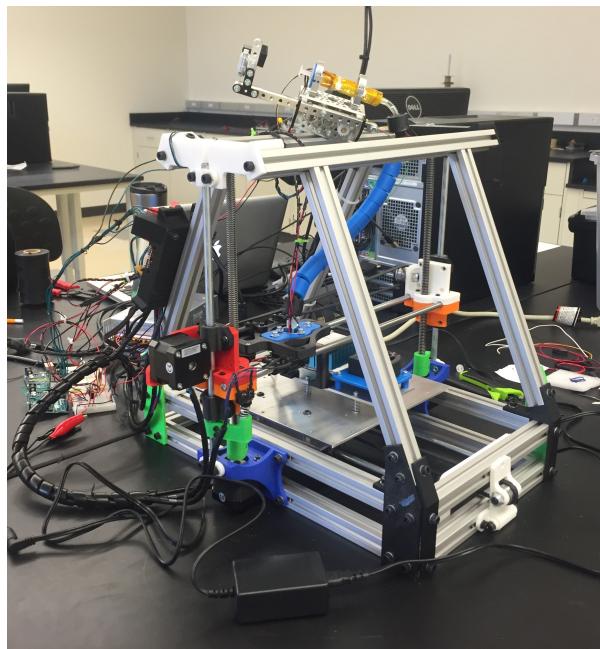


Open Source 3D Bioprinter

Assembly Instructions



Brought to you by:

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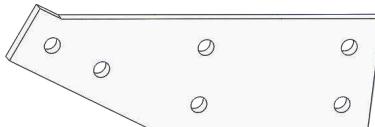
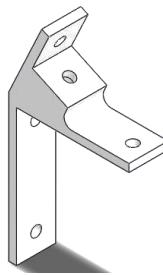
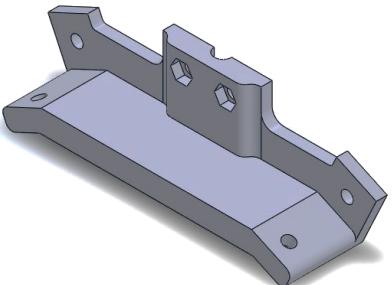
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Milestone 1

Mendel Frame and Y-Axis Construction:

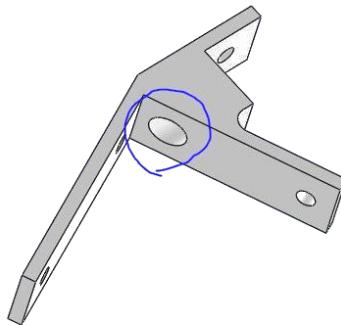
1) Mendel Frame Assembly

a) The following materials are needed to assemble the Mendel Frame:

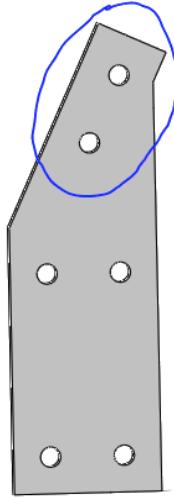
Part	Illustration
Aluminum Extrusions <ul style="list-style-type: none">● 4 – 26.5 cm (200-001)● 4 – 30 cm (200-002)● 4 – 38 cm (200-003)● 2 – 38.5cm with holes (200-004)	
6-Hole Flat Bracket (100-001) Quantity: 4	
L-Bracket (100-002) Quantity: 4	
Top Bracket (100-003) Quantity: 2	
M5x10 Bolts Quantity: 52	

M5 Washers	
Quantity: 52	
M5x16 Bolt, BHCS Black Oxide	
Quantity: 4	
T-Nuts	
Quantity: 52	

- b) Using the M5x10 bolts and M5 washers, attach the 30 cm Aluminum Extrusion (200-002) to the plastic L-Bracket (100-002) through the recessed hole shown in the image below, such that the extrusion is at an angle, extending away from the right angle of the bracket, this will need to be done four times.



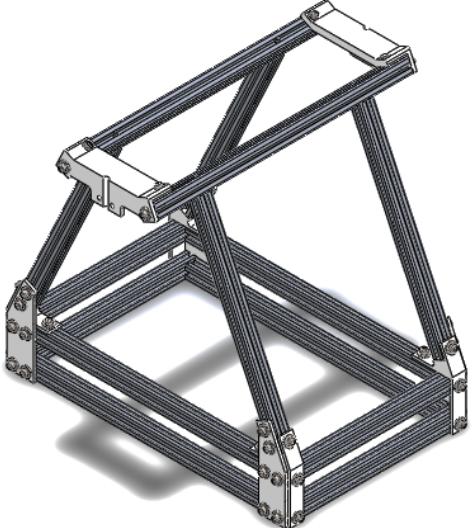
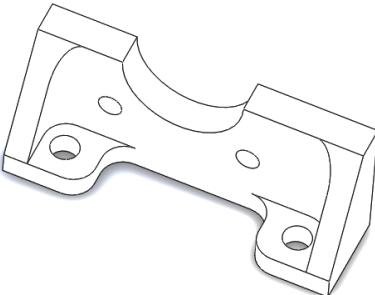
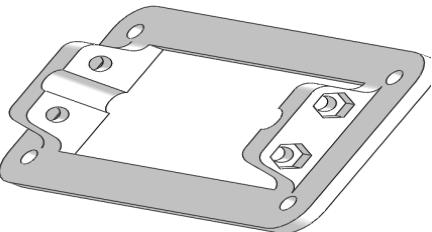
- c) Attach the 6-Hole Flat Bracket (100-001) to the 30 cm Aluminum Extrusion (200-002) using T-Nuts and M5x10 bolts and M5 washers through the upper two holes of the flat bracket as shown below, such that the 6-Hole Flat Bracket (100-001) is perpendicular to the L-Bracket (100-002), this will need to be done four times. Keep all of the screws a little loose during initial assembly.



- d) Take the 26.5 cm Aluminum Extrusions (200-001) and attach the ends of them to the outside holes of the 6-Hole Flat Bracket (100-001) using M5x10 bolts and M5 washers. Then secure the 26.5 cm Aluminum Extrusions (200-001) to the L-Bracket (100-002) using T-Nuts and M5x10 bolts and M5 washers. At this point two corners may be joined together, however make sure to include extra T-Nuts in the grooves of the 26.5 cm Aluminum Extrusions (200-001), there should be one on the outside of the frame and two on the inside for each 26.5 cm Aluminum Extrusions (200-001). Make sure the ends of the 26.5 cm Aluminum Extrusions (200-001) connect perpendicularly to the 6-Hole Flat Bracket (100-001), without using T-Nuts.
- e) Using the 38 cm long Aluminum Extrusions (200-003) attach the two ends of the frame together with M5x10 bolts, M5 washers, and T-Nuts through the inner holes of the 6-Hole Flat Bracket (100-001). The upper 38 cm Aluminum Extrusions (200-003) will also be attached to the remaining hole on the L-Bracket (100-002). Once again, 2 extra T-Nuts will need to be included in the outer grooves of each of the 38 cm Aluminum Extrusions (200-003); no extra T-Nuts are needed in the inner grooves.
- f) To assemble the top of the frame, screw the M5x16 BHCS bolt and the M5 washer into the top end of the 30 cm Aluminum Extrusions (200-002), then slide the 38.5 cm Aluminum Extrusions (200-004) over the head of the bolts so that the holes in the 38.5 cm Aluminum Extrusions (200-004) align over the head of the M5x16 BHCS bolts.
- g) Take the Top Brackets (100-003) and attach them to the 38.5 cm Aluminum Extrusions (200-004) using M5x10 bolts and M5 washers, through the outer most holes and the top holes of the top brace. You will need to include an extra T-Nut on the top groove of one of the 38.5 cm Aluminum Extrusion (200-004) this is where the syringe mount will be located; the Y-Axis motor will be located on the same side.

2) Y-Axis Assembly

- The following materials are needed to assemble the Y-Axis:

Part	Illustration
Mendel Frame	
Y-Motor Mount (100-004) Quantity: 1	
Y-Rod Mount (100-005) Quantity: 2	

<p>Y-Idler Tensioner (100-006)</p> <p>Quantity: 1</p>	
<p>Y-Idler Mount (100-007)</p> <p>Quantity: 1</p>	
<p>Z-Clamp (100-008)</p> <p>Quantity: 4</p>	
<p>Aluminum Rods 38 cm (200-005)</p> <p>Quantity: 2</p>	
<p>M5x10 Bolts</p> <p>Quantity: 20</p>	
<p>M5 Washers</p> <p>Quantity: 20</p>	
<p>M5 Nuts</p> <p>Quantity: 2</p>	

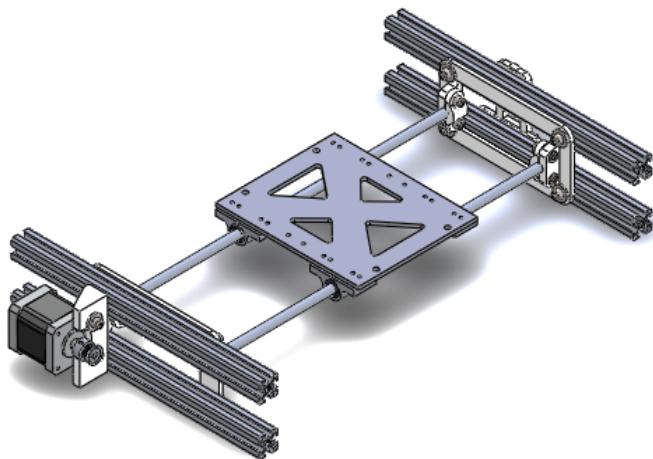
- b) Attach the Y-Rod Mount (100-005) to the inside of 26.5 cm Aluminum Extrusions (200-001) using the extra T-Nuts that were placed there during the Mendel Frame Assembly and four M5x10 bolts and M5 washers. Keep all screws a little loose while initially assembling, and center the rectangular piece, then repeat the same procedure at the other end.
- c) Loosely attach the Z-Clamp (100-008), to the Y-Rod Mount (100-005) with two M5x10 bolts and M5 nuts, once joined, the two brackets should make a circle. This process will need to be done four times.
- d) Attach the Y-Motor Mount (100-004) to the outside of a 26.5 cm Aluminum Extrusion (200-001) using two of the M5x10 bolts and M5 washers and the extra T-Nuts already in place.
- e) Sub Assembly of the Rod Attachments

1. Materials Needed for this sub assembly:

Part	Illustration
LM8UU Bearing Holder (100-009) Quantity: 4	
LM8UU Bearing Quantity: 4	
X-Plate (200-006) Quantity: 1	
M3x10 Bolts Quantity: 12	

M3 Washers	
Quantity: 12	

2. Insert each of the LM8UU bearings into each of the LM8UU Bearing Holder (100-009). These will be the attachment points for the rods.
3. Attach the four LM8UU Bearing Holders (100-009), containing the LM8UU bearings to the X-Plate using M3x10 bolts and M3 washers. Such that there is one-rod attachment point at each corner of the X-Plate.
- f) Slide the two 38 cm Aluminum Rods (200-005) through the circular space created between the Y-Rod Mount (100-005) and the Z-Clamp (100-008).
- g) Position the X-Plate in the center of the frame such that the rod attachments or the LM8UU Bearing Holders (100-009) line up with the rods. Make sure that the side of the X-Plate with the LM8UU Bearing Holders (100-009) is facing the rods. Slide the rods through the LM8UU Bearing Holders (100-009). If done correctly, the ends of the rods should slide right into the circular spaces on the opposite side of the frame.
- h) Tighten the M5x10 bolts connecting the Y-Rod Mount (100-005) and the Z-Clamp (100-008) such that the rod is secured in place. This process is done twice, once for each 38 cm Aluminum Rod (200-005). The 38 cm Aluminum Rods (200-005) should be parallel to each other and run the length of the frame. The assembly is shown below.



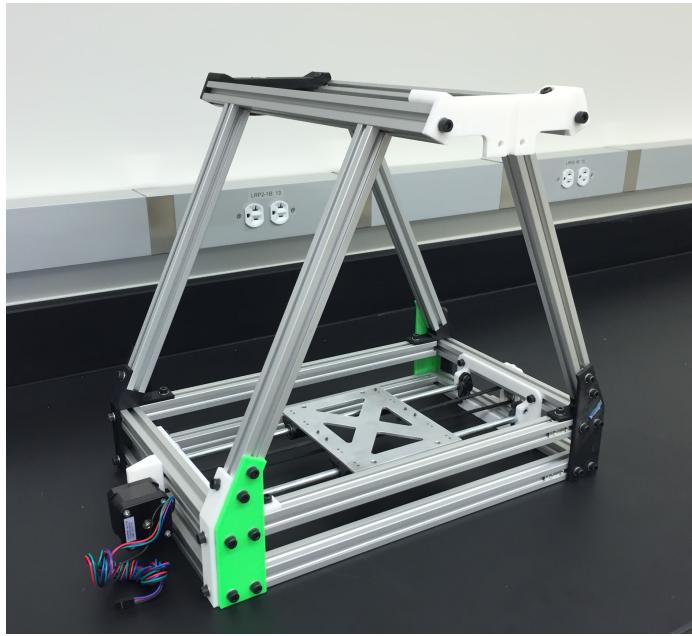
i) Sub Assembly of the belt track

1. Materials needed for Sub Assembly:

Part	Illustration
Y-Idler Tensioner (100-006)	
Y-Idler Mount (100-007)	
Belt Clamp (100-010) Quantity: 2	
M5x10 Bolts Quantity: 4	
M5 Nuts	

M8x30 Bolt SHCS Quantity: 1	
M8 Washers Quantity: 2	
M3x10 Bolt Quantity: 2	
M3 Washers Quantity: 2	
608ZZ 8x2287 Bearings Quantity: 2	
M8 Nut Nyloc Quantity: 1	
Y-axis Belt Length: 1.16m	
608ZZ Belt Motor Bearing Quantity: 1	

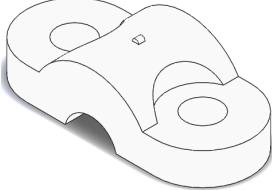
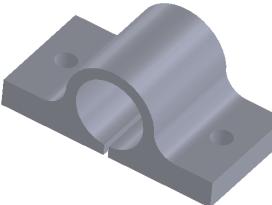
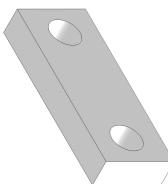
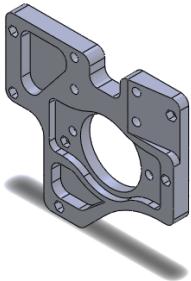
2. Slide the M5x10 nuts and M5 washers into the slots on the Y- Idler Tensioner (100-006), and then use the M5x10 nuts and M5 washers to attach the Y-Idler Tensioner (100-006) to the Y-Idler Mount (100-007).
 3. Insert M8x30 bolt through the Y-Idler Tensioner (100-006) with the 608ZZ bearings in the center and M8 washers on either side of the bearings, then secure with the M8 nut nyloc on the other side of the Y-Idler Tensioner (100-006).
- j) Attach the sub assembly of the belt track to the plastic frame attachment piece using the M5x10 bolts, M5 washers, and T-Nuts in place. This should be attached on the opposite side of the frame from the Y-Motor Mount (100-004).
 - k) Center the Y-Rod Mount (100-005) and tighten the bolts.
 - l) Attach the motor to the Y-Motor Mount (100-004) with the two M3x10 bolts and two M3 washers.
 - m) Cut the belt for the Y-Axis motor to 1.16m, and then thread it around the motor rotor, under the X-Plate, and around the 608ZZ bearings of the belt track sub assembly.
 - n) Align the belt parallel with aluminum rods. Tighten the ends of the belt to the X-Plate using the Belt Clamps (100-010) using M3x10 bolts and M3 washers.
 - o) Picture of what frame should look like at this point:

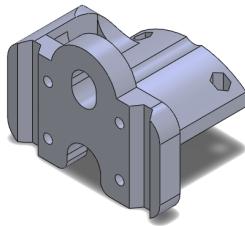
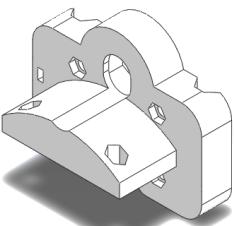


Milestone 2

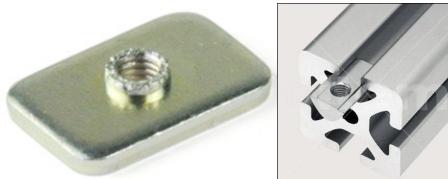
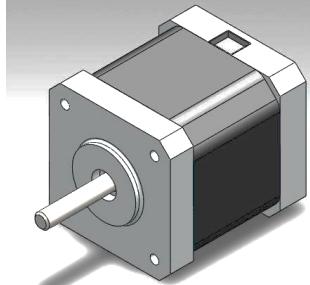
1) The X-axis and Z-axis Assembly

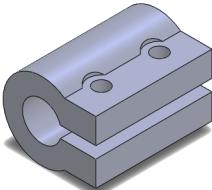
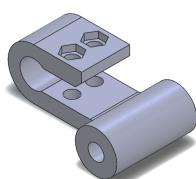
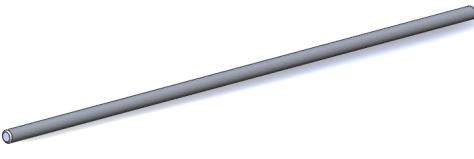
a) The following parts were needed for the assembly of milestone 2:

Part	Illustration
Aluminum Extrusions • 2 – 38.5cm with holes (200-004)	
Z-Clamp (100-008) Quantity: 4	
LM8UU Bearing Holder (100-009) Quantity: 7	
Belt Clamp (100-010) Quantity: 2	
Stabilized X-Carriage (100-011) Quantity: 1	

AO-X-End-Idle_Acme(100-012) Quantity: 1	
AO-X-End-Clamp_Acme_2.0(100-013) Quantity: 2	
M5x10 Bolts Quantity: 8	
M5 Washers Quantity: 16	
M3x16 bolt Quantity: 14	
M3x12 bolt Quantity: 6	

M8x30 bolt Quantity: 1	
M8 washer Quantity: 1	
608ZZ 8x2287 Bearings Quantity: 2	
M3x10 bolt Quantity: 13	
M3 washer Quantity: 43	
M3x5 bolt Quantity: 8	

M5x14 bolt Quantity: 8	
M5 nut Quantity: 16	
M3 nut Quantity: 28	
T-Nuts Quantity: 4	
Motor Quantity: 5	

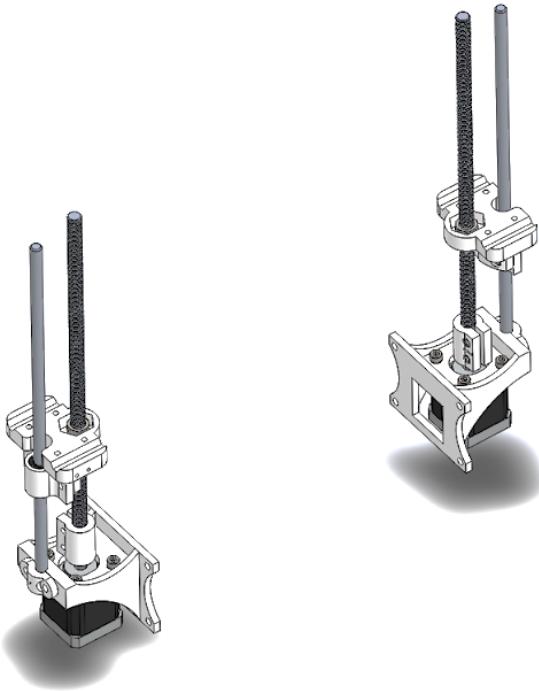
BeefeyCoupler_Acme(100-016) Quantity: 2	
Z-Stop-Holder_V2 (100-017) Quantity: 1	
LM8UU Bearing Quantity: 7	
29.3 cm Threaded Aluminum Rod (200-007) Quantity: 2	
Aluminum Rods <ul style="list-style-type: none"> • 2-30.5cm Aluminum Rod (200-008) • 2-40.5cm Aluminum Rod (200-009) 	

b) Using 4 M5x10 bolts, 4 M5 nuts, and 4 M5 washers, attach the Lower Z Motor Mount (100-015) to the 80/20 extrusion on the A frame. The flat side of the Lower Z Motor Mount (100-015) should be in contact with the extrusion, through the corner holes on the front of the Lower Z Motor Mount (100-015) to the T-Nuts on the 80/20 extrusions. This will be done twice to both sides.

c) Join bottom of AO-X-End-Motor_Acme (100-014) to top of AO-X-End-Clamp_Acme_2.0 (100-013), so that rounded back portion of each part is facing towards the inside of the printer with 4

M3x16 bolts, 4 M3 washers, and 4 M3 nuts making sure to put the nuts in first. On the other side the process will be repeated with AO-X-End-Idle_Acme (100-012) instead of AO-X-End_Motor_Acme (100-014).

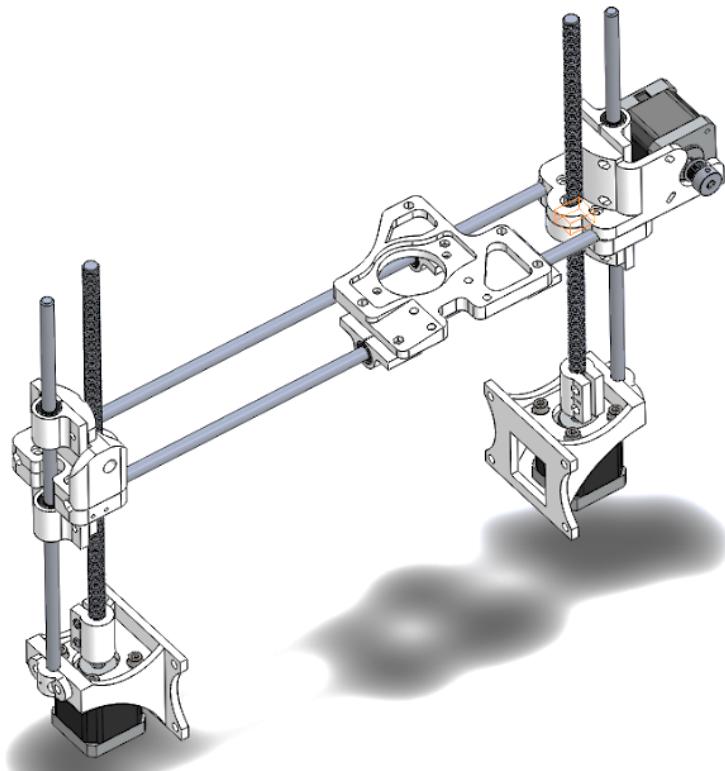
- d) Insert the LM8UU Bearing into LM8UU Bearing Holder (100-009). Attach that to top of the front face (facing away from inside of printer) of the AO-X-End-Motor_Acme (100-014) and to the bottom of the front face of the AO-X-End-Clamp_Acme2.0 (100-013) from step c using 4 M3x5 bolts, M3 washers, and M3 nuts for each assembly on both sides.
- e) Put 30.5 cm Aluminum Rod (200-008) through the hole in the LM8UU Bearing Holder (100-009).
- f) Attach Z-clamp (100-008) to Lower Z Motor Mount (100-015) using 2 M5x14 bolts, 2 M5 washers, and 2 M5 nuts with the 30.5 cm Aluminum Rod (200-008) from step e through the hole in the Z-clamp (100-008). Attach another Z-clamp (100-008) over the metal rod to Plastic Top Brace using 2 M5x14 bolts, 2 M5 washers, and 2 M5 nuts. This will be done to both sides so that the assembled piece from step c will be stabilized to the sides of the printer and the bottom of the AO-X-End-Motor_Acme (100-014). It should be 135 mm from the bottom of the Plastic Top Brace.
- g) Put 29.3 cm Threaded Aluminum Rod (200-007) through the back end hole of the Motor_Acme/Clamp_Acme (100-013/014) assembly into the Lower Z Motor Mount (100-015). The Beefey Coupler_Acme (100-016) was placed around base of 29.3 cm Threaded Aluminum Rod (200-007) near Lower Z Motor Mount (100-015) on both sides. Put 2 M3x16 bolts, M3 washers, and M3 nuts through both holes in each of the Beefey Coupler_Acme (100-016).
- h) At this point, the assembly appears close to the following. Notice the lack of the top portions of each holder (the AO-X-End-Motor_Acme (100-014) and AO-X-End-Idle_Acme (100-012). This is for clarity in the placement of the large nut.

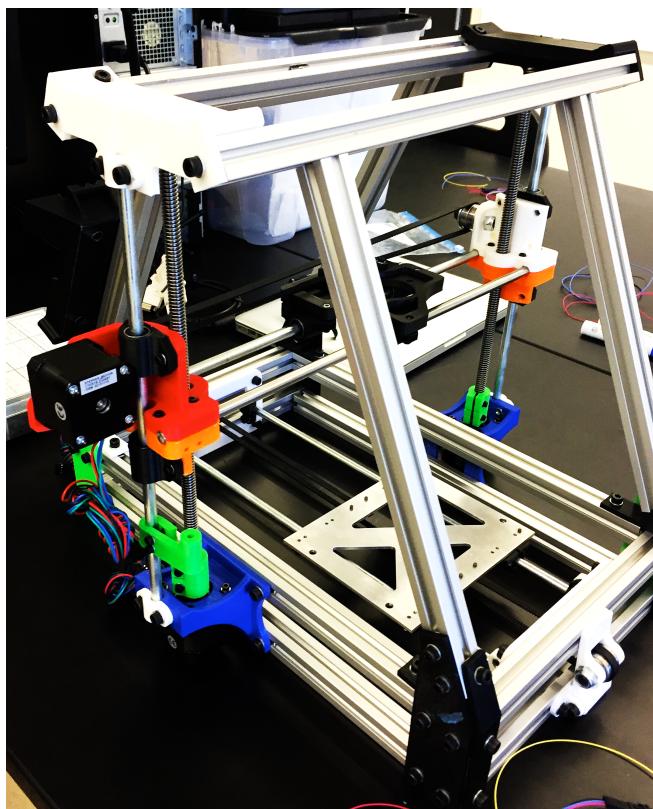


- i) Insert 2 40.5 cm Aluminum Rods (200-009) into the back of Motor_Acme/Clamp_Acme assembly (100-013/014) going over the X-Plate (200-006) and into the back of the Idle_Acme/Clamp_Acme assembly (100-012/013) on other side with 2 LM8UU Bearing Holders (100-009) going into one rod and 1 LM8UU Bearing Holder (100-009) going through the other rod. Make sure that it is on the side with the flat sides of the bearing holders facing up. The rod with the 2 LM8UU Bearing Holders (100-009) should be 75 mm apart.
- j) Place Stabilized X-Carriage (100-011) on top of LM8UU Bearing Holders (100-009) going into the 40.5 cm Aluminum Rods (200-009) and attach using 6 M3x12-16 nuts, 6 M3 washers, and 6 M3 nuts.
- k) Attach two Belt Clamps (100-010) to the top of Stabilized X-Carriage (100-011) using 2 M3x16 bolts, 2 3mm threaded inserts, and 2 M3 washers for each Belt Clamp (100-010).
- l) Attach the motor to the side of the Motor_Acme (100-014) portion of the Motor_Acme/Clamp_Acme assembly (100-013/014) using 3 M3x10 bolts and 3 M3 washers. Attach the motors to the bottom of each Lower Z Motor Mount (100-015) with 4 M3x10 bolts and M3 washers. Make sure that the 29.3 cm Threaded Aluminum rod (200-007) and make sure the motor does not touch. The Beefy Coupler Acme (100-016), from step g, should be positioned to make sure that 29.3 cm Threaded Aluminum Rod (200-007) and the motor does

not touch. Attach the motor to one of the Y-Motor Mounts (100-004) using the 2 M3x10 bolts and M3 washers.

- m) Insert 1 M8x30 bolt, 2 608ZZ 8x2287 Bearings, and 1 M8 washer into the side of the Idle_Acme/Clamp_Acme assembly (100-012/013) on the flat end of the Idle_Clamp (100-012).
- n) Attach the Threaded Belt from one Belt Clamp (100-010) to the motor to the Motor_Acme/Clamp_Acme (100-013/014) to the bearing on the Idle_Acme/Clamp_Acme (100-012/013) and back into the other belt clamp (100-010).
- o) Place Z-Stop-Holder_V2 (100-017) over the 30.5 cm Aluminum Rod (200-008) going through the Motor_Acme/Clamp_Acme assembly (100-013/014) halfway between the bottom of the assembly and top of the Z clamp (100-008) on the Lower Z Motor Mount (100-015). Secure into place with 2 M3x16 bolts, 2 M3 washers, and 2 M3 nuts.
- p) The final assembly appears as follows:

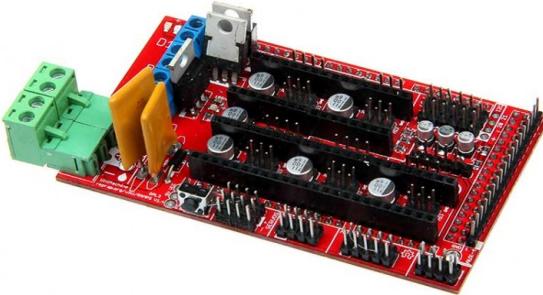




Milestone 3

1) Assembly of the endstops and the arduinos

a) The following parts were needed for the assembly of milestone 3:

Part	Illustration
Endstop Quantity: 3	
RAMPS 1.4 Board Quantity: 1	

Pololu A4988 Board

Quantity: 3



Heat Dissipater

Quantity: 3



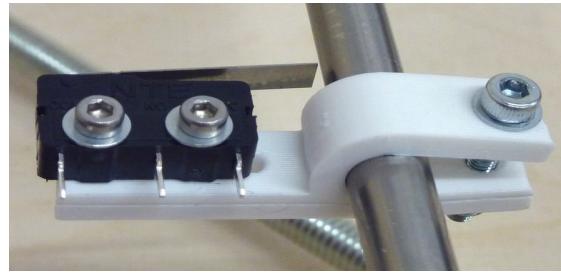
Extension cord (cut)

Quantity: 1



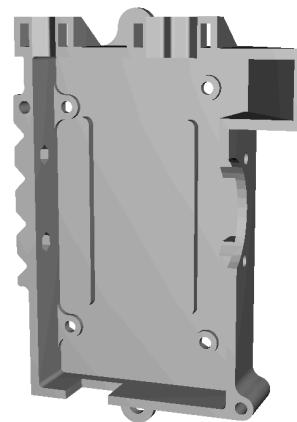
Endstop on mount (example, not ours)

Quantity: 1



Ramp Holder (100-018)

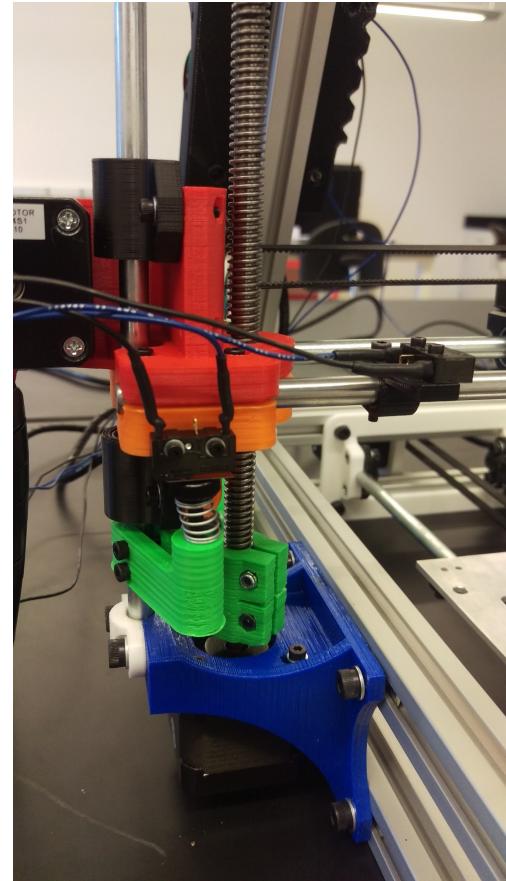
Quantity: 1



2) Wiring and Mounting of Endstops



Y-axis Endstop

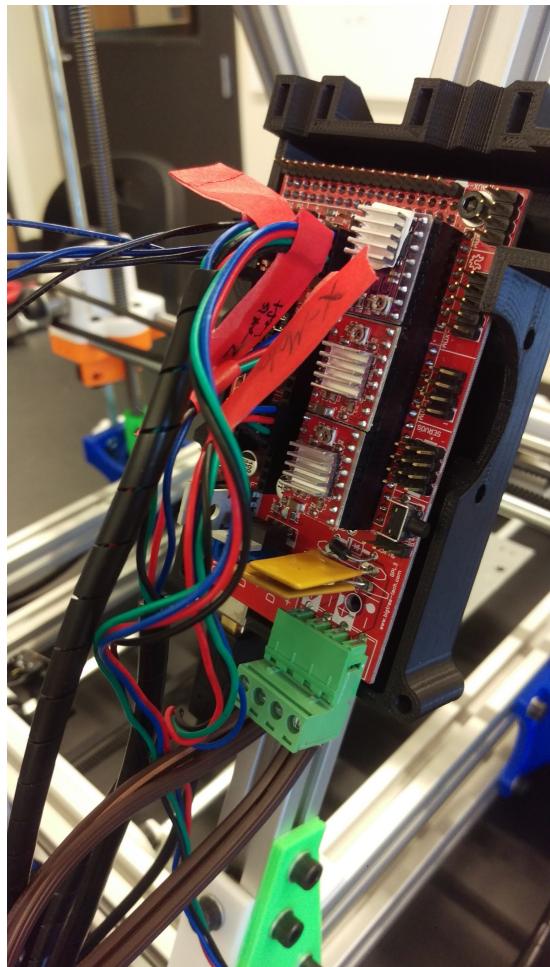


X-axis & Z-axis Endstops (Gay Pride)

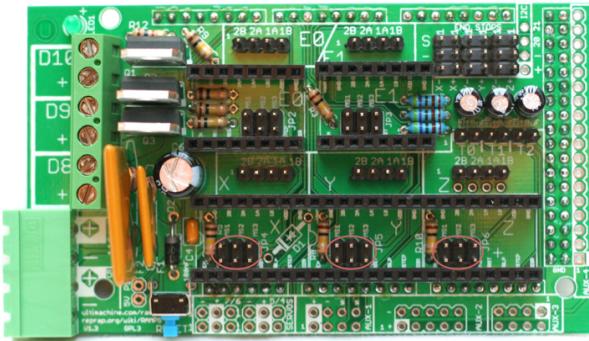
- a) Endstops come assembled, but require soldering of wires, and then fixation of rubber shrink-wraps to prevent exposure.
- b) Directionality is unimportant when assembling the endstops, however the direction in which the switch is flipped is important in specific instances where the structure that is impacting the endstop is asymmetric. As such, orientation of the endstops has been pictured above in order to give a suggested guide. Variations of structures belay variations in the location and position of the endstops.
- c) The Z-axis endstop has a mounting location on the side process of the motor mount for the X-axis. That is, endstop is mounted on the lower section of which the X-axis motor is mounted.

- d) The X and Y-axis endstops are mounted on smaller brackets that affix to the aluminum rod. They are attached to the bracket using smaller M1 screws, whereas the bracket is tightened using standard M3 screws.

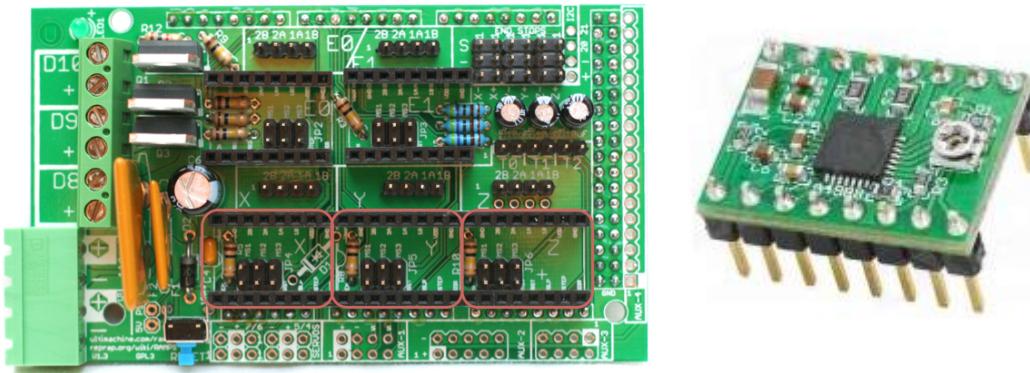
3) Arduino Mega and RAMPS 1.4 Shield



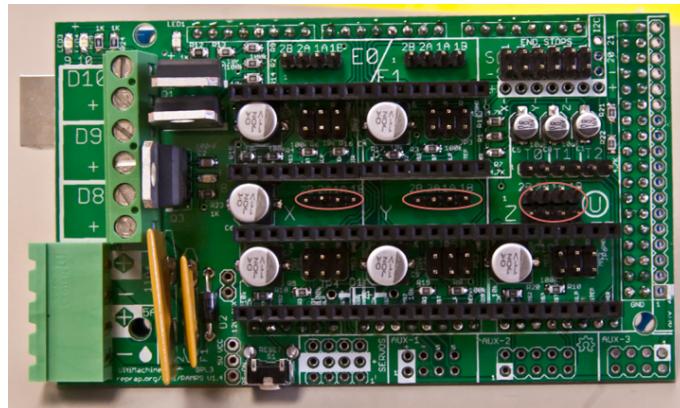
RAMPS 1.4 Shield mounted to Arduino Mega



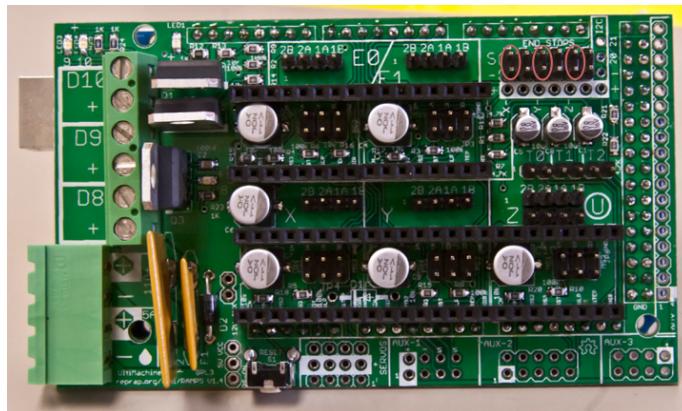
- a) The RAMPS 1.4 Shield, pictured above, requires jumpers to be set before the motor can be precisely controlled. The red ovals above indicate where the jumpers are placed, across the pins that have the same plastic base, 9 jumpers in total.
- b) Secondly, the Arduino Mega and RAMPS Shield are placed into one another, aligning the pins on the Shield with the input and output pins on the surface of the Arduino Mega.



- c) Plug in the Pololu A4988 boards in the sections assigned with the red rectangles in the image above. Make sure that the round section of the boards is oriented to the right in the above image. To prevent overheating, small metal heat dissipaters are adhered to the microprocessors.
- d) After this step, the board is affixed to the printer itself, using the appropriate board mount and the sections of the board that have holes for fixation. Standard M3 screws can be used.

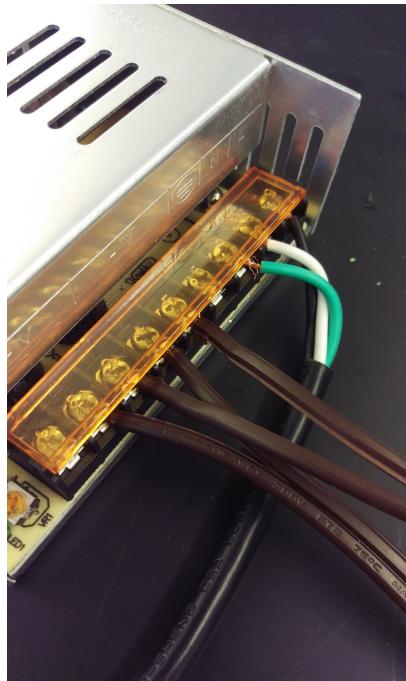


- e) Motors are plugged in in the pins circled above, X, Y, and Z-Axis motors from left to right.

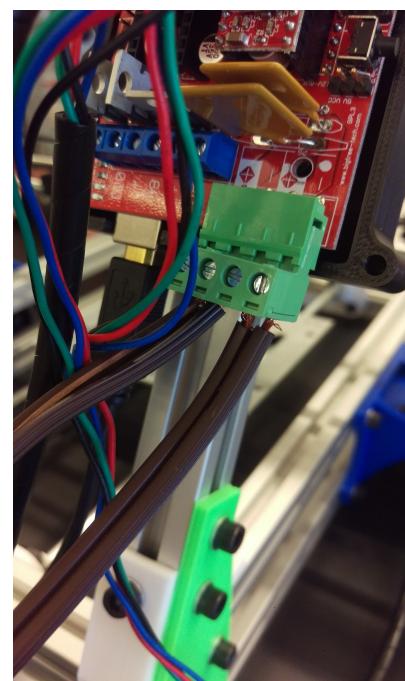


End stops are plugged in, after crimping into the appropriate connector, and are also ordered X, Y, and Z, from left to right.

4) Power Supply

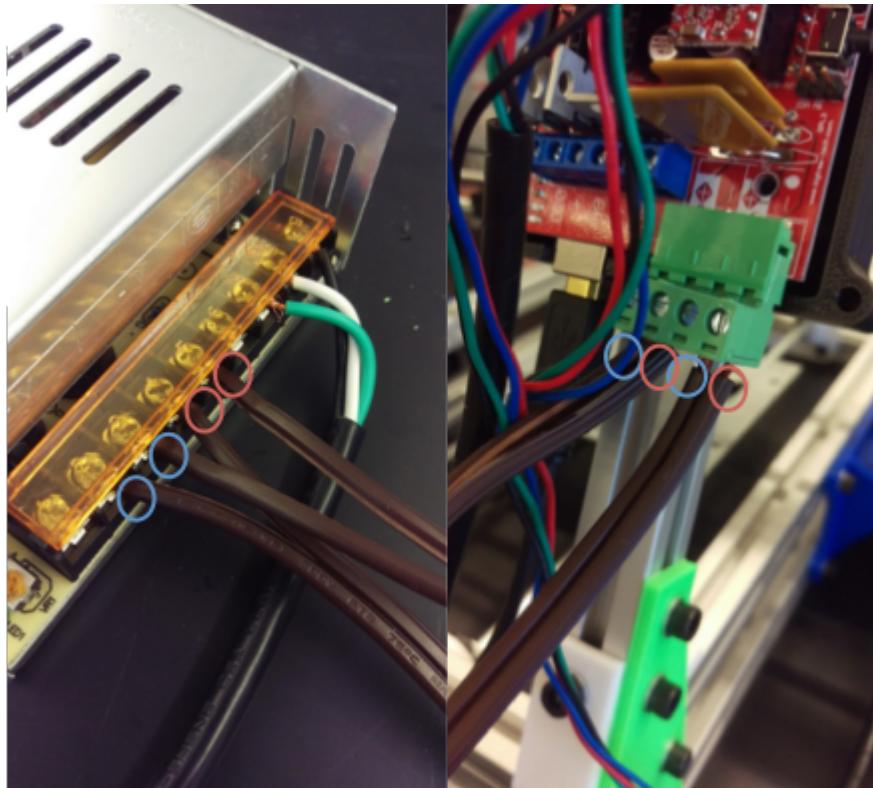


Power cords connected to power supply



Power cords connected to RAMPS
1.4 Shield

- a) The connection of the power supply to the electrical source is achieved by wiring a cord appropriate for AC current to the correct terminals, usually green for ground, white for the N terminal, and black for the L terminal.



- b) Connection between the power supply and the boards is achieved through connecting wires to the correct positive and negative terminals. In our case, an extension cord was used (and dismantled where appropriate). Blue circles indicate a positive terminal, and red a negative. The first blue from the left is connected to the first blue from the left in the second picture, and the first red in both pictures also agrees. Wire the last chord accordingly.

Milestone 4

- 1) Assembly Instructions for the Bioprinter Extruder
 - a) The parts needed to assemble the extruder

6.16" Aluminum Beam Actobotics P/N: 585416 Quantity: 2	
Beam Bracket F Actobotics P/N: 585612 Quantity: 2	
6-32 x ¾ inch Socket Head Cap Screw Actobotics P/N: 632120 Quantity: 5	
Standard Washers in the Actobotics Hardware Pack Quantity: 8	
6-32 Nylock Nuts Actobotics P/N: 632124	

Quantity: 9	
1.93" Aluminum Beam Actobotics P/N: 585404	
Quantity: 2	
Beam Crossover Adapter A Actobotics P/N: 585490	
Quantity: 1	
6-32 x ½ inch Bolt Actobotics P/N: 632114	
Quantity: 1	
Attachment Block A Actobotics P/N: 58540	
Quantity: 1	
6-32 x ⅜ inch Bolt Actobotics P/N: 632122	

Quantity: 2	
5 ¼ inch Beam Gear Rack Actobotics P/N: 637170	
Quantity: 1	
3" Aluminum Channel Actobotics P/N: 585442	
Quantity: 1	
6-32 x 3/16 inch Bolt Actobotics P/N: 632104	
Quantity: 4	
1" Bore Tube Clamp A Actobotics P/N: 585434	
Quantity: 2	

<p>0.375" Center Hole Adaptors</p> <p>Actobotics P/N: 633138</p> <p>Quantity: 4</p>	
<p>½" ID x ¾" OD Flanged Ball Bearing</p> <p>Actobotics P/N: 535206</p> <p>Quantity: 2</p>	
<p>Attachment Block B</p> <p>Actobotics P/N: 585600</p> <p>Quantity: 4</p>	
<p>Beam Bracket T</p> <p>Actobotics P/N: 585656</p> <p>Quantity: 4</p>	
<p>Stepper Motor Mount</p> <p>Actobotics P/N: 555152</p>	

Quantity: 1	
Hub Mount Actobotics P/N: 545424	
Quantity: 1	
Quad Mount Actobotics P/N: 545360	
Quantity: 1	
6-32x .750 inch Aluminum Standoffs (Round) Actobotics P/N: 633126	
Quantity: 4	
Brass Insert Spur Gear (32 DP 16 Teeth 20° Pressure Angle Acetal) Actobotics P/N: 615242	
Quantity: 1	

<p>55:1 Gear Ratio 55 Teeth Worm Gear</p> <p>Actobotics P/N:</p> <p>Quantity: 1</p>	
<p>3/16 inch to 5mm Set Screw Shaft Coupler</p> <p>Actobotics P/N: 625176</p> <p>Quantity: 1</p>	
<p>2024 Stainless Steel Gear</p> <p>(48 D.P. 24 Teeth 20° Pressure Angle AGMA Q10 Quality With (Hub / S.S.)</p> <p>Actobotics P/N:</p> <p>Quantity: 1</p>	
<p>303 Stainless Steel Gear</p> <p>(48 D.P. 24 Teeth 20° Pressure Angle AGMA Q10 Quality With (Hub / S.S.)</p> <p>Actobotics P/N:</p> <p>Quantity: 1</p>	

<p>Thick Shaft Spacer (0.125" I.D. 0.1875" O.D. 0.016")</p> <p>Actobotics P/N:</p> <p>Quantity: 3</p>	
<p>Thick Shaft Spacer (0.125" I.D. 0.1875" O.D. 0.031")</p> <p>Actobotics P/N: 545372</p> <p>Quantity: 1</p>	
<p>303 Stainless Steel Collar Style (0.1248" Bore 0.3125" O.D. 0.18" Wide)</p> <p>Actobotics P/N: 6432K13</p> <p>Quantity: 1</p>	
<p>Stainless Steel Worm (48DP/1 Lead/.33PD 20° Pressure Angle)</p> <p>Actobotics P/N:</p>	

Quantity: 1	
<p>Long 303 Stainless Steel Shaft (.12470" (+.000/-0.0002) Dia. 2.375")</p> <p>Actobotics P/N: 634060</p>	
Quantity: 1	
<p>Actobotics Hardware Pack A</p> <p>(25) 6-32 x 3/16" Socket Head Cap Screws (#632104)</p> <p>(25) 6-32 x 1/4" Socket Head Cap Screws (#632106)</p> <p>(25) 6-32 x 5/16" Socket Head Cap Screws (#632108)</p> <p>(25) 6-32 x 3/8" Socket Head Cap Screws (#632110)</p> <p>(25) 6-32 x 7/16" Socket Head Cap Screws (#632112)</p> <p>(25) 6-32 x 1/2" Socket Head Cap Screws (#632114)</p> <p>(25) 6-32 x 9/16" Socket Head Cap Screws (#632116)</p> <p>(25) 6-32 x 5/8" Socket Head Cap Screws (#632118)</p> <p>(25) 6-32 x 3/4" Socket Head Cap Screws (#632120)</p> <p>(25) 6-32 x 7/8" Socket Head Cap Screws (#632122)</p> <p>(25) 6-32 x 1" Socket Head Cap Screws</p>	

[\(#632124\)](#)

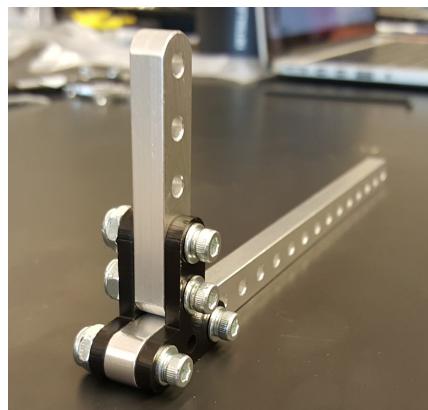
(24) Single Screw Plates [\(#585474\)](#)

(6) Dual Screw Plates [\(#585472\)](#)

(25) 6-32 Nylock Nuts (#632142)

(50) #6 Standard Washers (#632144)

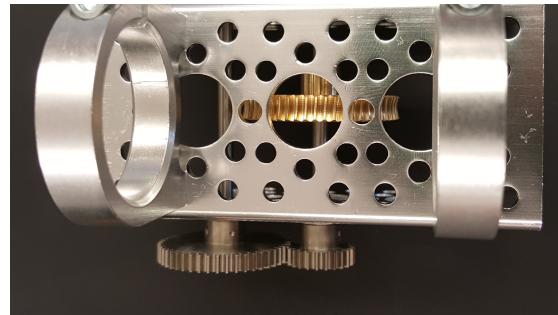
- b) Gather materials required for the subassembly of the extruder, listed in the table above.
- c) On one end of the 6.16 Aluminum Beam attach the Beam Bracket F using two 6-32 x $\frac{3}{4}$ inch bolt, two standard washers and two 6-32 Nylock Nuts.
- d) Attach the 1.93 aluminum beam to the Beam Bracket F using two 6-32 x $\frac{3}{4}$ inch bolts, two standard washers and two 6-32 Nylock Nuts.



- e) The Beam Crossover Adapter A should be connected to the 1.93 Aluminum Beam in the middle hole using one 6-32 x $\frac{3}{4}$ inch bolt, standard washer and a 6-32 Nylock Nut.
- f) Add the other 1.93 aluminum beam to the assembly by attaching it perpendicularly to the Beam Crossover Adapter A with two 6-32 x $\frac{3}{8}$ inch bolts, two standard washers and two 6-32 Nylock Nuts.
- g) Attachment Block A, should be secured to the end of the 1.93 Aluminum Beam that was just attached in step f, using a 6-32 x $\frac{1}{2}$ inch bolt and a 3 mm washer, the threaded hole on the Attachment Block A will serve as a nut for the bolt.



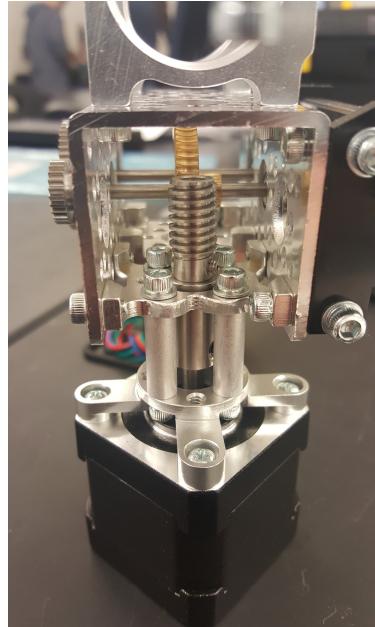
- h) Dremel the Beam gear Rack to 5 $\frac{1}{4}$ inches.
- i) Attach the 1.00" Bore Tube Clamp A to the 3" Aluminum Channel through the second row of outermost holes using two 6-32 x 3/16 inch bolts; this will be done twice on both ends of the 3" Aluminum Channel.
- j) Line up a 0.375" Center Hole Adaptor, a $\frac{1}{8}$ " ID x $\frac{3}{8}$ " OD Flanged Ball Bearing, and a thin 0.12" washer on the large center hole of the 3" Aluminum Channel; align the Brass Insert Spur Gear in the center of the Aluminum Channel, then slide the .12 x 2.3" rod through the aligned parts and anchor the end of the rod with the 0.3" round lock. Slide a 0.375" Center Hole Adaptor, a $\frac{1}{8}$ " ID x $\frac{3}{8}$ " OD Flanged Ball Bearing, and a thin 0.12" washer onto the opposite end of the rod and anchor it with the 2024 Stainless Steel Gear. The end of the rod anchored with the smaller aluminum gear should be on the side of the 3" Aluminum Channel such that it is opposite of the bolted side of the 1.00" Bore Tube Clamp A.
- k) Line up a 0.375" Center Hole Adaptor, a $\frac{1}{8}$ " ID x $\frac{3}{8}$ " OD Flanged Ball Bearing, and a thin 0.12" washer on the large end hole of the 3" Aluminum Channel; then slide a .12 x 2.3" rod through the aligned parts and anchor the end of the rod with the 303 Stainless Steel Gear such that it meshes with the 2024 Stainless Steel Gear from step j. Anchor the other end of the rod with a 0.375" Center Hole Adaptor, a $\frac{1}{8}$ " ID x $\frac{3}{8}$ " OD Flanged Ball Bearing, a thin 0.12" washer, followed by the small, white plastic gear.



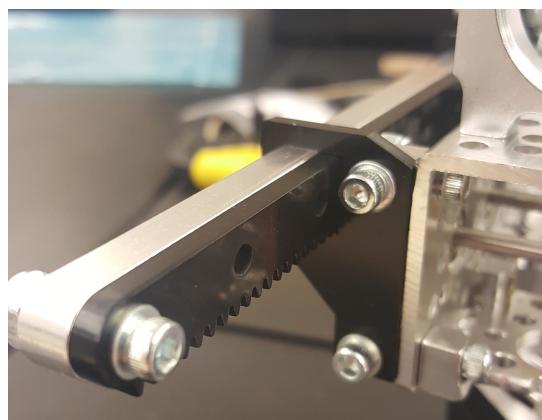
- I) The 0.75 inch Aluminum Standoff need to be attached to the Stepper Motor Mount (NEMA 17), using 7/16" bolts; the Aluminum Standoff is threaded, so nuts are not needed.
- m) Take the 3/16" to 5mm Set Screw Shaft Coupler and tighten it to the motor shaft with the 3/16" Allen wrench.



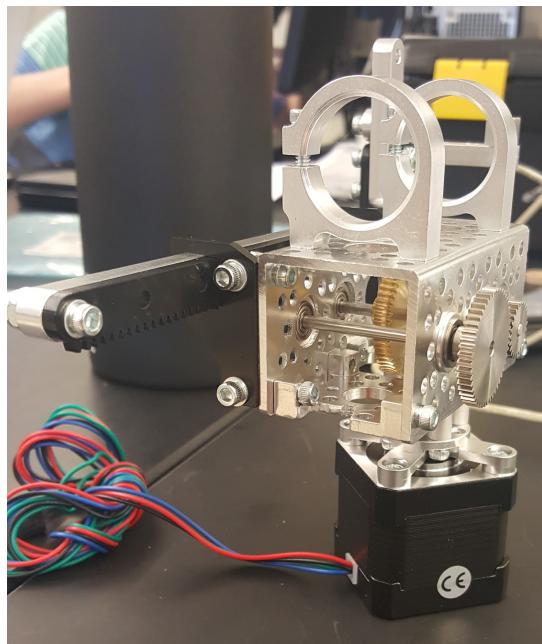
- n) Insert the "Aluminum Rod" into the other end of the 3/16" to 5mm Set Screw Shaft Coupler, tighten with an allen wrench.
- o) Slide the Worm Gear onto the Aluminum Rod that is extruding from the Coupler and tighten with the
- p) Attach the Hub Mount to the four 0.75 inch Aluminum Standoffs using the 7/16" bolts and standard washers.
- q) Connect the Hub Mount to inside of the 3" Aluminum Channel on the end furthest from the 303 Stainless Steel Gear and the small plastic white gear. Do so using three ¼" bolts, without washers. Two bolts are used on the side with the stainless steel gears and the third is used on the opposite side through the hole that is closer to the center of the Aluminum Channel. For the fourth hole on the Hub Mount, use a ¾" bolt and attach it through the Aluminum Channel, anchoring it with the hole on the flat side of an Attachment Block B.



- r) Attach the Quad Mount to the inside of the 3" Aluminum Channel on the end opposite from the Hub Mount. Do so using three $\frac{1}{4}$ " bolts, without washers. Two bolts are used on the side with the stainless steel gears and the third is used on the opposite side through the hole that is closer to the center of the Aluminum Channel. For the fourth hole on the Quad Mount, use a $\frac{3}{8}$ " bolt and attach it through the Aluminum Channel, anchoring it with the hole on the flat side of an Attachment Block B.
- s) Attach two more Attachment Block B's to the 3" Aluminum Channel directly above the other Attachment Block B's from steps q and r in the top, corner holes $\frac{1}{4}$ " bolts.
- t) Attach the Beam Bracket T to the outside of the Attachment Block B with 7/16" bolts with washers; this will be done on both ends of the Aluminum Channel.



- u) Thread the 6.16 Aluminum Beam with the cut Beam gear Rack through both of the Beam Bracket T's. Attach the Beam Gear Rack to the 6.16 Aluminum Beam with two $\frac{5}{8}$ " bolts with washers and nyloc nuts through the 1st and 7th hole.

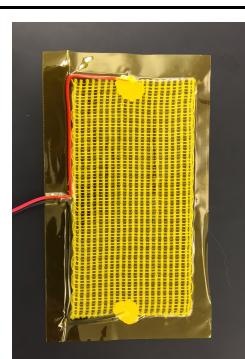


Milestone 5

1) Tube Heater Assembly Instructions

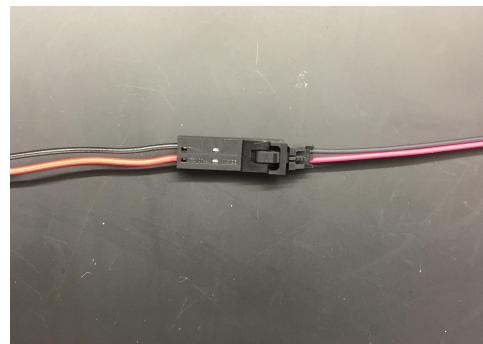
a) The parts needed for the assembly of the tube heater

DS18B20+-ND Temperature Sensor Quantity: 3	
Carbon Fiber Tube Quantity: 1	
Molex Connector Pin Crimp Gold 22-24AWG Quantity: 2	
Molex Connector Pin Crimp Gold 24-30AWG Quantity: 6	
Molex Connector Socket Crimp Gold 22-24AWG Quantity: 2	

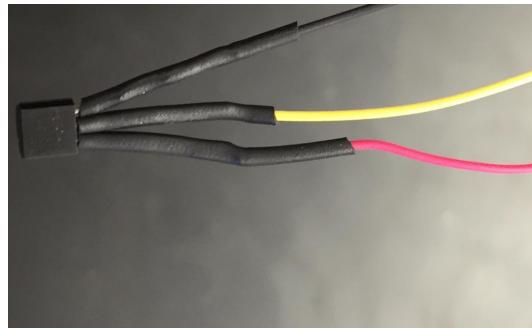
Molex Connector Socket Crimp Gold 24-30AWG	
Quantity:6	
3-POS Molex Female	
Quantity:2	
3-POS Molex Male	
Quantity:2	
2-POS Molex Female	
Quantity:1	
2-POS Molex Male	
Quantity:1	
Heating Pad	
Quantity:1	

Nozzle Head	
Quantity: 1	
Inner carbon fiber sleeve bracket	
Quantity: 2	
Outer carbon fiber sleeve bracket	
Quantity: 2	

- b) Make three wire harnesses, one using the 2-POS Molex parts and two using the 3-POS Molex parts.



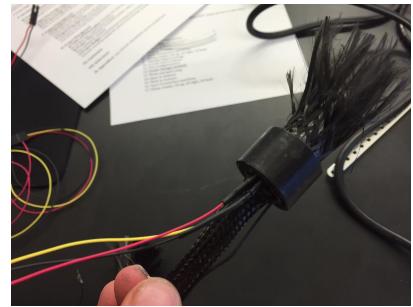
- c) A Temperature sensor was soldered onto the male end of a wire harness with 3 prongs in the following manner:



- e) Feed a 22-gage wire and a 3 pronged male wire harness through the nozzle head and then solder the temperature sensor on to the wire harness. In addition, strip the 22 gage wire and wrap it around the tip of the nozzle. Paint the wrapped wire with colloidal silver liquid at the contact point on the nozzle. Epoxy the entire setup; making sure that the temperature sensor has the curved end touching the nozzle.
Note: prevent the epoxy from getting into the hole on the nozzle tip.



- f) Insert the carbon fiber sleeve into the outer carbon fiber sleeve bracket so that the open end of the bracket is facing the end of the sleeve. In addition, insert the inner carbon fiber sleeve bracket into the carbon fiber sleeve on the same end as the outer bracket.
- g) Obtain a piece of 22-gage wire and strip about 3 inches off of it. Wrap the stripped portion of the wire around the carbon fiber sleeve and the inner carbon fiber sleeve bracket to hold the carbon fiber on to the inner bracket. Paint the wrapped wire with colloidal silver liquid at the contact point. Epoxy around the wire and pull the outer bracket over the inner bracket, making sure the wires are in the correct notches on the outer bracket. Wait for epoxy to dry.
- h) Repeat steps f and g for the other end of the carbon sleeve with a new 22 gage wire and in addition, a temperature sensor on the inside of the outer bracket, in the following manner:

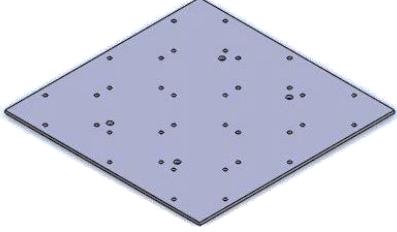
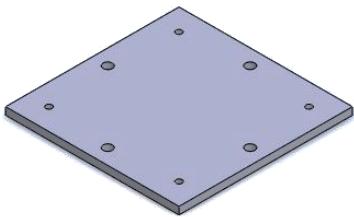


- i) Insert the plastic tube into the carbon fiber sleeve, through the brackets.
- j) Solder two 22-gage wires onto the heating pad from the 2-POS Molex Female.

Milestone 6

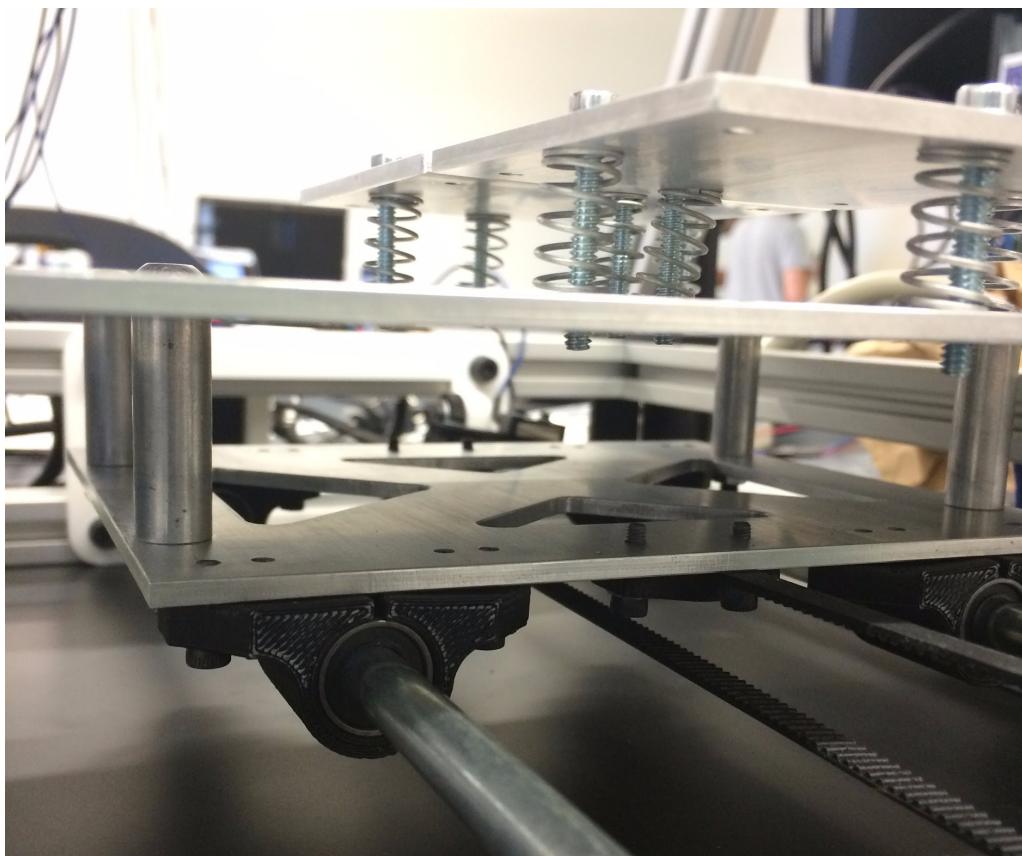
1) Print Plate Sub Assembly Instructions

a) The parts needed for the print plate assembly

Aluminum Standoff for M5, 30 mm long Actobotics P/N: 633126 Quantity: 4	
M5 x 45 Bolt, BHCS Black Oxide Quantity: 4	
M5 Nut Quantity:	
Large Aluminum Square Plate Quantity: 1	
Small Aluminum Square Plate Quantity: 2	

Springs (Part No C12-032-032)	
Quantity: 8	
3 x 25 mm Bolt	
Quantity: 8	

- b) Align the Large Aluminum Square plate over the X-Sub Plate so that it may be attached. To attach, use four 30 mm long Aluminum Standoffs and four M5 x 45 BHCS Bolts and secure the bolts on the bottom of the X-Sub Plate using M5 Nuts.



- c) Align one of the Small Aluminum Square Plates with the edge of the Large Aluminum Square Plate that is furthest from the motor on the Y-Axis and center the Small Plate along that edge. Secure using four 3 x 25 mm bolts, through the center edge holes on the Small Aluminum Square Plate. Use a small spring (Part No C12-032-032) on each bolt to separate the Small and Large Aluminum Plates. The Large Aluminum Square Plate is threaded so nuts are not needed.
- d) The other Small Aluminum Square Plate should be aligned with the Small Plate attached in step b and in the center of the Large Aluminum Square Plate. Attach using the same procedure in step b.

