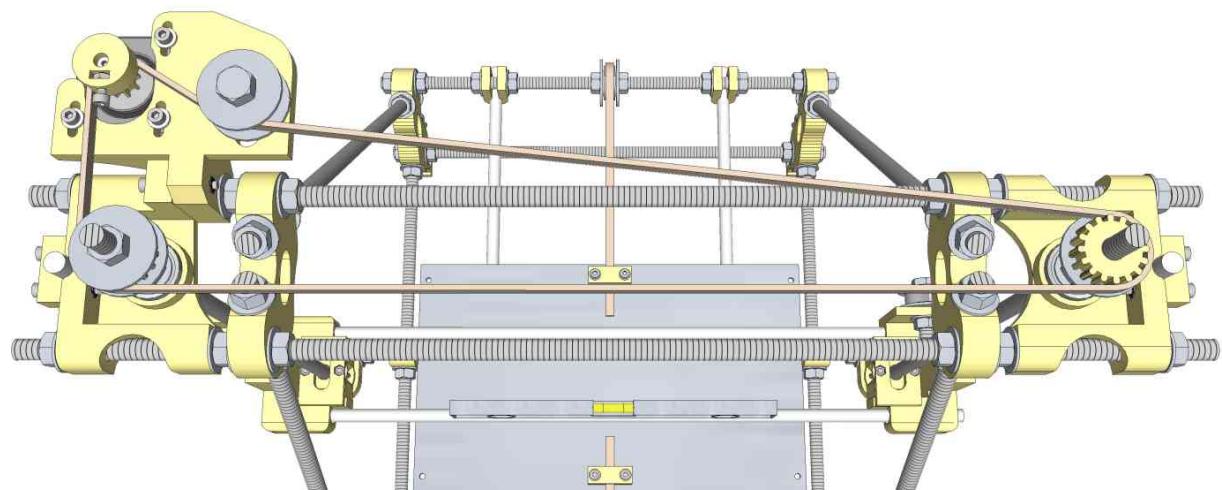
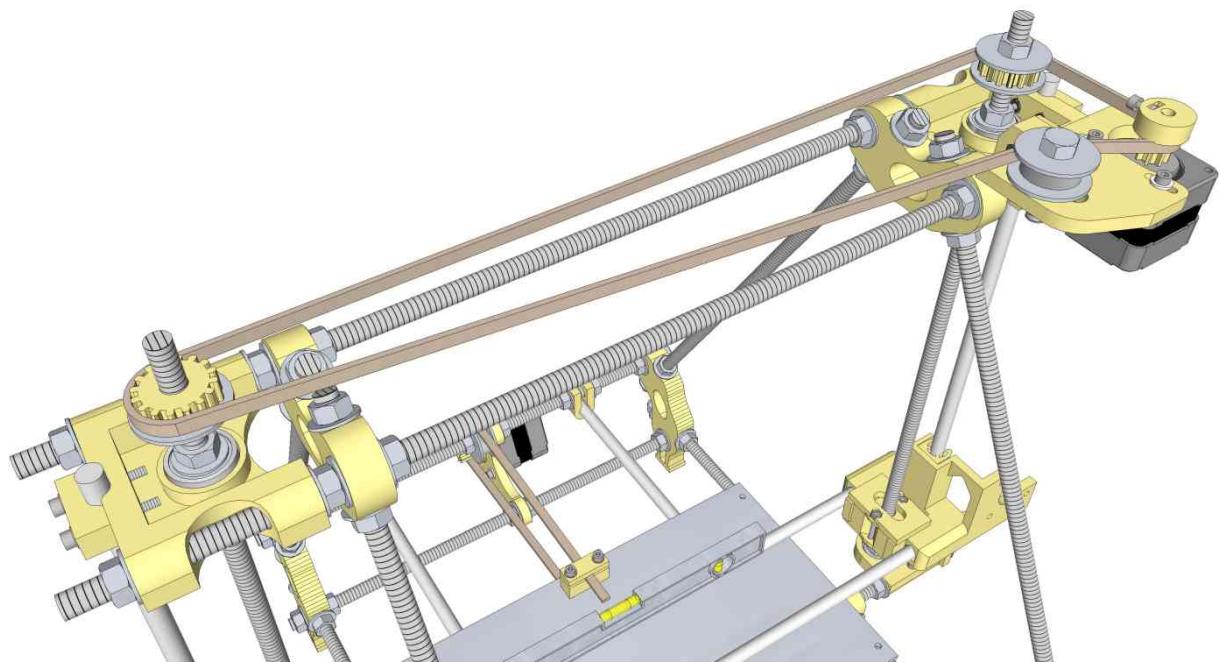


8.32

Mount a 840mm continuous belt outside both z-pulleys and the z-motor's pulley, and inside of the 608 bearing on the z-motor-mount.

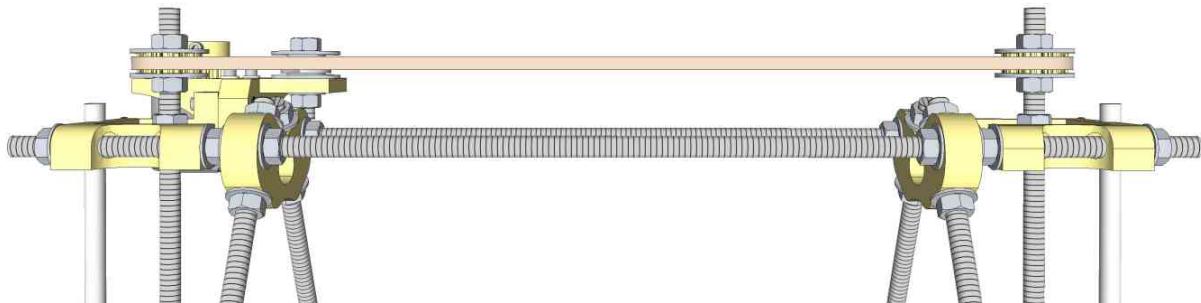
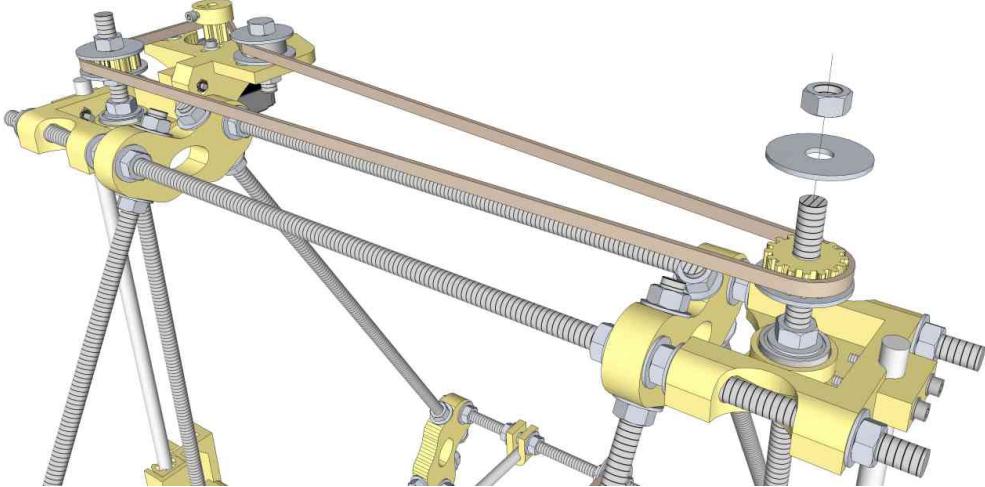
The toothed side of the belt should be facing inwards - all three pulleys should be on the inside of the belt loop. The 608 bearing should be on the outside of the belt loop, with the smooth side of the belt on the bearing.

Refer to the pictures on the following page.

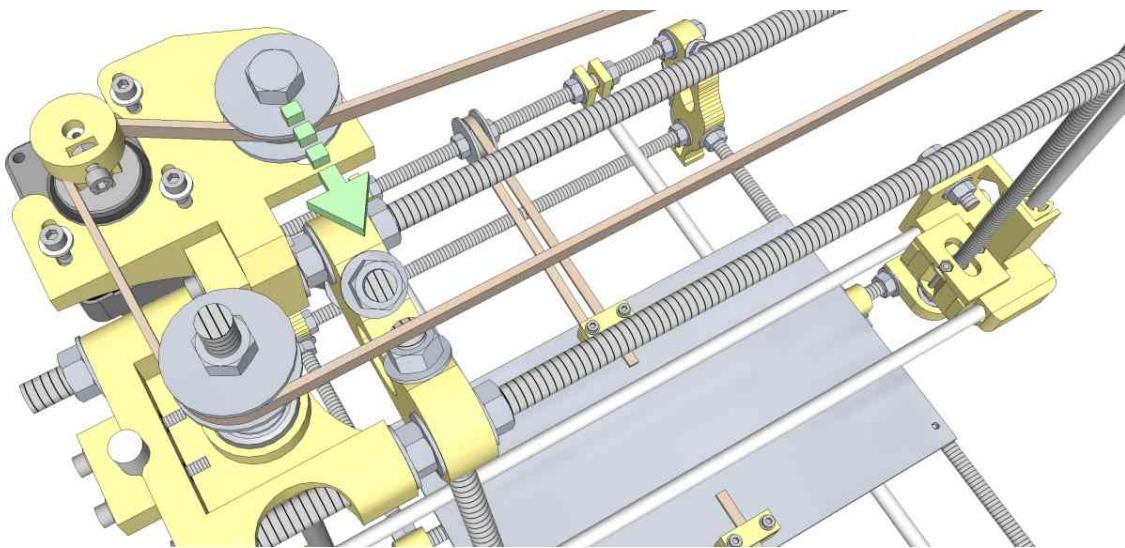


8.33

Insert a large washer followed by a nut onto the right threaded rod. Place a spirit level on the x axis smooth rods and reconfirm that they are level. Check that the height of the right z-pulley is still at the same level as the left z-pulley. Tighten the nuts well so that the pulley cannot turn on the threaded rod.

**8.34**

Push the 608 bearing on the z-motor-bracket inwards against the belt to tension it (loosen the nuts on the bearing if needed). The belt should be tensioned such that it engages the teeth on all three pulleys, but should not be so tight as to require a lot of force to turn the z threaded rods by hand. You might need to adjust the position of the z motor along its mounting holes as well to achieve proper tension. Tighten the bolts on the motor and the nuts on the bearing once you are satisfied with the belt tension.

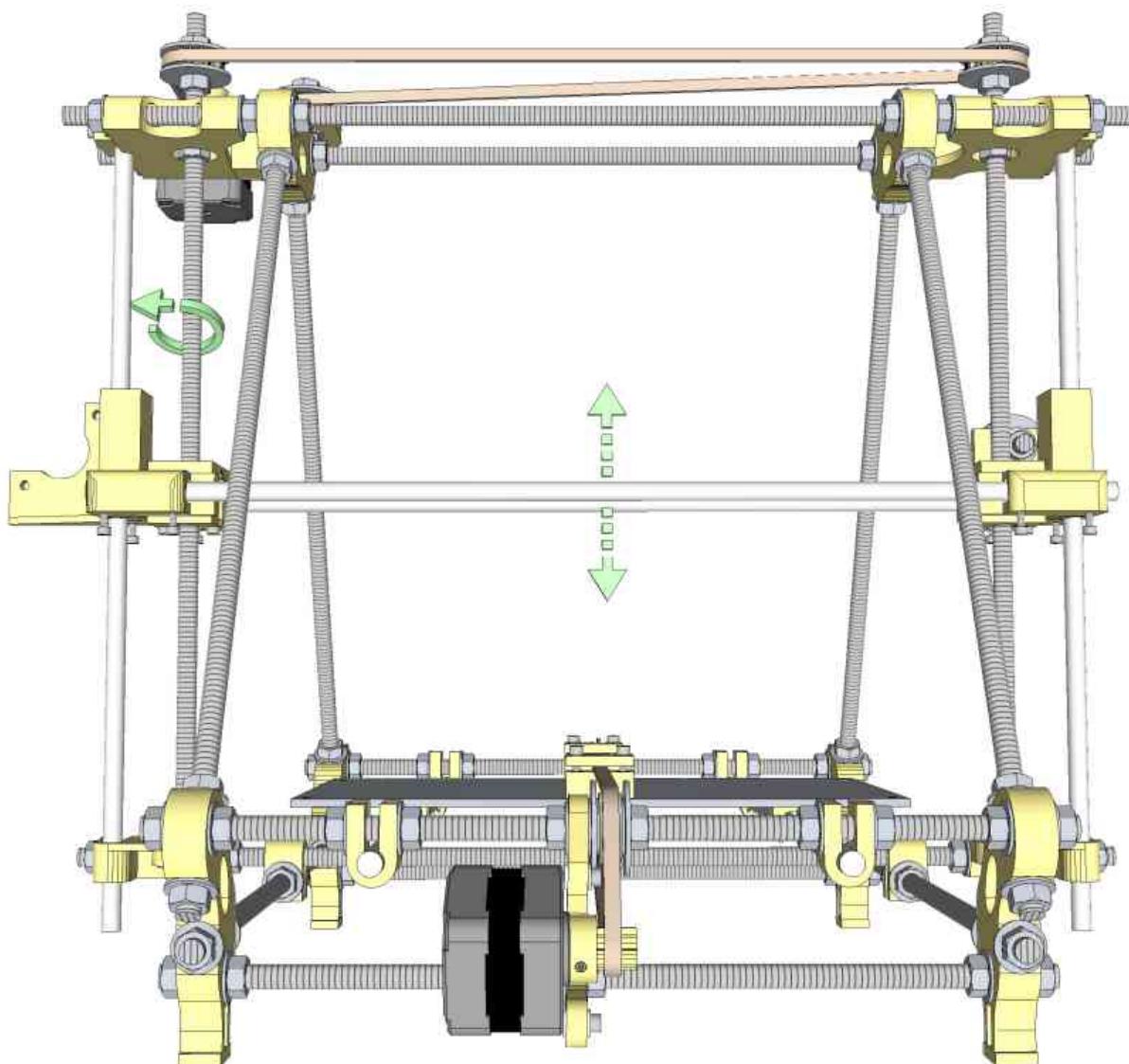


8.35

Turn one of the z threaded rods by hand. While turning, verify that the other z threaded rod also turns the same equal amount (driven by the z belt). Also verify that the x axis raises up and lowers down evenly and remains level as you turn one of the z threaded rods.

If your z axis threaded rods are slightly bent, they will wobble when turned. If so, verify that the slide couplings effectively slide on the x-end-motor and x-end-idler to compensate for this wobbling.

Your z axis is ready.

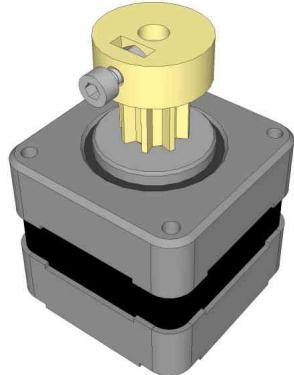


Part 9

Installing the x-carriage

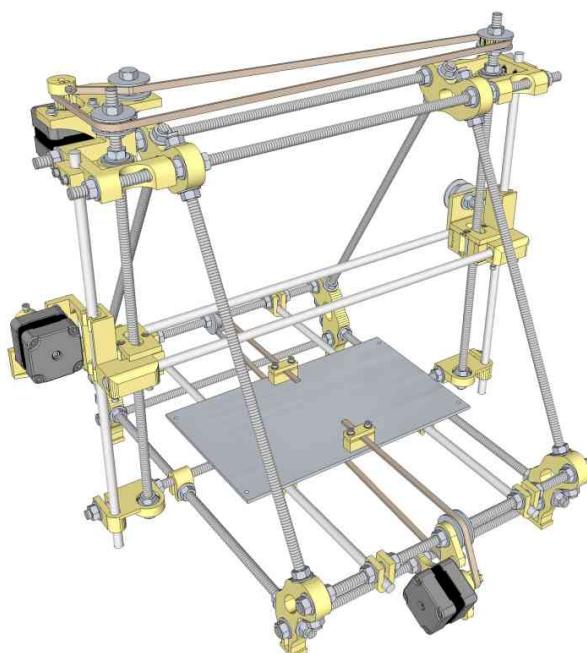
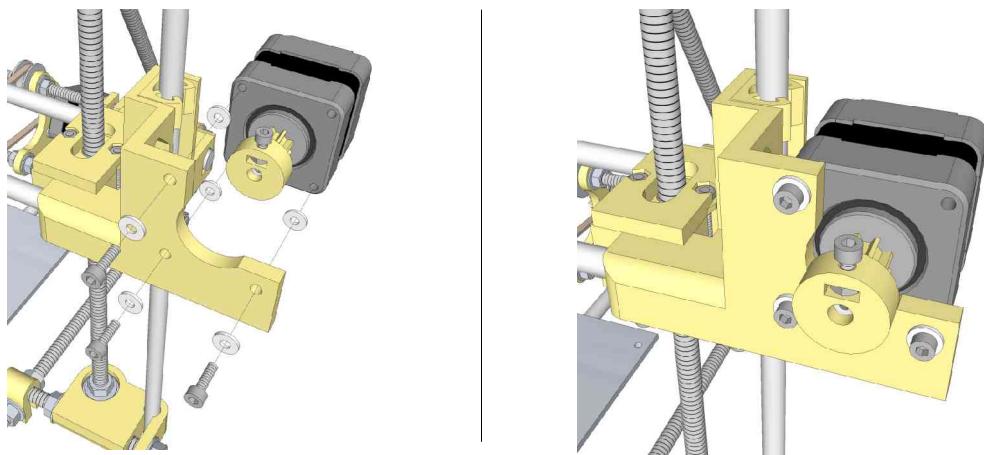
9.1

Fasten a motor-pulley onto the motor that is to be used on the x axis. You can refer to Part 6, steps 6.9 through 6.11, but this time, mount the pulley upside down – slide the pulley onto the motor shaft so that the pulley rim comes onto the shaft last. Leave a gap of about 1 mm between the pulley and the motor body, then tighten the grub screw.



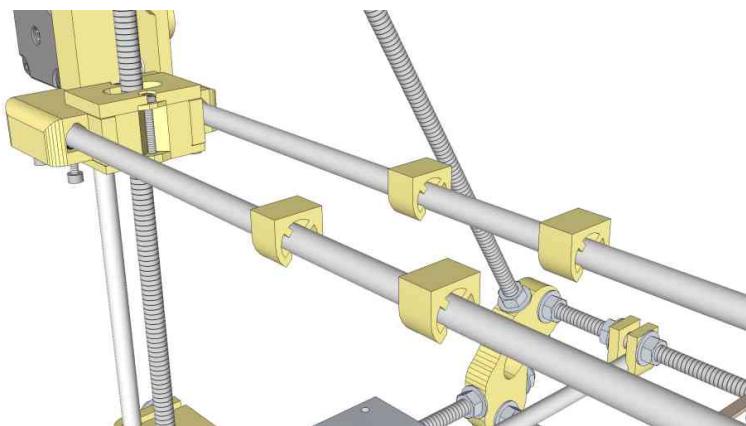
9.2

Fasten the motor onto the x-end-motor using 3 M3x10 bolts. Put a nylon washer between each bolt and the x-end-motor, as well as between the x-end-motor and the motor. Note the orientation: the motor body is on the front and the pulley points towards the rear. Tighten the bolts.



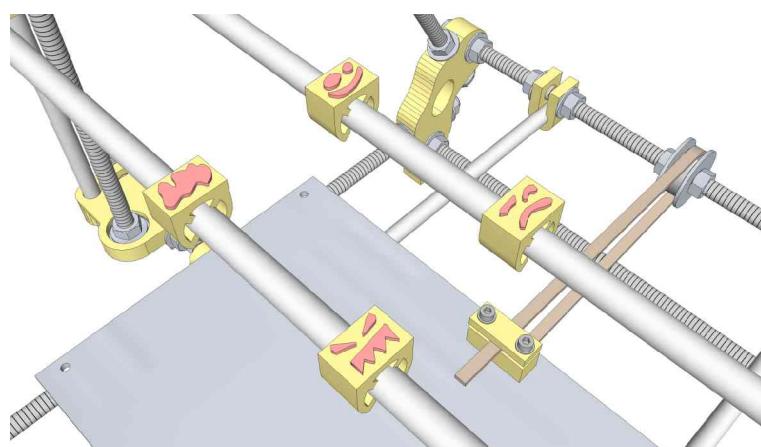
9.3

Place 4 PLA-bushings on the x-axis smooth rods. Make sure they slide freely.



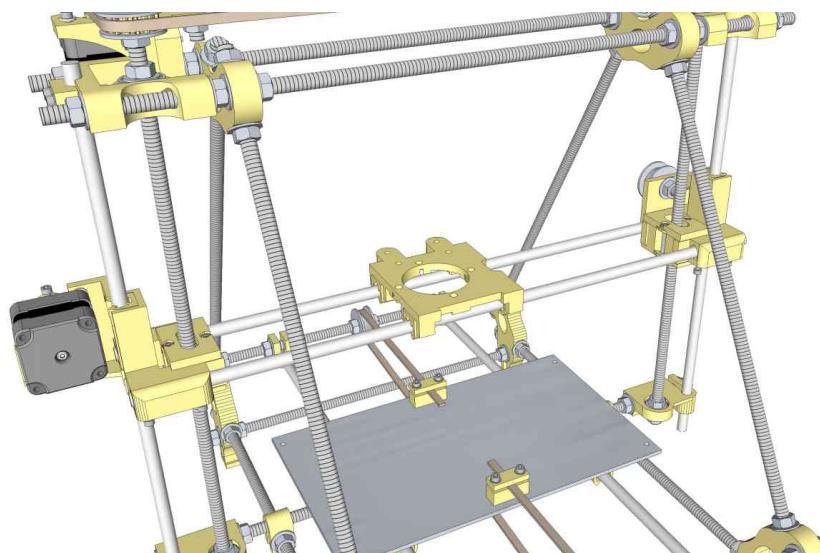
9.4

Put a blob of glue on the flat side of each bushing.



9.5

Place the x-carriage on top of the bushings, making sure they fit onto the channels. The protruding part of the x-carriage with the four nut traps should point towards the rear.



9.6

Wait for the glue to dry.

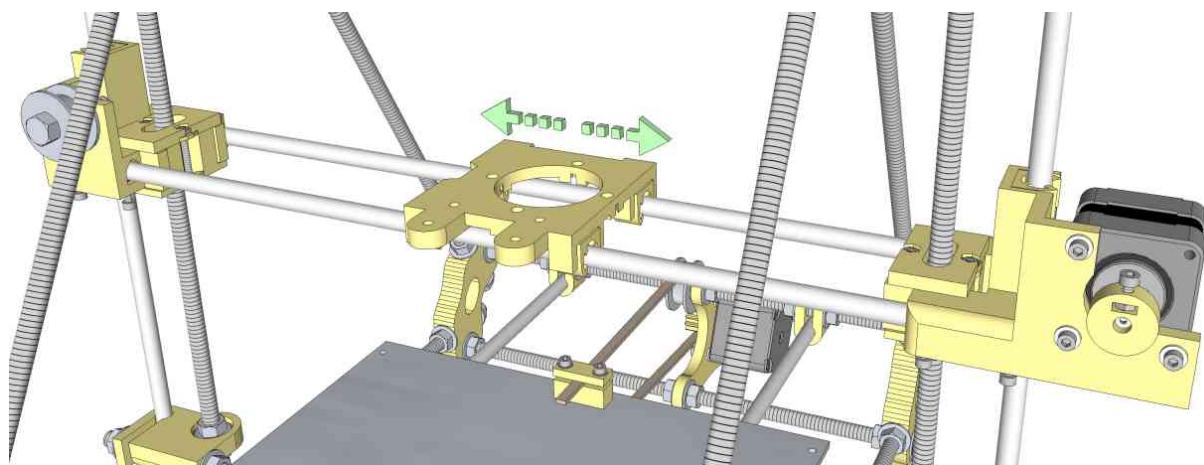
9.7

Optional: While the glue is drying, prepare yourself some coffee or other preferred beverage of choice. Enjoy with some biscuits or cookies and think happy thoughts. If you choose to have an alcoholic beverage, aim to remain sober (enough) to continue with the following steps. Also, if you have pets around, make sure they are less interested in the glue drying and other parts of your printer than you are.



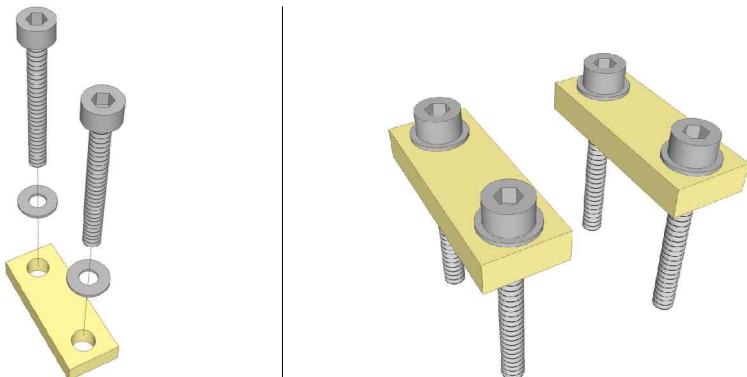
9.8

After the glue has dried, make sure the carriage can slide freely along the rods from end to end. Turn the frame around so that the rear of the machine faces towards you for the next step.



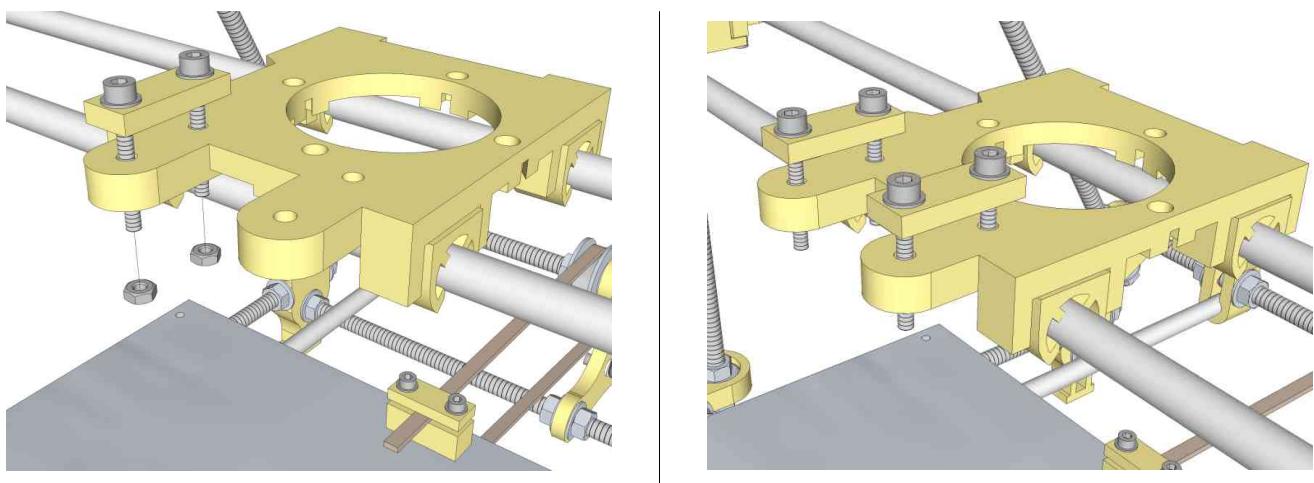
9.9

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.



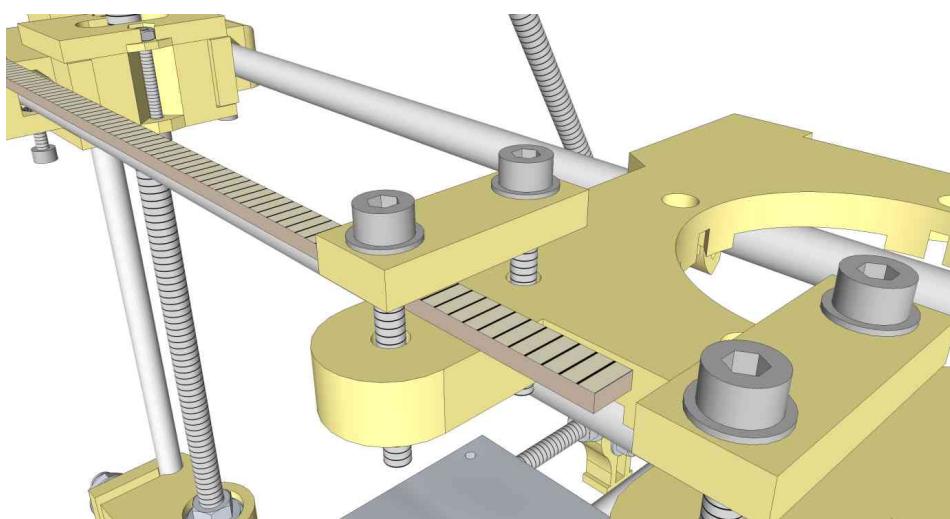
9.10

Loosely attach one of the belt-clamps to the x-carriage. Thread the two bolts through the holes in the x-carriage and attach nuts to them on the underside of the x-carriage. Make sure there is enough space for the belt to slide between the belt-clamp and the x-carriage. Repeat for the other clamp.



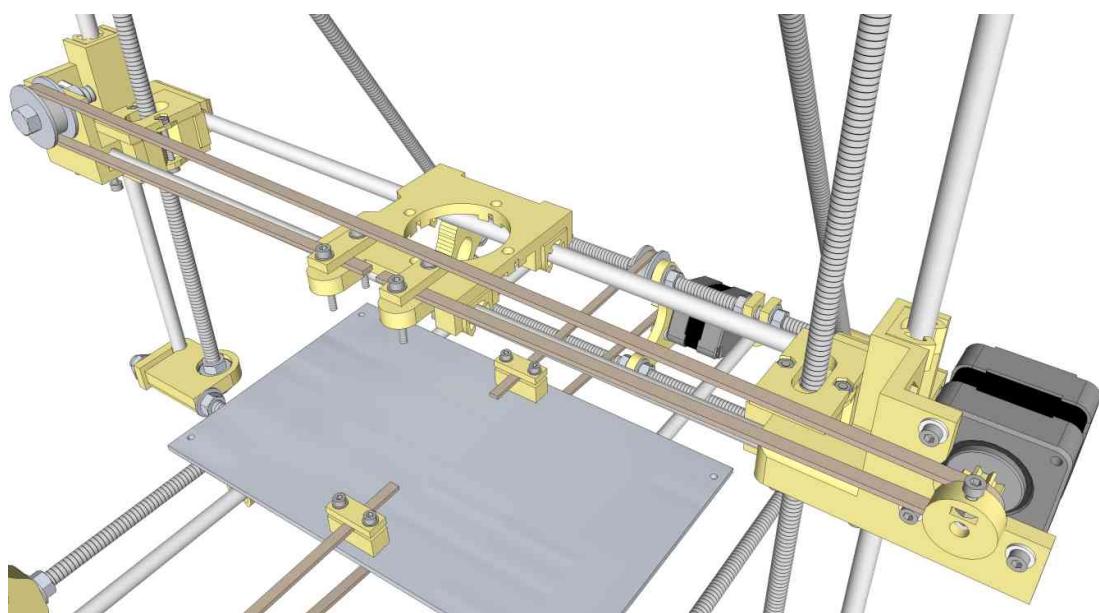
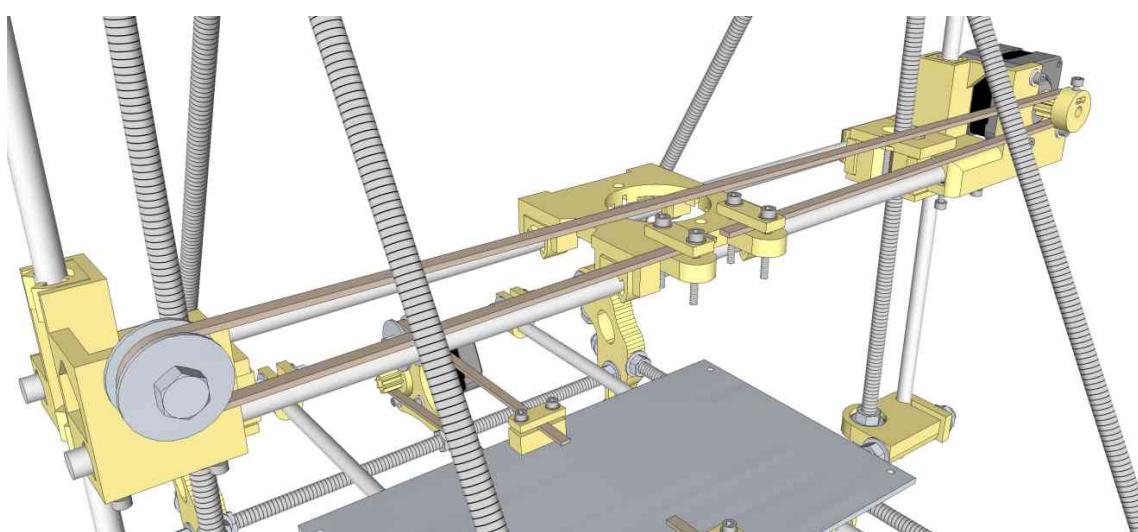
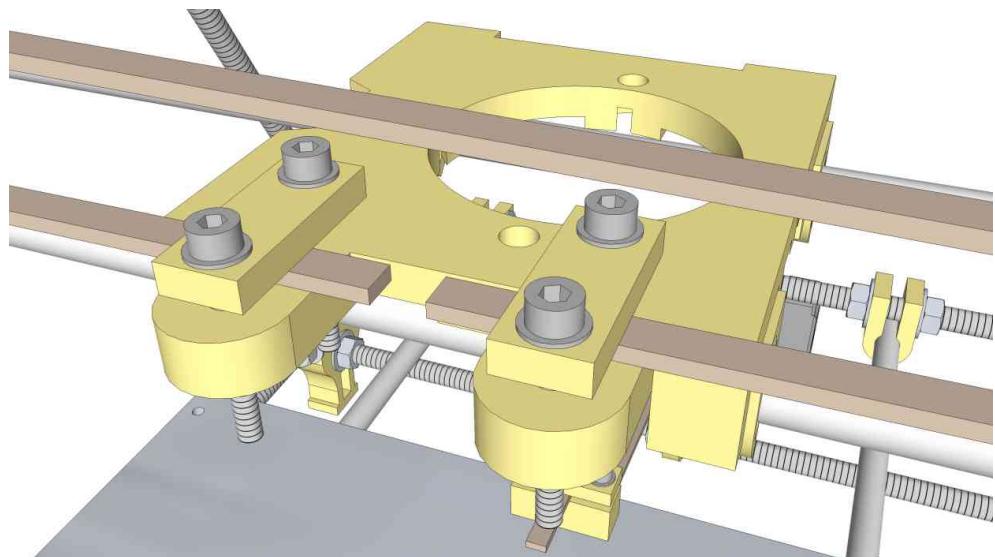
9.11

Slide one end of the 1380mm belt through the left clamp, toothed side up. Pull several centimetres through, then tighten the clamp.



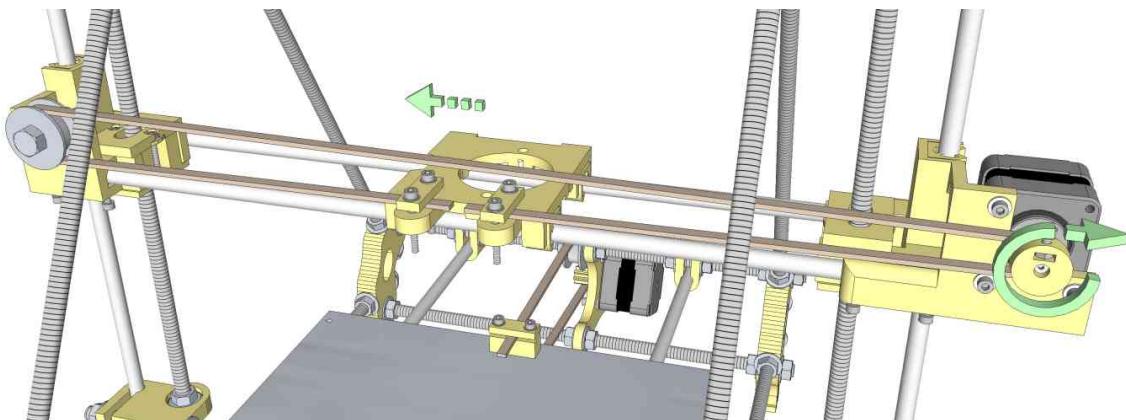
9.12

Run the belt over and around 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.



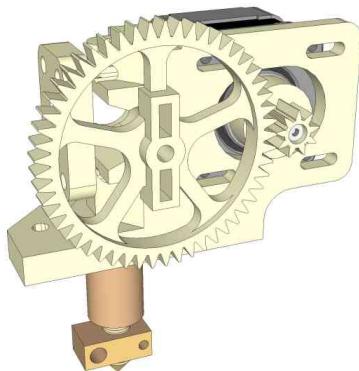
9.13

Verify that the belt tension is right. Turning the motor-pulley slightly by hand should make the x-carriage move immediately, but should not feel tight. The carriage should move freely along the entire length of the axis.



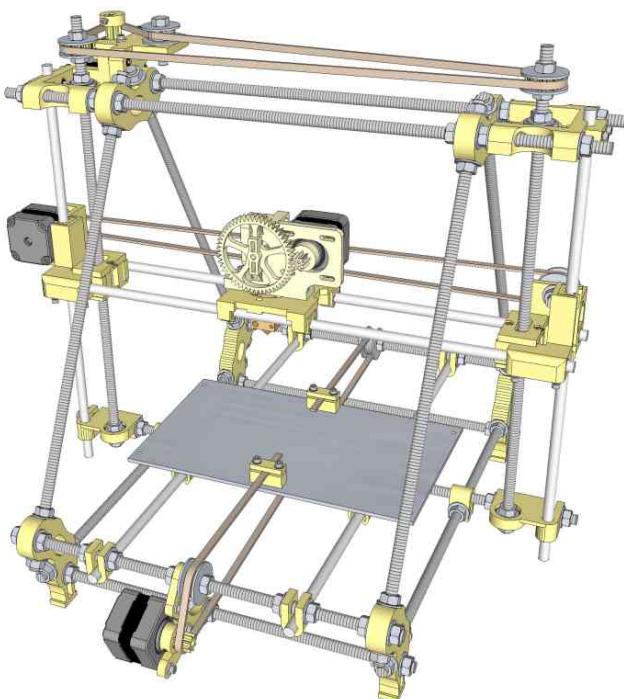
9.14

At this point, assemble your extruder before moving on to the next step (the instructions are not included here – refer to the build instructions for your particular extruder).



9.15

Use two M4x20 bolts with two M4 washers, and two M4 nuts to mount the extruder to the x-carriage. Your x-carriage is now ready.



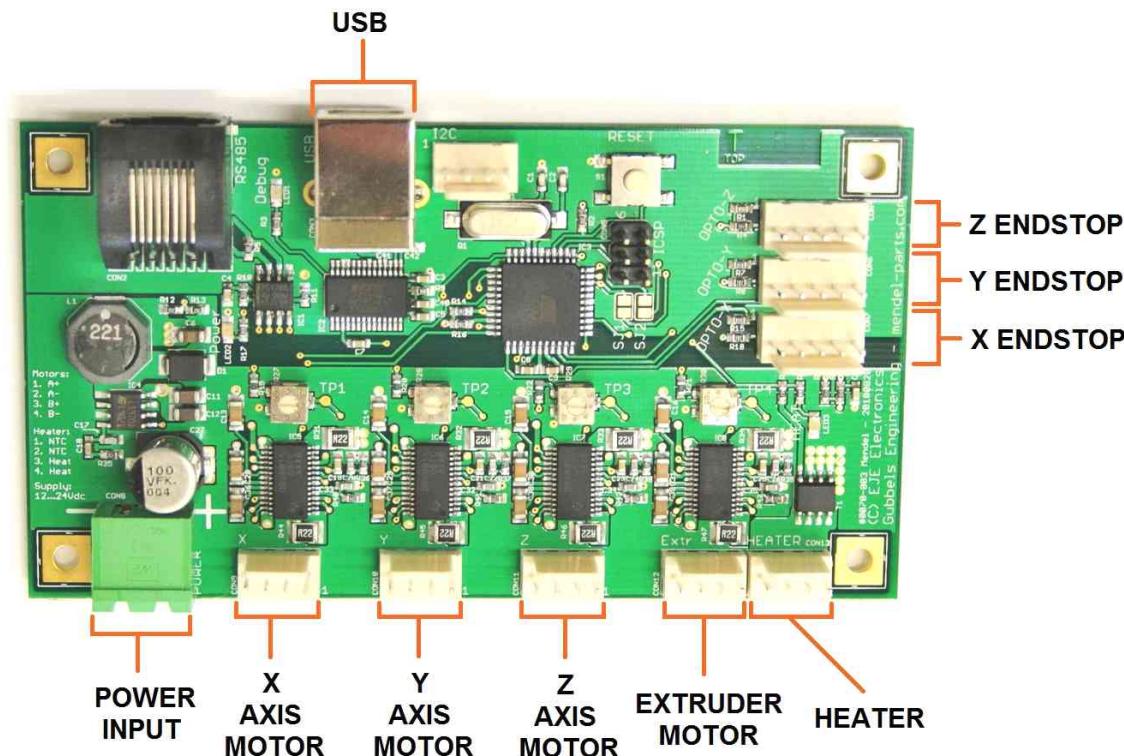
Part 10

Wiring the electronics

10.1

There are various electronics configurations out there, but they 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.

The connections for the Gen6 electronics configuration is shown below:

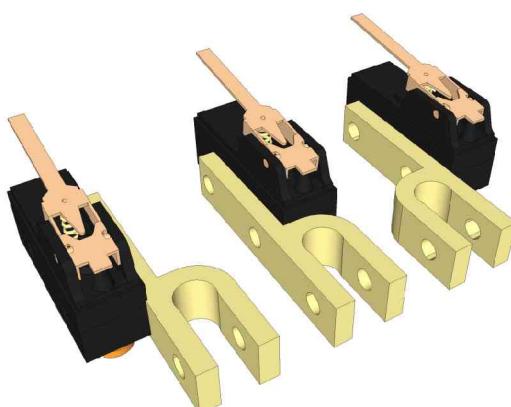


10.2

Screw or glue your endstops to the long side of the three endstop-holders.

(Note: Endstops shown here are indicative only. Please check positions and layout against your own printer)

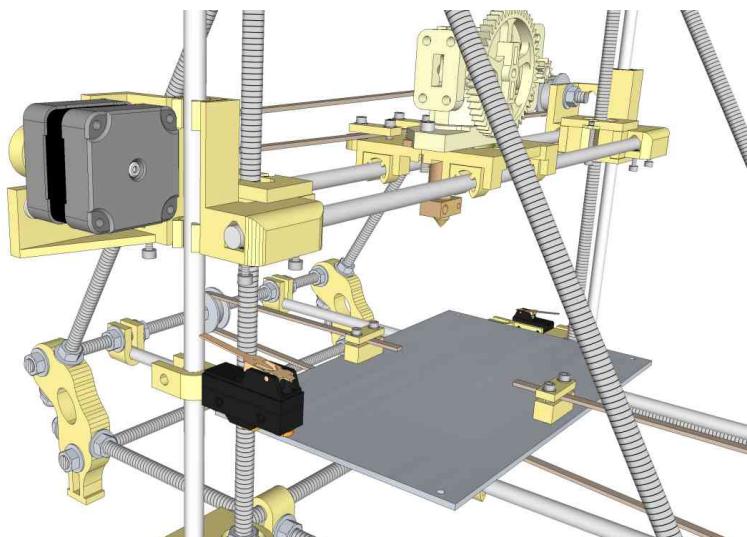
(Note 2: Endstops in these instructions refer to microswitch type endstops only. If you have opto type endstops, refer to the instructions at the RepRap wiki at http://reprap.org/wiki/Prusa_Mendel_Assembly under the “Wiring the electronics” section.)



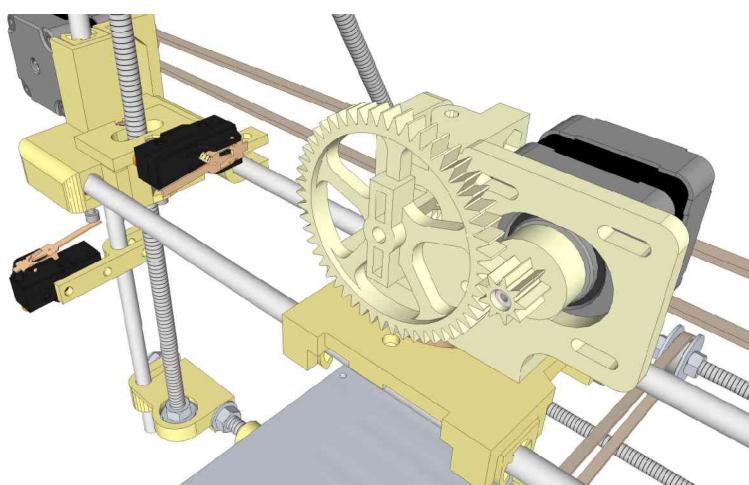
10.3

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 z endstop – refer to (A). Place one on the far left of the rear x axis smooth rod – this is your x endstop – refer to (B). Place the third one on the left y axis smooth rod behind the print-bottom-plate – this is your y endstop – refer to (C).

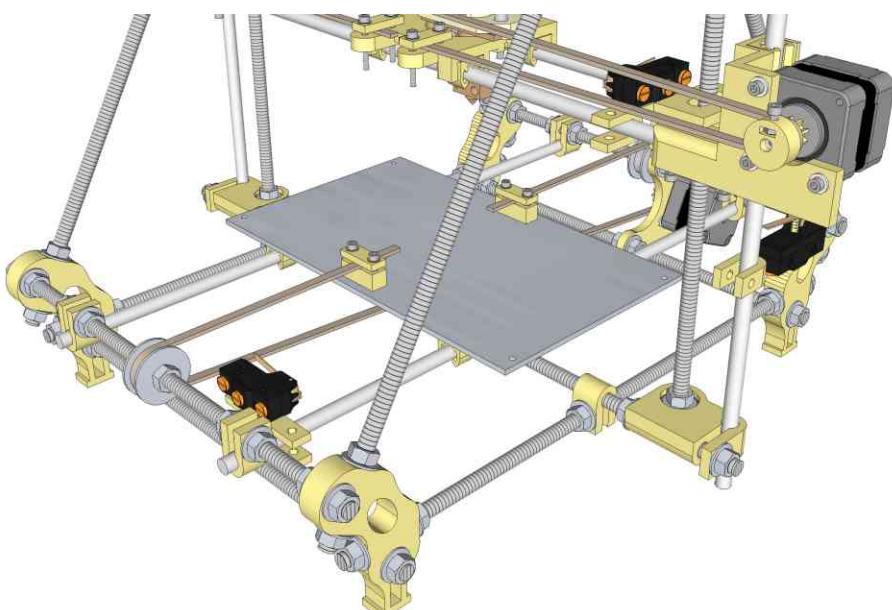
A



B

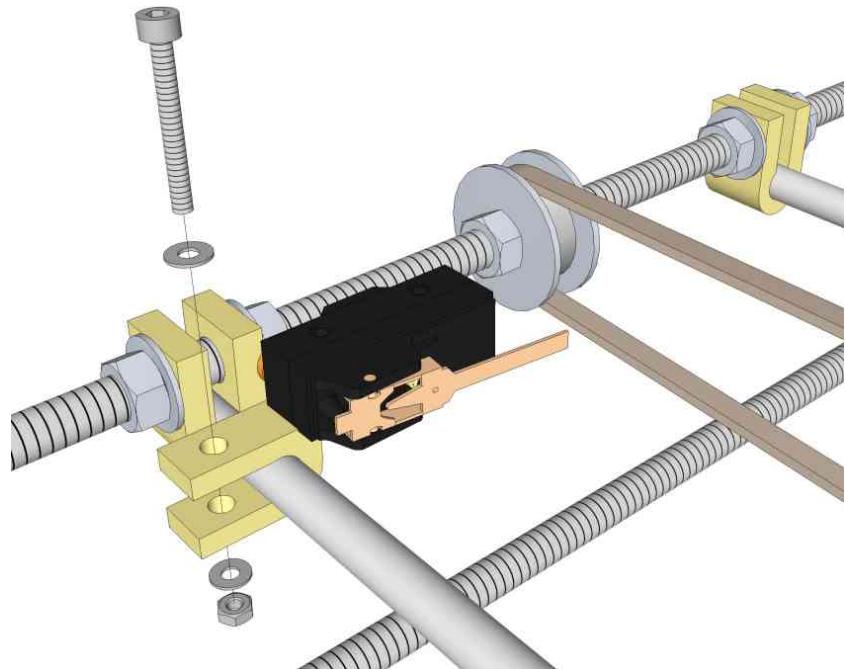


C



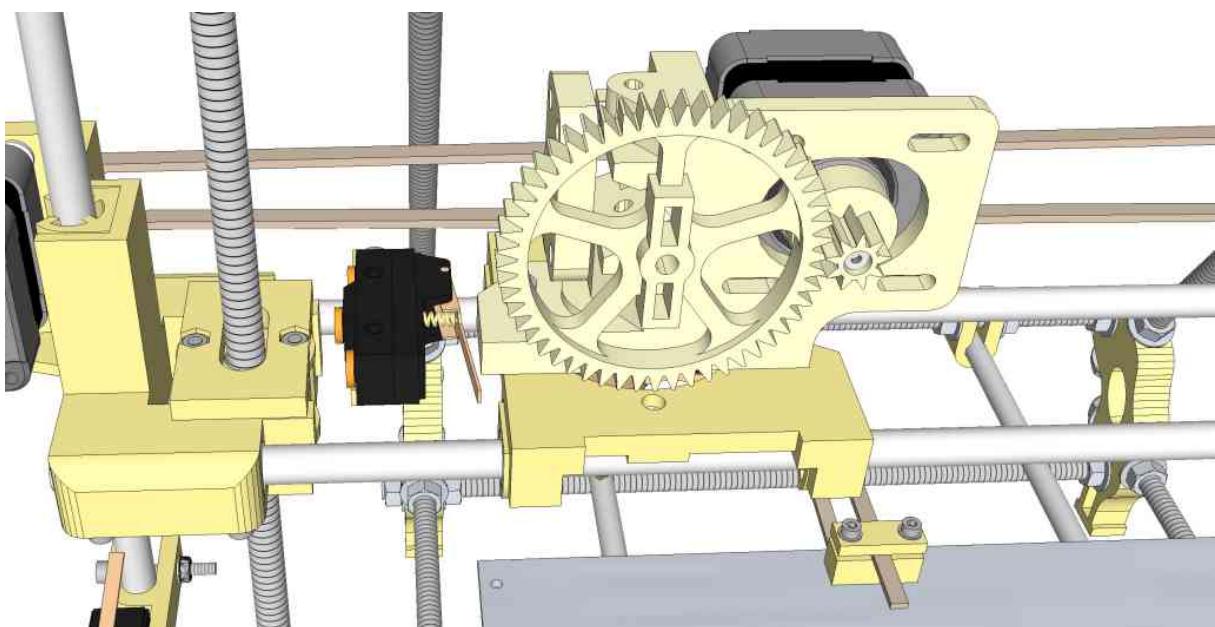
10.4

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.



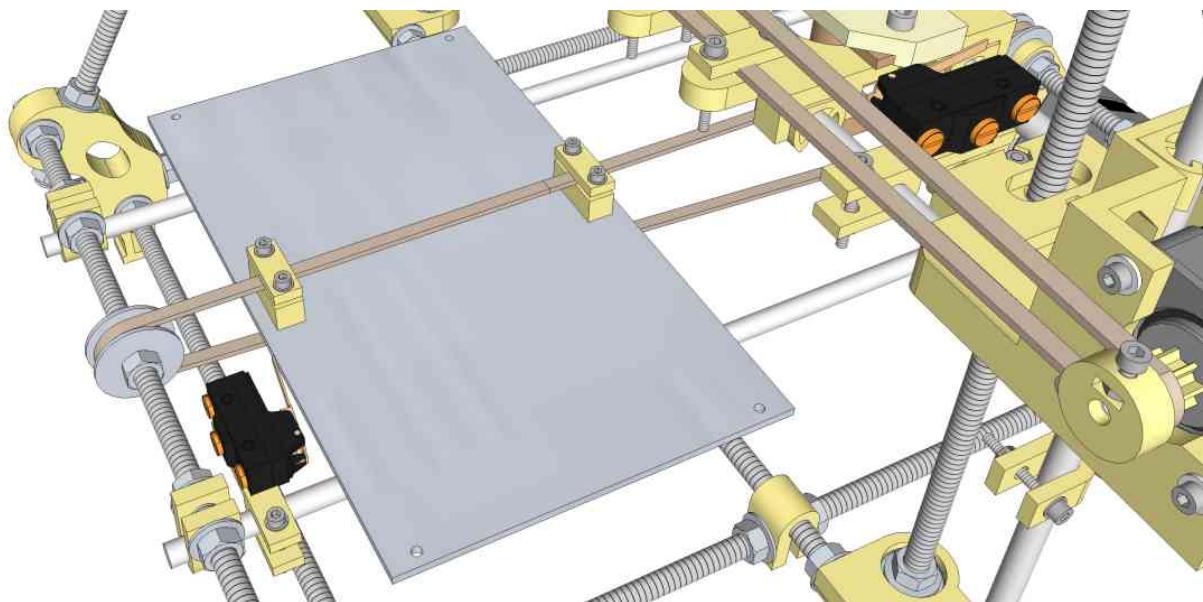
10.5

You now need to determine the limits of each axis. With the extruder/hotend installed, slide the X carriage to the left until the nozzle is 10mm to the right from the left edge of the print-bottom-plate. Reposition the endstop so that the microswitch is engaged in this position. Tighten the nut on the X endstop, being careful not to move it.



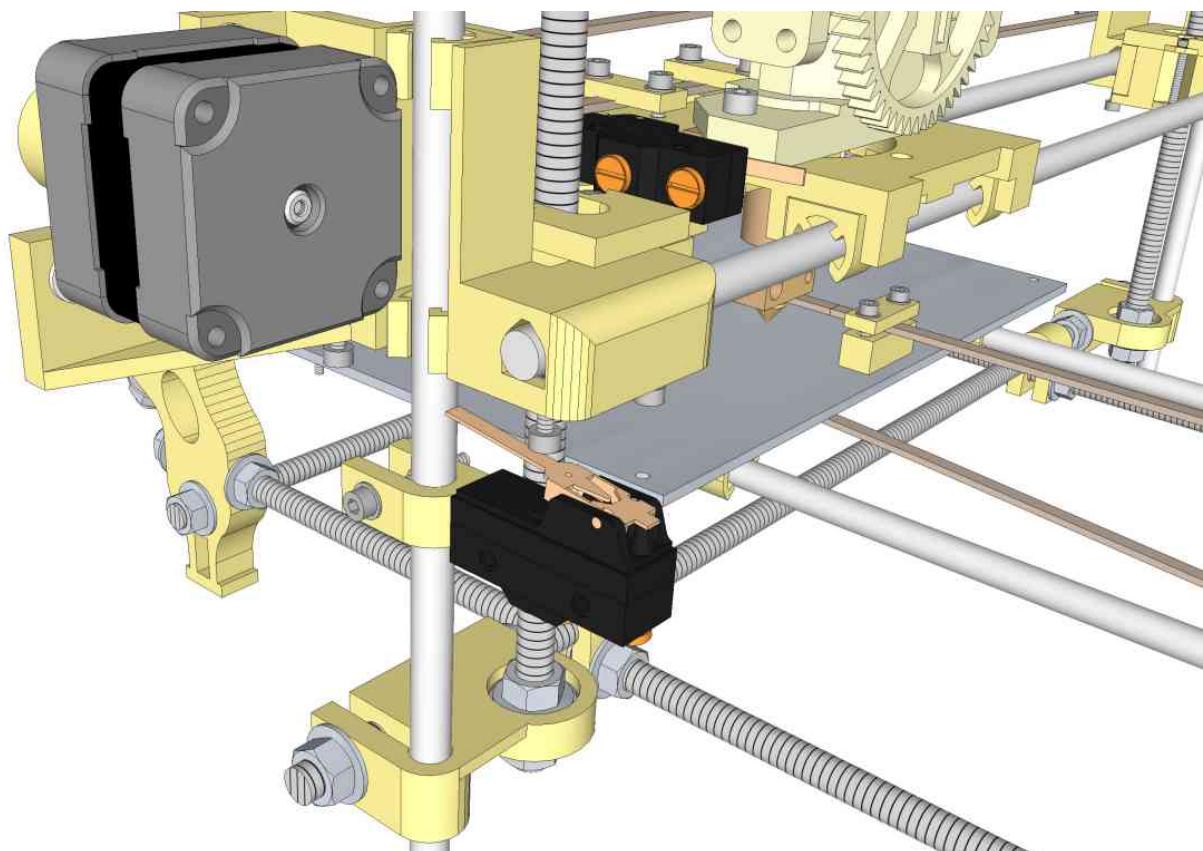
10.6

Slide the print-bottom-plate backwards until the nozzle is about 30mm 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.



10.7

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 more when the bed is installed and leveled.



10.8

Decide where your electronics will be mounted on your printer. For Gen6 electronics, we recommend mounting it on the bottom left frame threaded rod, facing outwards, using two endstop-holders. Note that additional hardware and two endstop-holders are required (more details below if you choose this method).

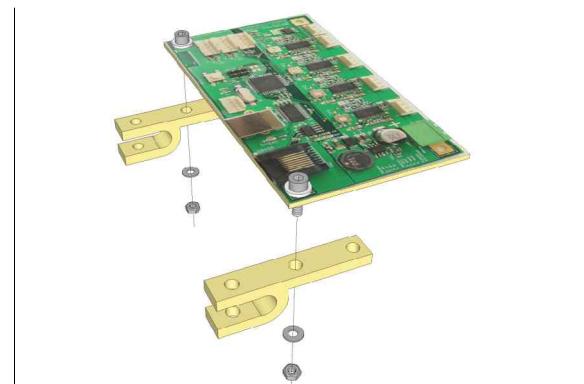
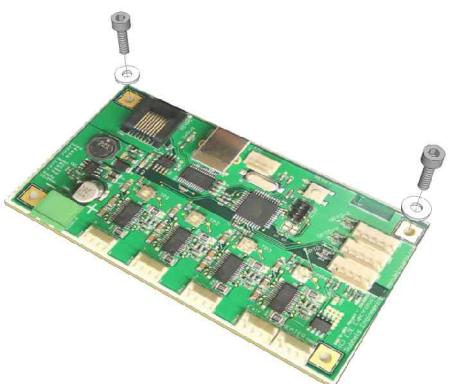
Additional items as listed in BOM for mounting Gen6 electronics:

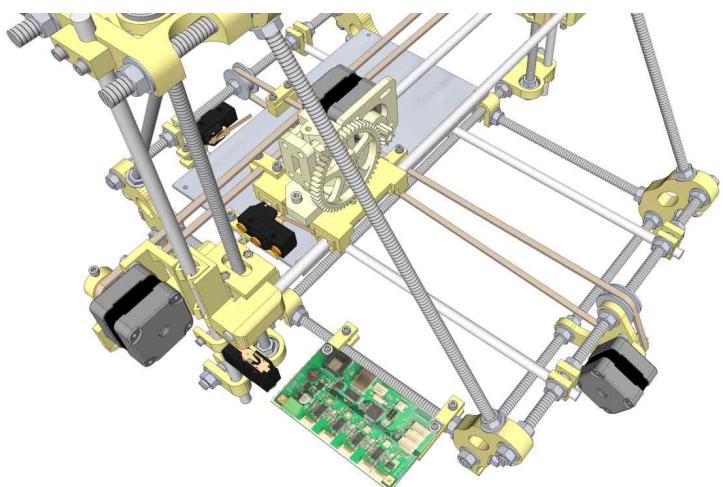
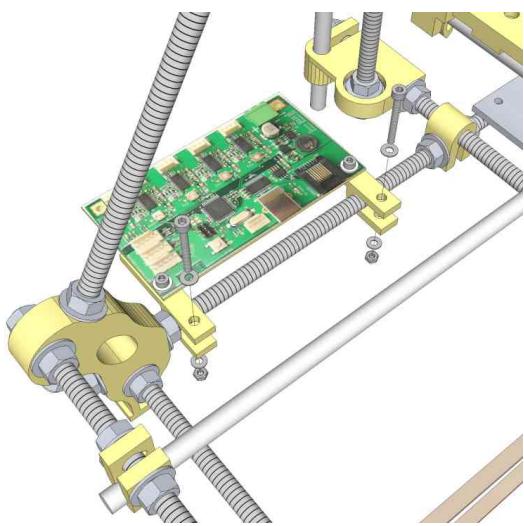
- 2 x endstop-holder
- 2 x M3x10 bolt
- 2 x M3 nylon washer
- 6 x M3 washer
- 4 x M3 nut

Sugested mounting method for Gen6 electronics: Put an M3 nylon washer onto two M3x10 bolt each and thread it through two of the holes on the Gen6 electronics board – along the long edge where the USB connector is. Thread each open end of the bolt through the middle holes of two endstop-holders, with the flat side on the underside of the board and the open “U” of the endstop-holder facing away from the long edge of the board. Put an M3 washer and an M3 nut to the ends of both bolts. Tighten the bolts.

Insert the “U” of both endstop-holders onto the bottom left frame threaded rod, aligning them to the extreme front of the inside of the rod. 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. Once you are satisfied with the position and orientation of the board, tighten the bolts onto the threaded rod.

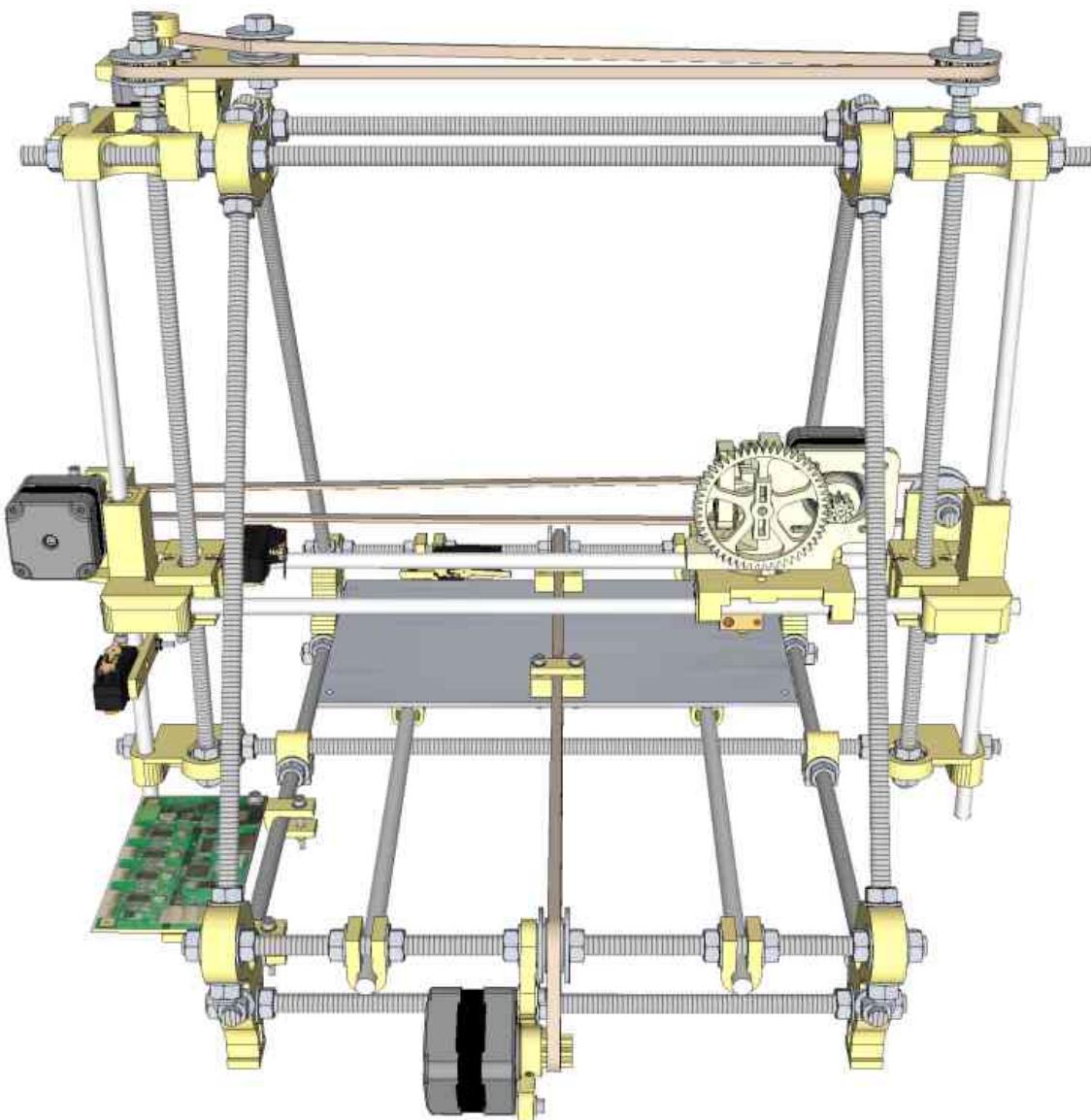
Refer to the photos below and on the following page.





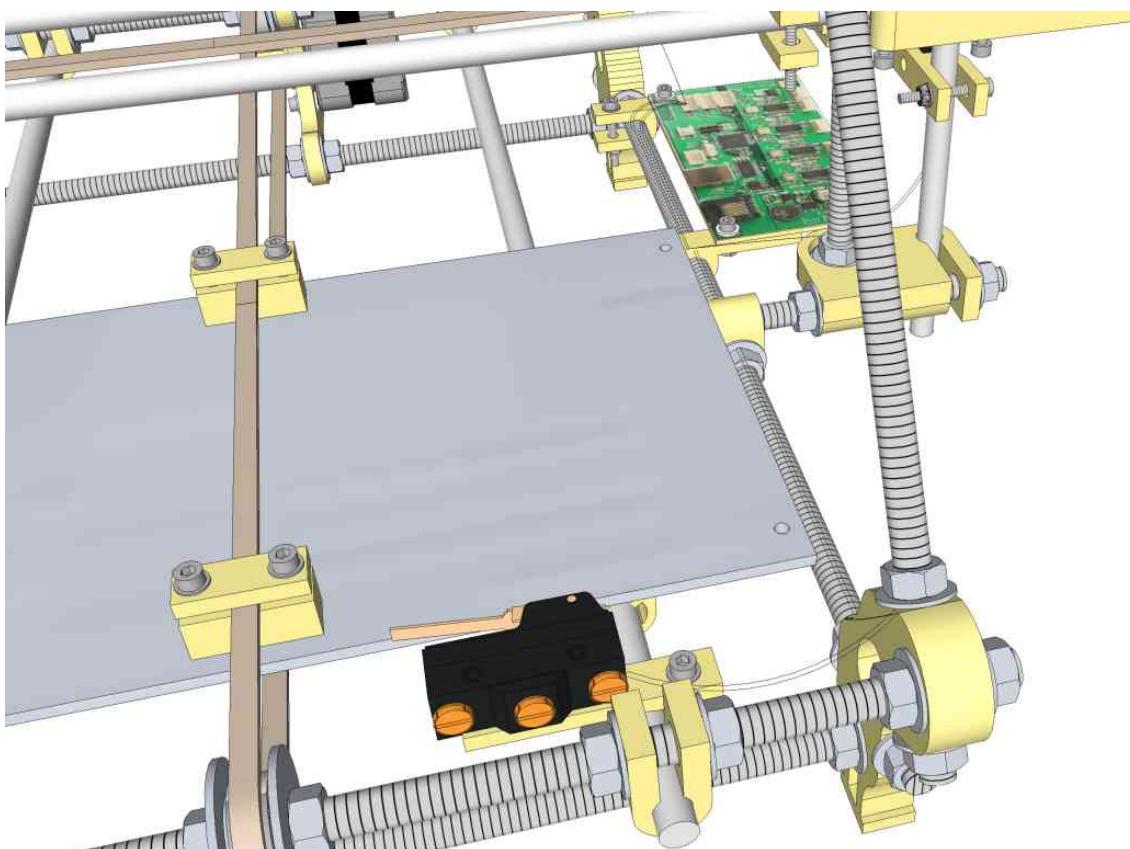
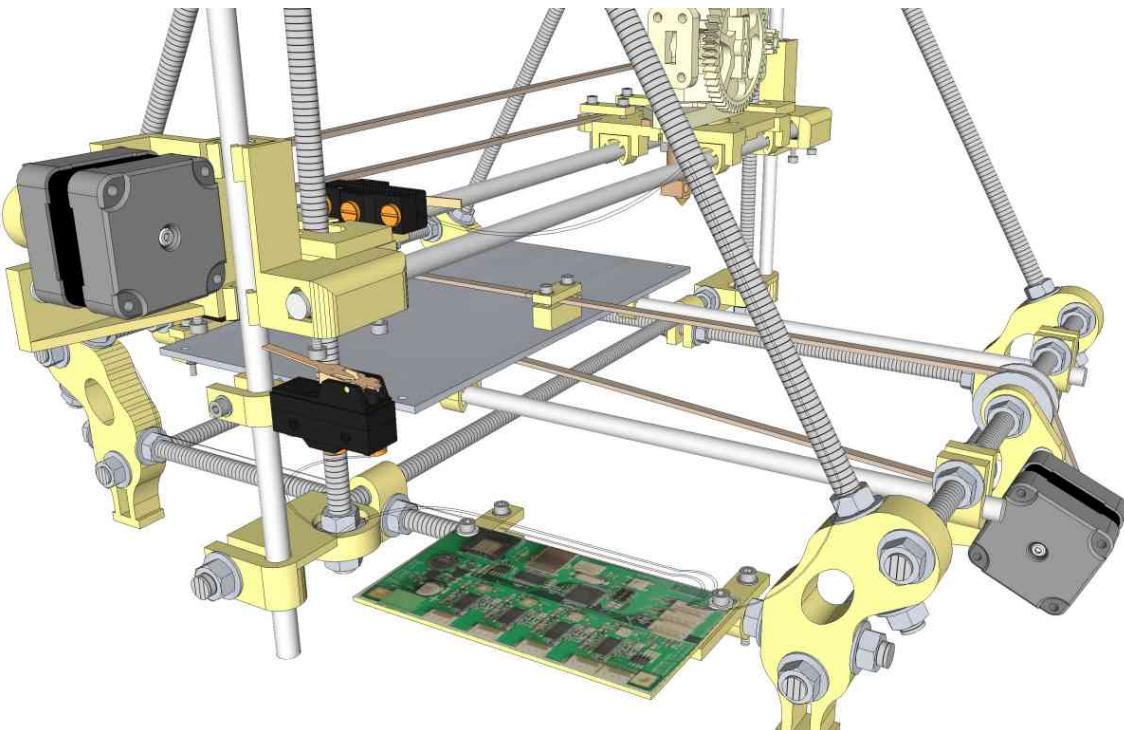
10.9

Slide the x-carriage as far away from the electronics as possible.



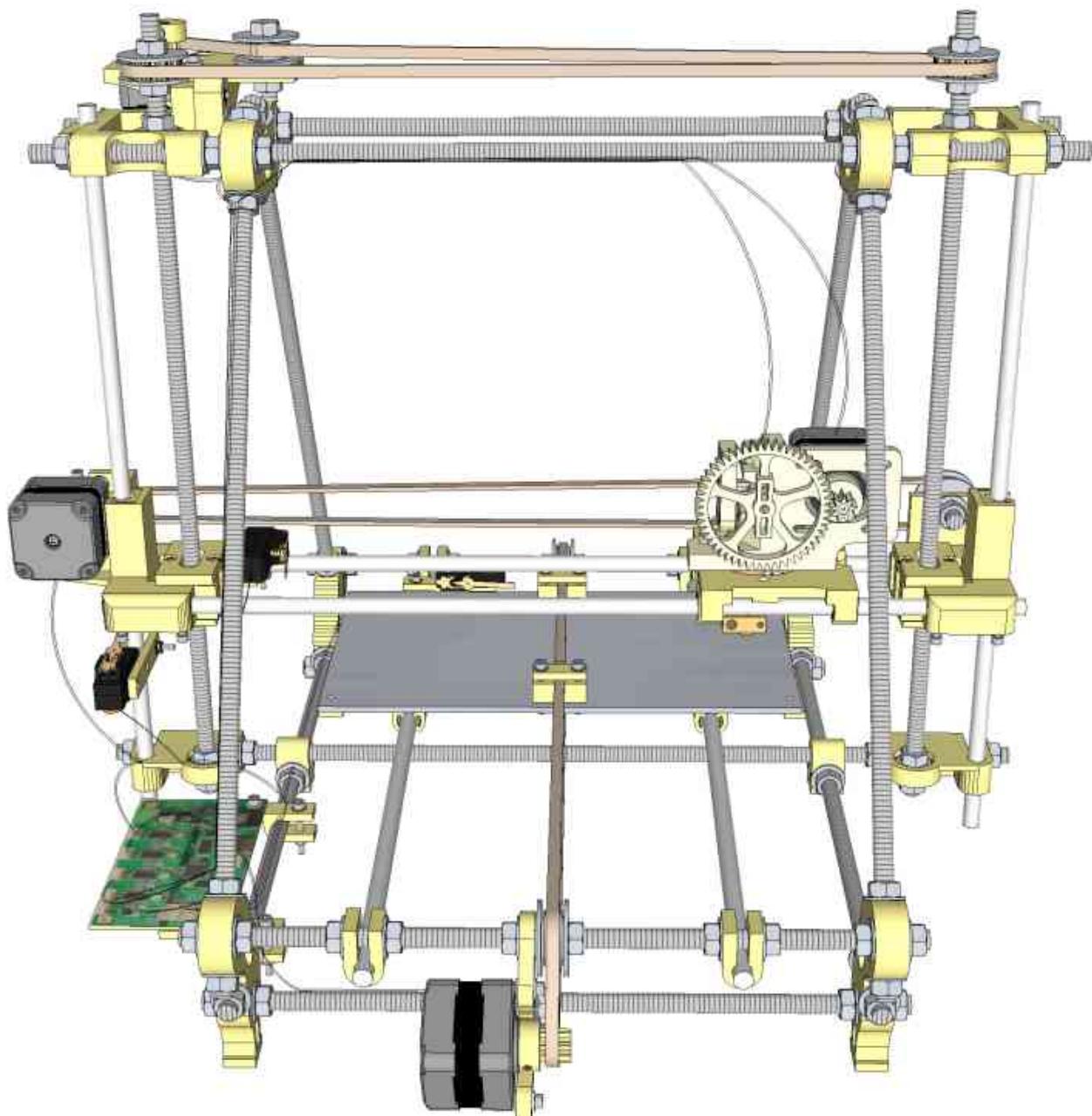
10.10

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 zip ties to fix the wires to the frame.



10.11

Route the wires along the frame to all the motors (x, y, z and extruder) as well as to the heater (hot end). Be sure to allow enough slack in the cables for the x motor, extruder motor and the heater to allow for the x axis and z axis to move to its extremes (x axis all the way to the right, z axis all the way to the top) without tugging on the cables. After you are satisfied with the cable layout, use zip ties to secure the wires to the frame.



10.12

Move the x and y axes all the way in each direction, and check that no wires interfere with movement.

Note: If you have obtained the Durbie Prusa Mendel as a kit from romscraj, all cable harnesses have been custom wired to work out of the box with the Gen6 electronics provided and firmware loaded and pre-calibrated. Otherwise, visit the RepRap wiki for up-to-date instructions on setup, troubleshooting and firmware calibration instructions for your printer:

http://reprap.org/wiki/Prusa_Mendel_Assembly

Some pre-calculated axis_steps_per_unit values to start with for the Durbie Prusa Mendel (metric) running on Marlin firmware are as follows (it is strongly recommended to run a recalibration to fine tune your own setup):

X, Y, Z Values for use with 8-toothed plastic pulleys (as illustrated in this documentation):

X – 40

Y – 40

Z – 2674.3602

X, Y, Z Values for use with romscraj custom 10-tooth aluminium pulleys:

X – 32

Y – 32

Z – 2057.2

E Value for Wade's V2 M4 Extruder:

E – 514 (rough calculation based on 6.5mm O/D M4 toothed insert, Skeinforge 41)

Part 1 1

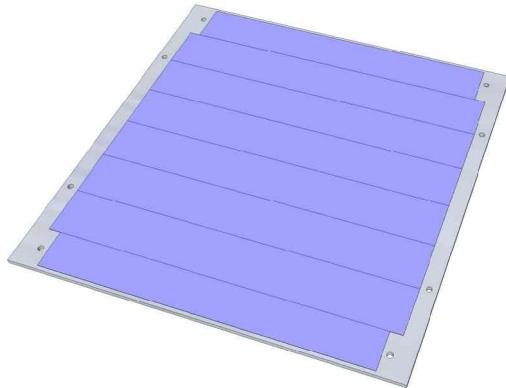
Attaching the print bed

11.1

If you have a heated build platform, install it on the print-top-plate at this point. If you have obtained the Durbie Prusa Mendel with experimental heated bed option included, refer to the assembly instructions and notes which are documented separately (under construction)

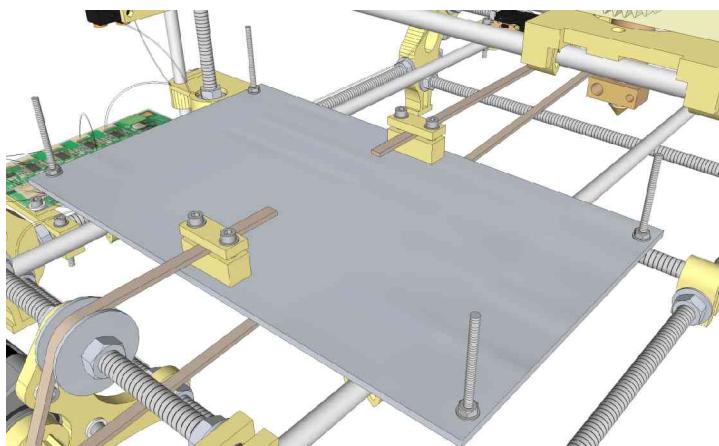
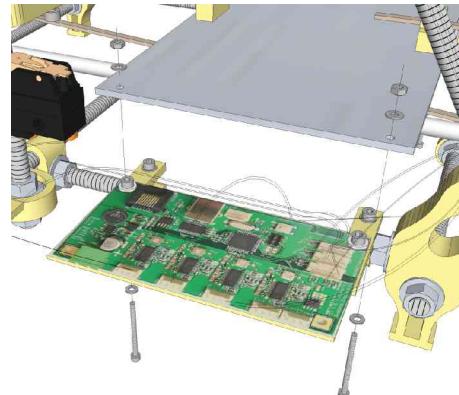
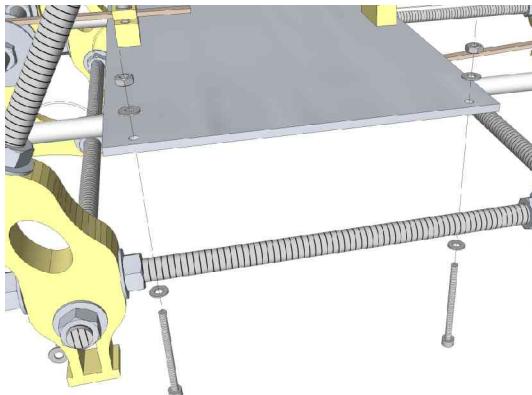
11.2

Cover your print-top-plate or build platform with the build surface material that you will be using (Kapton, blue tape, masking tape etc.)



11.3

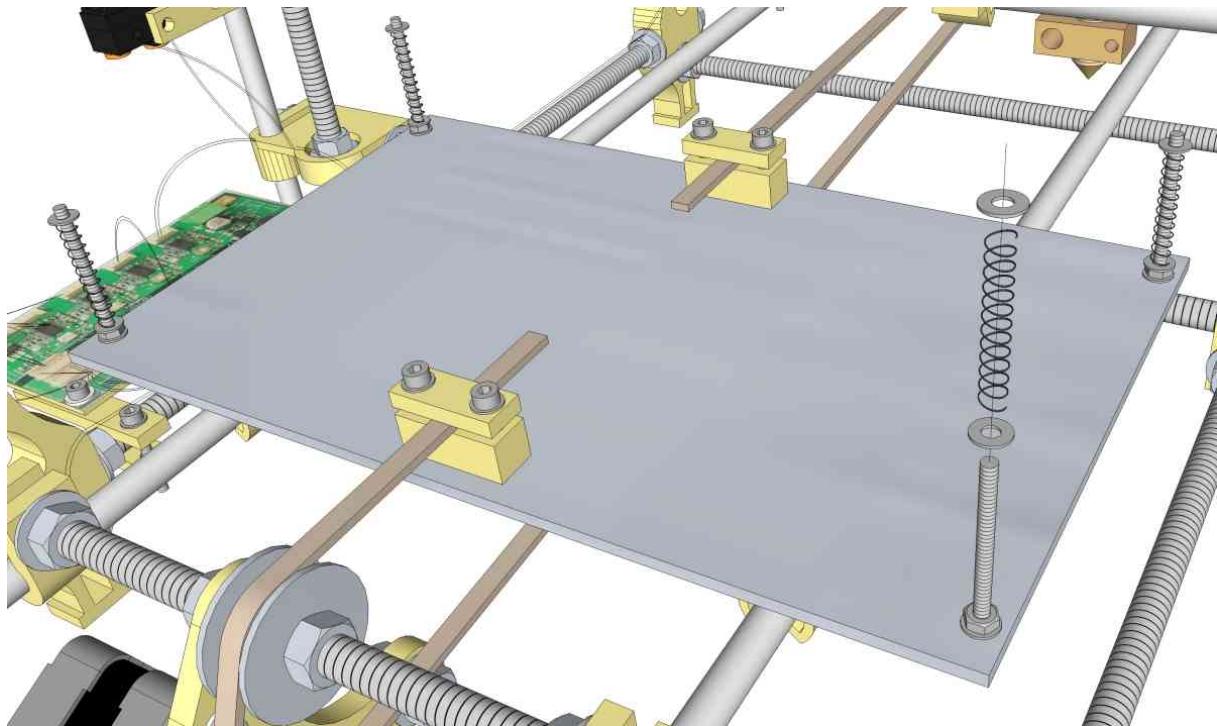
Put a washer on each of the four M3x40 bolts. Thread each bolt through the underside of the print-bottom-plate. Add a washer followed by a nut to the open end of each bolt and tighten everything against the print-bottom-plate.



11.4

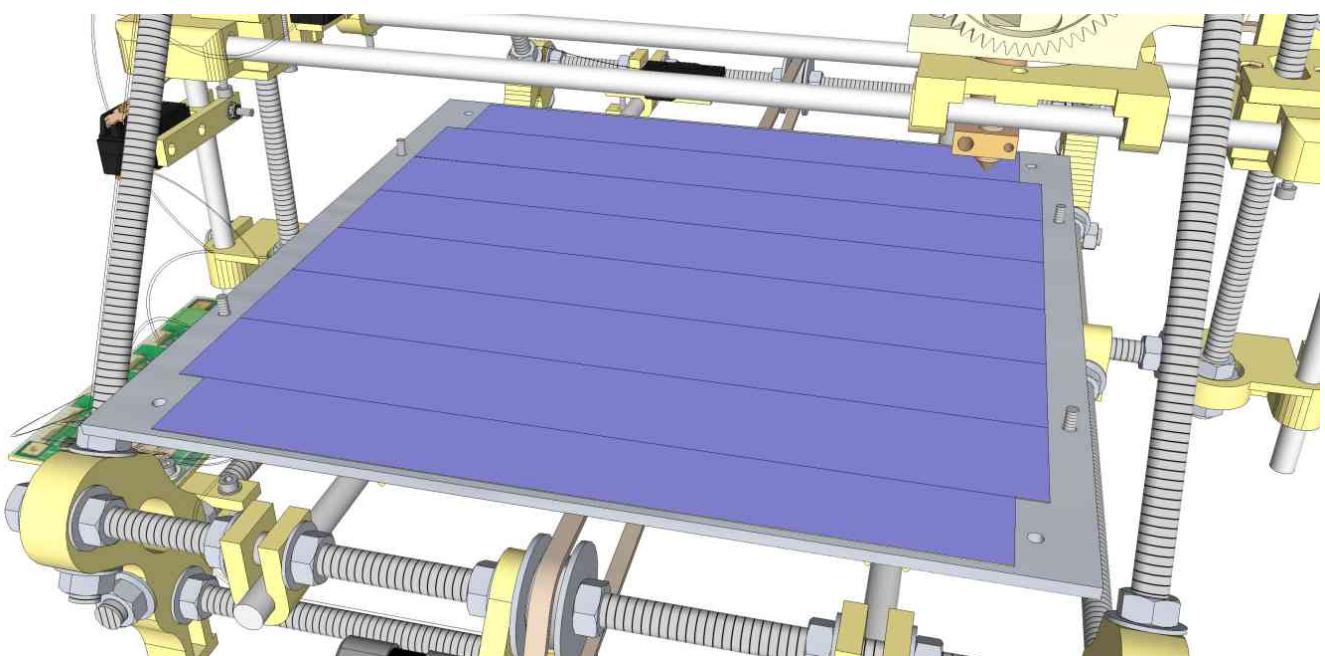
Insert the following into the open end of each M3x40 bolt:

- washer – 3mm ID spring (or ballpoint pen spring) – washer



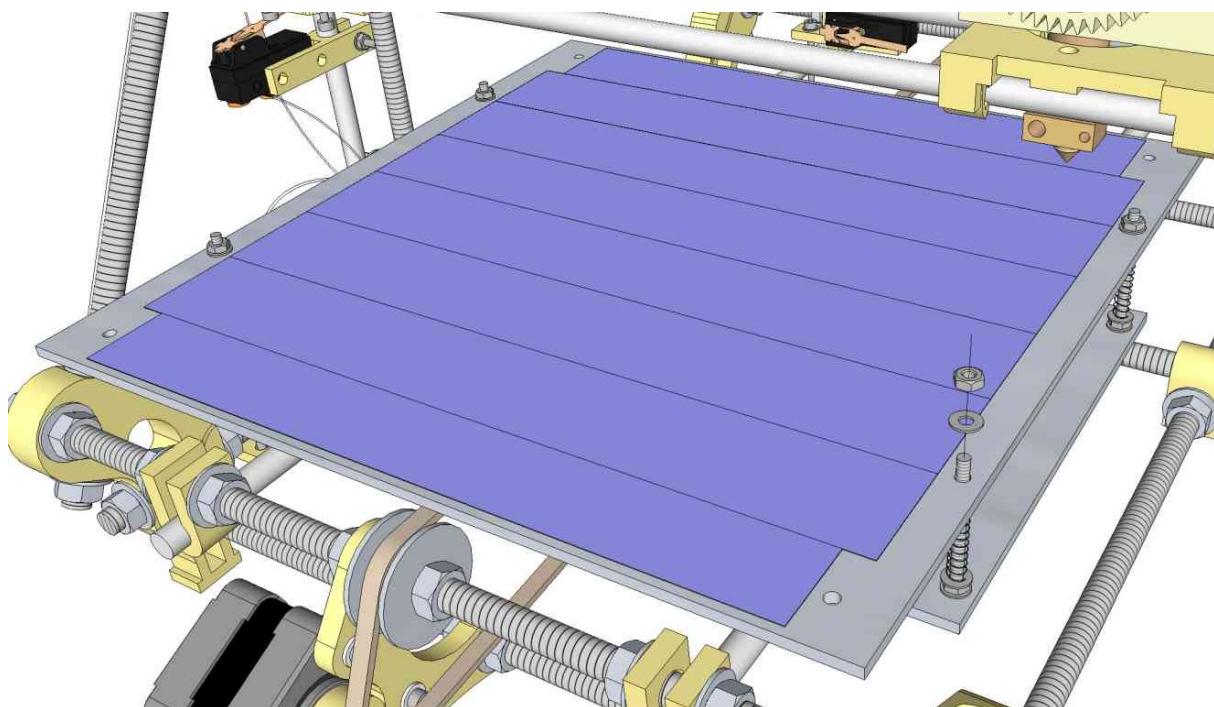
11.5

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-top-plate.



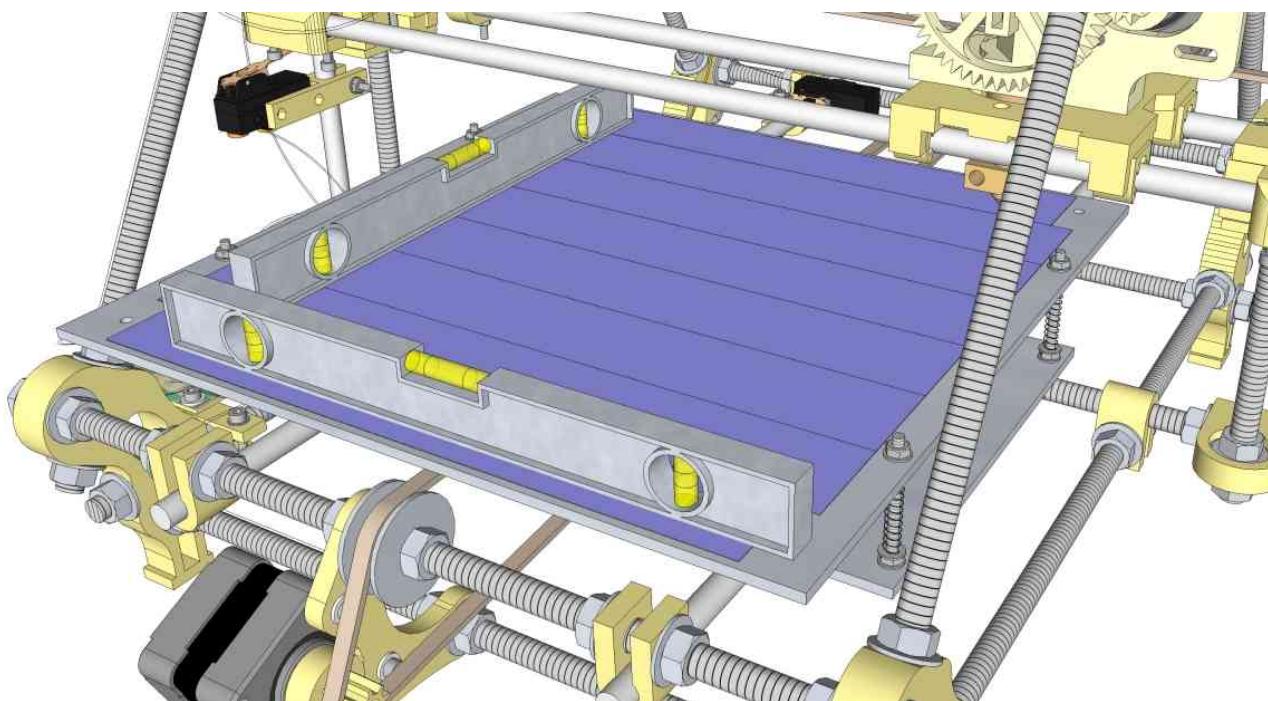
11.6

Put an M3 washer and a nut on the end of each of the bolts. Do not tighten.



11.7

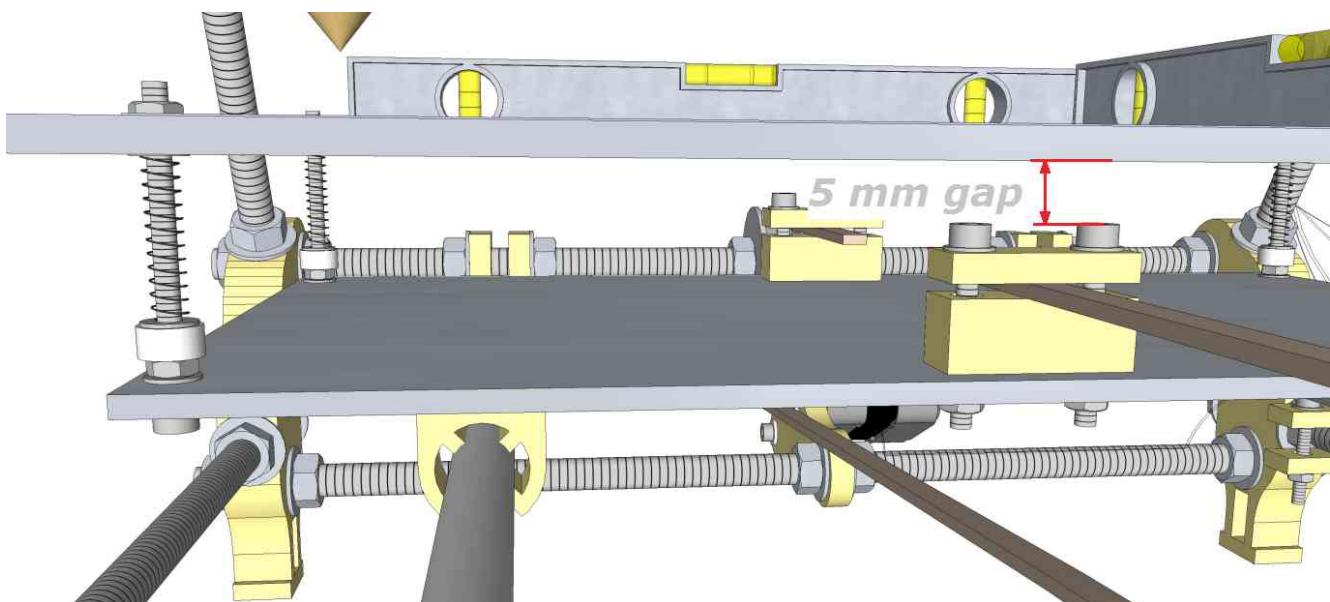
Level the bed. To do this, put a spirit level on top of the bed and adjust the nuts that are on the top of the print-top-plate on each M3 bolt until the spirit level shows that the bed is level.



11.8

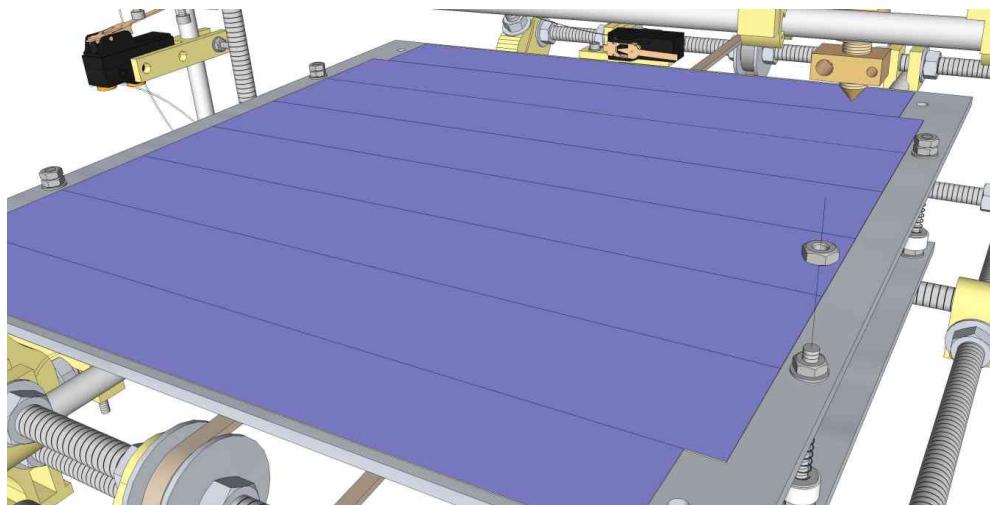
As a precaution, you may want to leave a small gap (approximately 5mm) between the underside of the print-top-plate and the heads of the M3 bolts on the y belt-clamps. This forms a 'floating bed' on the springs, allowing some downward movement to enable the print-top-plate to compress onto the springs should, for example, the nozzle ram into the bed if something goes wrong with the printer when in use (instead of possibly damaging or breaking something). The 'floating bed' can also assist the nozzle in 'overcoming' obstacles (blobs) while printing – something that you may or may not experience when you print.

If you choose to do this, ensure that your springs are adequately compressed under the print-top-plate and are stiff enough to exert sufficient upward force to support the print-top-plate (and heated bed, if any) as well as the weight of plastic parts being printed. You may find that you might need to add additional nuts or spacers under the springs against the top of the print-bottom-plate to achieve the proper spring tension. This adjustment should be based on trial and error and 'calculated judgement' or 'guesstimation' based on the springs that you use (too little spring tension and the bed will sag in use, too much tension and there will be no added benefit as the springs are too stiff).



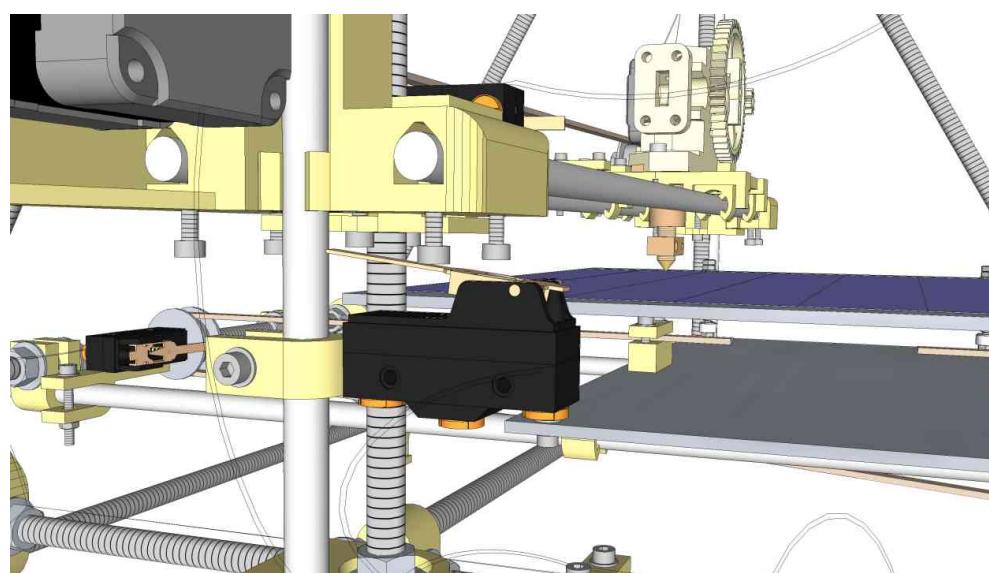
11.9

Once the bed is level, put a nut onto each of the M3 bolts on the print-top-plate. Tighten these nuts against the nuts that you have adjusted to make the bed level previously, to lock them in place. As you tighten, take care not to turn the earlier nuts that adjust the bed levelling – hold these nuts so that they not move and turn only the newly inserted nuts against them. Check the bed levelling again with the spirit level.



11.10

Adjust the z endstop so that it is triggered when the nozzle just barely touches the bed. Also confirm that the hot end does not hit the nuts on top of the print-top-plate when the x-carriage engages the x endstop, and the hotend is within the front boundary of the print-top-plate when the y endstop is engaged. Adjust the position of the endstops if necessary.



11.11

Your printer is now complete. You may repeat Step 9.7 of Part 9.