

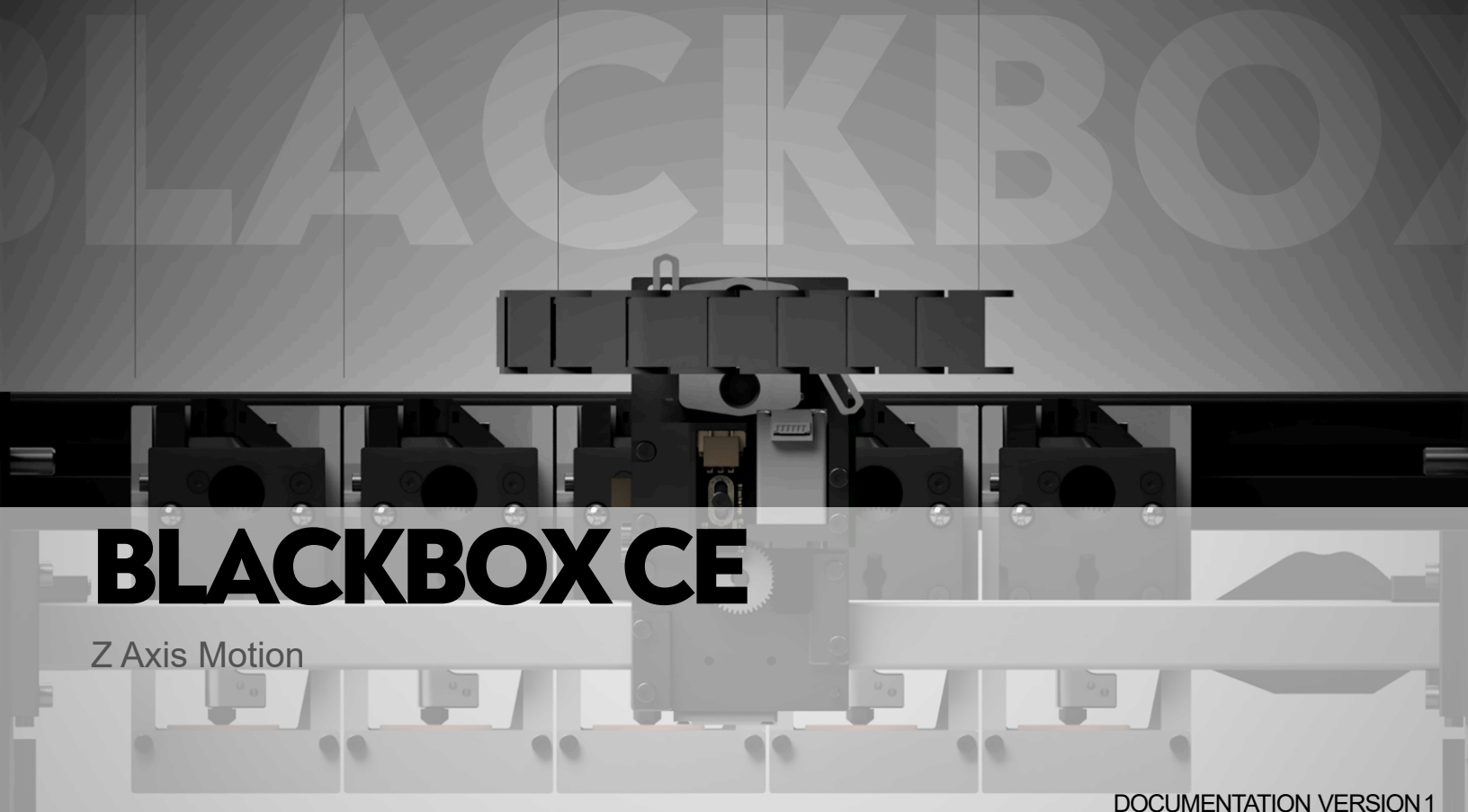
01

02

03

04

05



DOCUMENTATION VERSION 1

Blackbox CE Mechanical Assembly:

02. Z Axis Motion

Authored by Daniel Darms

Change Log

Version	Notes
1	Initial Release

Tools

Description
M3x0.5mm Tap
Electric Drill
Hand Tap Wrench
Hex Wrenches
Reamers
Threadlocker
Soldering Iron with Heatset insert tip

Parts

QTY	Description
2	Bearing_Flanged_5x10x4mm
2	Bearing_4x9x4mm
1	EF 10 Bearing
1	EK8 Bearing
1	GT2_40t_Pulley_9mm_Belt_5mm_Bore_Powge
2	GT2_16t_Pulley_9mm_Belt_5mm_Bore_Powge
2	GT2_40t_Pulley_9mm_Belt_8mm_Bore_Powge
1	GT2_80t_Pulley_9mm_Belt_8mm_Bore_Powge
1	GT2_94t_Belt_9x188mm
1	GT2_77t_Belt_9x154mm
1	Nema17_47mm
4	Linear_Shaft_5x25mm
1	Linear_Shaft_5x70mm
1	Linear_Shaft_8x520mm
1	T-Slot_10x20mm_Nut6_350mm_CE
1	20x20_Corner_Bracket
4	M4_6x5mm_Heat_Set_Insert
4	M3_4.6x4mm_Heat_Set_Insert
12	M4 20 Series T-Nut
4	Tnut_40Series_M4
2	ISO7380_M4_8mm_BHHS
4	DIN912_M3_8mm_SHCS
4	DIN912_M3_10mm_SHCS
3	DIN912_M4_10mm_SHCS
2	DIN912_M4_12mm_SHCS
1	DIN912_M4_14mm_SHCS
2	DIN912_M4_20mm_SHCS
2	DIN912_M4_22mm_SHCS
6	DIN912_M4_35mm_SHCS
2	DIN912_M4_45mm_SHCS
2	DIN916_M3_5mm_Set_Screw
2	DIN916_M3_6mm_Set_Screw
8	DIN916_M4_4mm_Set_Screw
2	DIN916_M4_6mm_Set_Screw
2	DIN916_M5_12mm_Set_Screw
2	DIN125_M4_Washer
4	DIN7349_M4_Thick_Fender_Washer

Printed Parts

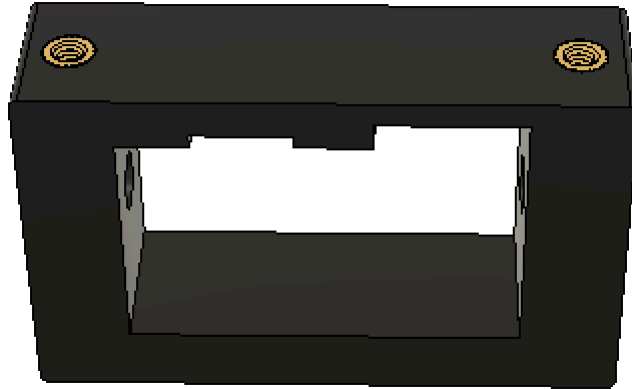
QTY	Description	Material	Ver	Link
2	Print_Z-Axis_40t_Pulley_Installation_Tool_(7.551)	PLA	1	
1	Print_Z-Axis_80t_Pulley_Installation_Tool_(122.5)	PLA	1	
1	Print_Z-Axis_EF10_Installation_Tool_(160.006)_CE	PLA	1	
1	Print_Z-Axis_EK8_Installation_Tool_(169.006)_CE	PLA	1	
1	Print_Z-Axis_Idler_Pulley_Installation_Tool_(168.889)_CE	PLA	1	
1	Print_Z-Axis_Motor_Installation_Tool_(4.6)	PLA	1	
1	Print_Pulley_Reduction_40t_Pulley_Installation_Tool_(1.85)	PLA	1	
1	Print_Pulley_Reduction_16t_Pulley_Installation_Tool_(0.9)	PLA	1	
1	Print_PulleyReduction_part02	>=ABS	1	
2	Print_PulleyReduction_part03	>=ABS	1	
1	Print_PulleyReduction_part01_CE	>=ABS	1	
1	Print_Z-Axis_Motor_Bracket	>=ABS	1	
1	Print_2020_Corner_Bracket_Lock_Part_01_CE	>=ABS	1	
2	Print_2020_Corner_Bracket_Lock_Part_02_CE	>=ABS	1	
1	Print_EK8_Spacer	>=ABS	1	
2	Print_EF10_Liner	>=ABS	1	
2	Print_EK8_Liner	>=ABS	1	
1	Print_Z-Axis_Belt_Idler_Right_Part_01	>=ABS	1	
1	Print_Z-Axis_Belt_Idler_Right_Part_02_CE	>=ABS	1	
2	Print_Z-Axis_Tackle_Roller	>=ABS	1	
1	Print_Z-Axis_Belt_Idler_Left_Part_01	>=ABS	1	
1	Print_Z-Axis_Belt_Idler_Left_Part_02_CE	>=ABS	1	

Step 1 – Preparation

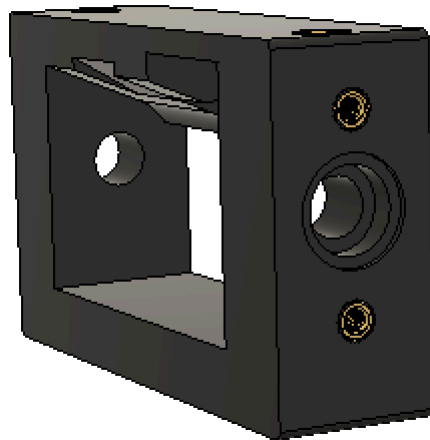
For this section a small hand vise or small arbor press is listed in tools. This will be used for pressing linear shafts through bearings if needed. Never bang on bearings to install them. The impact to the outer race of a small bearing will cause flat spots on the actual bearing balls. These flat spots will cause friction and heat that both reduces the life of the bearing and introduces drag resistance. Dropping a bearing will have the same result. If you drop a bearing onto a hard surface, it is best to discard and replace it. If you find a linear shaft to have excessive resistance during installation, the first thing to try is to insert the linear shaft from the other end. If both ends of the linear shaft seem to have excessive resistance, then you can install the linear shaft into your hand drill. Pinch a small piece of fine grit sandpaper (#4000) onto one end as you operate the drill for a few seconds. For the printed parts, all the Installation Tools may be printed in a cheaper material such as PLA. For the through holes of printed parts, verify that a reamer of the same size will fit through. If there is resistance in the hole, use the reamer until the hole is free and clear. Both M3 and M4 heat set inserts are used in this guide. Most soldering iron installation kits for heat set inserts have a different tip for M3 and M4 inserts. You will need to let the iron cool after installing inserts of one size before switching to the other installation tip to continue with the other size.

Step 2 – Pulley Reduction Housing

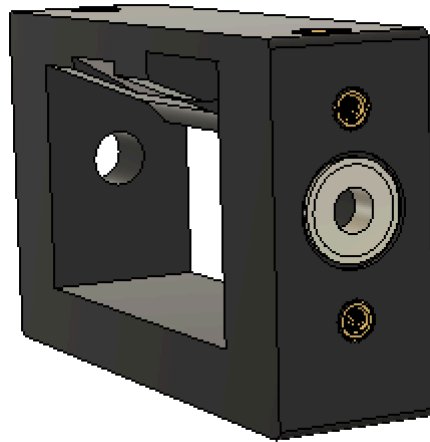
Locate the printed Pulley Reduction Part 02 and insert two M4 heat set inserts into the top of the printed part.



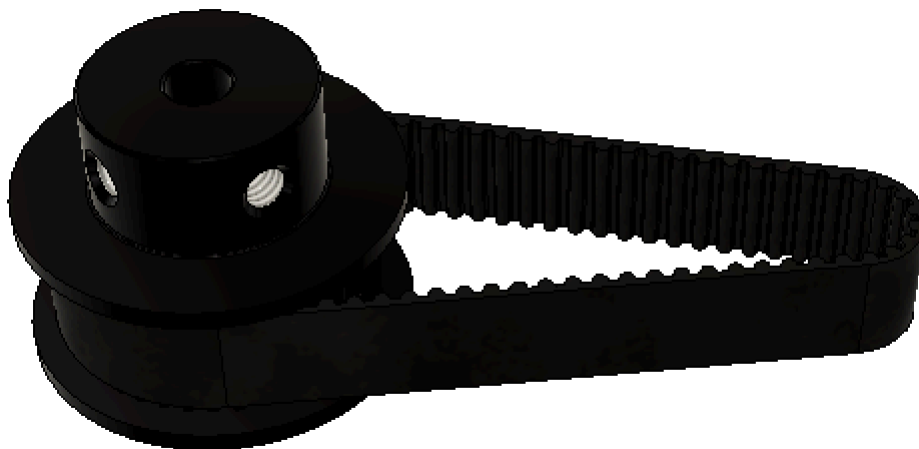
Insert two M3 heat set inserts into the left side, then rotate the part 180 degrees and repeat with two M3 heat set inserts on the right side.



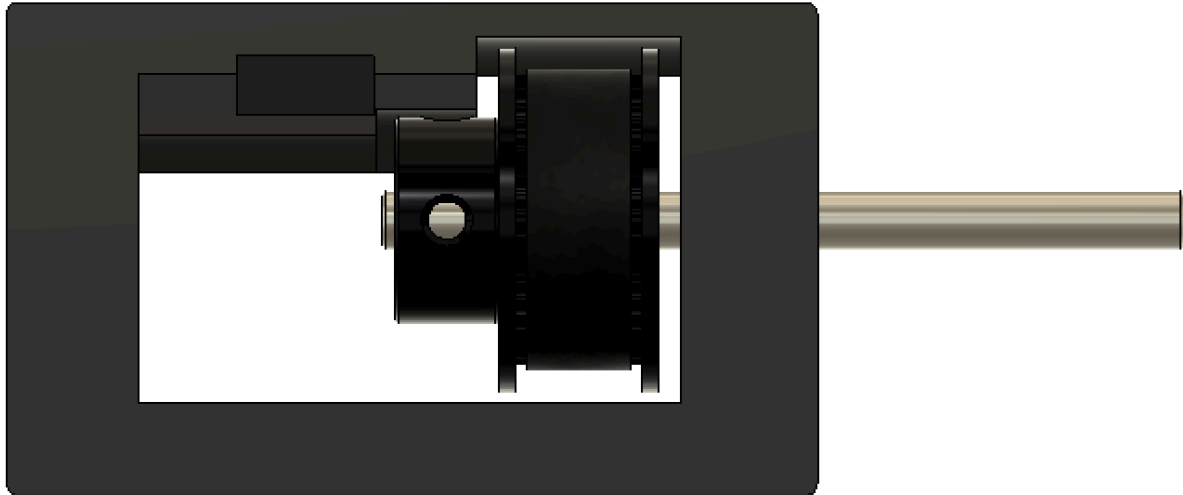
Insert a flanged 5x10x4 bearing into the pocket on the left face of the printed part.



Locate the GT2 77tooth loop belt 9x154 and place it around the GT2 40t pulley with 5mm bore.



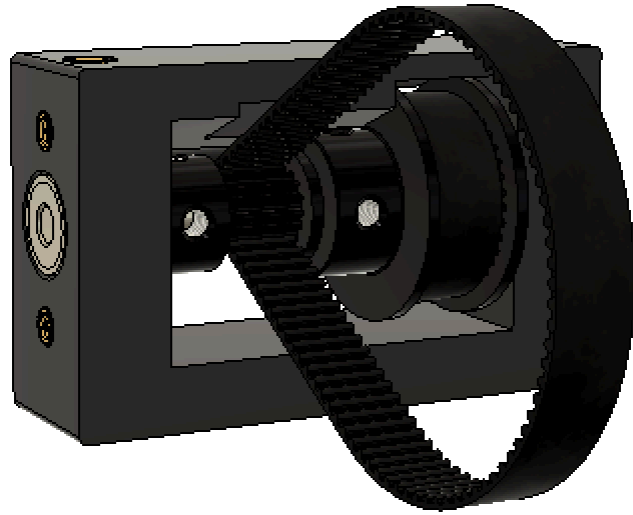
Place the GT2 40t pulley into the printed part with the hub facing toward the right (left for perspective of picture) of the printed part. The pulley can only fit into the part one way. Press the 5x70mm linear shaft through the flanged bearing, through the printed part, and through the GT2 40t pulley until it just protrudes from the hub of the pulley.



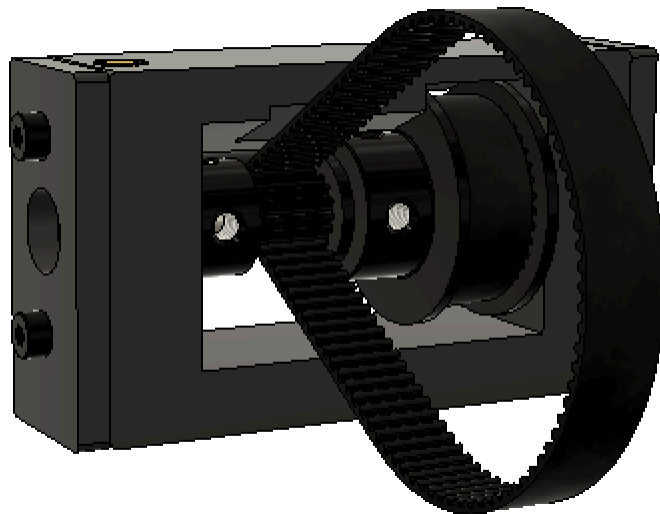
Locate the GT2 94tooth 9x188 loop belt and place it around a GT2 16t pulley with 5mm bore.



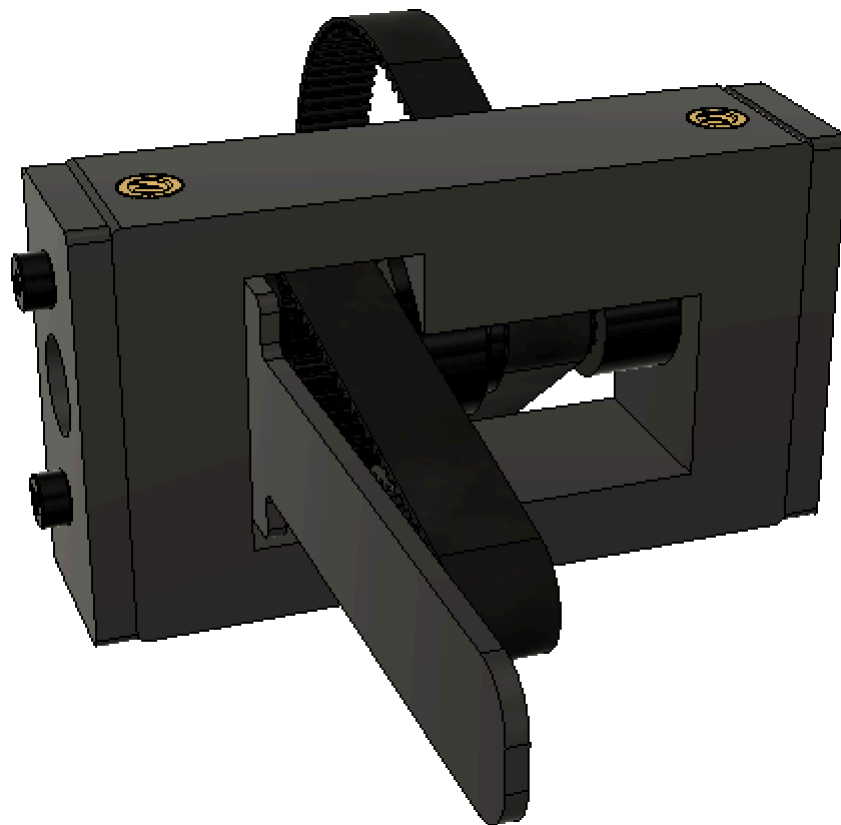
Insert a flanged 5x10x4 bearing into the pocket on the right face of the printed part. Insert the GT2 16t pulley into the printed part with the hub facing the hub of the 40t pulley. Continue to press the 5x70mm linear shaft through the 16t pulley, through the printed part, and through the 5x10x4 flanged bearing. Squeeze each end of the 5x70mm linear shaft to center it into the printed part.



Locate the two printed Pulley Reduction Part 03. You will notice that one face of these printed parts has a recess. Install one of these printed parts onto the right of the Pulley Reduction assembly with the recess facing the flanged 5x10x4 bearing, then secure with two M3x8mm SHCS. Repeat this with the other printed part and two more M3x8mm SHCS on the left end of the Pulley Reduction Assembly.



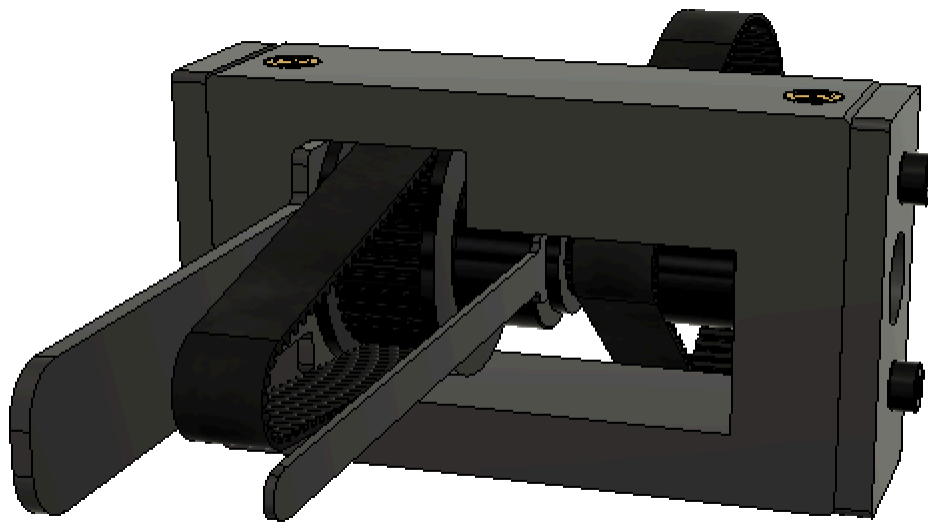
Rotate the assembly and insert the printed Pulley Reduction 40t Installation Tool between the flat face of the 40t pulley and the printed Pulley Reduction Part 02.



From the rear side of the Pulley Reduction assembly, secure the 40t pulley to the 5x70mm shaft. Apply medium strength thread locker to two M4x6mm Set Screws. Hold the 40t pulley tight to the left of the Pulley Reduction Assembly using the printed tool to set the proper clearance. Tighten the M4x6mm set screws into the hub of the 40t pulley completely. You may need to rotate the 40t pulley to access one or both of the set screw holes in the hub.



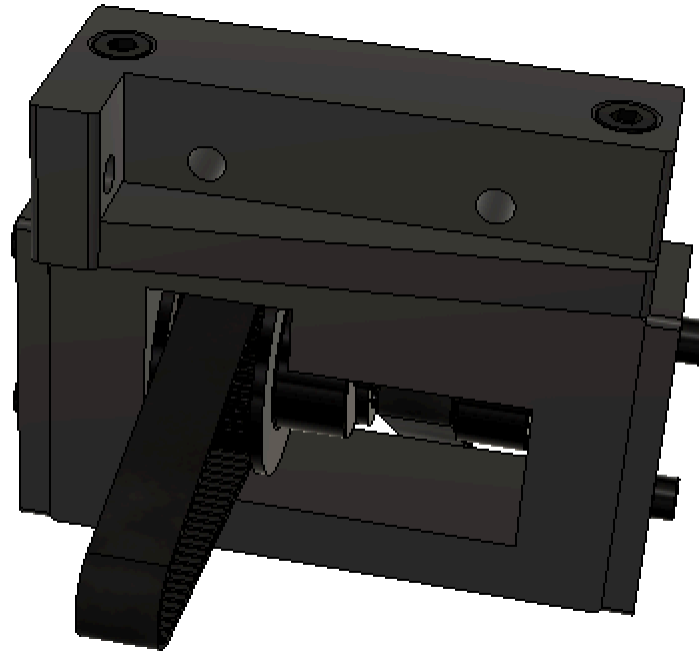
Rotate the assembly and insert the printed Pulley Reduction 16t Installation Tool between the hub of the 40t pulley and the hub of the 16t pulley.



From the rear side of the Pulley Reduction assembly, secure the 16t pulley to the 5x70mm shaft. Apply medium strength thread locker to two M4x4mm Set Screws. Hold the 16t pulley tight to the left of the Pulley Reduction Assembly using the printed tool to set the proper clearance. Tighten the M4x4mm set screws into the hub of the 16t pulley completely. You may need to rotate the 16t pulley to access one or both of the set screw holes in the hub.

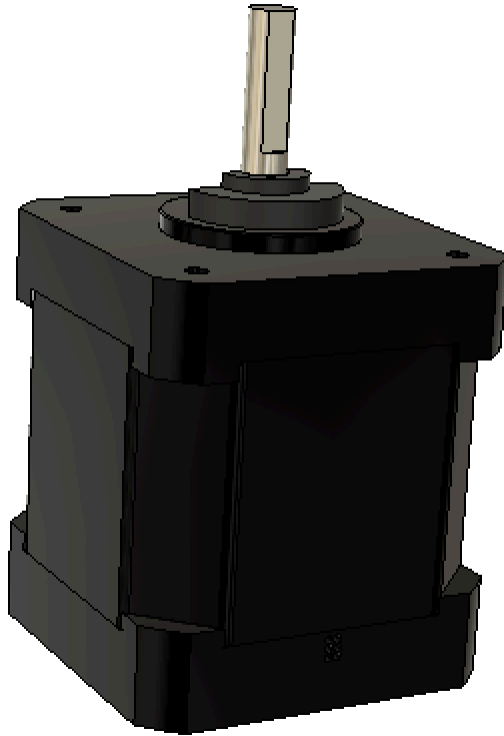


Remove the printed Pulley Reduction Installation Tools. Place the printed Pulley Reduction Part 01 on top of the Pulley Reduction Assembly and secure with two M4x20 SHCS.



Step 3 – Z-Axis Motor

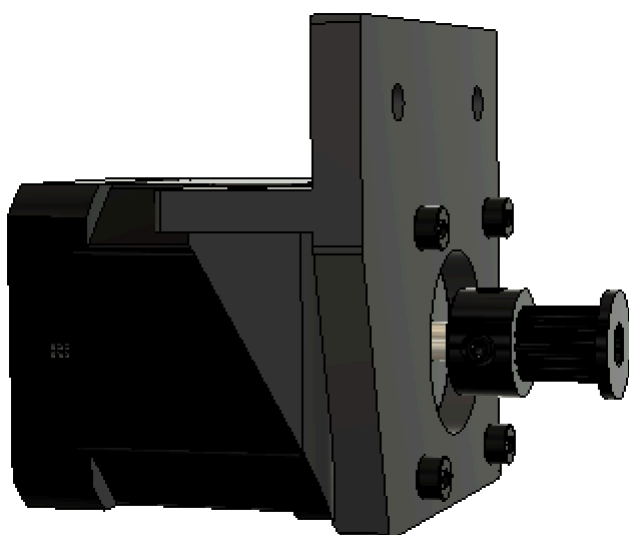
Set the Pulley Reduction Assembly aside and locate a NEMA17 motor. Place the printed Z-Axis Motor Installation Tool onto the shaft of the NEMA17 motor.



Install a GT2 16t pulley with 5mm bore onto the NEMA17 motor shaft. Align one of the set screw holes with the flat of the motor shaft. Coat two M4x4mm set screws with medium strength thread locker. Secure the 16t pulley to the NEMA17 motor shaft with the two M4x4mm set screws securely. Start by securing the set screw facing the flat of the motor shaft. As this screw tightens, wiggle the 16t pulley to assure the flat end of the set screw mates flush with the flat of the NEMA17 motor shaft. Keep the hub of the 16t pulley tight with the printed Installation Tool to set the proper pulley height. Tighten both M4x4mm set screws completely.

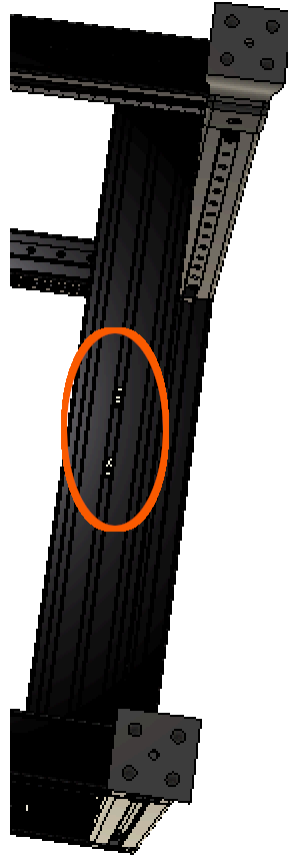


Remove printed Installation Tool. Orient motor as below with connection for wiring harness facing you. Place the printed Z-Axis Motor Bracket onto the NEMA17 motor and secure it with four M3x10mm SHCS.

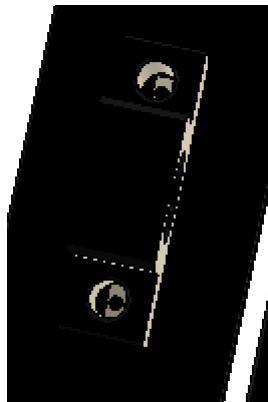


Step 4 – Z-Axis Drive Shaft

Set the Z-Axis Motor Assembly aside. Turn your assembled frame upside down and orient the front toward you. Insert two M4 Slot 6 roll-in nuts into the center slot of the left (right as to perspective of picture) 2060 extrusion as shown.



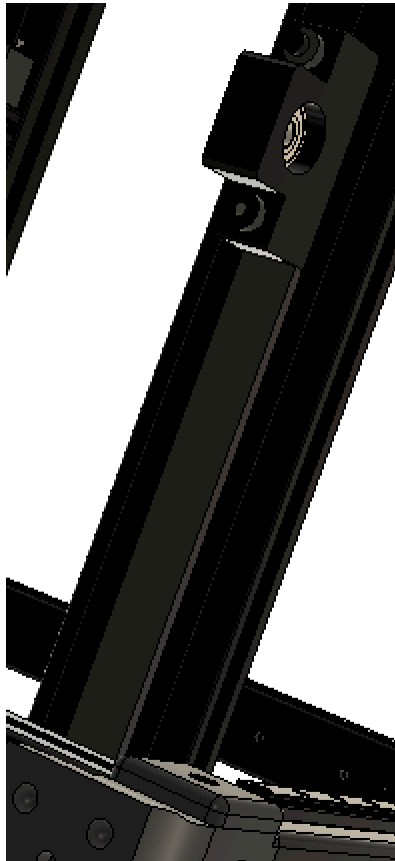
Place the EF10 Bearing on top of the left 2060 extrusion. Line up the holes in the M4 Slot 6 roll-in nuts with the mounting holes in the EF10 Bearing.



Place a printed EF10 liner into each of the mounting holes of the EF10 Bearing. Insert an M4x35mm SHCS through an M4 Fender Washer, then through the printed EF10 Liner, and into the M4 Slot 6 roll-in nut. Loosely tighten the M4x35mm SHCS and repeat for the other EK8 Bearing mounting hole with another M4x35 SHCS and M4 Fender Washer.



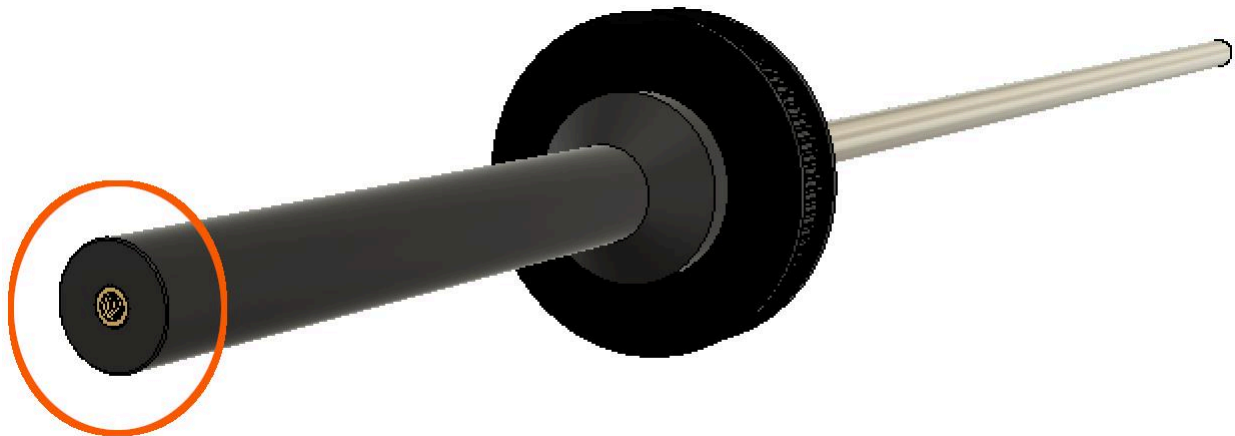
Place the ribs of the printed Z-Axis EF10 Installation Tool into the center slot of the 2060 rail between the EF10 Bearing and the front 470mm 4040 extrusion. Slide the EF10 Bearing assembly until it is flush with the printed installation tool and the printed installation tool is flush to the 470mm 4040 extrusion. Fully tighten all the M4x35 SHCS.



Remove the printed EF10 Installation Tool. Locate the printed Z-Axis 80t Pulley Installation tool. Slide the 8x520mm linear shaft into the printed tool until it is flush to the bottom. Install the GT2 80t pulley so the flat side of the pulley is flush with the printed tool. Coat two M5x12mm set screws with medium strength thread locker. Secure the 80t pulley to the 8x520mm linear rod with the two M5x12mm set screws. Tighten the two M5x12mm set screws completely.



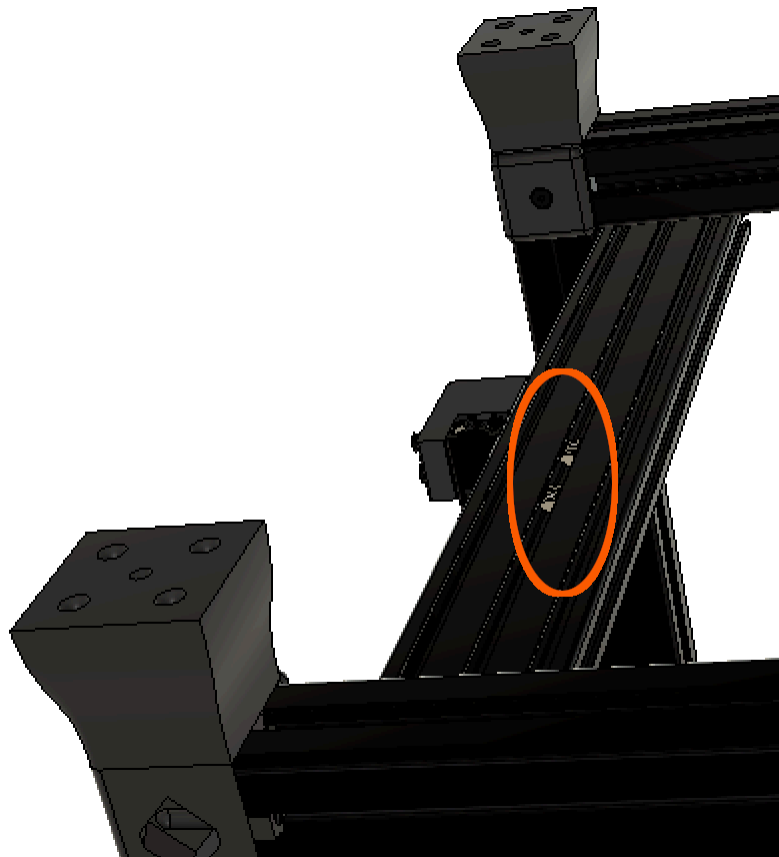
Remove the printed tool from the linear shaft. If you find it difficult to remove the printed tool, you can install a M3 heat set insert into the bottom of the printed tool while it is still attached to the linear shaft,



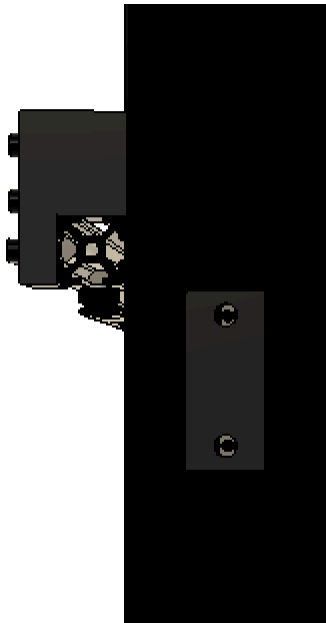
Then use a long M3 SHCS to press the linear shaft far enough away from the printed tool to facilitate easy removal.



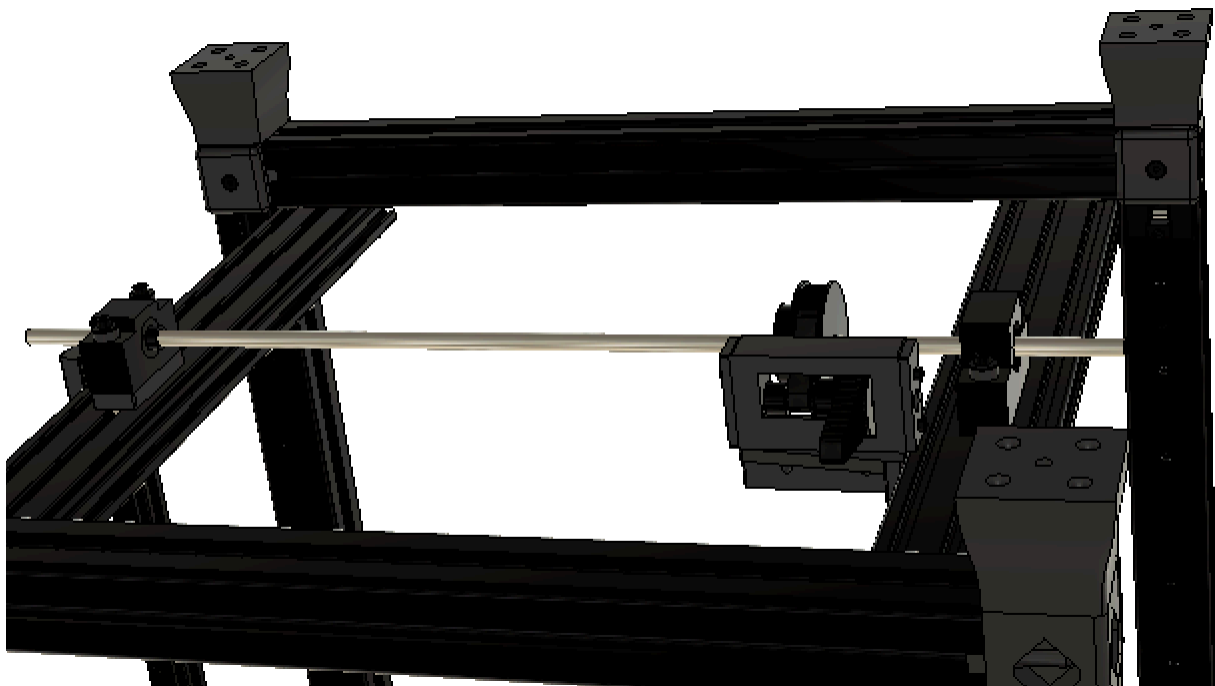
Place two M4 Slot 6 roll-in nuts into the center slot of the right (left in perspective to picture) 2060 extrusion as shown.



Place the printed part EK8 Spacer on top of the 2060 extrusion and align the holes of the M4 Slot 6 roll-in nuts with the holes in the printed part.



Wrap the GT2 94t 9x188mm loop belt from the Pulley Reduction assembly around the GT2 80t pulley mounted on the 8x520mm linear shaft. It is okay if the Pulley Reduction Assembly is dangling at this point. Slide the EK8 Bearing onto the 8x520mm linear shaft at the end opposite the 80t pulley. If a bearing guide is present on one side of the EK8 bearing, orient that side toward the 80t pulley. Place the EK8 Bearing with 520mm linear rod assembly installed on top of the printed EK8 spacer. Be certain the EK8 Bearing is oriented properly over the printed EK8 Spacer. Locate the printed EK8 Liner parts and install one into each mounting hole of the EK8 bearing. Insert an M4x45mm SHCS through an M4 Fender Washer, through the printed EK8 Liner, and into the M4 Slot 6 roll-in nut. Repeat for the other EK8 Bearing mounting hole with another M4x45mm SHCS and M4 Fender Washer. Loosely secure both M4x45 SHCS. Slide the opposite end of the 8x520mm linear shaft (end closer to 80t pulley) through the secured EF10 Bearing. You may need to slide the EK8 Bearing assembly from front to back (up or down in perspective of picture) to line up 520mm linear shaft with the secured EF10 Bearing.



Place the ribs of the printed Z-Axis EK8 Installation Tool into the center slot of the 2060 rail between the EK8 Bearing and the front 470mm 4040 extrusion. Slide the EK8 Bearing assembly until it is flush with the printed installation tool and the printed installation tool is flush to the 470mm 4040 extrusion. Fully tighten all the M4x45 SHCS.



Remove the printed EF10 Installation Tool.

Step 5 – Pulley Reduction Assembly Brace

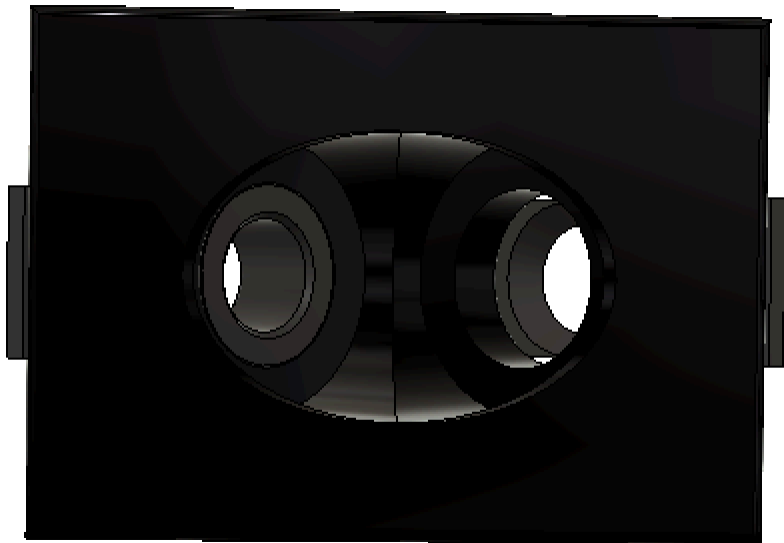
Place a 1020 extrusion of 350mm in front of you with the slot facing up. Install three M4 Slot 6 roll-in nuts as shown.



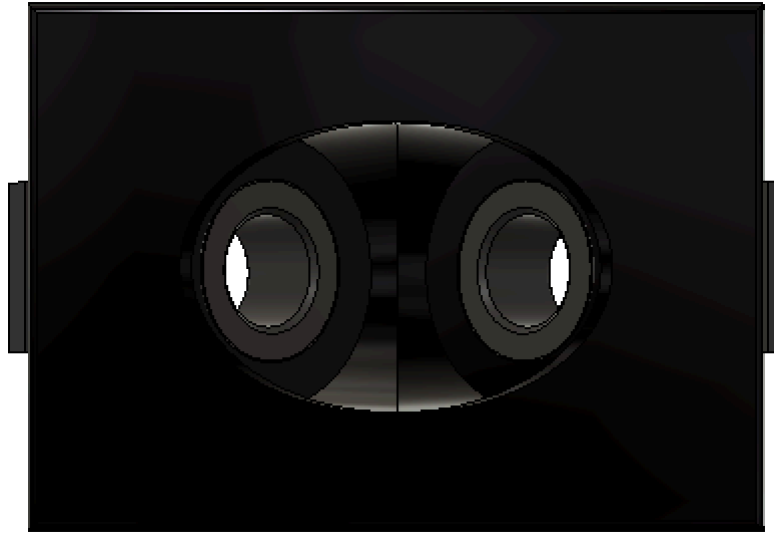
Place Print_2020_Corner_Bracket_Lock_Part_01_CE on the outside of a 2020 Corner Bracket as shown.



Now insert a Print_2020_Corner_Bracket_Lock_Part_02_CE through one of the holes of the 2020 Corner Bracket until it is flush with the bracket and locked into the printed Part 01.



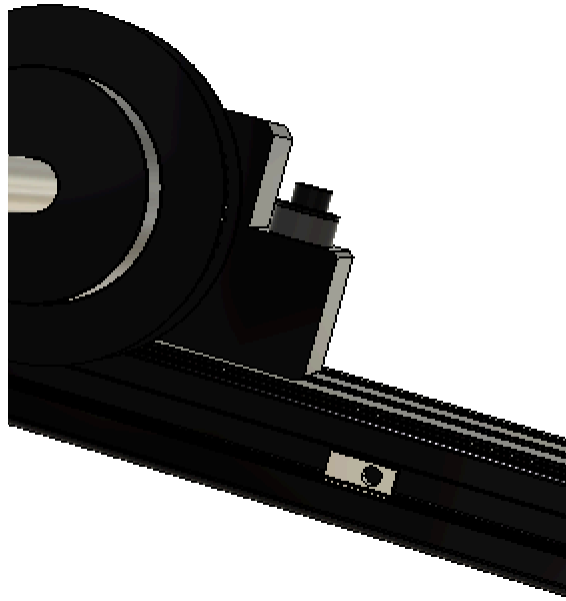
Repeat for the other hole of the 2020 Corner Bracket with another printed Part 02.



Place the assembled 2020 Corner Bracket on the extrusion at the right end. Align the bracket flush and secure with an M4x8mm BHHS through an M4 washer. Tighten the M4x8mm BHHS securely.



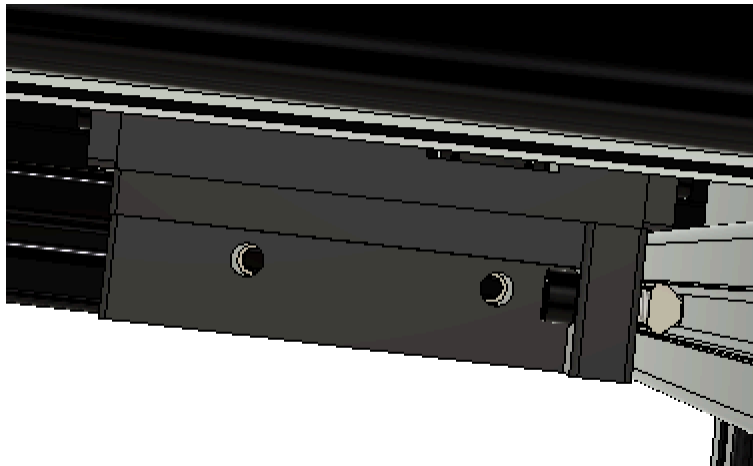
Move the Pulley Reduction Assembly out of the way and place an M4 Slot 6 roll-in nut into the side slot of the left 2060 extrusion as shown.



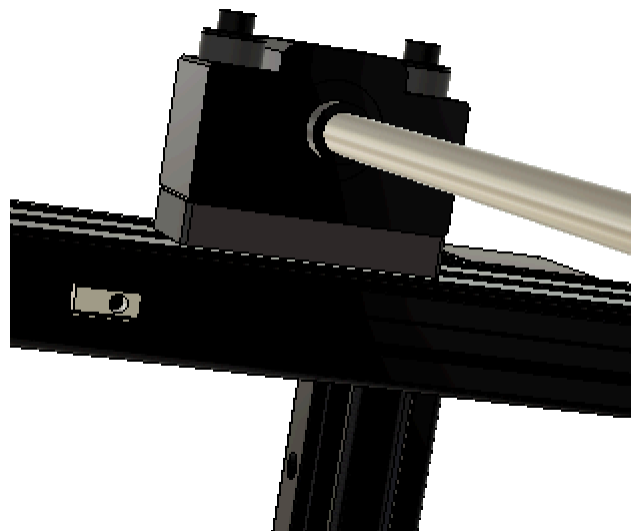
Move the Pulley Reduction Assembly back into position and insert an M4x14mm SHCS through the Pulley Reduction Assembly into the M4 Slot 6 roll-in nut. Loosely fasten the M4x14mm SHCS.



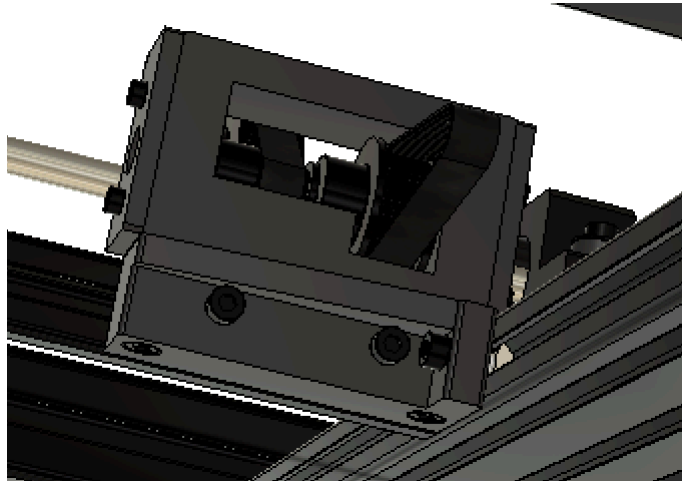
Hold the assembled 1020 extrusion against the Pulley Reduction Assembly and move the M4 Slot 6 roll-in nuts until they line up with the holes in the Pulley Reduction Assembly.



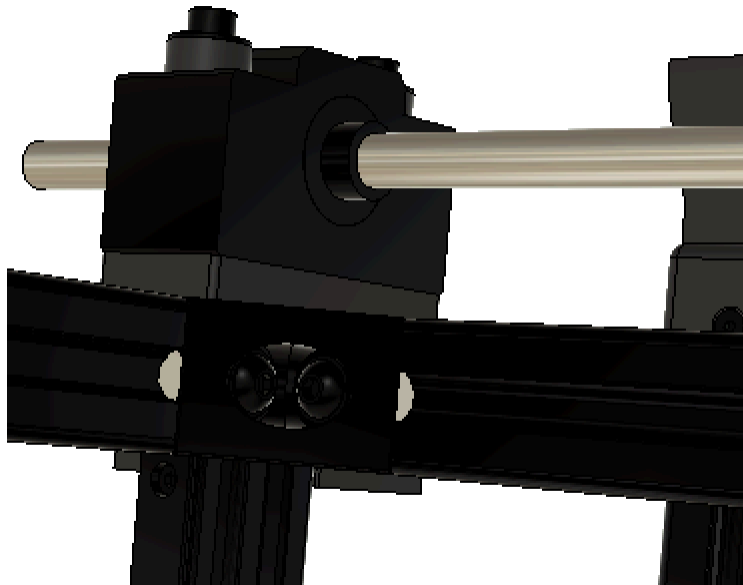
Put the assembled 1020 extrusion down. Install an M4 Slot 6 roll-in nut on the side of the right 2060 extrusion as shown.



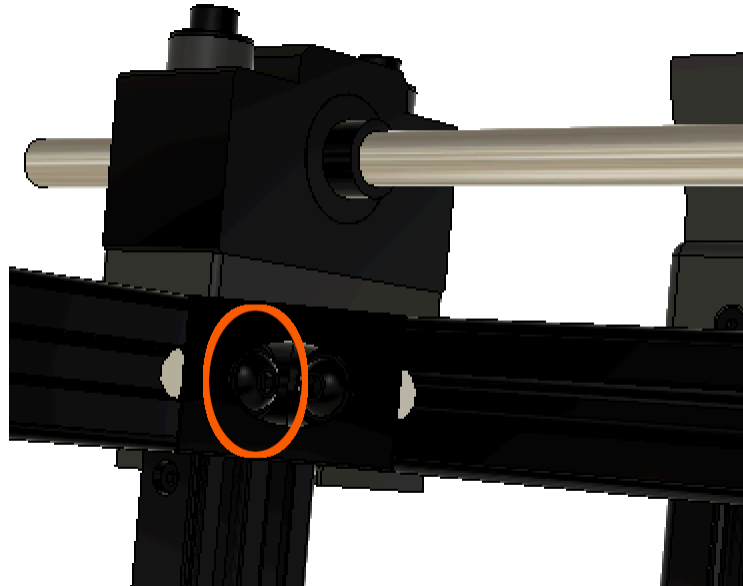
Place the assembled 1020 extrusion against the Pulley Reduction Assembly again. Secure the Pulley Reduction Assembly to the 1020 extrusion with two M4x22mm SHCS. Keep the 1020 extrusion flush to the left 2060 extrusion and tighten the two M4x22mm SHCS completely.



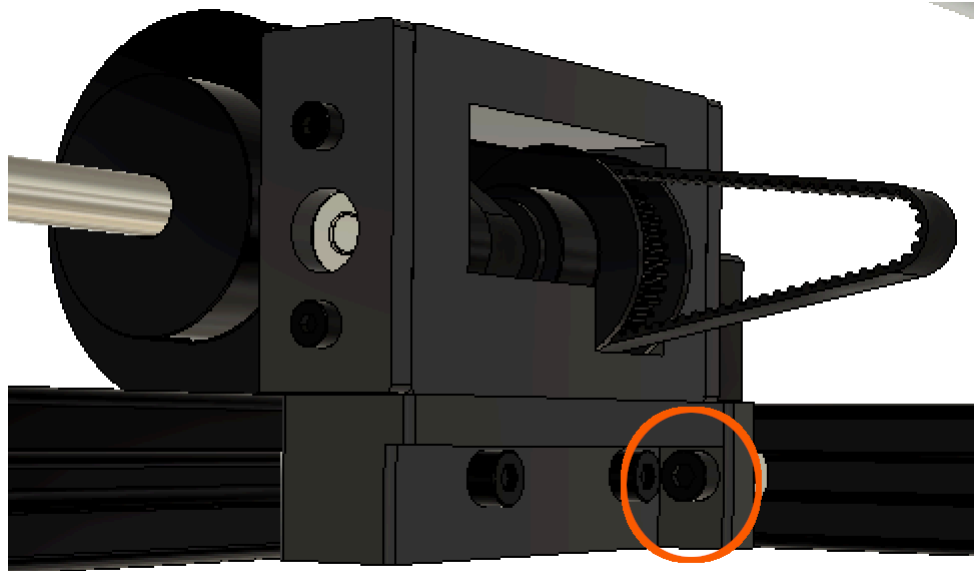
At the other end of the 1020 extrusion, secure the 2020 Corner Bracket to the right 2060 extrusion by inserting an M4x8mm BHHS through an M4 washer, through the 2020 Corner Bracket, and into the M4 Slot 6 roll-in nut. Loosely secure the M4x8mm BHHS.



Moving the 1020 extrusion of the Pulley Reduction Assembly away from the 8x520mm linear shaft will set the tension for the GT2 94t 9x188mm Loop Belt. Move this assembly now and set the belt tension. Be certain to measure each end of the 1020 extrusion to the end of its corresponding 2060 extrusion to keep the 1020 extrusion perpendicular. When the GT2 94t 9x188mm Loop Belt is properly tensioned and the measurements of the 1020 extrusion are equal to a reference frame part, tighten the M4x8mm BHHS completely at the 2020 Corner Bracket.

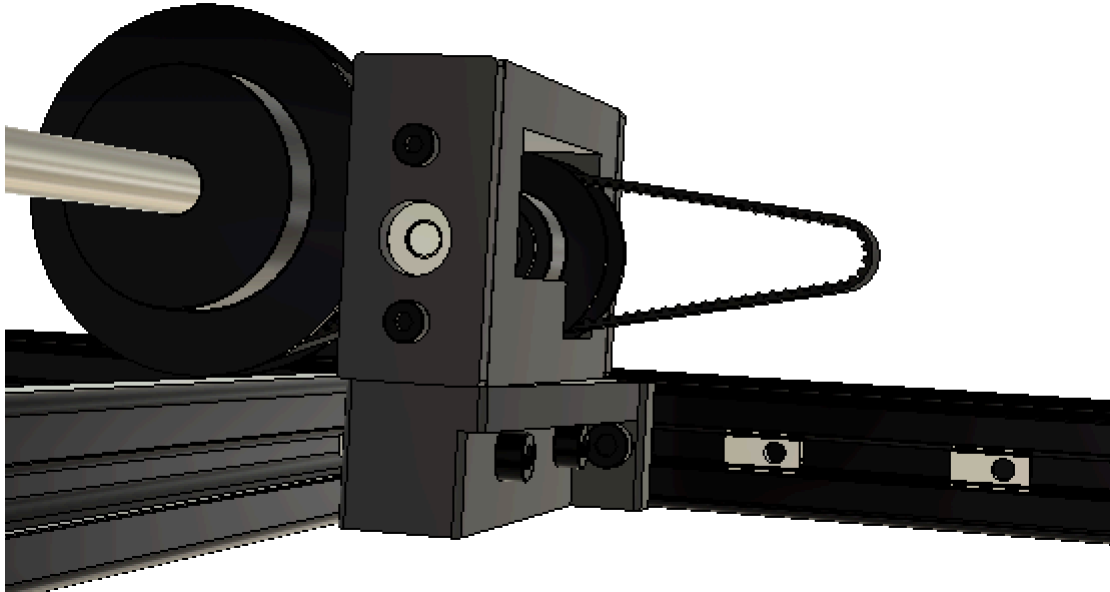


And tighten completely the M4x14mm SHCS of the Pulley Reduction Assembly.

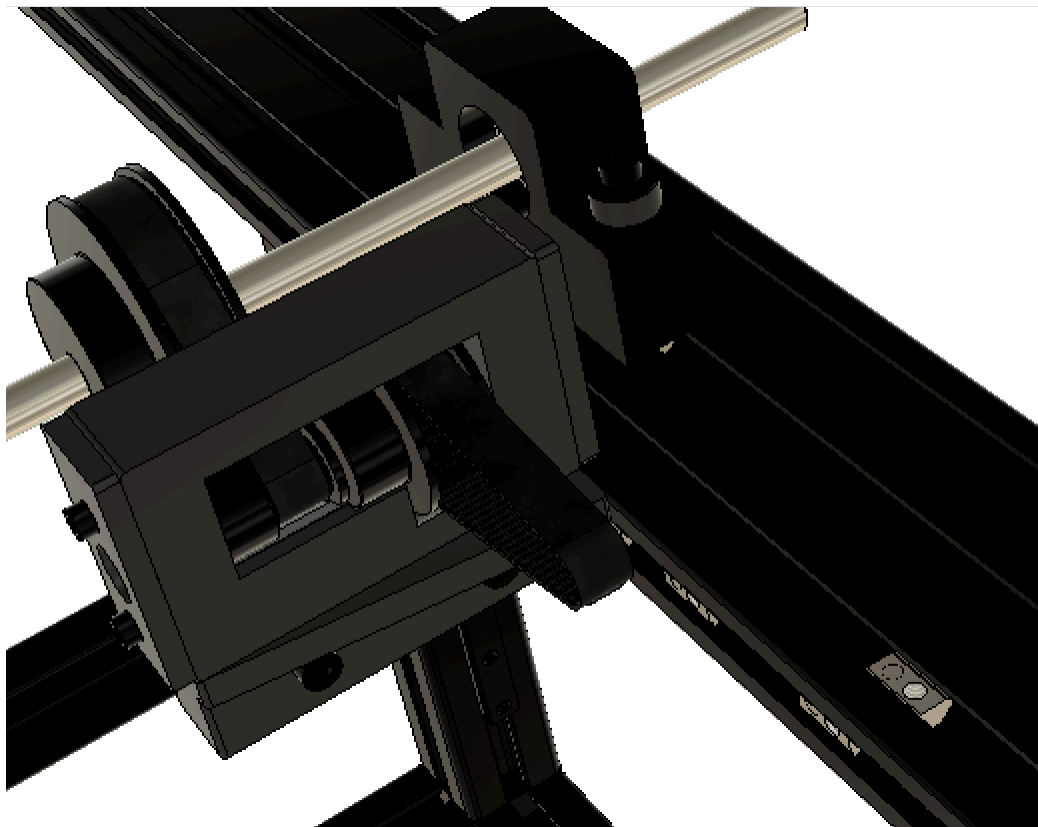


Step 6 – Z-Axis Motor Tensioner

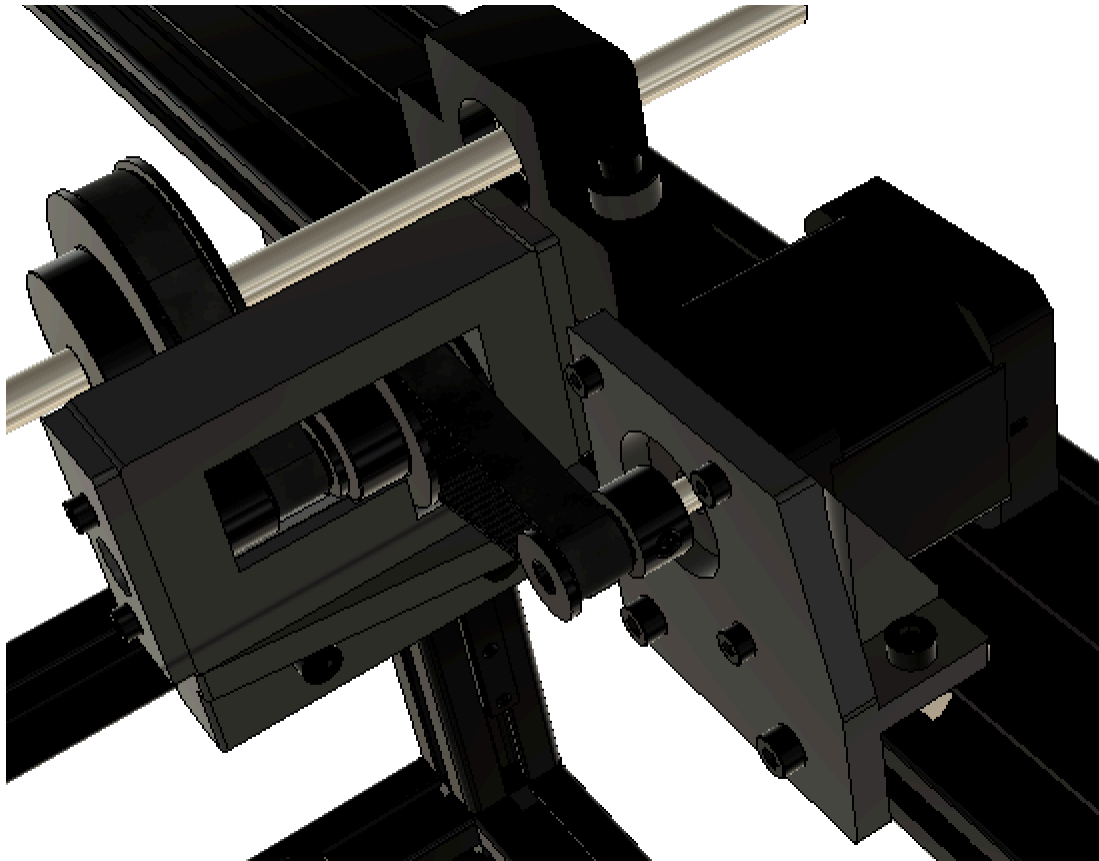
Place two M4 Slot 6 roll-in nuts into the side of the left 2060 extrusion as shown.



Place an M4 Slot 6 roll-in nut into the bottom of the left 2060 extrusion as shown.

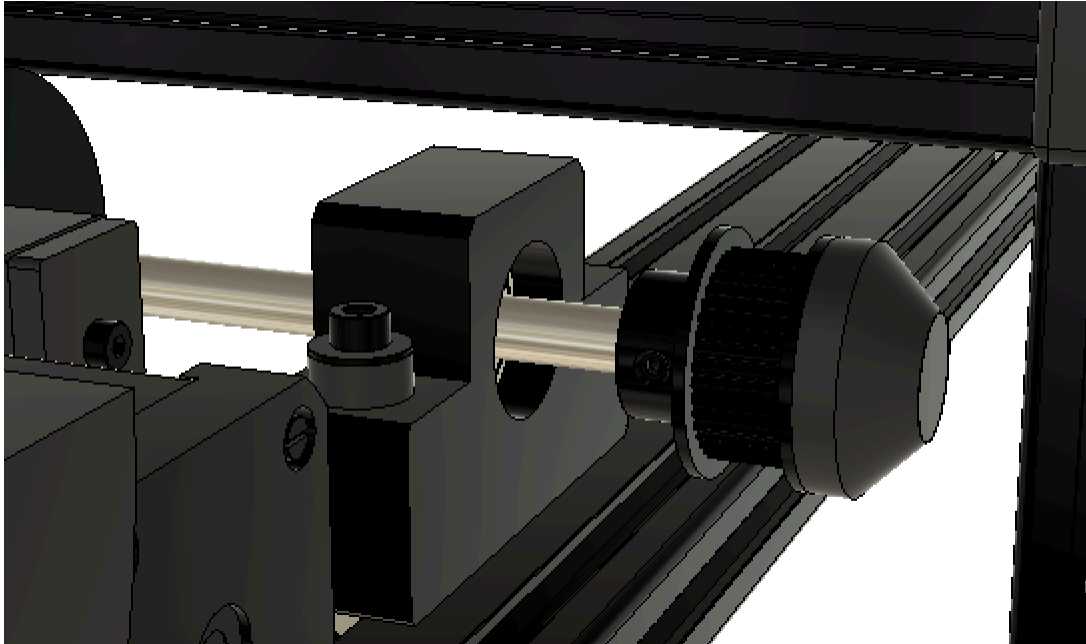


Guide the GT2 16t pulley of the Z-Axis Motor assembly into the GT2 75t 9x154mm Loop Belt of the Pulley Reduction Assembly. Orient the Z-Axis Motor assembly as shown and secure to the 2060 extrusion with one M4x10mm SHCS into the M4 Slot 6 roll-in nut on the bottom of the 2060 extrusion and two M4x12mm SHCS into the M4 Slot 6 roll-in nuts on the side of the 2060 extrusion. Loosely secure these screws. Slide the Z-Axis Motor assembly away from the Pulley Reduction assembly to set the proper tension of the GT2 77t 9x154mm Loop Belt. With the proper tension of the loop belt achieved, completely secure all the SHCS attaching the Z-Axis Motor Assembly to the 2060 extrusion.



Step 7 – Z-Axis Belt Pulleys

Locate a GT2 40t Pulley with 8mm Bore. Slide the 40t pulley onto the left end of the 8x520mm linear shaft with hub facing inward. Now slide the printed Z-Axis 40t Pulley Installation Tool onto the end of the 8x520mm linear shaft. Coat two M4x4 set screws with medium strength thread locking compound. Hold the 40t pulley against the Installation tool and secure it to the 8x520mm linear shaft with the two M4x4mm set screws. Fully tighten both M4x4mm set screws. You may need to rotate the 8x520mm shaft to access the holes for one or both set screws.

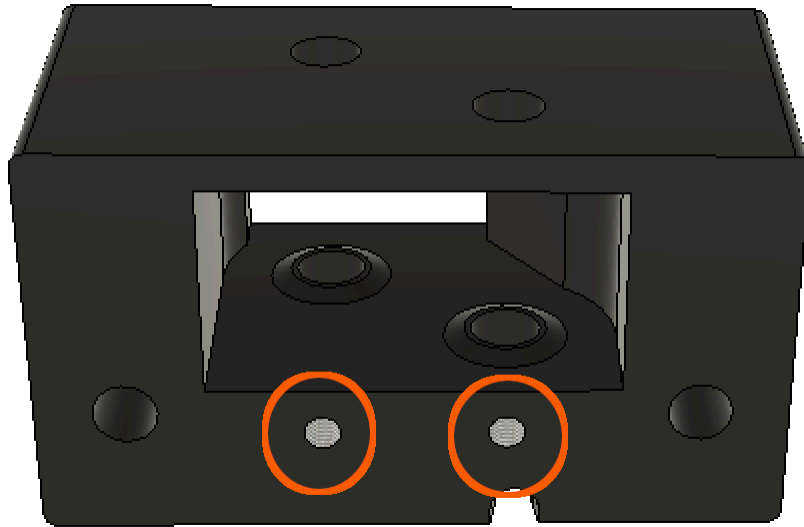


Remove the printed Installation Tool. Repeat the above steps to install the other GT2 40t Pulley with 8mm Bore on the right end of the 8x520mm linear shaft using the printed Installation Tool and two M4x4mm set screws coated in medium strength thread locker.

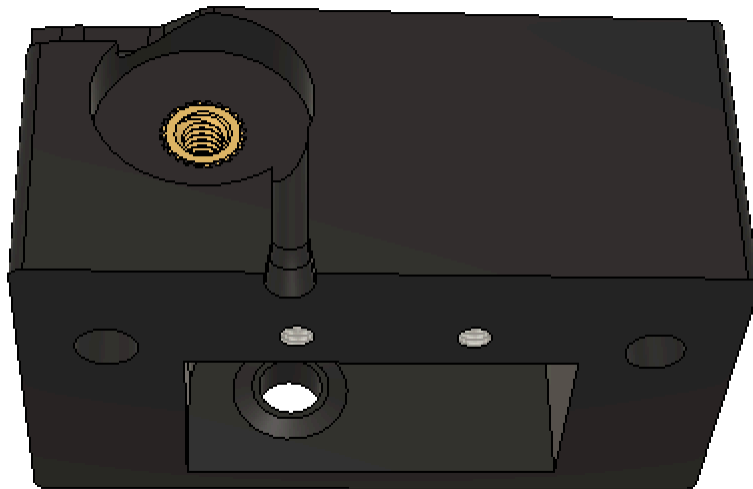


Step 8 – Z-Axis Idler Pulleys

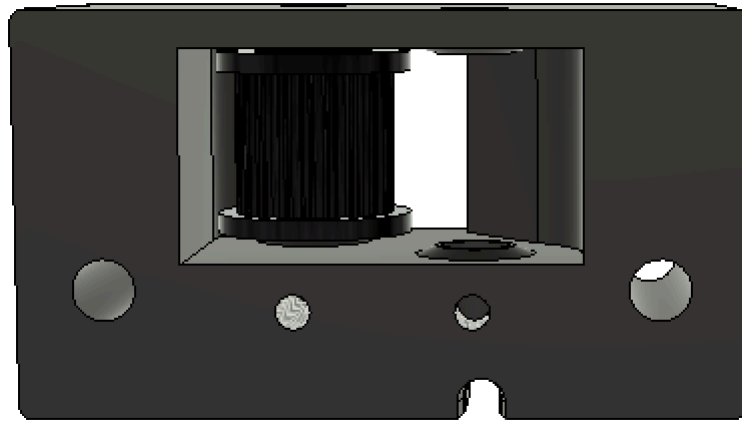
The Z-Axis Idlers are mirrored parts of each other. We will build the right side idler with diagrams and then you will build the left side to mirror this one. Start with printed Z-Axis Belt Idler Right Part 01 and tap M3 threads into the plastic at the locations shown. Tap the holes until they intersect with the 5mm hole coming from the back of the part.



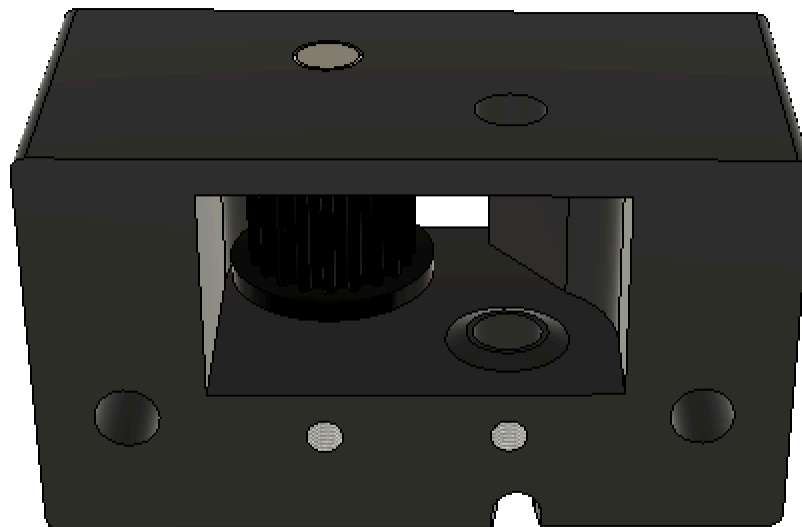
Place an M4 heat set insert into the hole as shown.



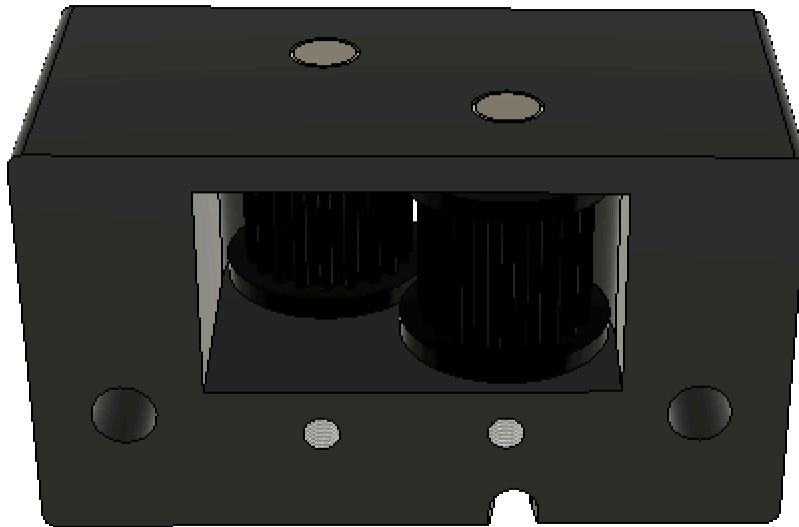
Orient the part as shown and snap a GT2 20t Idler Pulley with 5mm Bore into printed part. The upper Idler Pulley must be installed first.



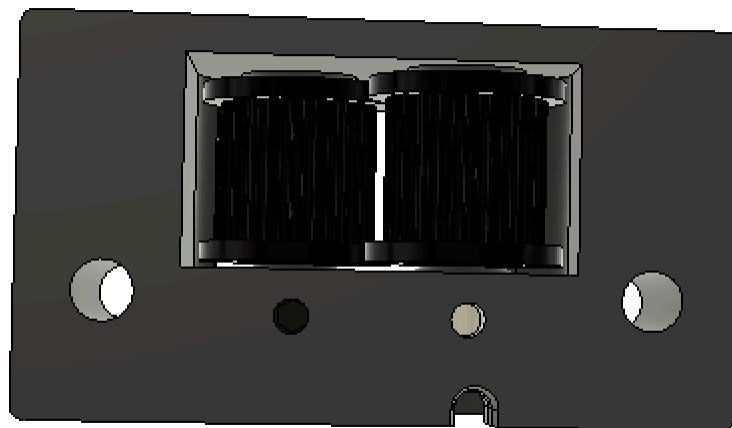
Press a 5x25mm Linear Shaft through the hole in the top of the printed part and fully through the Idler Pulley until the end of the linear shaft is flush with the rear (top in perspective of picture) of the printed part. Use the hand vise or arbor press if the linear shaft seems difficult to press in by hand.



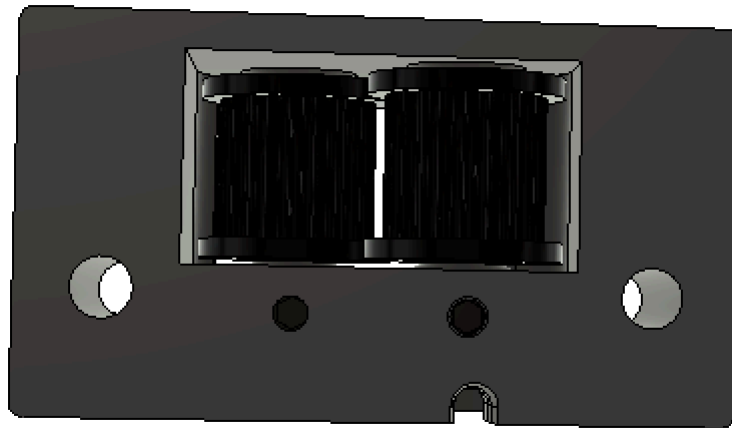
Repeat this for the other location with another GT2 20t Idler Pulley with 5mm Bore and another 5x25 Linear Shaft.



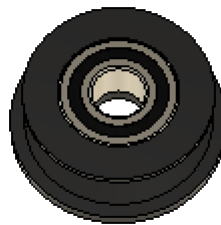
Coat an M3x6mm set screw in medium strength thread locker and install into the deeper M3 threaded hole. Tighten the set screw until secure with the M5x25mm linear shaft.



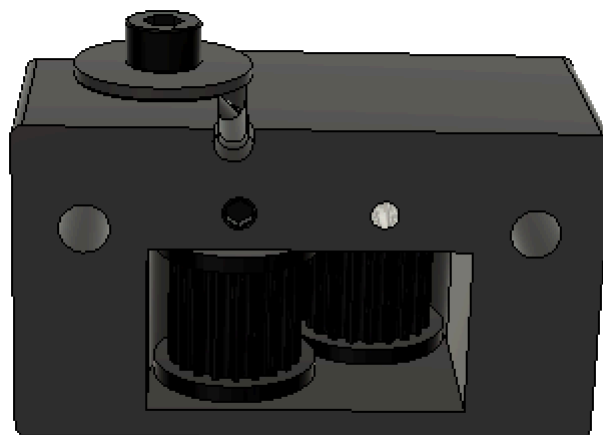
Coat an M3x5mm set screw in medium strength thread locker and install into the other M3 threaded hole. Tighten the set screw until secure with the M5x25mm linear shaft.



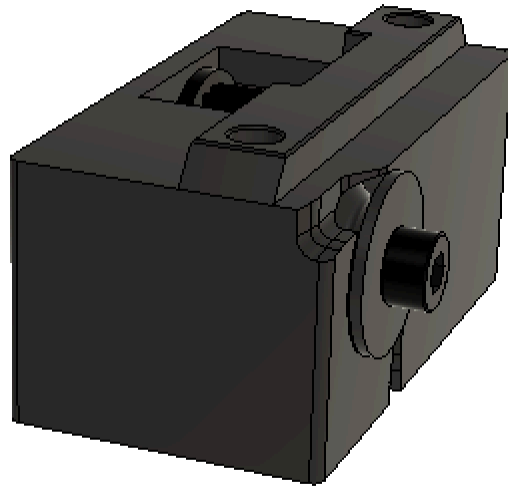
Press a 4x9x4 Bearing into printed Z-Axis Tackle Roller.



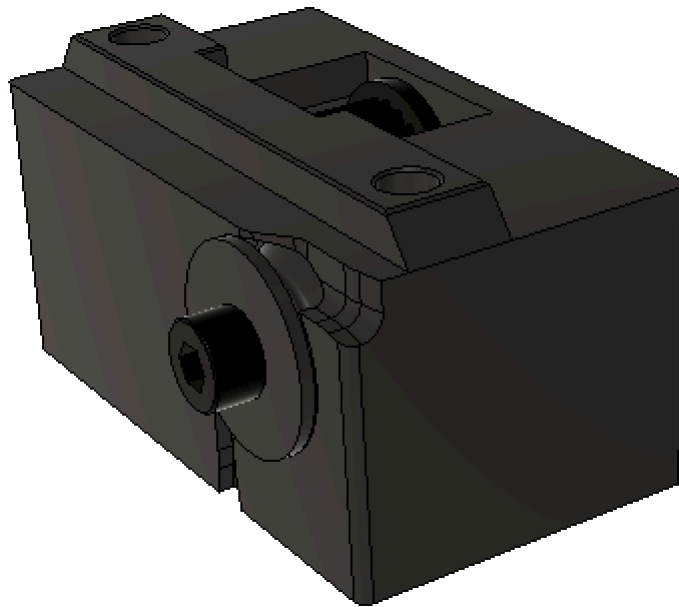
Coat an M4x10mm SHCS with medium strength thread locker. Put the M4x10mm SHCS through the assembled Z-Axis Tackle Roller and into the heat insert of the main printed part. Tighten the M4x10mm SHCS until snug, then back it off until the assembled tackle roller turns easily.



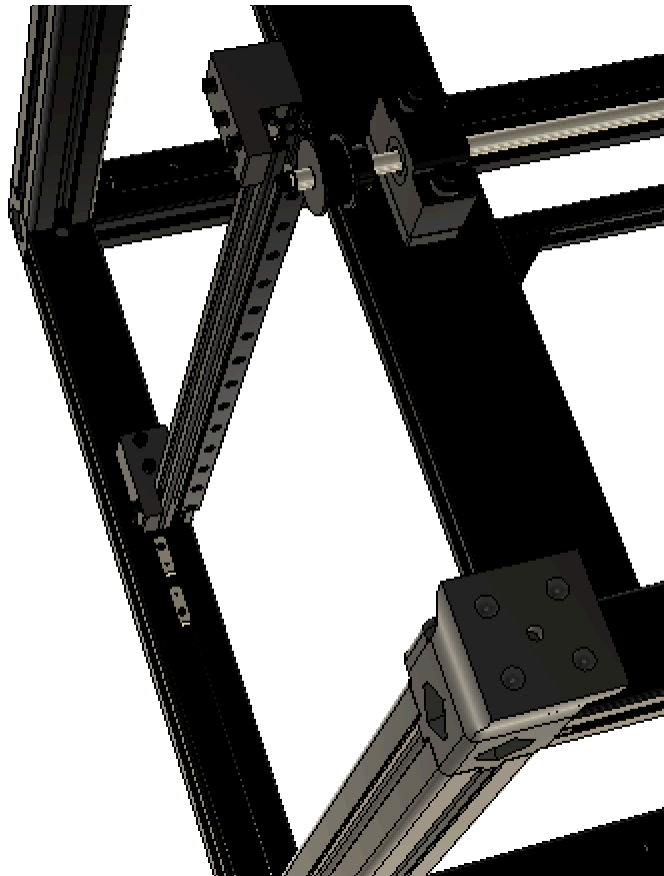
Snap the printed Z-Axis Belt Idler Right Part 02 CE onto the top of the Z-Axis Belt Idler Assembly.



Now repeat these steps to build the left side Z-Axis Idler Assembly.



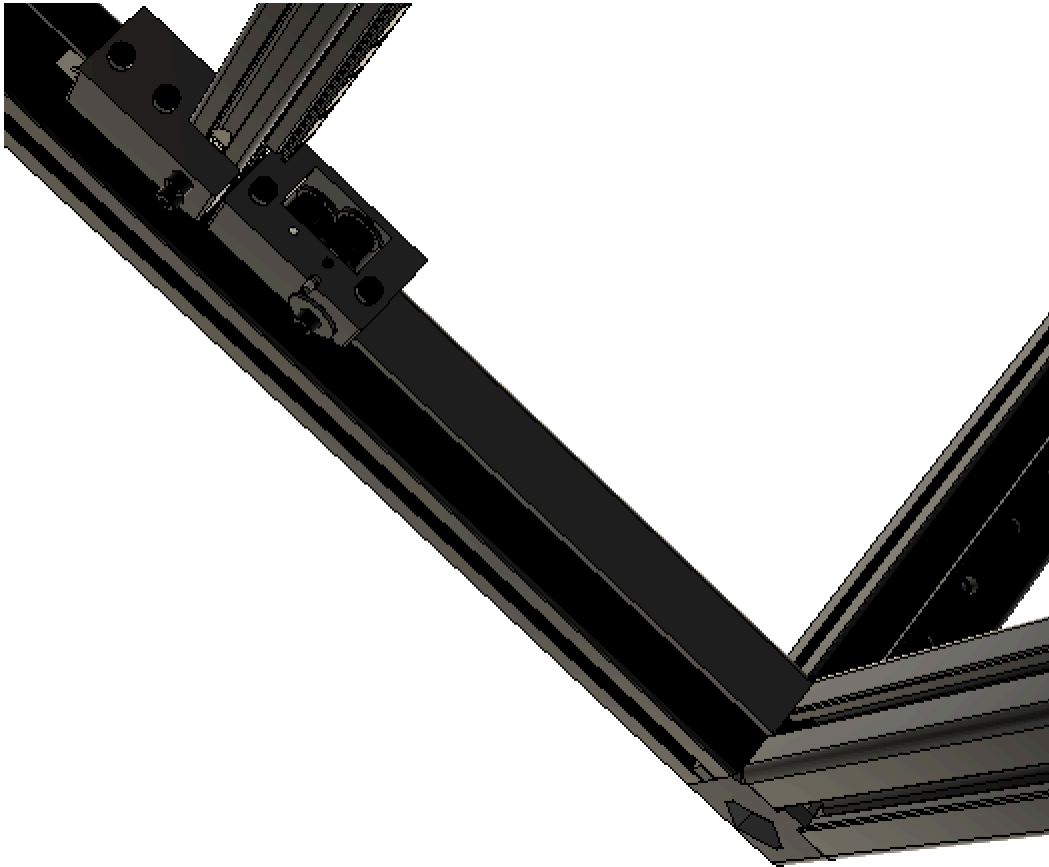
Install two M4 Slot 8 roll-in nuts into the underside of the right 420mm 4040 extrusion as shown.



Place the right Z-Axis Belt Idler assembly on the underside of the right 420mm 4040 extrusion and align the holes of the M4 Slot 8 roll-in nuts with the holes in the assembly. Loosely attach two M4x35mm SHCS through the Z-Axis Belt Idler assembly into the M4 Slot 8 roll-in nuts.



Place the printed Z-Axis Idler Pulley Installation Tool with the ribbed side toward the underside of the 420mm 4040 extrusion. Slide the Z-Axis Idler Pulley assembly until it is flush with the printed Installation Tool and the printed tool is flush to the 395mm 4040 extrusion. Fully tighten the two M4x35 SHCS.



Remove the printed Installation tool. Repeat the previous steps to install the left Z-Axis Belt Pulley Idler assembly. Turn the frame upright. Congratulations, you have completed the Z-Axis Motion Assembly.