

PRINT Swerve Drive for FTC

Designed and built by Team FTC 9773, Robocracy 4H

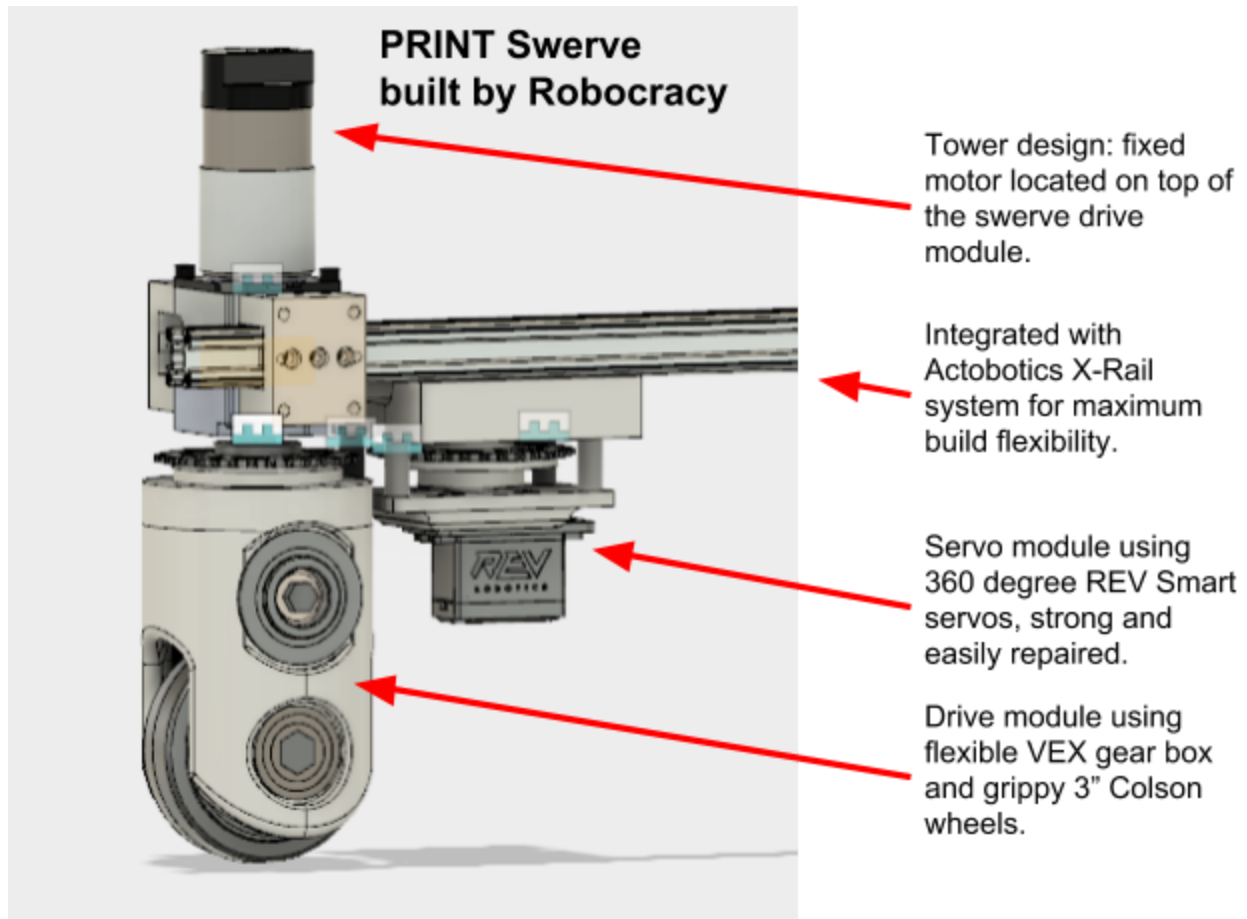
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1. Introduction

We provide here the full instruction on how to build your very own PRINT Swerve. This innovative swerve drive is entirely built out of 3D printed part, no CNC machining required. It uses FRC-level gears and sprockets (VEX-pro) for unprecedented reliability. We use a novel "Tower" design where the drive motor is directly mounted on top of the drive to deliver the compact footprint needed for FTC robots. To our knowledge, this is the first 3D printable, nearly-indestructible integrated swerve drive, optimized for the tight spaces using FRC-level gears. We named it PRINT Swerve module, for PRIntable INtegrated Tower Swerve.





You will need between 2 to 4 Swerve Drive Modules, typically 4. A Swerve Drive Module consists of two assemblies: a Motor Module and a Steering Module. The two are connected by a chain and are mounted on a chassis made of Actobotics X-Rails. The Colson wheel has a 3" diameter, sufficient for climbing most obstacles. Once you have assembled the 122 parts, you will own your very own PRINT Swerve drive.


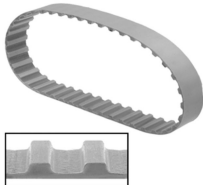

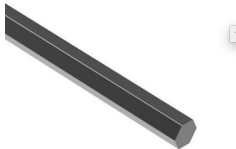

Section 2 list the parts that you need to build one Swerve Drive. For each part, we list a vendor and its part number. Section 3 lists the parts that you will need to 3D print, and Section 4 details the tools required to build it. Section 5 provides a step by step description and illustration of how to build the Swerve Motor Module. Section 6 details how to build the Swerve Steering Module. Section 7 let you assemble the two modules on the X-rails.





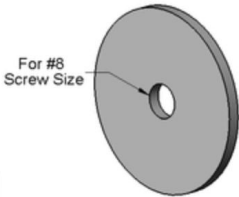
2. List of parts

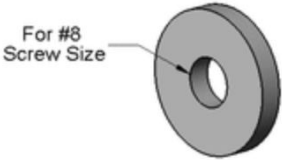
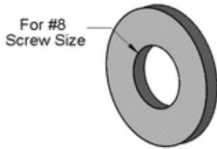
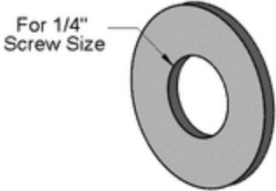


2.1 Parts for the Swerve Motor Module

Part name	#	Part description	Part number
Motor (1)	1	AndyMark NeveRest Classic Motor 	AndyMark part am-3104
Gear box (2)	1	VersaPlanetary Gearbox with $\frac{3}{8}$ " hex shaft with recommended 9:1 gear ratio. You may want to buy a spare VersaPlanetary 3/8" Hex Output Shaft as you will need to tap the end. 	VEX PRO <ul style="list-style-type: none"> • Base kit $\frac{3}{8}$" Hex output, part 217-4974 • 9:1 Gear kit part 217-3106 • Ring gear part 217-2816 • Additional shaft part 217-2894 (optional)
$\frac{3}{8}$ " Flanged ball bearing (3)	2	Flanged ball bearing for $\frac{3}{8}$ " shaft, 0.375" Hex ID x 1.125" OD x 0.313" WD	VEX-pro part 217-2735




			
Thunderhex flanged ball bearing (4)	2	<p>Flanged ball bearing for 1/2" ThunderHex 1/2" ID x 1.125" OD x 0.313" WD</p> 	VEX-pro part 217-4006
Alternator ball bearing (5)	1	<p>AB Open Alternator Ball Bearing 18.7mm x 37mm x 9mm</p> 	VXB part 6904DW
Large flanged ball bearing (6)	1	<p>Flanged ball bearing for 3/4" Shaft Diameter, 1-5/8" OD</p> 	McMaster part 6384K367
Bevel gear (7)	2	<p>15t Steel Bevel Gear, 12DP, 3/8" Hex Bore</p> 	VEX-pro part 217-3344
Wheel (8)	1	<p>Colson Performa wheel, 3" x 0.875", 1/2" Hex Bore</p>	VEX-pro part 217-4047

			
Timing belt (9)	1	185mm timing belt Dust-Free Timing Belt, T5 Series, Trade No. T5-185-1 	McMaster part 1679K441
$\frac{1}{2}$ " Thunderhex shaft (10)	2.6"	thunderhex shaft $\frac{1}{2}$ " 	VEX-pro part 217-4002
$\frac{3}{8}$ " Hex shaft (11)	2.75"	Hex shaft $\frac{3}{8}$ " 	VEX-pro part 217-3310
Sprocket (12)	1	32t Aluminum Plate Sprocket for #25 Chain, 1-1/8" Bearing Bore 	VEX-pro part 217-2690
Chain (13)	12"	#25 Standard Roller Chain (10 feet)	VEX-pro part 217-2775

			
1/4" Screw (14)	2	18-8 Stainless Steel Button Head Hex Drive Screw, 1/4"-20 Thread Size, 3/4" Long 	McMaster part 92949A540
#8 Screw (15)	3	18-8 Stainless Steel Button Head Hex Drive Screw, 8-32 Thread Size, 1/2" Long 	McMaster part 92949A194
Long #6 Screw and nylon nut (part 16)	4	18-8 Stainless Steel Button Head Hex Drive Screw, 6-32 Thread Size, 1" Long 316 Stainless Steel Nylon-Insert Locknut, Super-Corrosion-Resistant, 6-32 Thread Size 	McMaster parts 92949A153 and 90715A007
Large #8 washer (17)	1	316 Stainless Steel Washer, Oversized, Number 8 Screw Size, 0.188" ID, 1" OD 	McMaster part 91525A268
Small #8	1	316 Stainless Steel Washer, Oversized,	McMaster part



washer (18)		Number 8 Screw Size, 0.172" ID, 0.5" OD 	91525A318
Very small #8 washer (19)	1	18-8 Stainless Steel Washer for Number 8 Screw Size, 0.172" ID, 0.375" OD 	McMaster part 92141A009
1/4" washer (20)	2	316 Stainless Steel Washer for 1/4" Screw Size, 0.281" ID, 0.625" OD 	McMaster part 90107A029
Hex spacer (21)	1	1/2" Acetal Spacer - 1/2" Hex (10-pack) 	VEX-pro part 217-3261
Hex spacer (22)	1	1/8" Acetal Spacer - 3/8" Hex (10-pack) (can use a 1/2" Hex if you have them already) 	VEX-pro part 217-3256
Loctite (23)	1	Tube/bottle of blue loctite	Hardware store

2.2. Parts for the Swerve Steering Module

Part name	#	Part description	Part number
Servo (100)	1	Smart REV servo 	REV part REV-41-1097
Servo plate (101)	1	Standard Servo Plate A 	Servocity part 575112
Absolute encoder (102)	1	Absolute encoder with cable 	AndyMark part am-2899
3/4" 6-32 Screw (103)	4	Black-Oxide Alloy Steel Socket Head Screw, 6-32 Thread Size, 3/4" Long	McMaster part 91251A151
Locknut (104)	11	316 Stainless Steel Nylon-Insert Locknut, Super-Corrosion-Resistant, 6-32 Thread Size	McMaster part 90715A007
Ball bearings (105)	2	12x18x4 Metal Shielded Bearing 6701-ZZ	Various vendors, e.g. Newegg.com

			
Servo gear (106)	1	48P, 25T 3F Spline Servo Mount Gears (Metal) 	Servocity part RSA48-FMG-15
3/8" 6-32 screws (107)	4	Black-Oxide Alloy Steel Socket Head Screw, 6-32 Thread Size, 3/8" Long	McMaster part 90128A855
Sprocket (108)	1	32t Aluminum Plate Sprocket for #25 Chain, 1-1/8" Bearing Bore 	VEX-pro part 217-2690
3/8" 6-32 screw with button head (part 109)	3	Button Head Hex Drive Screw, Black-Oxide Alloy Steel, 6-32 Thread, 3/8" Long	McMaster part 91255A146
1 1/2" 6-32 screws (110)	4	Black-Oxide Alloy Steel Socket Head Screw, 6-32 Thread Size, 1-1/2" Long	McMaster part 91251A157

2.3. Parts for the Swerve Chassis

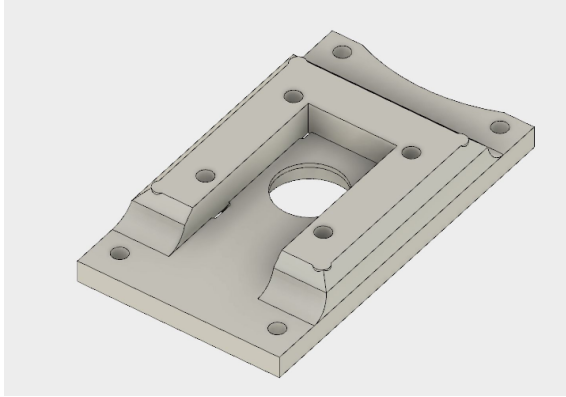
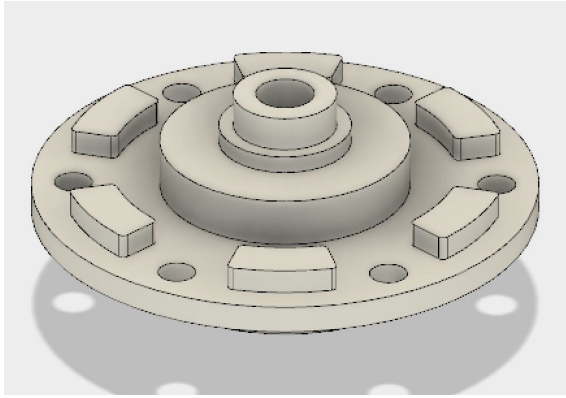
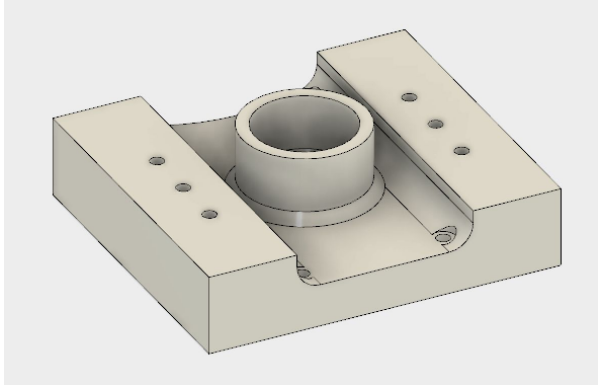
Part name	#	Part description	Part number
Xrail (part 150)	2	Actobotics® X-Rail of desired length (here 18"). Need 2 rails per pair of swerve drives 	Servocity part 565062
Xrail screw plates (part 151)	6	X-Rail Screw Plate (2 pack) 	Servocity part 585757
3/8" 6-32 screws (152)	12	Black-Oxide Alloy Steel Socket Head Screw, 6-32 Thread Size, 3/8" Long	McMaster part 90128A855
3/4" 6-32 screws (153)	6	Black-Oxide Alloy Steel Socket Head Screw, 6-32 Thread Size, 3/4" Long	McMaster part 92949A151
1 1/4" 10-32 screw (154)	8	18-8 Stainless Steel Button Head Hex Drive Screw, 10-32 Thread Size, 1-1/4" Long	McMaster part 92949A272

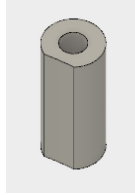
3. Printed Parts

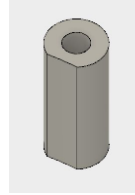
3.1 Printed Parts for Swerve Motor Module

Part Name	Description
Swerve motor module body (201)	
Top pulley (202)	
Bottom pulley (203)	
X rail adapter (2x) (204)	

3.2 Printed Parts for Steering Module

Part Name	Description
Steering module bottom plate (301)	
Sprocket adapter plate (302)	
Steering module Top plate (303)	

3d printed standoffs (4x) (304)	
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4. Tools

1. 3D printer
2. Tap tool for 8-32 and $\frac{1}{4}$ "-20 threads
3. Dremel with sandpaper bit and/or files of various sizes
4. Hex screwdriver and wrenches

5. Assembling a Swerve Motor Module

Step 1: Prepare Shafts

1. Cut $\frac{1}{2}$ " shaft (part 10) to 2.6" length.
2. Cut $\frac{3}{8}$ " shaft (part 11) to 2.75" length.
3. Tap $\frac{1}{2}$ " shaft ends with $\frac{1}{4}$ -20 thread and verify that screw (part 14) fits.
4. Drill and tap $\frac{3}{8}$ " shaft ends with 8-32 thread and verify that screw (part 15) fits.

Step 2: Prepare Motor

1. Remove VersaPlanetary 3/8" Hex Output Shaft from gearbox (part 2).
2. Drill and tap $\frac{3}{8}$ " shaft end with 8-32 thread and verify that screw (part 15) fits.
3. Build gearbox and attach to motor (part 1) using VEX-pro instructions.



Bevel gear

3/8th shaft with
washer to block
bevel gear



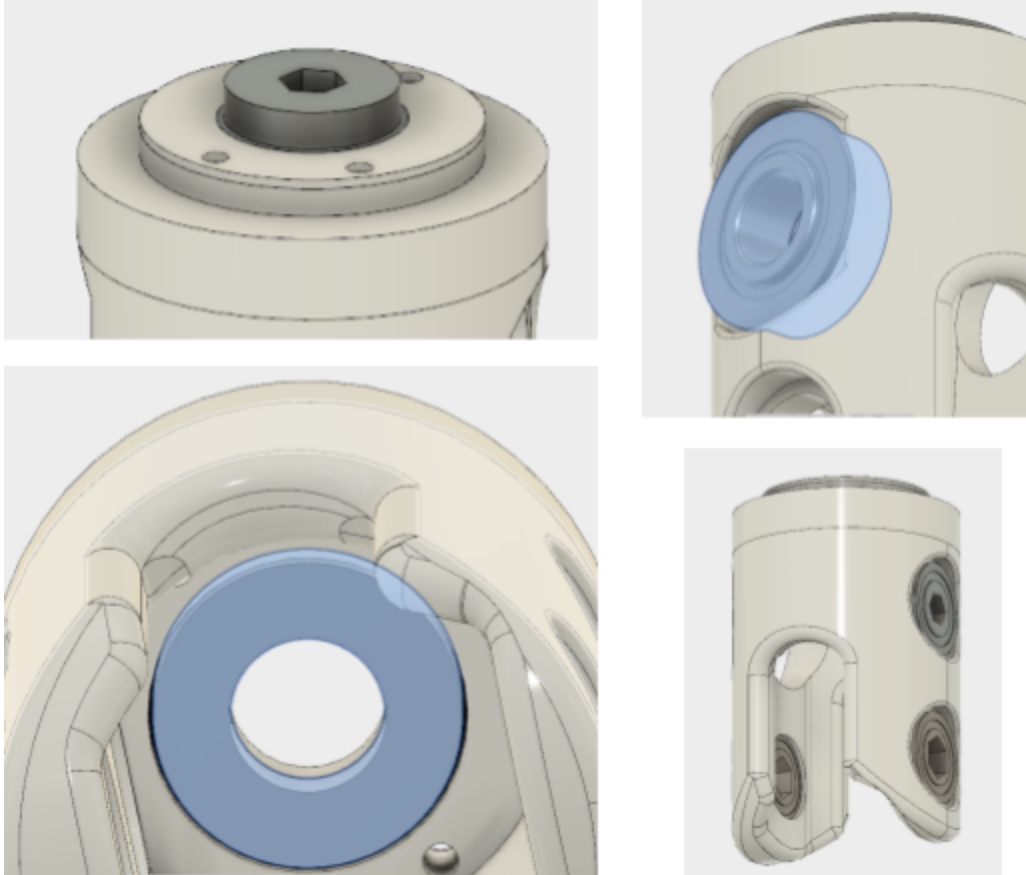
Sanding of the
outer shaft of the
bevel gear

Step 3: Prepare one bevel gear

1. The outer shaft of one of the two bevel gears (part 7) must be sanded down to fit inside alternator ball bearing (part 5). Best is to use a short piece of $\frac{3}{8}$ " shaft with a washer at one end. Place the bevel gear on the shaft on the end of the washer, insert the shaft on the other end in a drill press, and carefully sand the outer shaft of the bevel gear until the ball bearing fits snugly. If too snug, the ball bearing will not rotate easily. If too loose, the swerve module will wobble. This is a critical step.

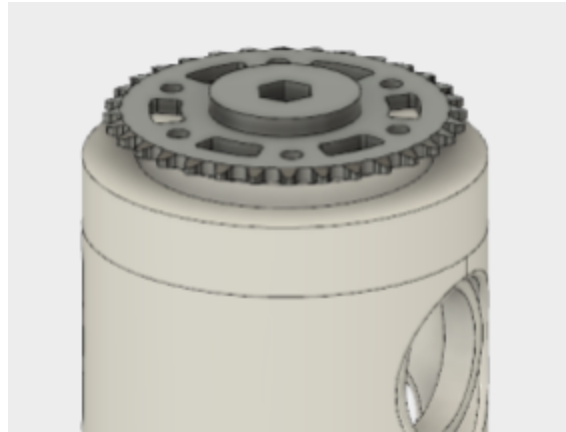
Step 4: Print swerve motor module parts

1. Print swerve motor module (part 201), with a high infill (>30%) and a shell line number (>5) and with support for the ball bearing holes. We strongly recommend Polymaker's PC-Max filament, as it is essentially Lexan. Note that not all printer support PC filaments. You should also print several smaller parts as you don't want to experiment with the large swerve module.

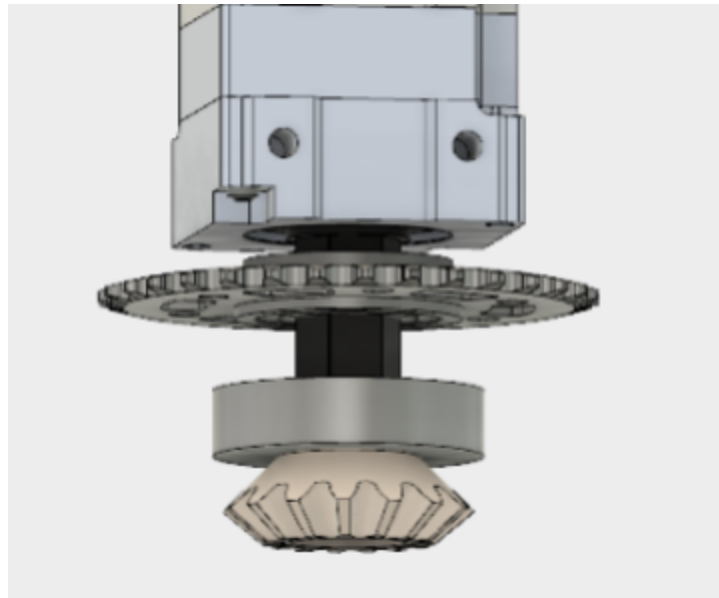


2. Fit all the ball bearings in the bearing holes in the module. Key is to get the vertical bearings (parts 3 & 5) to fit snugly. If too snug, the shaft will not turn smoothly; if too loose, the module will wobble. Best is to use a dremel with a sandpaper bit, or a drill bit of the right size. The CAD model tuned the holes to be a bit snug, as the filaments do not always cool off to a round hole (we often witnessed an oval shape). So sanding is key to get the bearing to fit snugly.
3. Print the other 2 pulleys (parts 202 & 203).

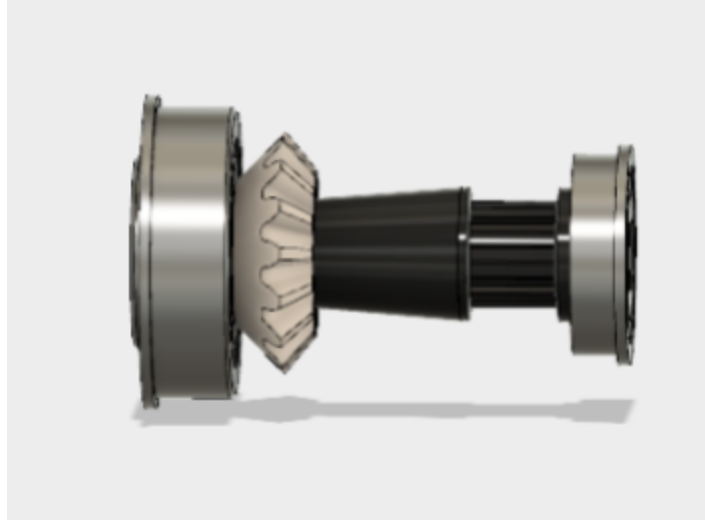
Step 5. Assemble swerve motor module



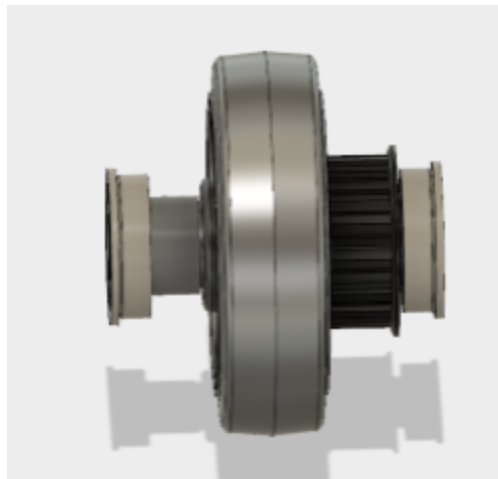
1. **Assemble the sprocket.** Insert top shaft ball bearing (part 3) with flange down, lock with one sprocket (part 12) and screw (part 16) with screw head on side of sprocket and nut inside the swerve module.



2. **Attach the motor.** Insert the 1/8" spacer (part 22), inner shaft ball bearing (part 5), then slide the sanded down bevel gear (part 7, machined in Step 3) inside the inner shaft ball bearing. Then slide the motor and gear assembly (parts 1 & 2, machined in step 2). Then insert screw (part 15) with washer (part 19) to lock the assembly. Use locktite on the screw as you definitely don't want that screw to loosen. Picture above shows the assembly without the 3D printed part.



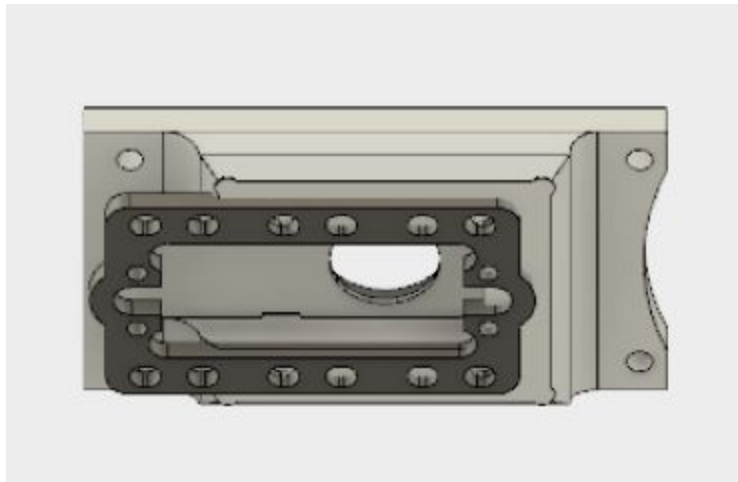
3. **Attach the top horizontal shaft.** Insert the second bevel gear (part 7) inside the large flanged ball bearing (part 6), with the bevel gear on the side without the flange. Insert the bearing inside the swerve module, and then partly slide the $\frac{3}{8}$ " shaft (part 11, machine in Step 1). Then insert the top pulley (part 202) on the shaft and slide the timing belt (part 9). Complete by inserting the shaft ball bearing (part 3) and continue pushing the shaft. Then use the #8 screw and washer (parts 15 & 17) on the side of the large ball bearing, and use the #8 screw and washer (parts 15 & 18) on the side of the small ball bearing. Use loctite on the screws. Picture above shows the assembly without the 3D printed part.



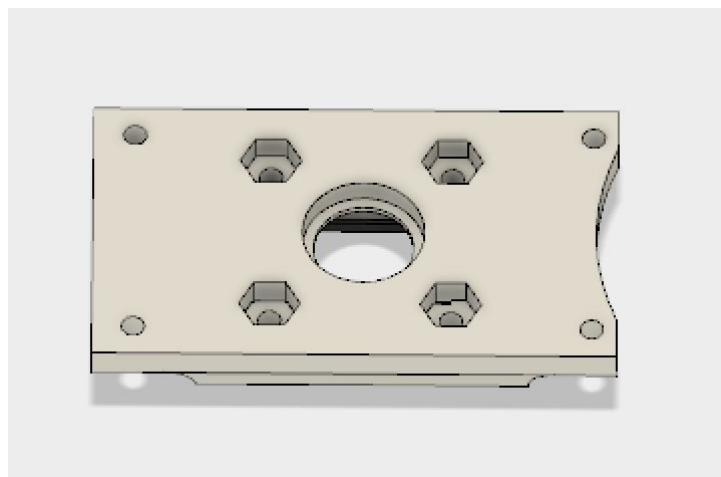
4. **Attach the bottom horizontal shaft.** Insert the shaft flanged ball bearing (part 4) on the side of the belt. Slide the shaft (Part 10, machined in Step 1) inside the ball bearing, and slide the bottom pulley (part 203). The pulley is asymmetrical; the side with the small integrated washer goes flush against the bearing; the side with the concave hole will go against the wheel. Insert the belt on the pulley. Slide the wheel (Part 8) on the shaft, and

add the hex washer (Part 21). Insert the second ball bearing (Part 4) on the swerve motor module. Then use the 1/4" screws and washers (parts 14 & 20) with loctite. Picture above shows the assembly without the 3D printed part.

6. Assembling a Swerve Steering Module

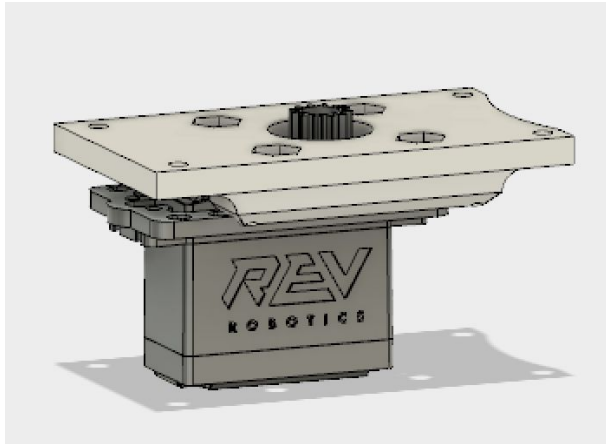


1. Attach the servo plate (part 101) on printed steering module bottom plate (part 301) on the bottom side, with #6 3/4" (part 103) and nut (part 104). Nut will be flush inside the 3D printed part. Above picture shows the result. You may have to insert washers, or shorten the screws.

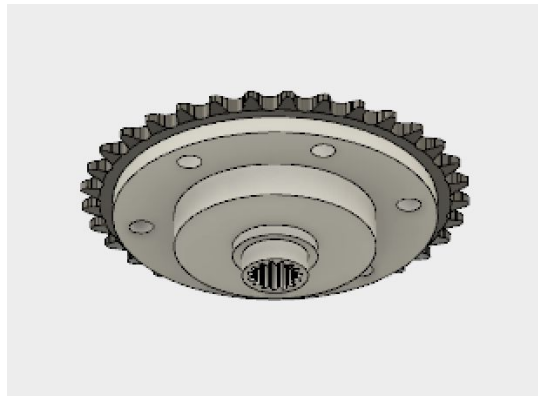


2. Insert the ball bearing (part 105) on the top side of steering module (part 101), depicted above.

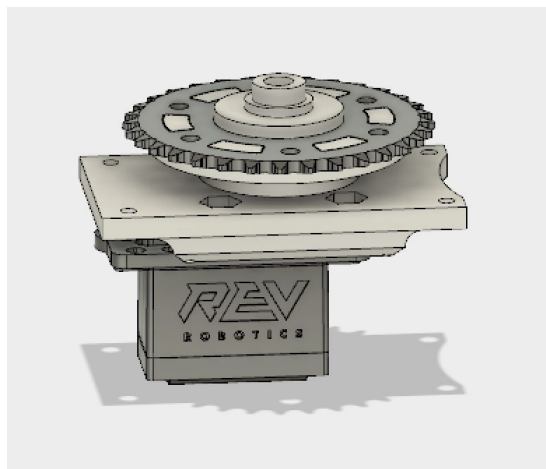
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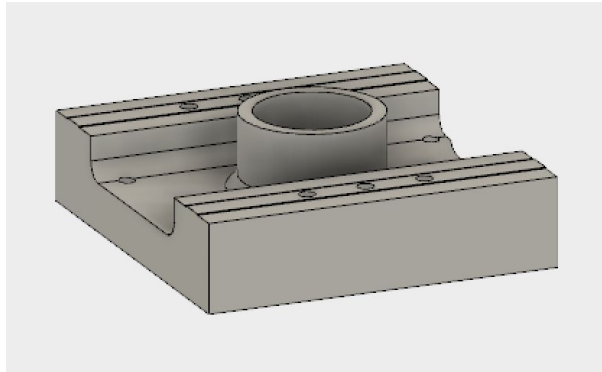
4. Attach the REV servo on the assembly by using 4 3/8" 6-32 (part 107). You should get the part as shown by the above drawing.



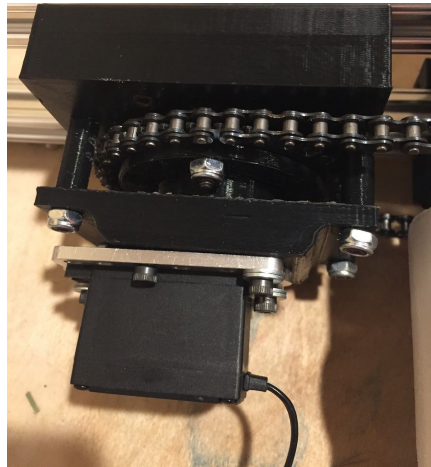
5. Insert the servo gear (part 106) inside the sprocket adapter plate (part 302), and attach sprocket (part 108) on the other side with 3 button head screws (part 109) and associated locknuts. Result should look like the above drawing (servo gear and screws not shown here).



6. Slide sprocket adaptor on on the steering module (part 101). Result shown above.

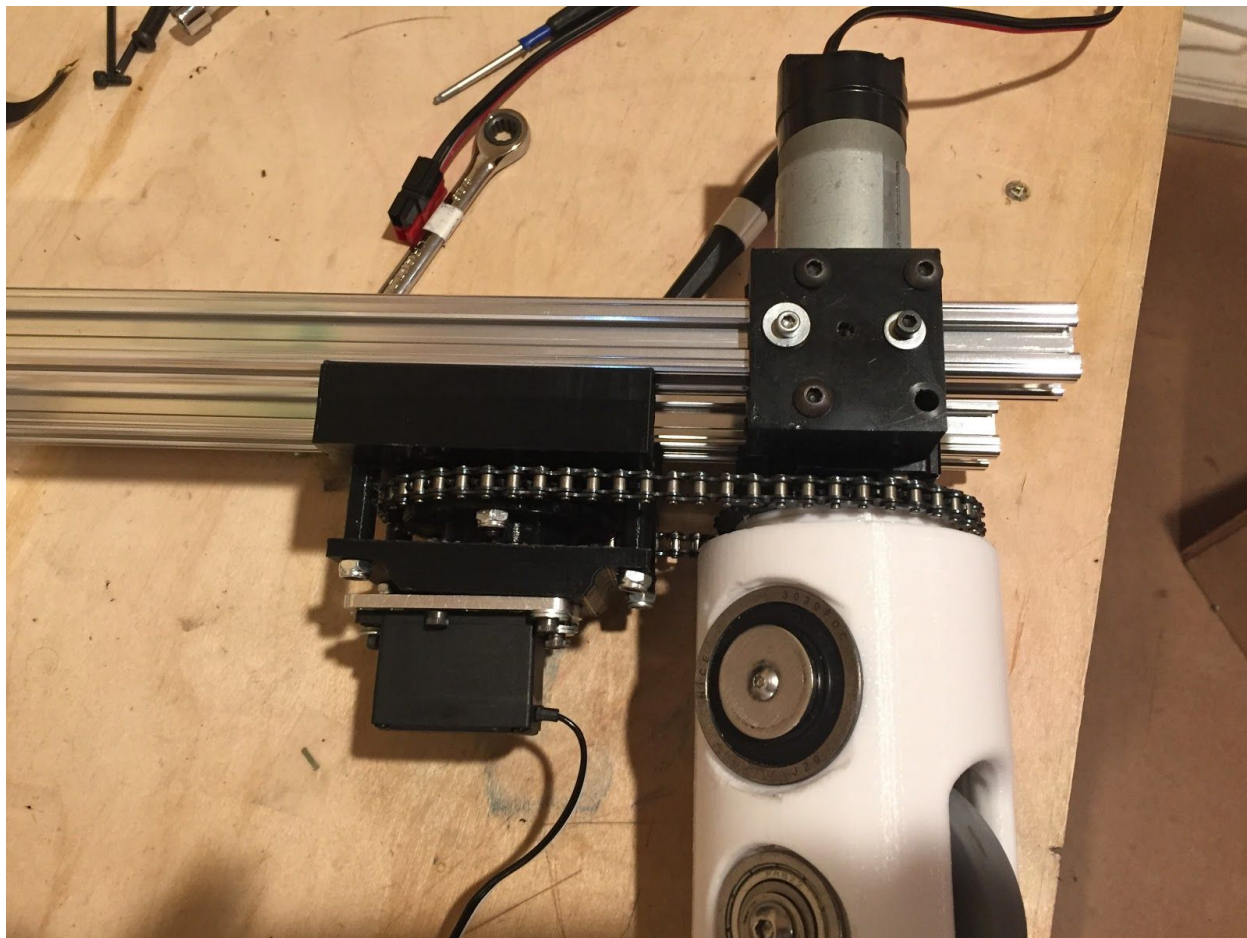


7. Now working with the Steering module Top plate (part 303). Insert the second ball bearing (part 105) into the lower middle hole. Then add the Absolute encoder (part 102). Attach firmly.
8. Complete the assembly by using 4 1½" inch screws (part 110) through the above part, into the 4 tubes (part 304) and into the lower assembly, and attached with 4 locknuts. It is sometime better to also insert the chain now before tightening the assembly. The result should look as below.



7. Assembling the Chassis with Swerve Modules

1. Attach the servo module on the xrails (part 150) using two screw plates (151) and 6 ¾" 6-32 screws (part 153) on both xrails.
2. Attach the 4 brackets (part 204) on both side of the VEX-pro gear box of the swerve module using the 8 10-32 screws (part 154). You may have to adjust the length of the screws so that they don't damage the gearbox while being sufficiently tight.
3. Attach the serve module using 4 screw plates (151) and 12 6-32 screws (part 152).



Voilà, you are now the proud owner of a PRINT swerve module. Hope you enjoyed the process. Feel free to contact us at any time for suggestions or help.