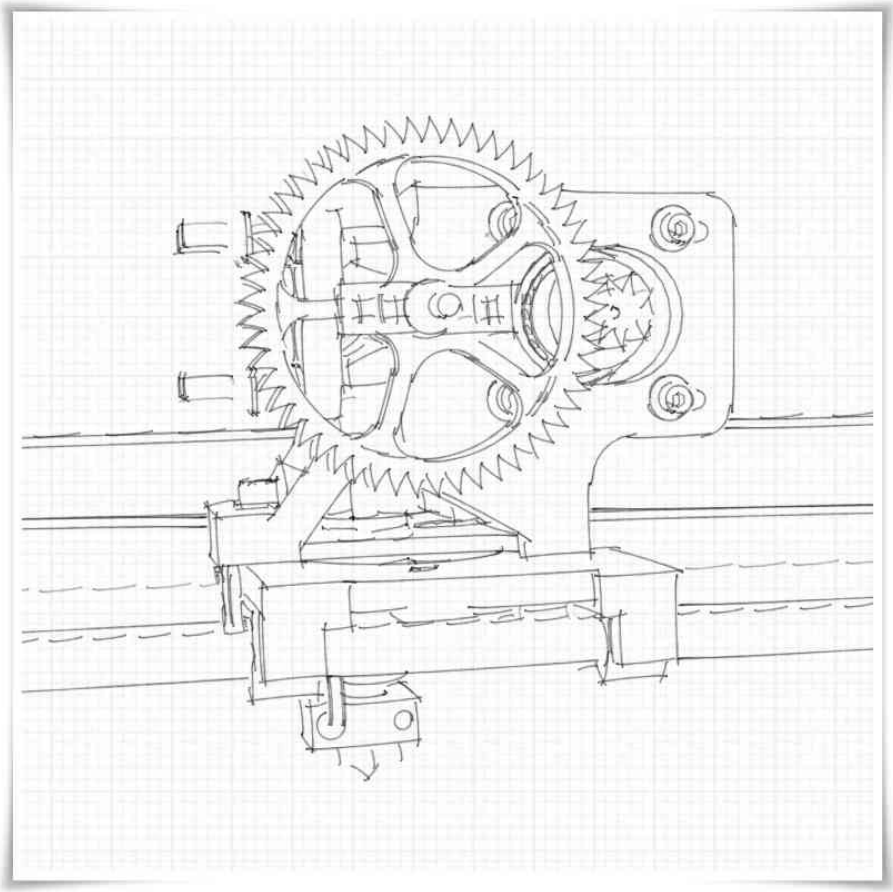
Wade's Extruder V2 (M4)



Assembly Instructions

RepRap

orange.knob
{ romscraj }

Introduction

Document Version & Date: V1.0 Dec 2011

Goal:

Provide a visual guide of the steps needed to construct a Wade's Extruder V2 (M4).

Original Authors:

Wade (original design from which this work was based on and modified upon)

Author of this Document:

Md Noh

Special Thanks:

Gary Hodgson (author of work from which inspiration for this document was taken from)

STL Model Files:

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):

- 'Retractable hobby knife' by J-m@n
  http://sketchup.google.com/3dwarehouse/details?mid=59481570acb7a0872d4ba5e1aa44cc40
- 'Premier Prismacolor® Markers' by Jon
  http://sketchup.google.com/3dwarehouse/details?mid=f352190b5a788ecff788b21b3d1cd437
- 'Straight dashed line and arrow, ground' by Google
  http://sketchup.google.com/3dwarehouse/details?mid=f352190b5a788ecff788b21b3d1cd437
- 'NTC Thermistors Accuracy Line R25= 10 kOhms ± 3 %' by TraceParts
  http://sketchup.google.com/3dwarehouse/details?mid=ebef97838a867a61c946e255b102bb0f
- 'stepper motor - nema 17' by russ_anderson
  http://sketchup.google.com/3dwarehouse/detailsmid=7b5ee9e35f85c343757b961dad12f52

Licensing:

Wade's Extruder V2 (M4): 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:

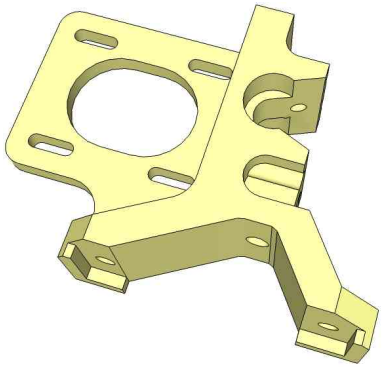
romscraj@orangeknob.com

Bill of Materials (1/2)

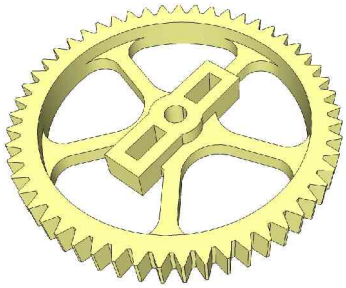
Printed Parts

Note: Part drawings not shown to scale.

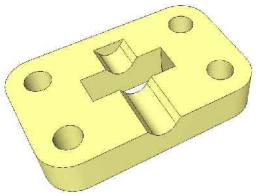
1x extruder-block



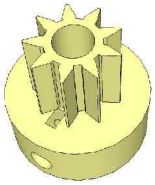
1x 53-tooth-driven-gear



1x idler-block



1x 9-tooth-drive gear



Non-Printed Parts

Note: Quantities stated are absolute mimimum requirements – it is recommended to procure extra quantities of common parts to be on the safe side.

Quantity	Description	Remarks
1	M3 hex nut	
8	M3 nylon flat washer (1mm thick)	Used as insulating washers.
4	M3x10 bolt	Socket Cap head recommended
1	M3x6 brass machine screw	Pan head recommended.
1	M3x10 set screw / grub screw	
1	M3 aluminium flat washer (large OD)	10mm outside diameter
1	M3 silicone flat washer (large OD)	10mm outside diameter, 2mm thick
10	M4 hex nut	
12	M4 flat washer	
1	M4 wing nut	
1	M4x20 bolt	Any head type
4	M4x45 hex head bolt	
1	M4x55 bolt	Stainless steel material recommended
2	M8 hex thin nut / jam nut	4mm thickness
3	624 ball bearing	

Bill of Materials (2/2)

Non-Printed Parts (continued)

Note: Quantities stated are absolute mimimum requirements – it is recommended to procure extra quantities of common parts to be on the safe side.

Quantity	Description	Remarks
1	M4 threaded insert	6.5mm OD, 7mm length, with suitable external 'teeth'
1	NEMA 17 bipolar stepper motor + cable	
1	Slidemount plate	Refer to Part 1 of instructions for details.
1	Hot end nozzle	Refer to Part 1 of instructions for details.
1	Heater block	Refer to Part 1 of instructions for details.
1	Insulator Barrel	Refer to Part 1 of instructions for details.
1	Teflon tape / thread seal tape	12.7mm (1/2”) width, 50mm length
1	Heating element	Typically a power resistor
1	Thermistor	Typically an NTC, glass bead, standard type
70mm	PTFE (Teflon) tubing	3mm ID x 5mm OD, 70mm length minimum
100mm	PTFE / silicone glass fibre sleeving	For insulating leads of hot end components.
1	High-temp glue / epoxy	Able to withstand at least 80°C/176 °F
-	Wires	Adequate length to connect heating element and thermistor to printer's electronics
4	4mm ID spring	10mm free length, 4 active coils, 25-35N load provided per spring. Extruder may work without these springs but they are recommended.
1	Ziptie	Used to affix wires / cables. Minimum quantity 1pc as used in Part 3, Step 3.22

Recommended Essential Tools / Items

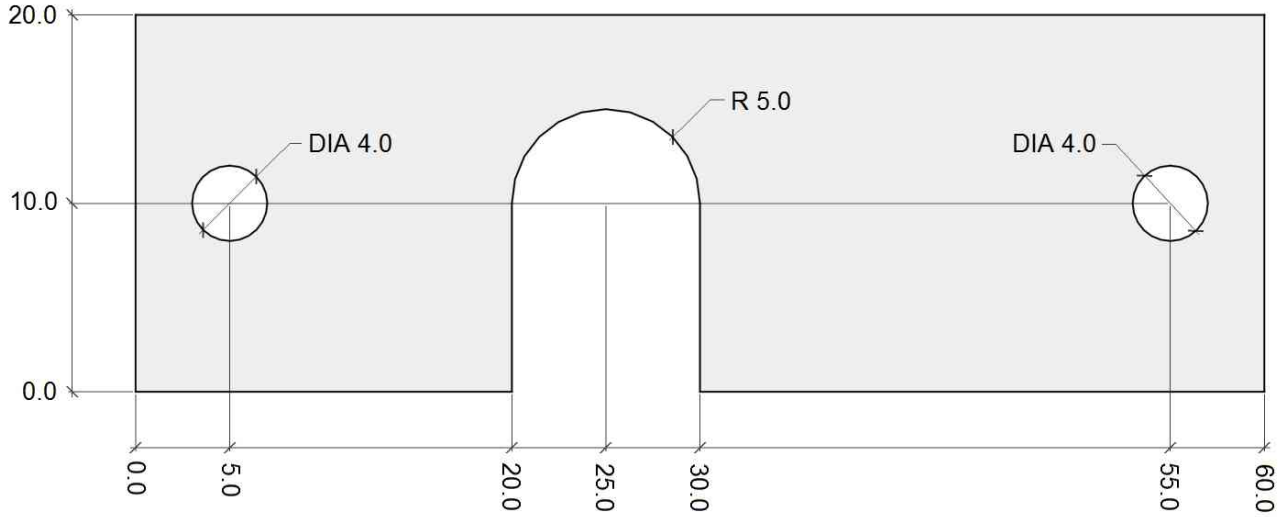
1	Safety eyewear	*Very very highly recommended* especially if you do not wear eyeglasses. Injured eyes will inconvenience you for a considerably long period of time which could otherwise be spent looking at beautifully printed 3D objects, as well as other beautiful things worth looking at.
1	Marker pen	Fine tip, permanent.
1	Penknife / box cutter / utility blade	With a very sharp blade
1	2.5mm Allen key	For use with M3 socket cap head
1	3mm Allen key	For use with M4 socket cap head
2	13mm spanner / wrench	Ideal tool to use for locking together the M8 thin nuts in Part 2, Step 2.5
1	Steel rule	At least 15cm/6” long
1	Needle Nose / Snipe Nose Pliers	Useful for gripping M4 nuts in tight spaces
Assortment	Files	Needle files, plus assorted bastard files.

Part 1

Machining the hot end and hot end mount

There are four parts that require machining – the slidemount plate, the hot end nozzle, the heater block and the insulator barrel. If you have not obtained these parts pre-made, you can refer to the following drawings as a suggested guide to make them (or you may also design your own). If you have obtained these parts pre-made, skip this section and proceed to Part 2.

Slidemount Plate

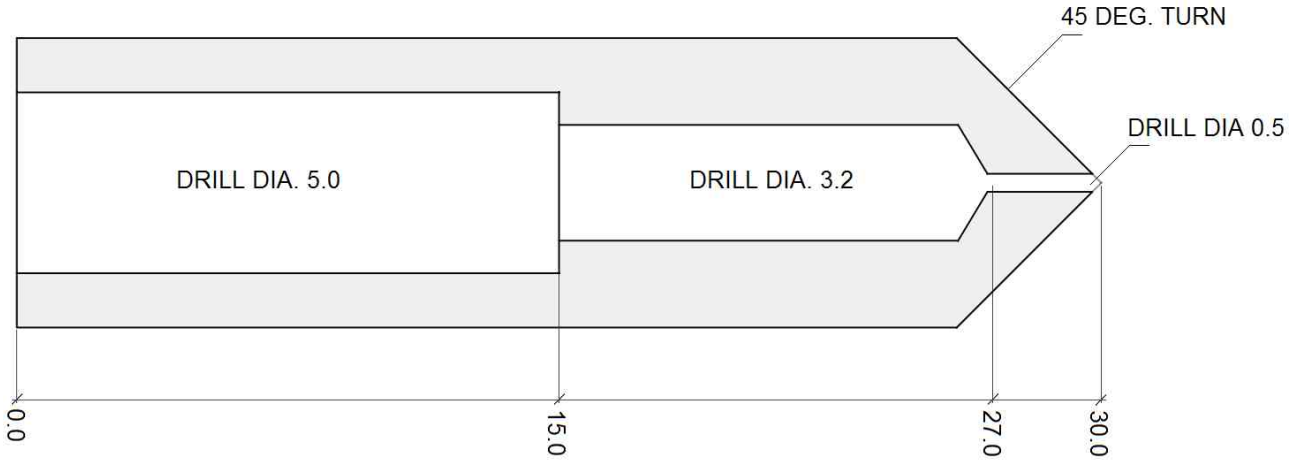


ALL DIM. IN MM

Notes on material: 3mm thick, stiff, heat resistant and insulating (needs to be mechanically stable at temperatures up to approx. 80°C/176 °F). High density / hardwood / birch plywood, or FR4 laminate is recommended.

Machining notes: A dia. 10 drill can be used to make the R 5.0 arc portion, thereafter performing two cuts to complete the cutout.

Hot End Nozzle



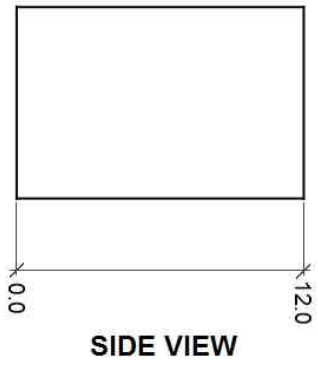
CROSS SECTION VIEW

ALL DIM. IN MM

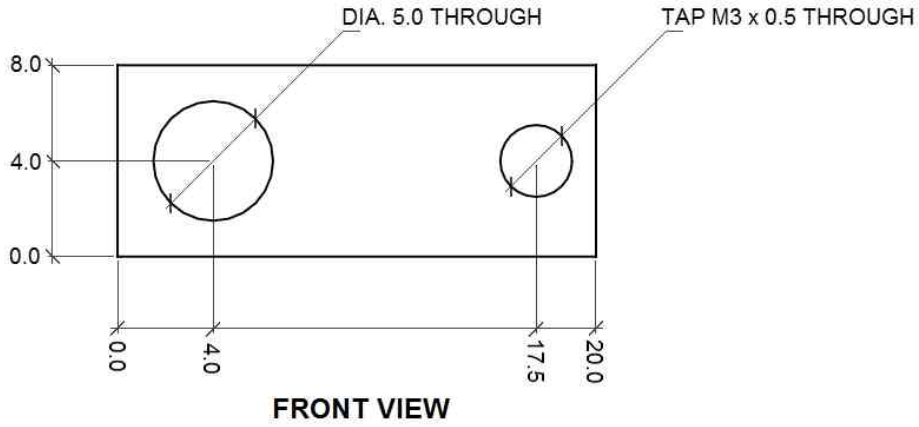
Notes on material: Brass recommended. To be made from M8 threaded rod cut to length, or 8mm brass smooth rod and M8 x 1.25 die cut male thread. May be substituted with other materials (untested).

Machining notes: 45 deg. lathe turn to be performed as a final operation after all holes have been drilled.

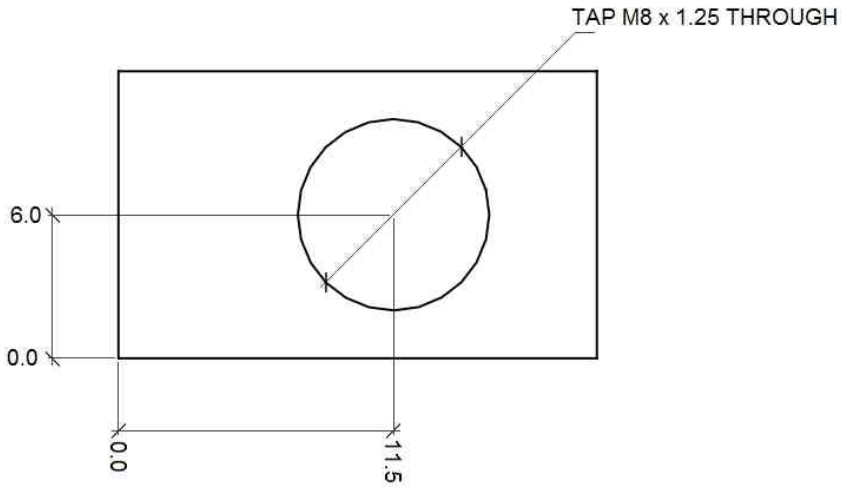
Heater Block



SIDE VIEW

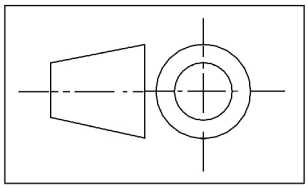


FRONT VIEW



PLAN VIEW

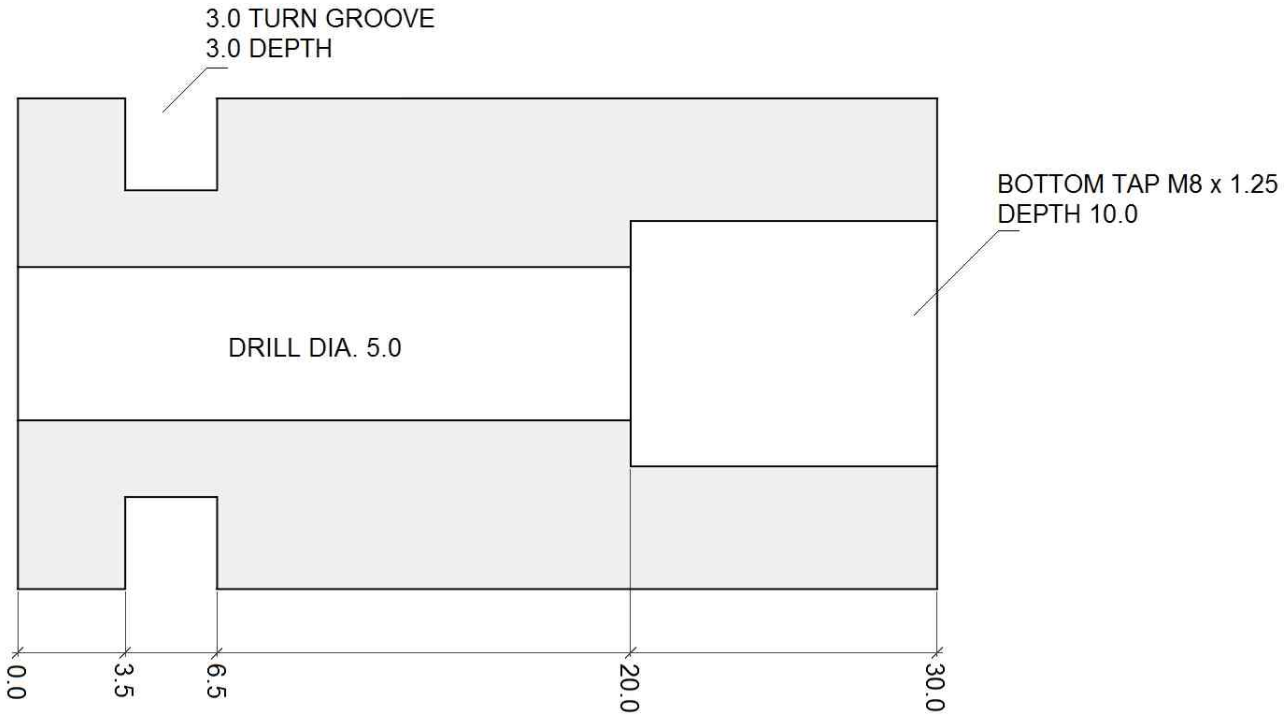
ALL DIM. IN MM



Notes on material: Brass recommended. May be substituted with other materials (untested).

Machining notes: Dia. 5.0 hole may need to be of different drill size, depending on the particular heating element (resistor) that you have.

Insulator Barrel



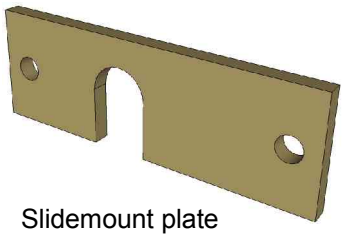
CROSS-SECTION VIEW

ALL DIM. IN MM

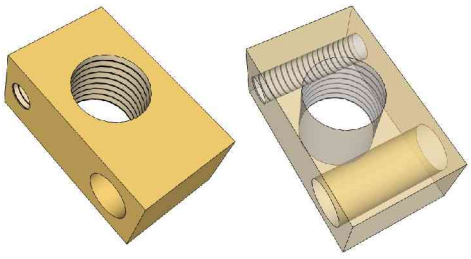
Notes on material: PEEK (polyether ether ketone) plastic recommended. To be made from 16mm PEEK rod cut to length. Filled variants (having higher thermal conductivity) may be safely used as the design of the extruder mount isolates the insulator barrel away from printed plastic parts, preventing softening/deformation issues (even with PLA printed extruder parts). May be substituted with other materials with similar strength, heat resistance and insulating characteristics (untested).

Machining notes: 3mm cut groove for mounting onto slidemount plate. In the absence of a lathe, modified groove designs may be substituted (eg. two 3mm wide, 3mm deep parallel file cuts on opposite ends, i.e. groove need not be all the way around the barrel in order to fit onto slidemount plate).

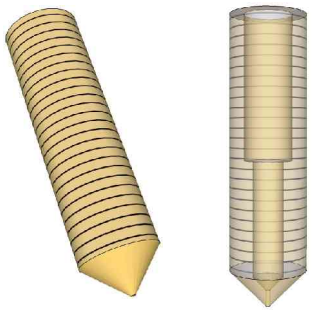
(illustrations not shown to scale)



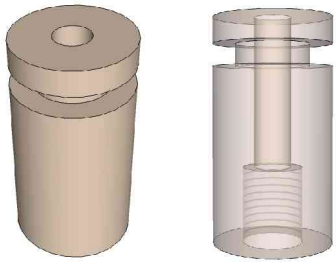
Slidemount plate



Heater block



Hot end nozzle



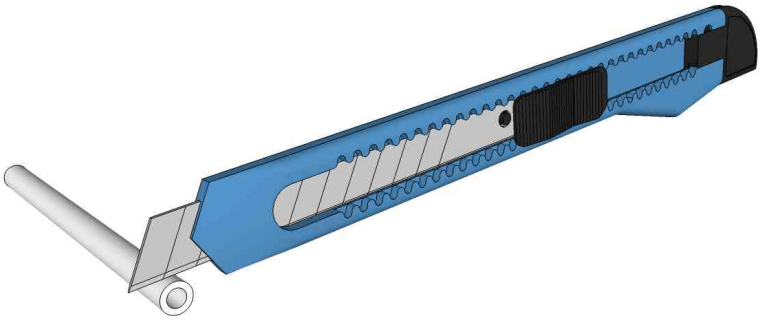
Insulator barrel

Part 2

Assembling the hot end

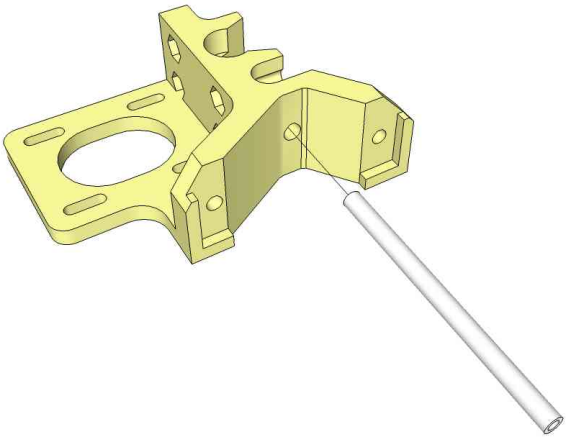
2.1

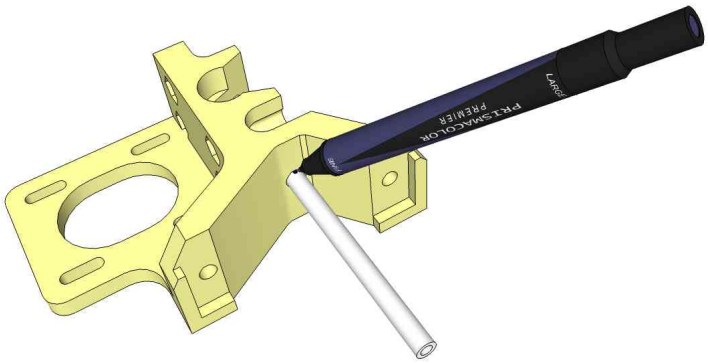
Using a very sharp blade, slice away approximately 2mm off one end the PTFE tubing. Aim to get as straight and perpendicular a cut as possible. Do not cut off too much as the tubing may end up being too short.



2.2

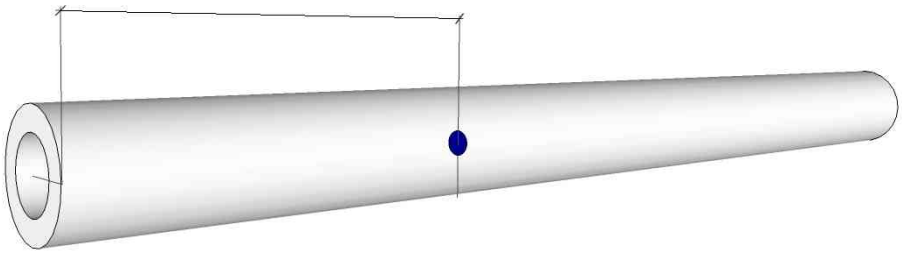
Insert the cut end of the tubing all the way into the filament channel from the underside of the extruder-block. Using a marker pen, mark the PTFE tubing at the point where it just enters the extruder-block.





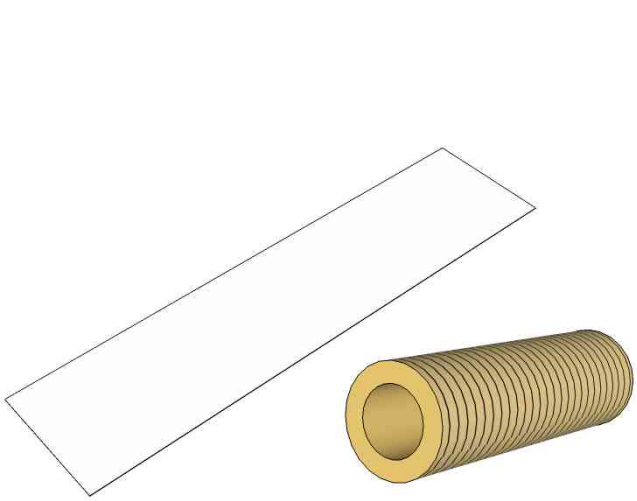
2.3

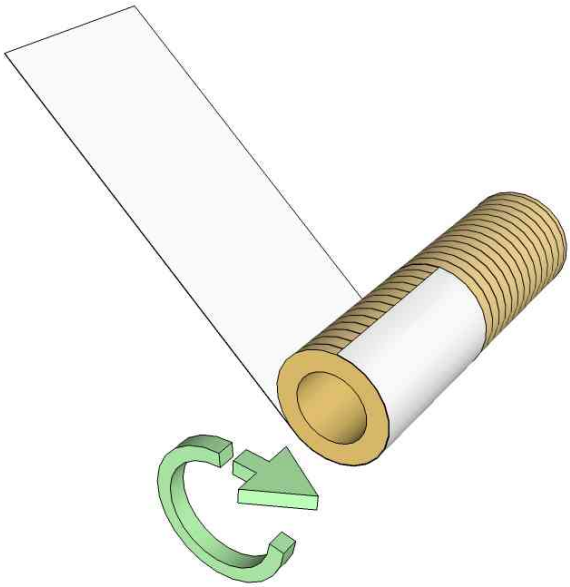
Remove the PTFE tubing from the extruder-block. Measure the distance between the end of the tubing that was inserted earlier and the mark that was made. Record down this value.



2.4

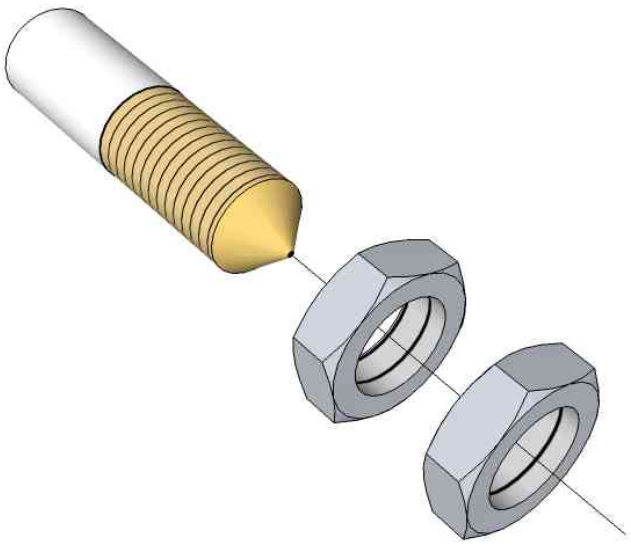
Cut off a 50mm length of teflon tape. Take the hot end nozzle and orientate it such that the non-tapered end is facing you. Wrap the teflon tape tightly around the hot end nozzle *in a clockwise manner*, right at the edge of the non-tapered end. You should be able to wrap approximately two full rounds.

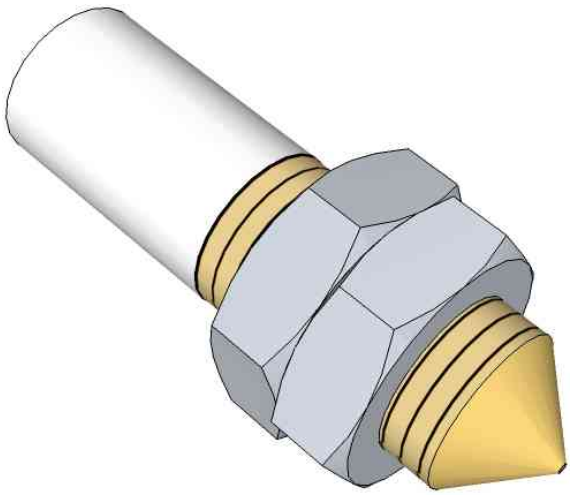




2.5

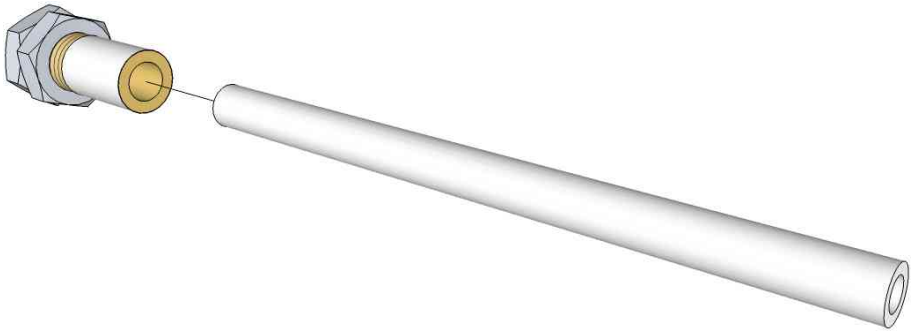
Insert the two M8 thin nuts into the hot end nozzle through the tip end (the end without the teflon tape). Position them near the nozzle tip and tighten them together so that they cannot move.

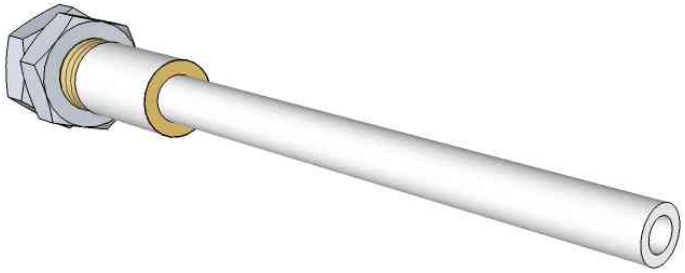


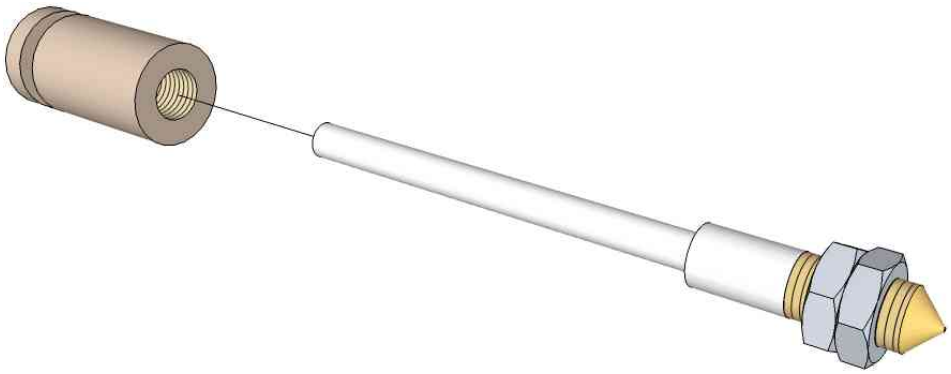


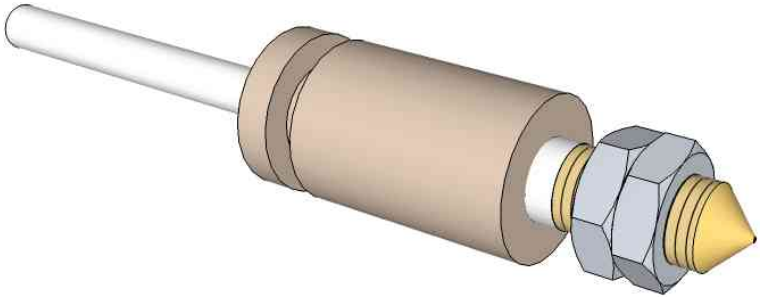
2.6

Insert the cut end of the PTFE tubing into the hot end nozzle. Push it in as far as it can go – it should be about 15mm deep. While making sure the PTFE tube remains in the nozzle, insert the free end of the PTFE tube into the insulator barrel through the female M8 threaded end. Screw in the end of the hot end nozzle with the teflon tape into the insulator barrel as far as it can go. Turn the outside M8 nut with a suitable tool if needed. Make sure that the PTFE tubing remains in the hot end nozzle throughout this step and the steps that follow.







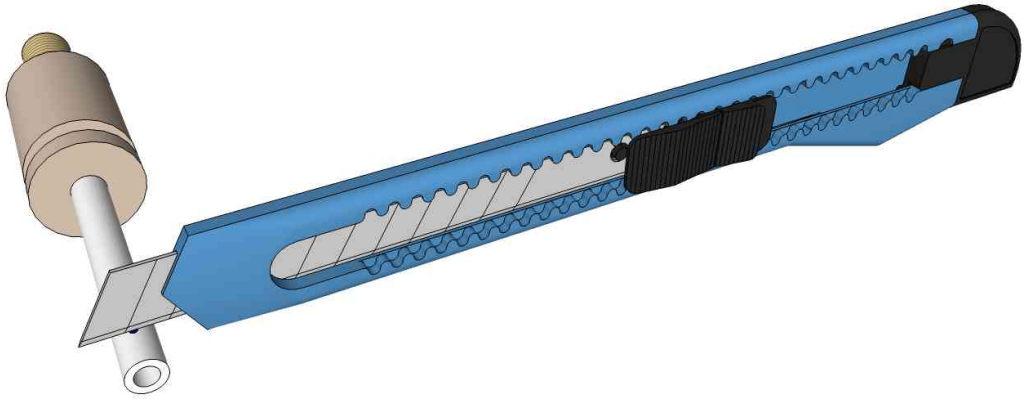


2.7

Remove the two M8 nuts from the hot end nozzle. Add 10mm to the measurement from step 2.3. Mark out this new length on the PTFE tubing, measured from the point where the tubing just enters the insulator barrel.

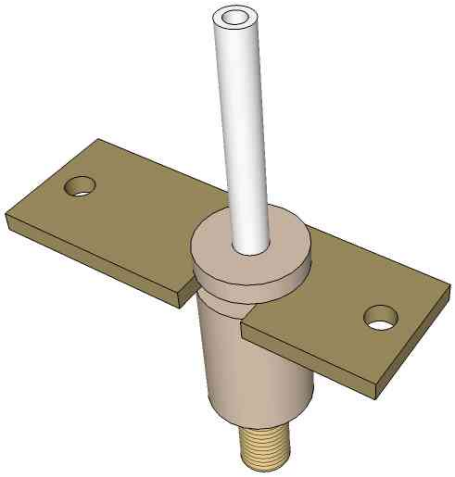
2.8

Using a very sharp blade, slice the PTFE tubing at the point you have just marked. Aim to get as straight and perpendicular a cut as possible, but *it is very important not to cut off tubing beyond the marked point (i.e making it shorter than the measurement in step 2.7), even if the cut is not very straight*. Remember to ensure the PTFE tubing does not come out of the nozzle/insulator barrel or your measurement and cut will not be accurate.



2.9

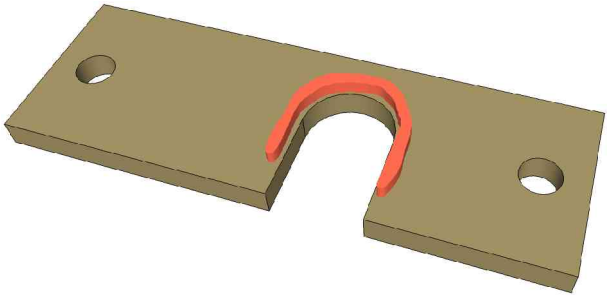
Check that the slidemount plate is able to slide into the groove on the insulator barrel. A little resistance is alright, but if it is too tight to slide in and force is exerted, the slidemount plate may crack or fracture (depending on material used). If the fit is too tight, do not force the parts together, instead carefully file the cutout on slidemount plate until the fit feels right.

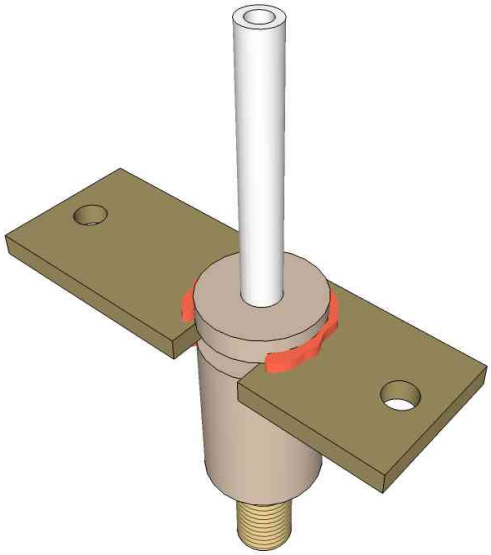


2.10

Remove the slidemount plate from the insulator barrel. Apply a bead of high-temp glue / epoxy to the top and bottom edges around the cutout on the slidemount plate. Insert the slidemount plate into the insulator barrel, gluing the two parts together. Let the glue dry.

Note: you may also choose not to glue the slidemount plate to the insulator barrel if the fit is tight enough and there is no wobble or freeplay when the two parts are assembled. However, gluing is highly recommended.





2.11

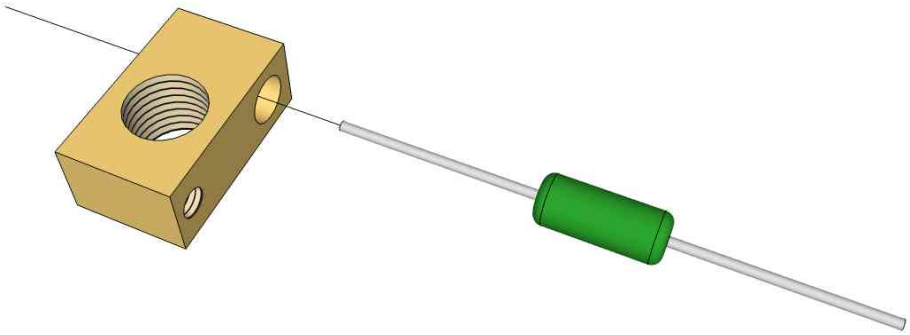
Insert the heating element (resistor) into the 5mm diameter hole on the side of the heater block. A *slightly tight* fit is good.

If it is *too tight* to fit, do not force it in as this may damage the resistor's enamel coating and may cause it to short out on contact against the insides of the heater block. Instead, carefully file out the hole to accomodate the resistor.

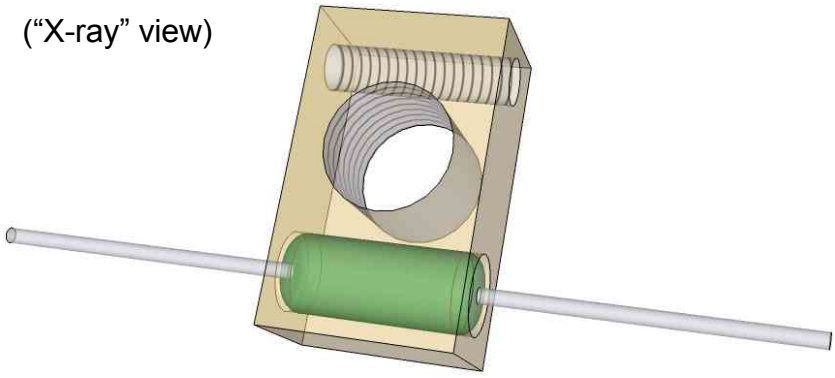
If the fit is loose, wrap short lengths of kapton/polyimide tape or aluminium foil around the resistor body. If the fit is very loose, use aluminium foil as it will conduct heat well when used to fill the large gap. You may try using a tiny bit of kapton/poyimide tape to fasten the start and end points of the aluminium foil onto the resistor body.

Aluminium foil is recommended over aluminium tape, as the adhesive commonly used on the latter is usually not suited to be heated up to temperatures that are required. However, there are specific high-temp aluminium tapes that can be used (eg. 3M #433).

Another method would be to affix the resistor with high-temp gap filling epoxy, RTV silicone / gasket maker, or specialised high-temp retaining compounds. Results may vary, as the hardened material may or may not disintegrate in use over time (shrink / crack / crumble / 'turn to powder'). Be sure the material you choose is able to withstand sustained exposure to the required working temperatures, plus some safety margin to ensure long term reliability (ability to withstand temperatures above 300°C / 572°F is ideal).

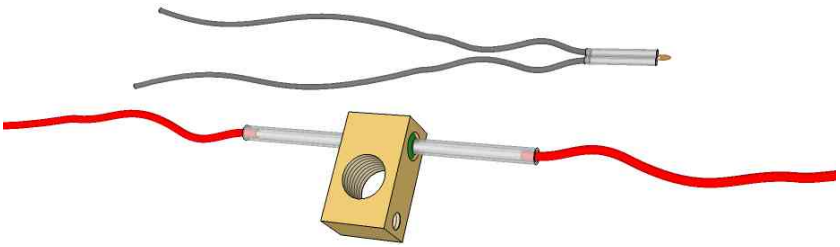


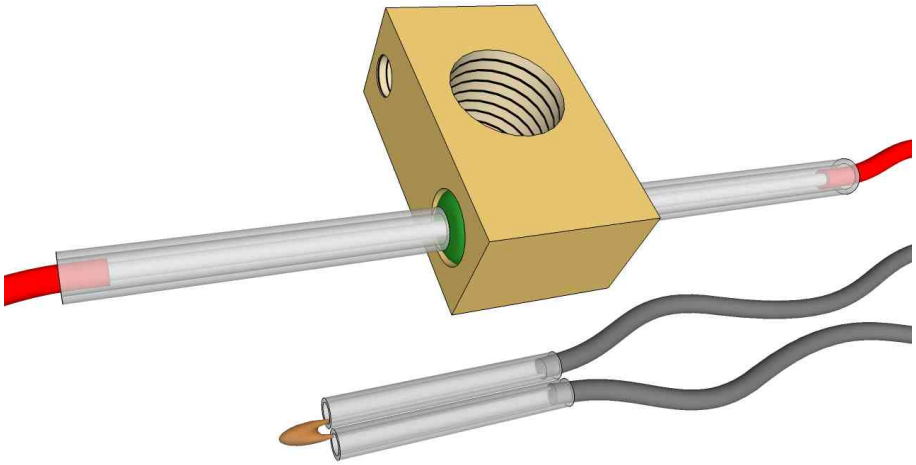
("X-ray" view)



2.12

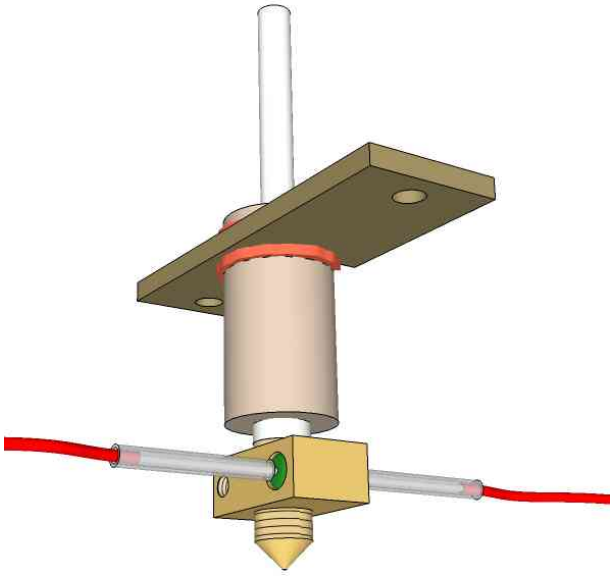
Solder, or crimp using uninsulated bootlace ferrules, the necessary wires to the heating element and thermistor. Insulate the joints with suitable silicone or PTFE tubing, or kapton/polyimide tape. Remember to insert the insulation tubing (and bootlace ferrule if used) before soldering/crimping. (Note: wire lengths should be based on your particular build requirement. Wire length shown in picture for illustrative purposes only)

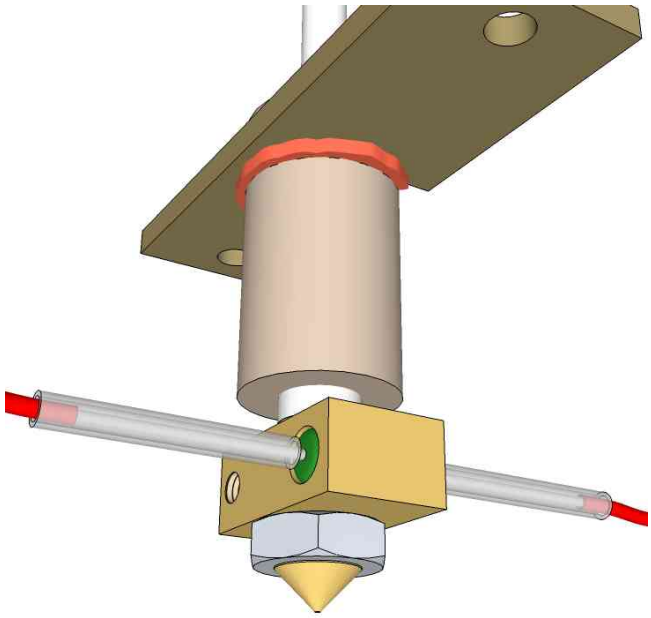




2.13

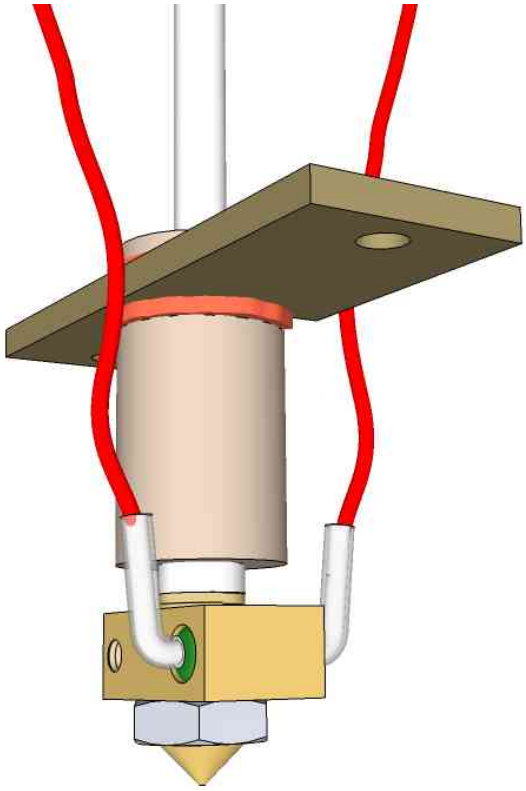
After the glue has dried from Part2, Section 3.10, thread the heater block onto the nozzle. Leave approximately 4mm of exposed threads on the tip end of the nozzle. Insert the M8 thin nut and tigthen it against the heater block so that it is not able to move.

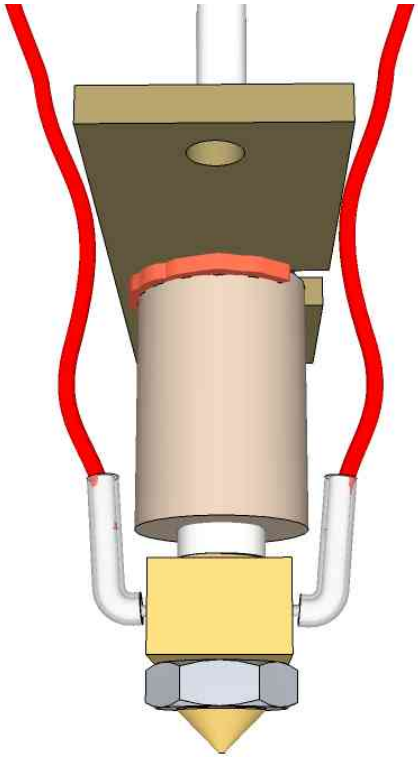




2.14

Carefully bend the resistor leads upwards away from the nozzle tip, approximately 2mm away from where each of the leads meet the resistor body.





Part 3

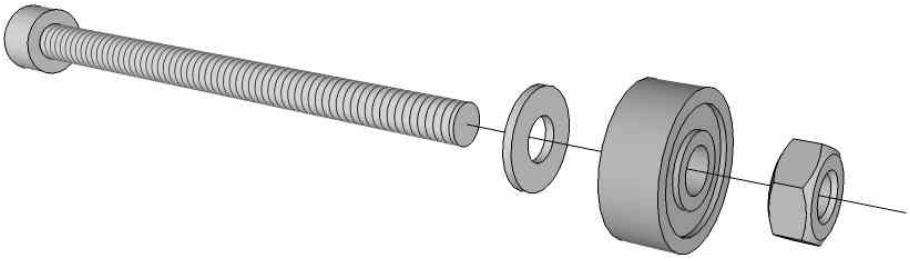
Assembling the extruder

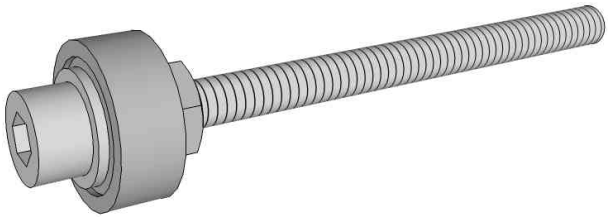
3.1

Take the M4x55 bolt and insert the following:

1 washer – 1 624 bearing – 1 nut

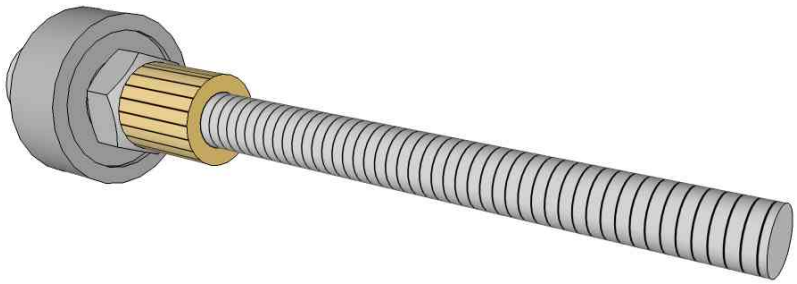
Thread them all the way in and tighten them well against the bolt head.

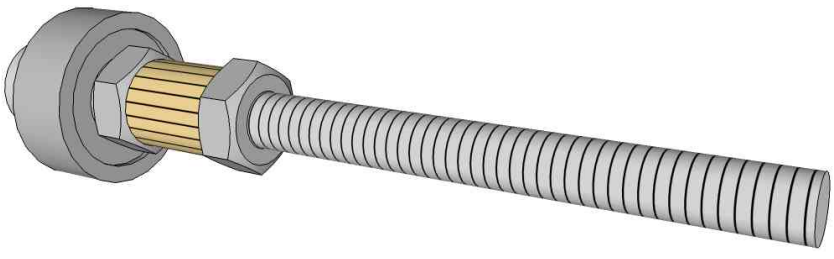




3.2

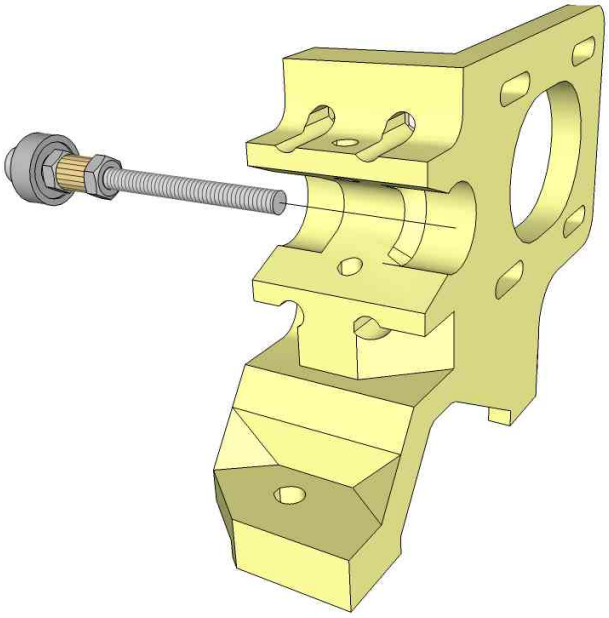
Insert the M4 brass insert into the bolt. Thread it all the way in and tighten *by hand* against the other parts inserted earlier. It is important not to use tools as this may damage the 'teeth' on the brass insert. Next, insert 1 nut and tighten it against the brass insert (using a suitable tool for the nut).

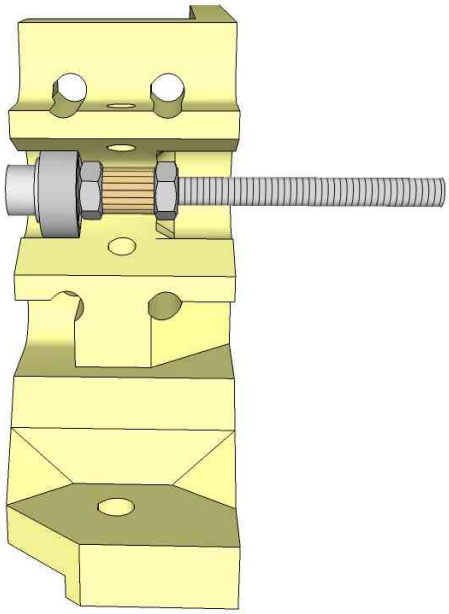




3.3

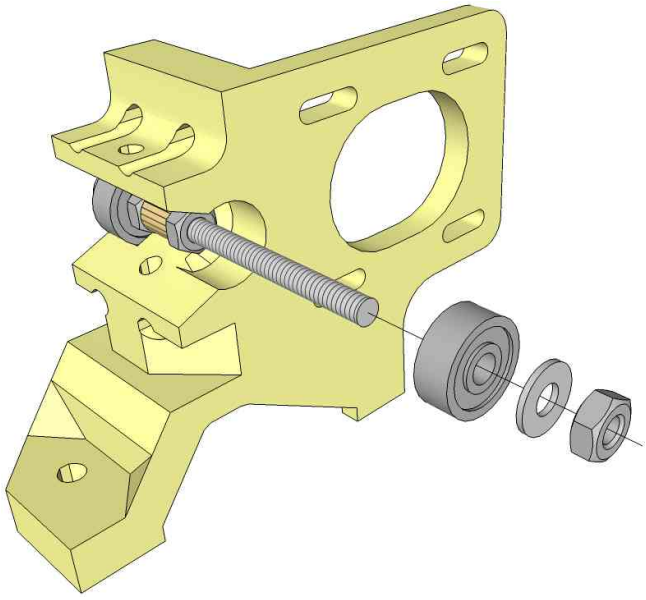
Insert the assembled parts into the extruder-block. Note the orientation: with the motor bracket facing away from you, insert the parts into the left bearing cavity until the 624 bearing is seated snugly inside. Refer to the pictures below:

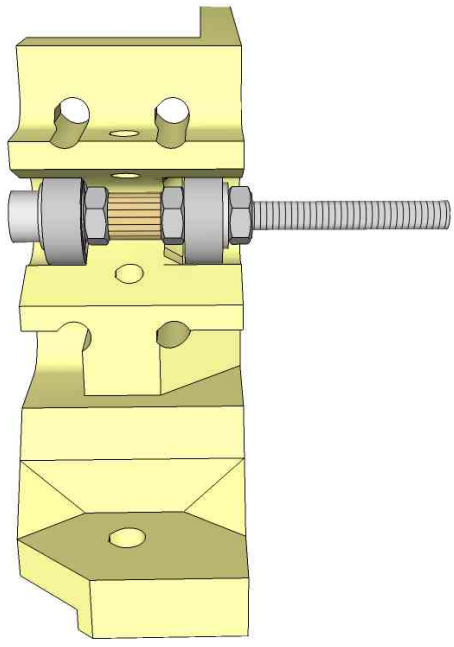




3.4

Insert a 624 bearing into the open end of the M4x55 bolt until it fits snugly into the bearing pocket on the right side. Add an M4 washer followed by a nut and tighten everything together.

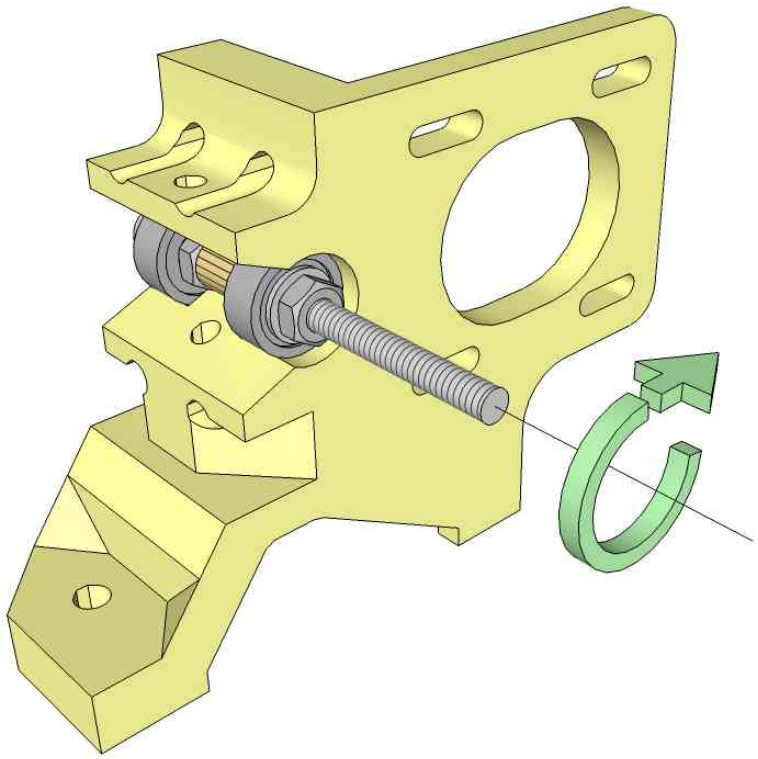




3.5

Turn the bolt shaft and ensure that it turns without much effort. Ideally the turning action should be very smooth if the bolt is very straight, the bearings and mating faces of the hardware are of high tolerance (very flat and parallel) and the extruder-block bearing pockets hold the bearings absolutely straight. However as the above ideals may not be easy to achieve, some degree of minor intermittent turning resistance is still acceptable – the shaft turns smoothly except for certain points when it encounters slight resistance. This should not affect the extruder when in use.

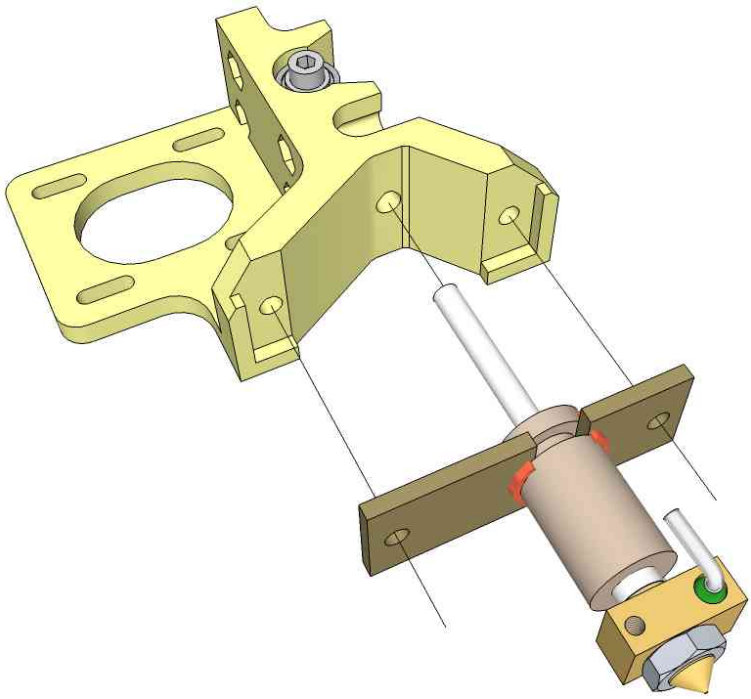
In the case that the shaft is unable to turn relatively smoothly, or there is intermittent points that feel very tight when turning, you may need to replace the outermost M4 nut (from step 3.4) with an M4 nyloc nut and assemble it with a very small gap against the right bearing. This allows for more freeplay in the case of alignment problems (which is usually the cause of the turning resistance).

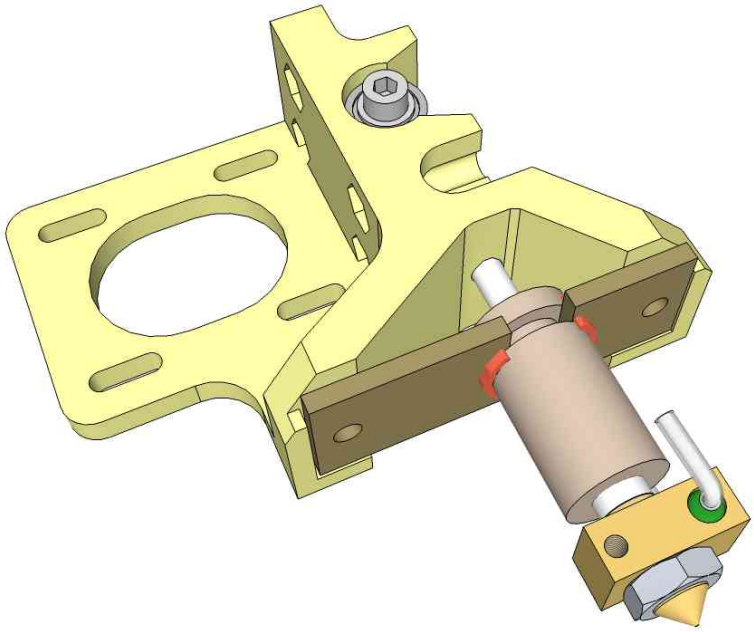


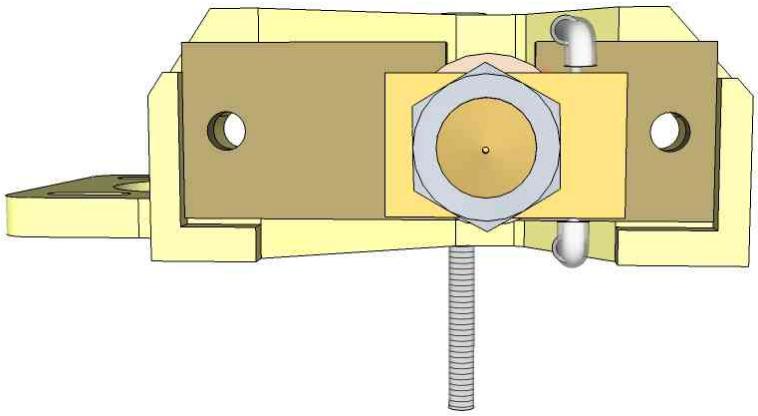
3.6

Attach the assembled hot end parts to the underside of the extruder-block, inserting the PTFE tubing into the filament channel. The slidemount plate should be flat against the recessed underside of the extruder-block, and the two holes on the underside of the extruder-block should be aligned with the holes on the slidemount plate.

Refer to the pictures on the following page (wires not shown):



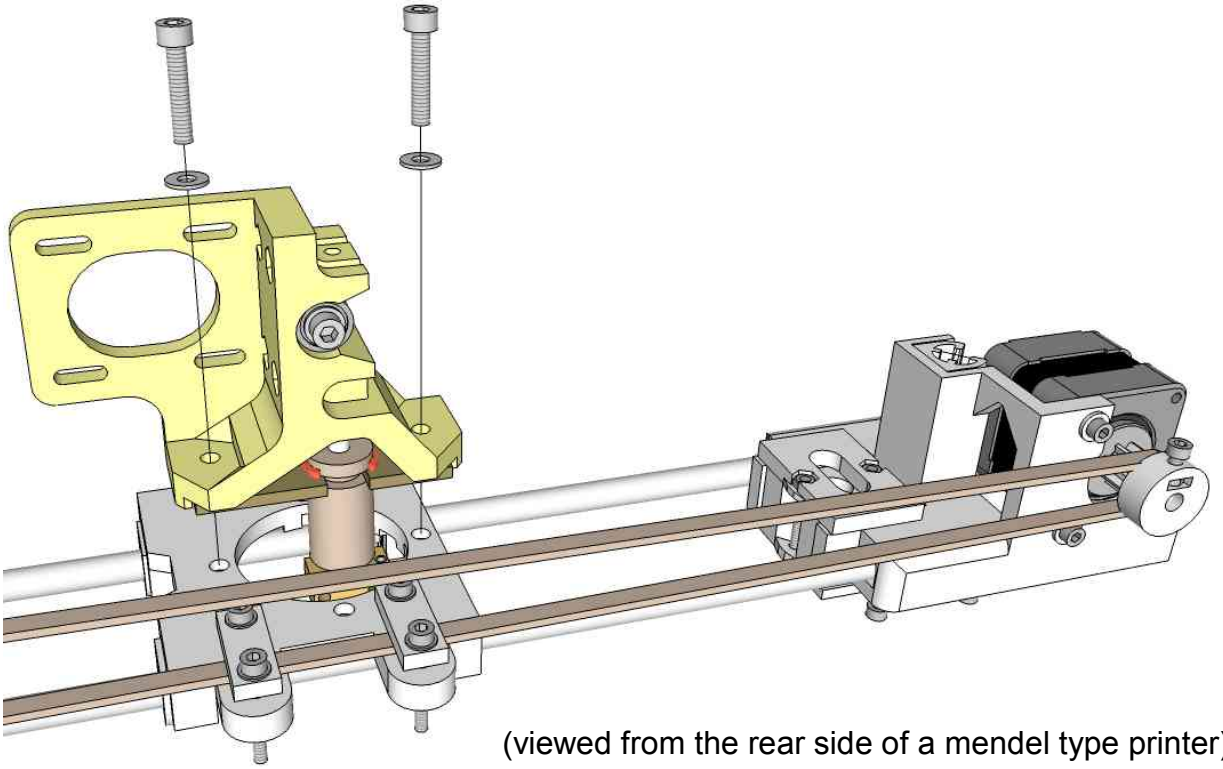




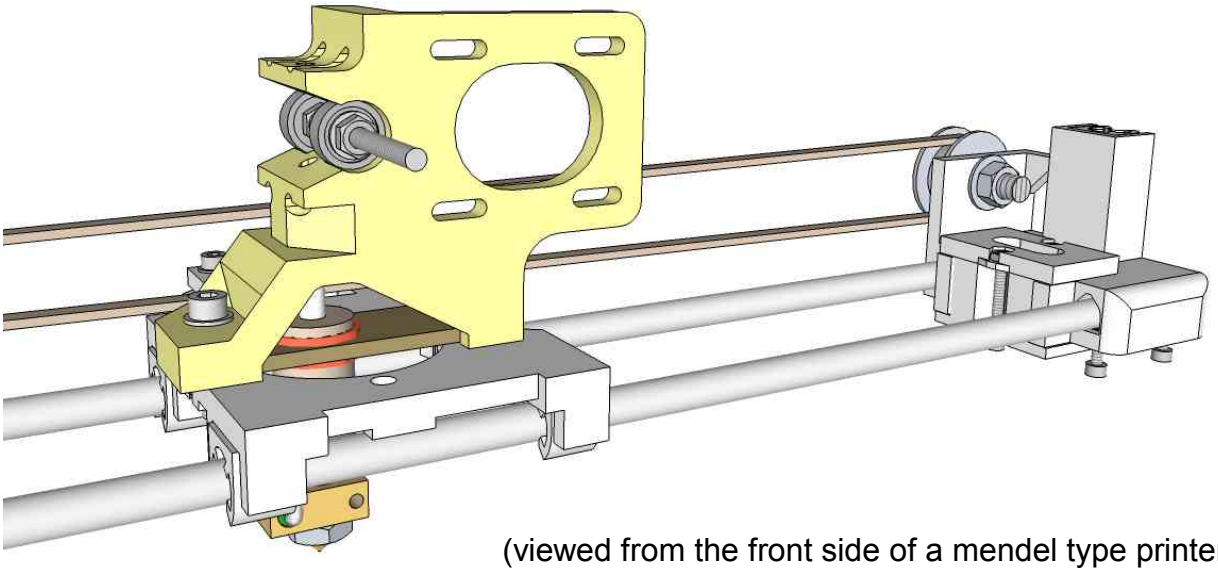
3.7

Attach the extruder-block together with the hot end assembly onto your printer. The hardware required should be part of your particular machine's BOM, and instructions should be found in it's Assembly Instructions. The wires on the resistor should be leading up to the top of the extruder, routed through the gap between the bottom of the extruder-block and your printer's x-carriage (or other suitable path)

Note: For mendel type printers the motor bracket on the extruder-block should face the right side of your printer.



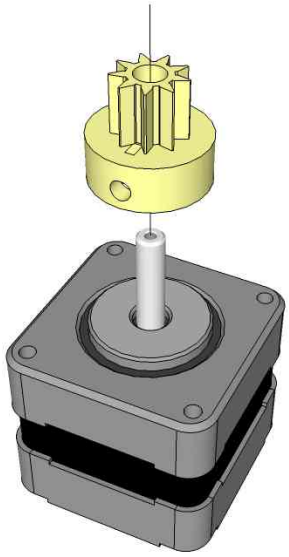
(viewed from the rear side of a mendel type printer)



(viewed from the front side of a mendel type printer)

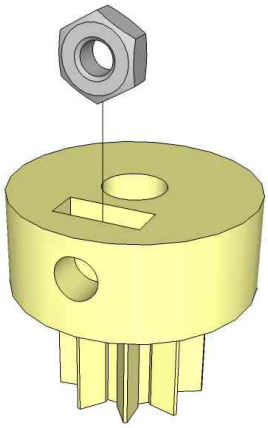
3.8

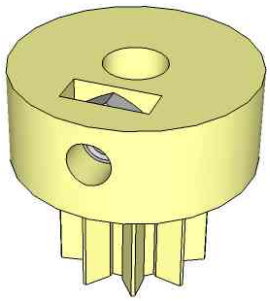
Ensure that the hole in the centre of the 9-tooth-drive-gear matches your motor shaft – it should slide on and fit very snugly. If it is too tight, carefully drill or file the hole.



3.9

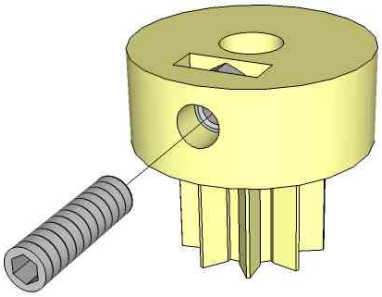
Insert an M3 nut into the rectangular slot on the bottom of the pulley. You may need to widen the slot slightly to do this. Make sure that the centre of the nut is aligned with the channel in the pulley that goes to the centre hole.

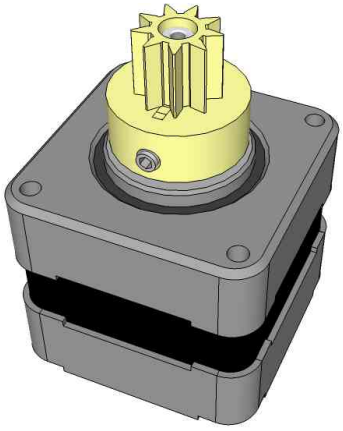




3.10

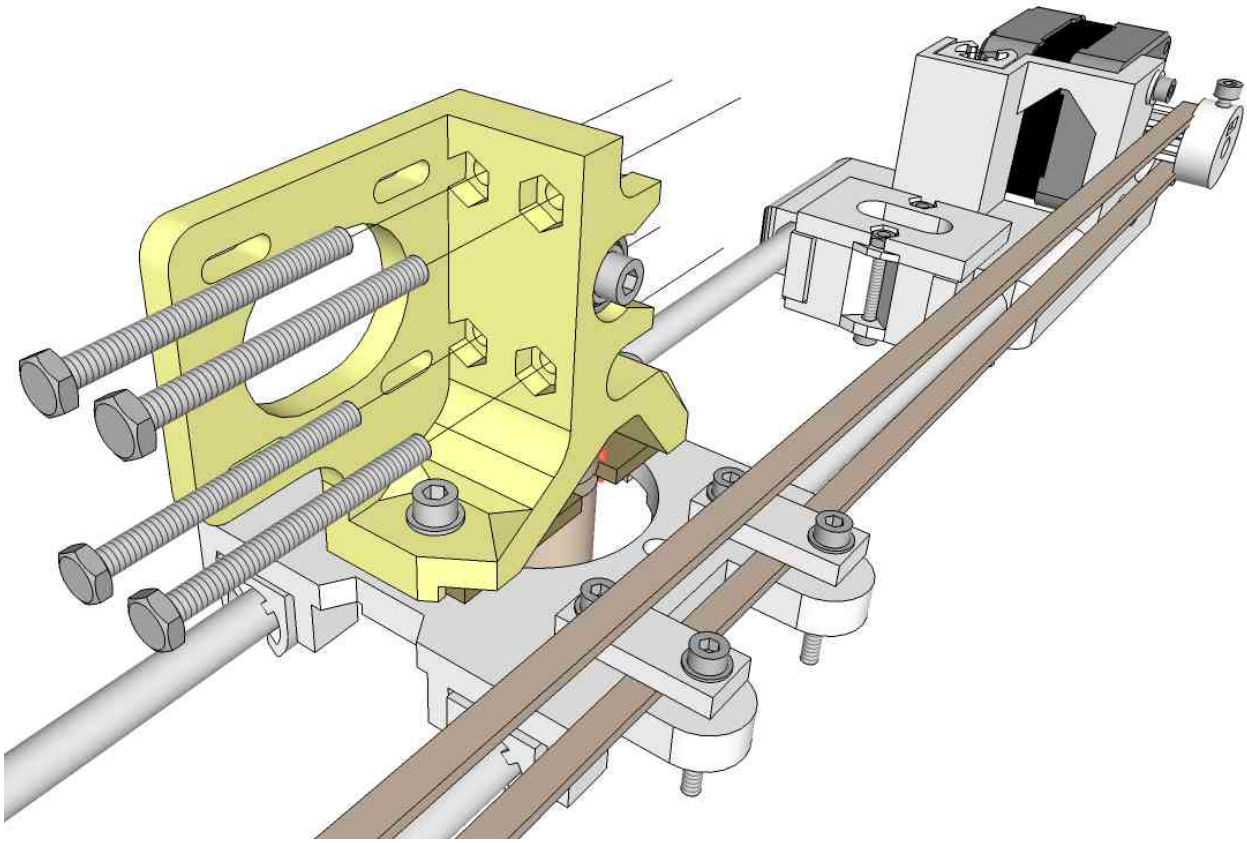
Insert an M3 grub screw into the channel on the rim of the hub, screwing it through the M3 nut until you see the end of the screw inside the centre hole, then unscrew it enough to slide the pulley onto the motor shaft. Leave a gap of about 1mm between the pulley and the motor body, then tighten the grub screw.

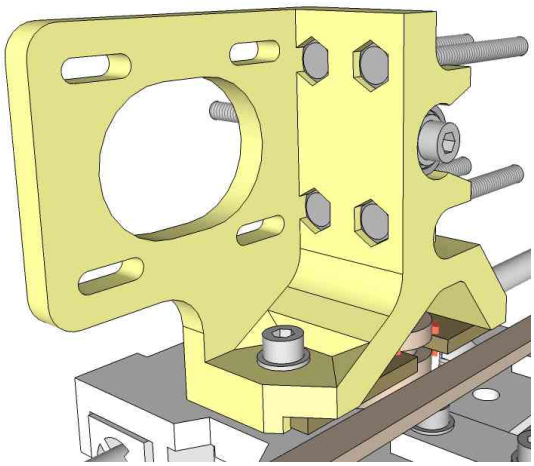


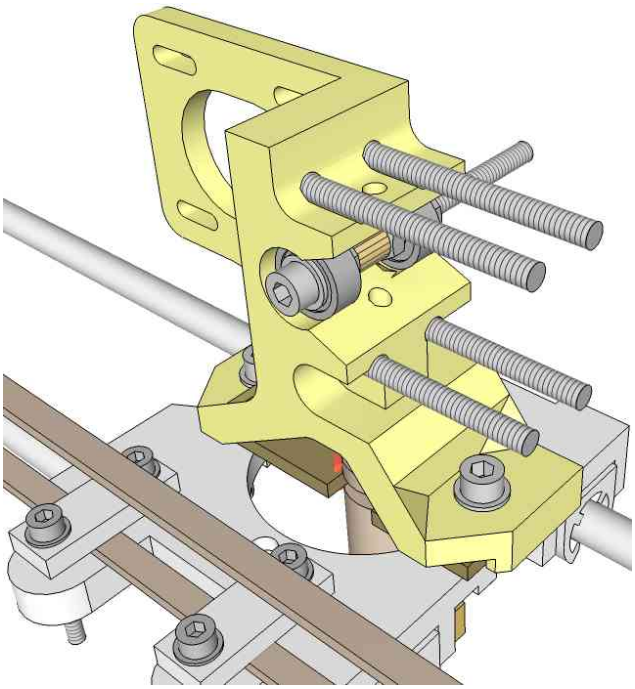


3.11

Insert the four M4x45 hex head bolts into the holes on the extruder-block from the right side. The free ends of the bolt should be pointing towards the left of the extruder, and the hex heads should fit in their recessed 'pockets'.

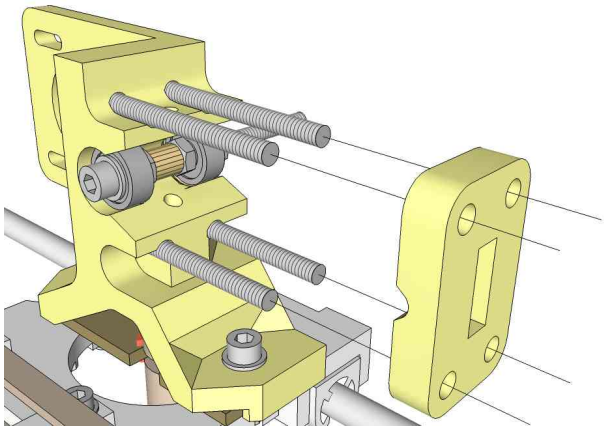


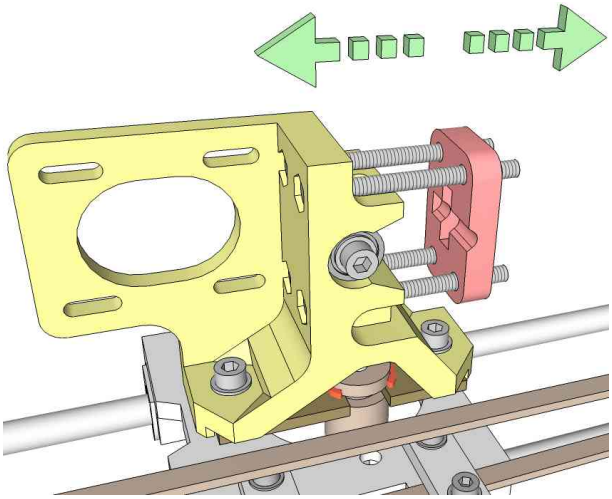




3.12

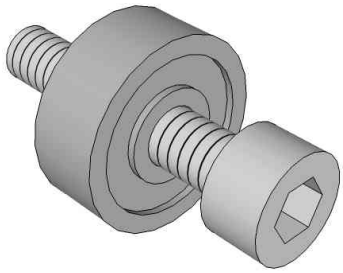
Take the idler-block and ensure that the four holes align with the free ends of the four bolts you have inserted earlier. Insert the idler-block in, threading the four bolts through the holes. The idler-block should be able to slide in and out of the bolts smoothly – clean out the holes if this is not so. Once this is done, remove the idler block.

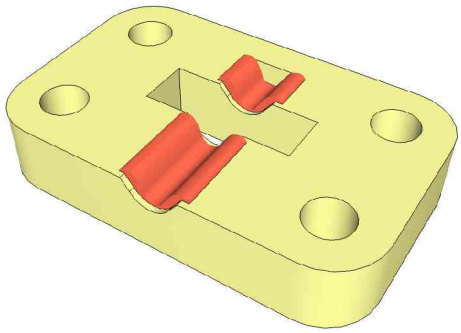


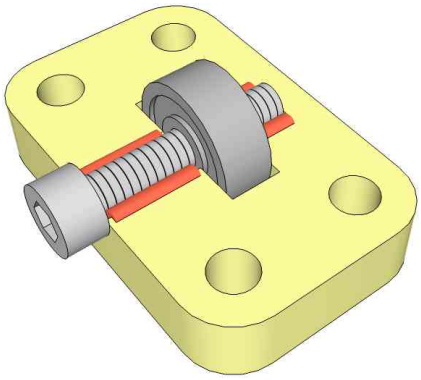


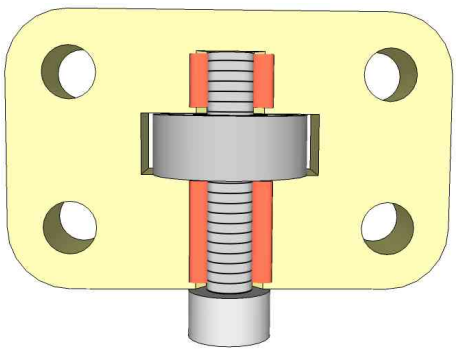
3.13

Take the remaining 624 bearing and insert it into the M4x20 bolt. Apply a dab of glue to the shaft channel on the idler-block. Lay down the M4x20 bolt onto the channel – the bolt head should be positioned out of the side with the channel which extends all the way to the edge, and the 624 bearing should be in the rectangular hole in the centre of the idler block. Let the glue dry.



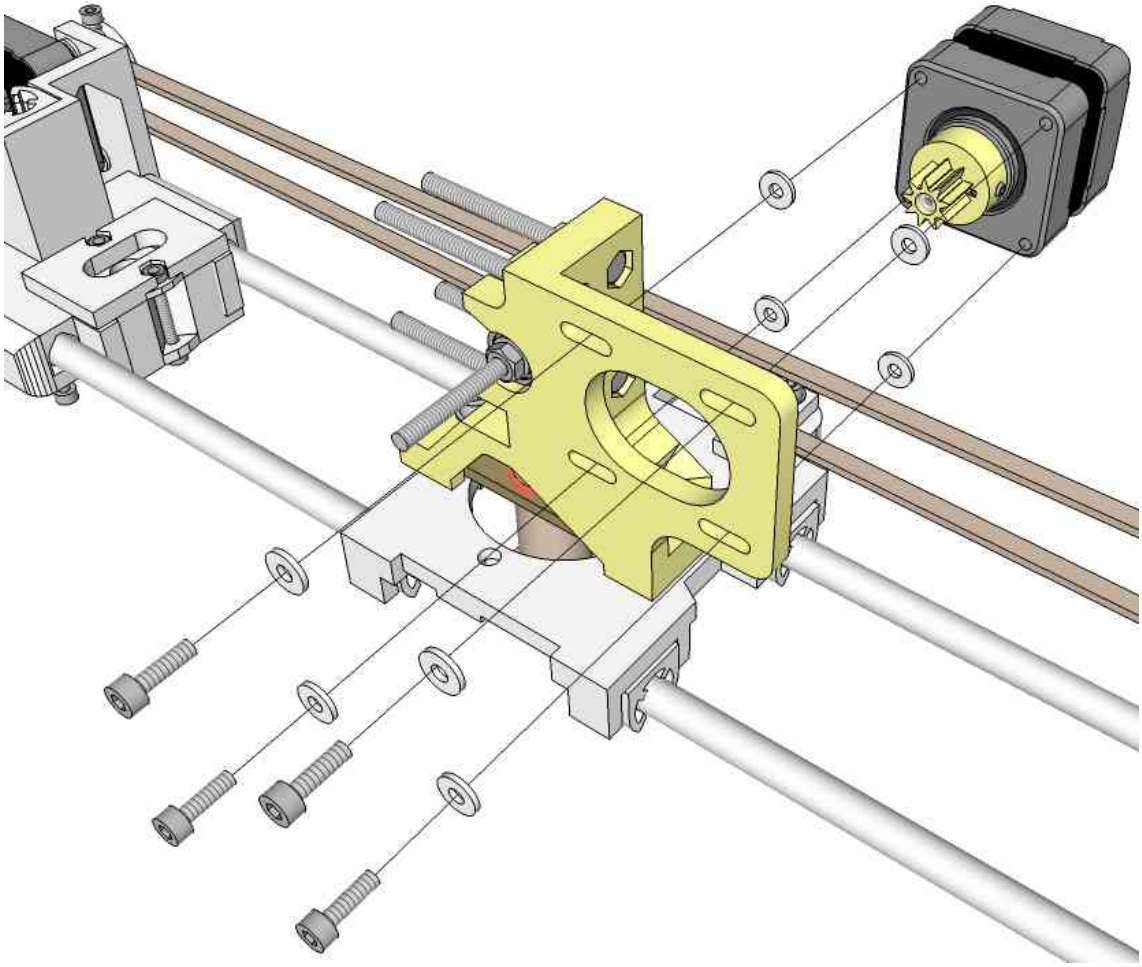


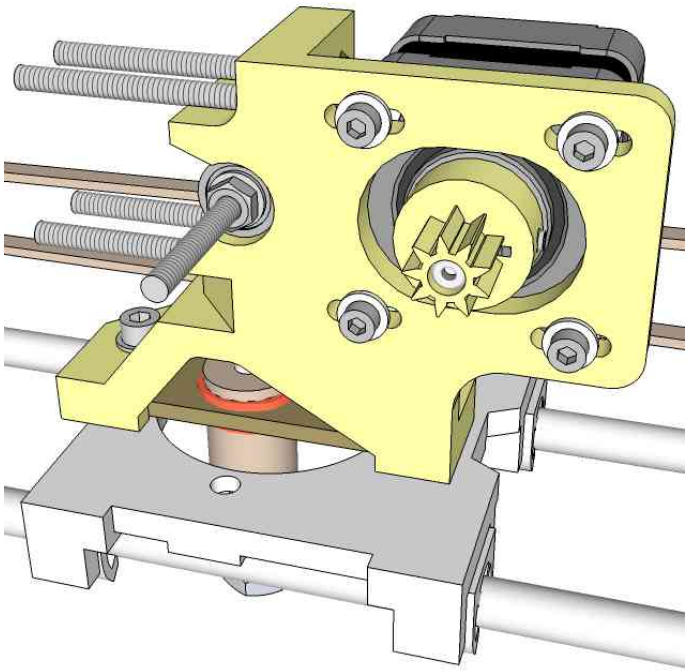




3.14

Attach the motor to the extruder-block motor bracket using 4 M3x10 bolts. Put a nylon washer between each bolt and the extruder-block, as well as between the extruder-block and the motor. Thread in the bolts such that the motor is secure, but leave them loose enough so that you can slide the motor from side to side along the mounting holes.



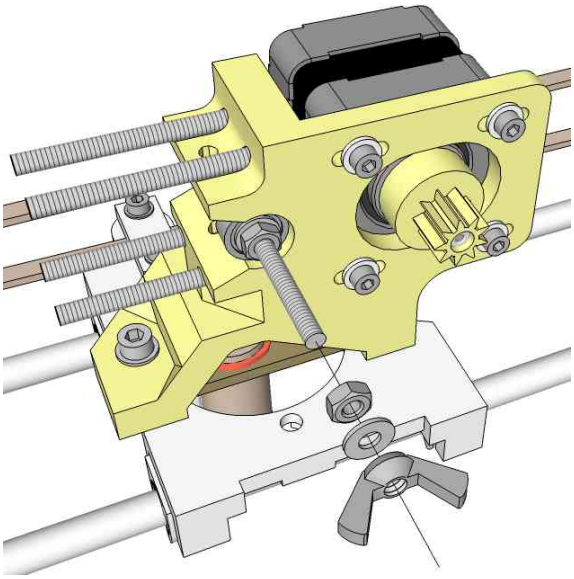


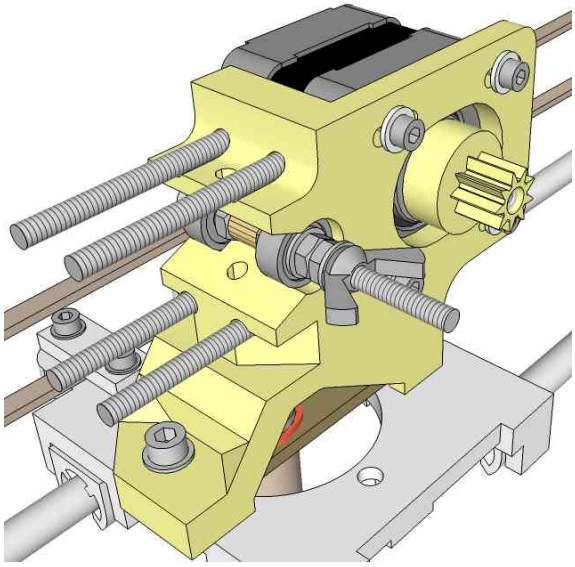
3.15

Take the following and insert it into the open end of the M4x55 bolt:

1 nut – 1 washer – 1 wing nut (with the 'wings' pointing out towards the open end of the bolt)

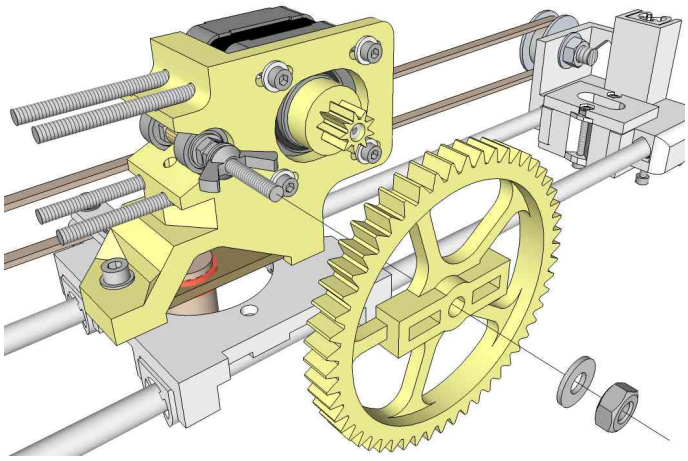
Thread the parts in all the way and tighten everything together.

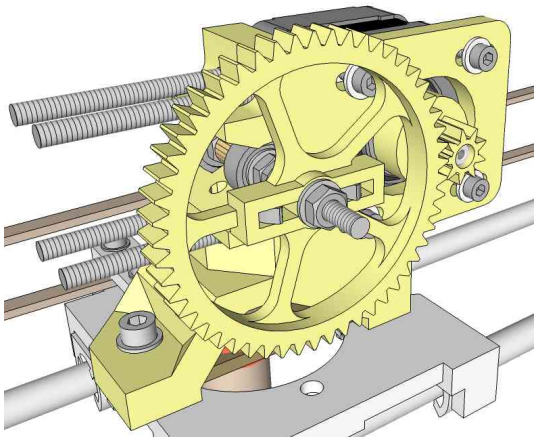




3.16

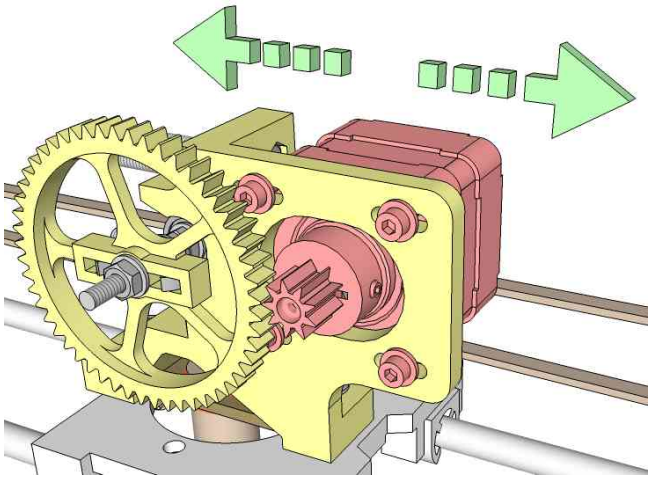
Take the 53-tooth-driven-gear and insert it into the open end of the bolt. Push the rectangular slots on the gear against the wing nut so that the 'wings' of the wing nut is embedded into the gear. If it is too tight to fit in, carefully file the insides of the rectangular slots on the 53-tooth-drive-gear. Be careful not to remove too much plastic – the fit should not be too loose. Add a washer followed by a nut and tighten everything together.

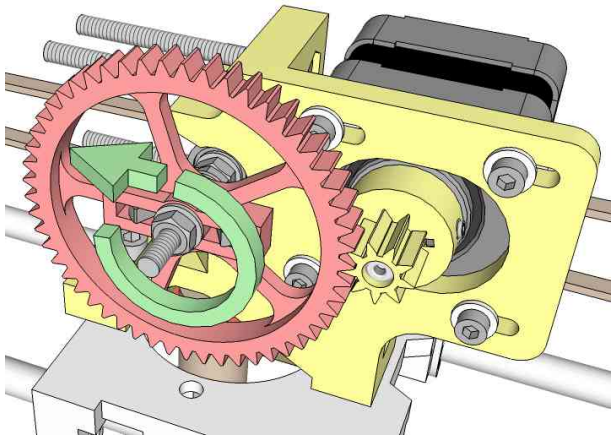




3.17

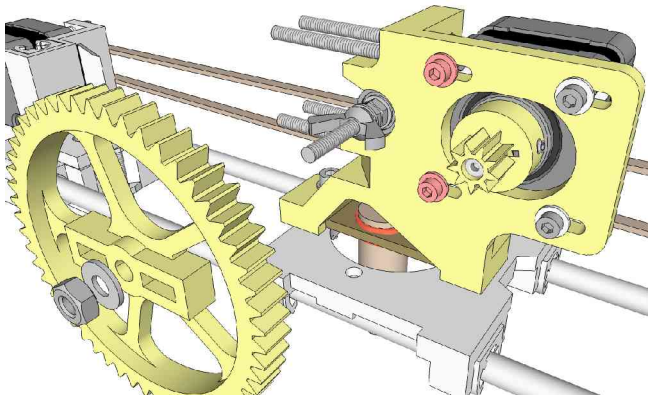
Slide the motor towards the 53-tooth-driven-gear until the teeth on both gears mesh. Tighten the outermost bolts on the motor so that it cannot move. Verify that the teeth on the gears mesh smoothly together when rotated and there is no 'skipping' (i.e. points where certain teeth on the gears do not mesh when the gears are rotated). Turn the gears for a few revolutions to confirm this, and slide the motor to adjust the meshing of the gears if necessary. Once you are satisfied, tighten the outermost bolts on the motor fully.

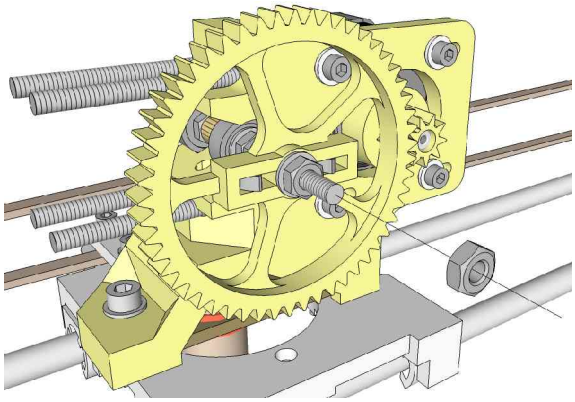


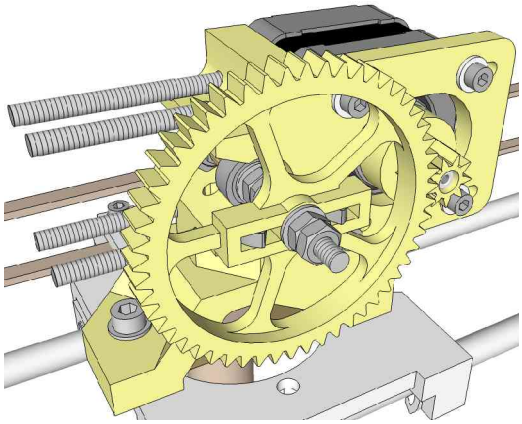


3.18

Remove the 53-tooth-driven-gear by loosening and unthreading the outermost nut and washer from the M4x55 bolt. Tighten the remaining two bolts on the motor. Re-insert the 53-tooth-driven-gear, washer and nut, and tighten everything together. Add another nut to the end of the bolt and tighten it against the existing nut to lock all the parts together.





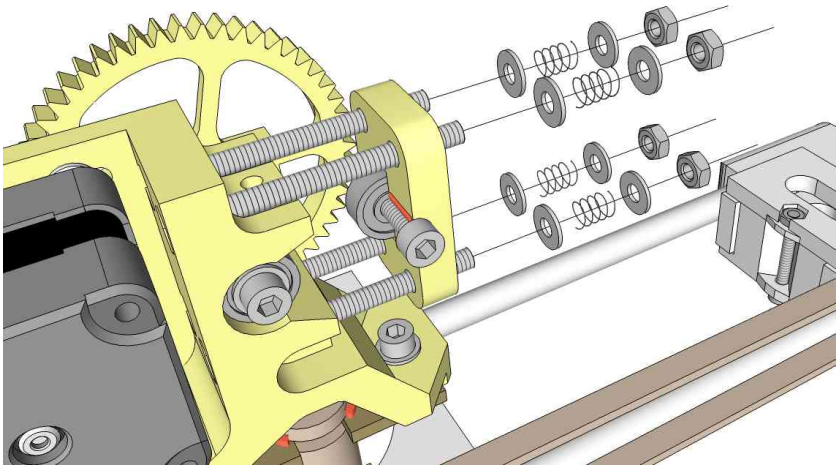


3.19

After the glue has dried from Step 3.13, insert the idler-holder into the open end of the four M4x45 bolts. Note the orientation: the head of the M4x20 bolt that has been glued to the idler-holder should face the rear of the extruder (away from the 53-tooth-driven-gear). Insert the following into the open end of each M4x45 bolt:

1 washer – 1 4mm ID spring – 1 washer – 1 nut

Do not tighten them yet.

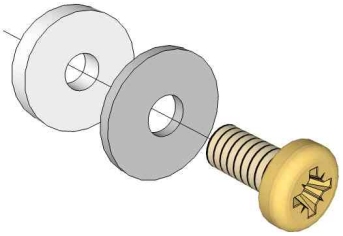


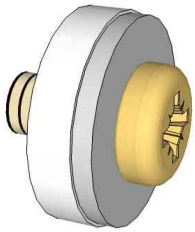
3.20

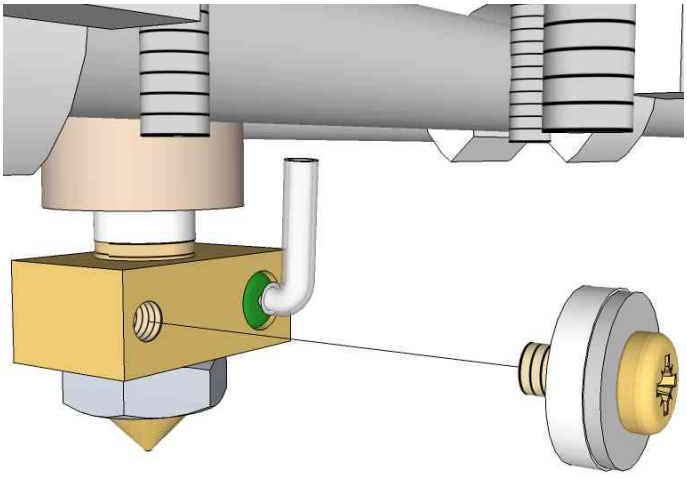
Insert the following into the M3x6 brass screw, all the way in:

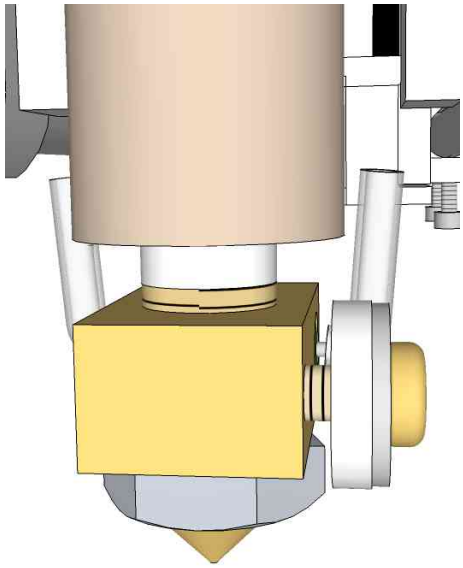
1 large OD M3 aluminium washer – 1 large OD M3 silicone washer

With the rear of the extruder facing you, thread in the brass screw into the M3 hole on the heater block. Leave a gap of approximately 1.5mm between the silicone washer and the heater-block.









3.21

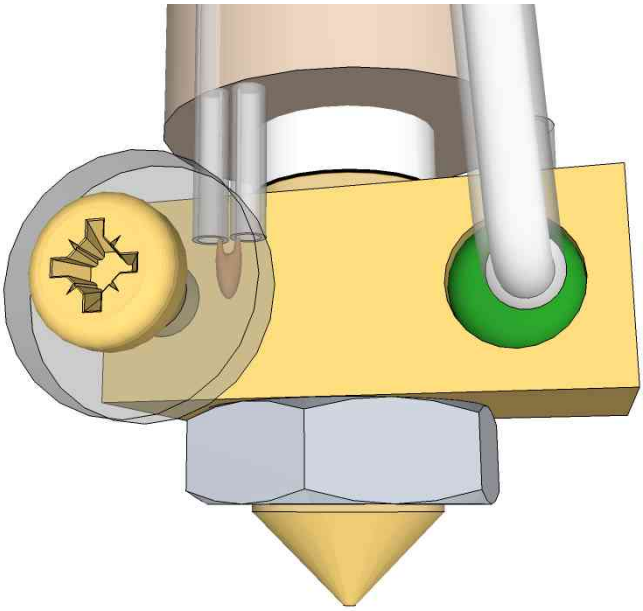
Read through this step before performing it. It is *very important* that you understand what needs to be done beforehand, and what may go wrong.

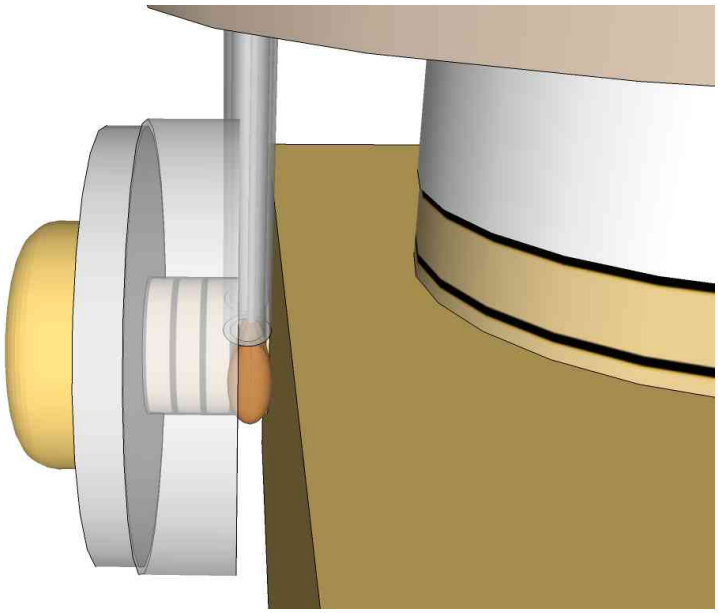
Slide in the thermistor between the silicone washer and the heater-block. The wires of the thermistor should be leading up to the top of the extruder, routed through the gap between the bottom of the extruder-block and your printer's x-carriage (or other suitable path).

Carefully screw in the brass screw until the silicon washer compresses against the thermistor, holding it in place against the heater block.

Very important: Stop tightening the screw once the silicon washer has compressed against the thermistor and is holding it securely in place. The glass bead thermistor is fragile and will break if you tighten further.

(Note: routing path of wires not shown)





3.22

Secure the wires from the resistor and thermistor onto the x-carriage at a suitable point using a ziptie to relieve stress on the components when the extruder is in use (eg. accidental tugging of wires, repeated back and forth motion dislodging thermistor etc).

3.23

Insert your filament into the filament entrance at the top of the extruder, past the brass insert and guide it into the PTFE tubing, subsequently through the insides of the insulator barrel and into the nozzle. Tighten the nuts on the four M4x45 bolts against the idler bearing to enable the brass insert to grip the filament.

It is very strongly recommended to wear safety eyewear and having proper ventilation, especially during hot end testing where you will need to visually monitor for any abnormalities at a typical distance of less than 1m. Remote visual aids eg. USB cameras and low magnification scopes (mono/binoculars) may be used, though for the latter you may be too far away from your printer to react when something happens. A fire extinguisher (or a bag of quality marshmallows) is handy to have around for worst-case-scenarios.

If *anything* goes wrong during the testing phase, immediately turn off the mains power supply to your printer, *then* review the situation and troubleshoot. This may mean the difference between a simple-to-remedy issue vs destroyed components or circuit boards. As such, make sure that you are close to the mains switch/plug so that you can do this quickly.

Perform temperature testing beginning with low temperatures and gradually increasing to the operational temperature (eg. 50°C, 80°C, 100°C, 150°C, 185/195°C for printing with PLA). Observe at each successive temperature point any problems that may arise, like smoke, fire, power trip, rising arctic sea levels etc. Also observe your electronics board for any abnormalities.

Once the hot end has successfully reached the operational temperature, extrude very short lengths (2mm) of filament at a low speed and observe for any problems. Common problems include the idler bearing not exerting enough force for the brass insert to grip and feed the filament, the gears do not mesh or mesh intermittently, broken or loose parts as a result of wrong parts / wrong part assembly sequence or alignment issues et al. If all is well, maintain the temperature and extrude longer filament lengths and increase the extrusion speed *gradually.* Continue this for about 10 – 20mins to check the initial reliability of the extruder, thereafter performing a test print of your choice.

3.24

Your extruder is now ready.