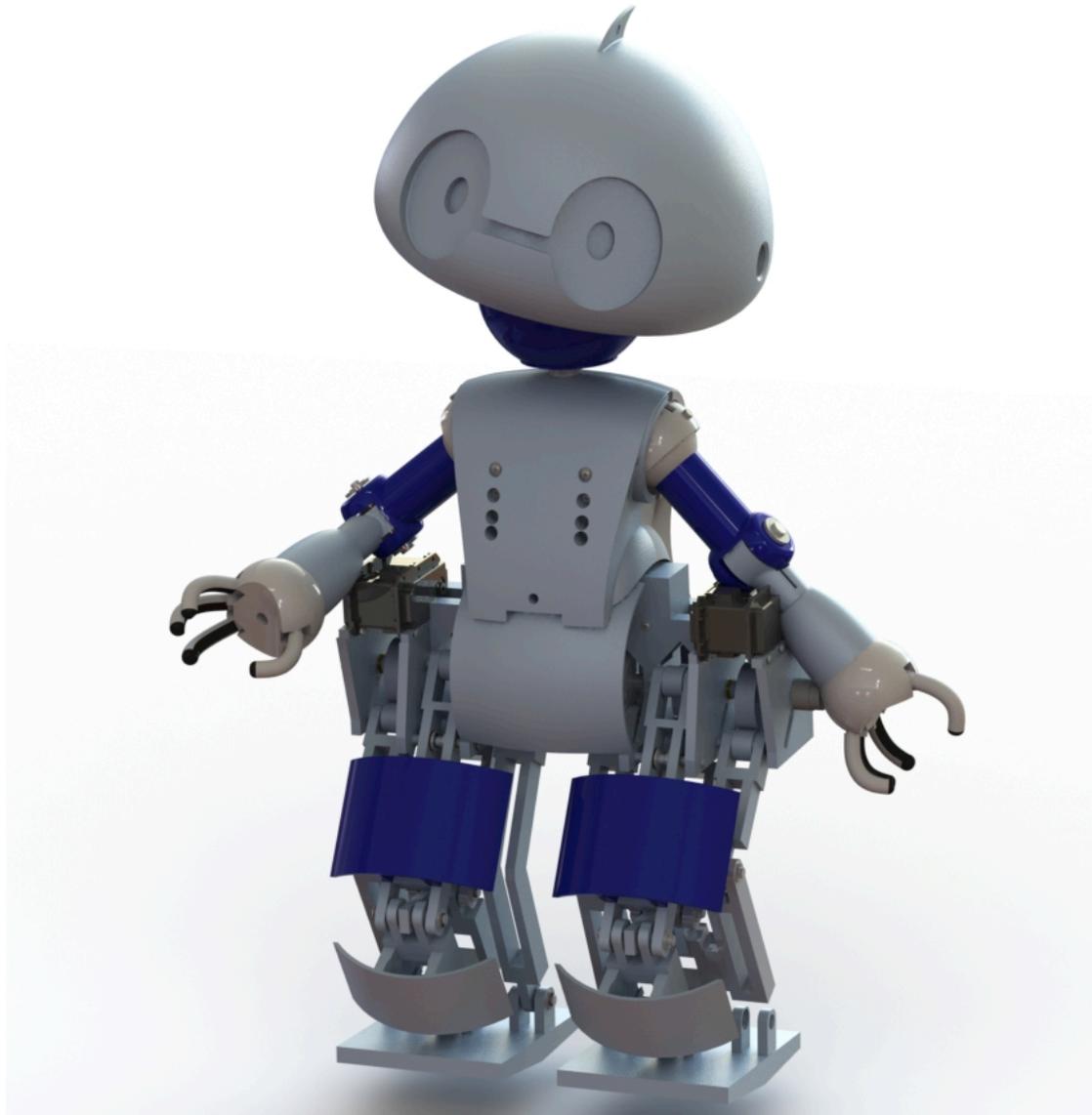


**OLIN COLLEGE MECHANICAL DESIGN**

Jimmy: An Accessible Humanoid Robot

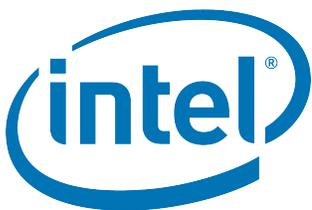


*Designed by*

Aaron Crenshaw, Zachary Del Rosario,

Elliott Donlon, Laurel Kroo,

Kathryn Lau and Orion Taylor



**Olin College**  
of Engineering

# Executive Summary

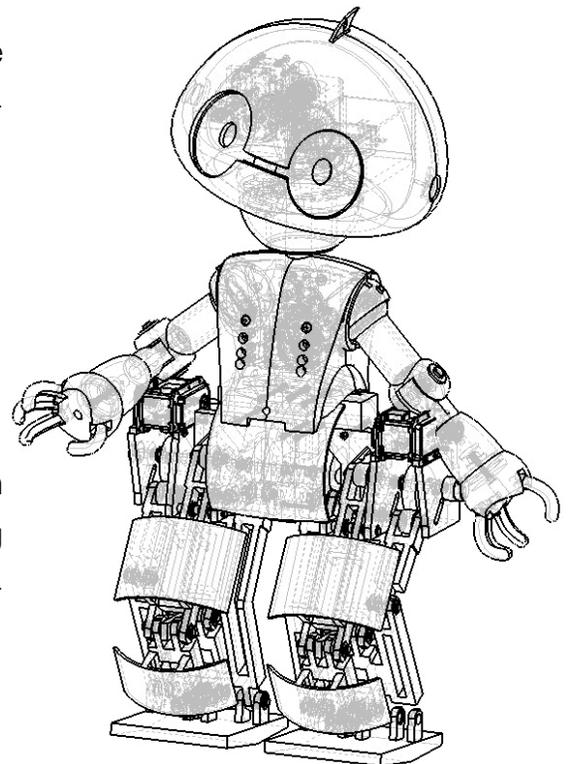
Here we present a humanoid robot design motivated by the artistic vision of Intel's futurist, Brian David Johnson. Our challenge was to build a humanoid named "Jimmy", capable of biped walking in addition to meaningful character expression for under 500 USD. The purpose of this project is to bring humanoid robotics platforms to environments outside of professional and graduate-level robotics research labs.

We accomplish this assuming our users have access to one of the recently released MakerBot2X 3D printers - the majority of our pieces are printable with minimal, if any, modification necessary. Jimmy is just over 24 inches in total height: a goal that aggressively challenges effective walking and character expression, especially when considering home-3D printing tolerances. Additionally, the cost goal limits our design to using just 4 high-end servo motors to control all degrees of freedom. We do this by using cams and clutch transmissions extensively.

Because of our limited resources, we prioritized the following actions for each of Jimmy's three sub-regions:

Legs	Torso	Head
Biped Walking	Arm Raising	Nodding
Turning	Hugging	Head tilt

In this report we will discuss our approach and design to achieve all of these motions by carefully stepping through how each mechanism is assembled in a highly-pictographic format.



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**Bill of Materials and Printed Part Information**

**Assembly Instructions**

**Assembly Drawings**

**Part Drawings**

**Revision Notes and Conclusions**

# Bill of Materials for Legs and Torso

## List of Bought Parts

Part Name	Part Number	Supplier	Description	Quantity	Cost (per unit)	Extended Cost
	FG-C0430	US Composites	4oz E Glass (sold by yard)	1	\$3.50	\$3.50
	105-A	West System	Resin (sold by qt)	1	\$41.29	\$41.29
	205-A	West System	Fast Hardener (sold 0.44 pt)	1	\$21.32	\$21.32
	57272	Goodwinds	Spectra Cable	1	\$14.99	\$14.99
JIMMYMA-MOTOR-AX12A	AX12A	Robotis	Servomotor	1	\$44.90	\$44.90
JIMMYMA-2009-CAMFOLLOWER	A 7Y 5-CF2512	SDP-SI	Shallow Head Cam Follower	3	\$8.83	\$26.49
JIMMYMA-2021-1.75INDSHAFT	8632T134	McMaster Caar	D-Profile Shaft	1	\$7.14	\$7.14
JIMMYMA-2022-BENTNAIL	97820A736	McMaster Caar	Steel Finishing Nail	4	\$0.00	\$0.01
JIMMYMA-2025-#0SSFLATWASHER	92141A001	McMaster Caar	18-8 Stainless Steel General Purpose Flat Washer	9	\$0.01	\$0.11
JIMMYMA-2026-D.5INSTEELBEARING	57155K356	McMaster Caar	Mini High-Precision Stainless Steel Ball Bearing	2	\$4.98	\$9.96
JIMMYMA-2027-0.25SSFLATWASHER	93852A102	McMaster Caar	18-8 Stainless Steel Type A USS Flat Washer	1	\$0.12	\$0.12
JIMMYMA-2028-.0625INSSDOWELPIN	97395A418	McMaster Caar	Corrosion Resistant Dowel Pin	2	\$0.61	\$1.23
JIMMYMA-2030-.1875INRETAININGRING	97431A280	McMaster Caar	Side-Mount External Retaining Ring	1	\$0.00	\$0.00
JIMMYMA-2032-SHOULDERSPRING	9271K642	McMaster Caar	Music Wire Torsion Spring	2	\$1.02	\$2.04
JIMMYMA-2033-ELBOWSPRING	9271K56	McMaster Caar	Music Wire Torsion Spring	2	\$1.30	\$2.60
JIMMYMA-2035-ELBOWPIN	92735A260	McMaster Caar	Grooved Clevis Pin with Retaining Ring	2	\$1.58	\$3.16
JIMMYMA-2036-M2X.4MACHINESCREW	92005A033	McMaster Caar	Metric Pan Head Phillips Machine Screw	4	\$0.04	\$0.15
JIMMYMA-2037-M2X.4MACHINESCREW	92010A003	McMaster Caar	Metric 18-8 Stainless Steel Flat Head Phillips Machine Screw	4	\$0.04	\$0.15

JIMMYMA-2038-M2SSFLATWASHER	93475A195	McMaster Caar	Metric DIN 125 18-8 Stainless Steel Flat Washer	4	\$0.01	\$0.04
JIMMYMA-2039-#4FLATWASHER	90126A005	McMaster Caar	Zinc-Plated Sttel Type A SAE Flat Washer	16	\$0.01	\$0.15
JIMMYMA-2040-#4MACHINESCREWHEXNUT	91841A005	McMaster Caar	18-8 Stainless Steel Machine Screw Hex Nut	8	\$0.03	\$0.22
JIMMYMA-2041-#4MACHINESCREW	91772A110	McMaster Caar	18-8 Stainless Steel Pan Head Phillips Machine Screw	8	\$0.04	\$0.36
JIMMYMA-2044-.125INSSDOWELPIN	90145A473	McMaster Caar	18-8 Stainless Steel Dowel Pin	1	\$0.21	\$0.21
JIMMYMA-2045-.375INSSFLATWASHER	92141A009	McMaster Caar	18-8 Stainless Steel General Purpose Flat Washer	2	\$0.02	\$0.04
JIMMYMA-2046-1032TENSIONER	91251A345	McMaster Caar	Black-Oxide Alloy Steel Socket Head Cap Screw	2	\$0.10	\$0.20
JIMMYMA-2047-1032NYLOCK	91831A411	McMaster Caar	18-8 Stainless Steel Nylon-Insert Hex Locknut	2	\$0.07	\$0.13
JIMMYMA-2051-SSCLEVISPIN	92390A075	McMaster Caar	18-8 Stainless Steel Clevis Pin	1	\$2.83	\$2.83
JIMMYMA-2054-CAPTIVEPIN	95648A400	McMaster Caar	Captive Pin	4	\$0.22	\$0.89
JIMMYMA-3012-leg_retaining_ring1	97633A130	McMaster Caar	Retaining Ring	52	\$0.08	\$4.07
JIMMYMA3013_leg_washer_1	90295A440	McMaster Caar	Flat Washer	68	\$0.06	\$4.05
JIMMYMA3024_flange_bushing	6338K411	McMaster Caar	Flange Bearing	56	\$0.74	\$41.44
JIMMYMA3009_leg_cam_follower	6831K11	McMaster Caar	Cam Follower	6	\$16.93	\$101.58
JIMMYMA3028_M2.5_hex_nut	90592A006	McMaster Caar	M2.5 Hex Nut	10	\$0.01	\$0.10
JIMMYMA3027_M2.5_14mm_bolt	92000A108	McMaster Caar	M2.5 Size, 14mm Length	22	\$0.06	\$1.27
JIMMYMA3037_440_1_1d8in_bolt	91772A118	McMaster Caar	4-40 Bolt, 1-1/8" Length	4	\$0.06	\$0.26

JIMMYMA3036_440_1_1d2in_bolt	91772A119	McMaster Caar	4-40 Bolt, 1-1/2" Length	1	\$0.07	\$0.07
JIMMYMA3035_440_3d4in_bolt	91772A113	McMaster Caar	4-40 Bolt, 3/4" Length	2	\$0.05	\$0.10
JIMMYMA3033_440_2in_bolt	91772A121	McMaster Caar	4-40 Bolt, 2" Length	4	\$0.09	\$0.38
JIMMYMA3034_440_hex_nut	90545A005	McMaster Caar	4-40 Hex Nut	7	\$4.90	\$34.30
XXX	1886K4	McMaster Caar	1/4" OD, 36" Length Shaft	1	\$13.98	\$13.98
XXX	8632T141	McMaster Caar	1/4" OD, 24" Length D Shaft	1	\$15.19	\$15.19
JIMMYMA3022_timing_pulley	A 6M16-030DF2508	SDP-SI	30 Teeth Timing Pulley	2	???	
JIMMYMA3023_motor_pulley	A 6M16-030DF25	SDP-SI	30 Teeth Timing Pulley with hub	2	???	
XXX	A 6Z16-072025	SDP-SI	72 Teeth Timing Belt	2	???	

Total \$401.00

# Bill of Materials for Legs and Torso

## List of Printed Parts

Part Name	Volume (kg)	Cost (per unit)
JIMMYMA-2001-RIGHTARMSHOULDERGIMBAL	0.01401287	\$0.49
JIMMYMA-2002-ELBOW	0.04202597	\$1.47
JIMMYMA-2004-FOREARM	0.04450945	\$1.56
JIMMYMA-2006-RIGHTUPPERARM	0.02523122	\$0.88
JIMMYMA-2007-TORSOBACKSHELL	0.2222692	\$7.78
JIMMYMA-2008-CABLEPULLEY	0.13883	\$4.86
JIMMYMA-2010-24T	0.00128068	\$0.04
JIMMYMA-2011-48T	0.00532635	\$0.19
JIMMYMA-2012-LOWERMOTORMOUNT	0.01409867	\$0.49
JIMMYMA-2013-MOTORPLATE	0.10392	\$3.64
JIMMYMA-2014-ONEARMLEVER	0.00124595	\$0.04
JIMMYMA-2015-SPOOLGEAR	0.00237758	\$0.08
JIMMYMA-2016-TWOARMLEVER	0.00072252	\$0.03
JIMMYMA-2017-ARMRAISINGCAMPROFILE	0.00536422	\$0.19
JIMMYMA-2018-HUGCAMPROFILE	0.00300524	\$0.11
JIMMYMA-2019-ARMRAISEHOLDER	0.00033911	\$0.01
JIMMYMA-2020-40T	0.00881808	\$0.31
JIMMYMA-2023-TORSOFRONTSHELL	0.27469956	\$9.61
JIMMYMA-2024-FLUXCAPLINKAGE	0.00049625	\$0.02
JIMMYMA-2029-HUGHOLDER	0.00053397	\$0.02
JIMMYMA-2031-UPPERMOTORMOUNT	0.03227794	\$1.13
JIMMYMA-2048-SHORTSPACER	0.00030602	\$0.01
JIMMYMA-2049-LONGERSPACER	0.00047168	\$0.02
JIMMYMA-2050-TENSIONERBLOCK	0.00232613	\$0.08
JIMMYMA-2052-SMALLCABLEPULLEY	0.00014547	\$0.01
JIMMYMA-2053-HAND	0.0842311	\$2.95
JIMMYMA300_with_follower	0.053	\$1.86
JIMMYMA3004	0.04	\$1.40
JIMMYMA3002	0.1	\$3.50
JIMMYMA3002	0.045	\$1.58
JIMMYMA3005	0.009	\$0.32
JIMMYMA3001	0.01	\$0.35
JIMMYMA3006	0.07	\$2.45
JIMMYMA3008	0.025	\$0.88
JIMMYMA3014	0.276	\$9.66
JIMMYMA3011	0.002	\$0.07
97633A130	0.001	\$0.04
90295A140	0.001	\$0.04
JIMMYMA3010	0.017	\$0.60
JIMMYMA3015	0.001	\$0.04
JIMMYMA3020	0.001	\$0.04
JIMMYMA3019	0.291	\$10.19
JIMMYMA3016	0.016	\$0.56

JIMMYMA3017  
JIMMYMA3018

0.026  
0.008

\$0.91  
\$0.28

Total 1.02886523

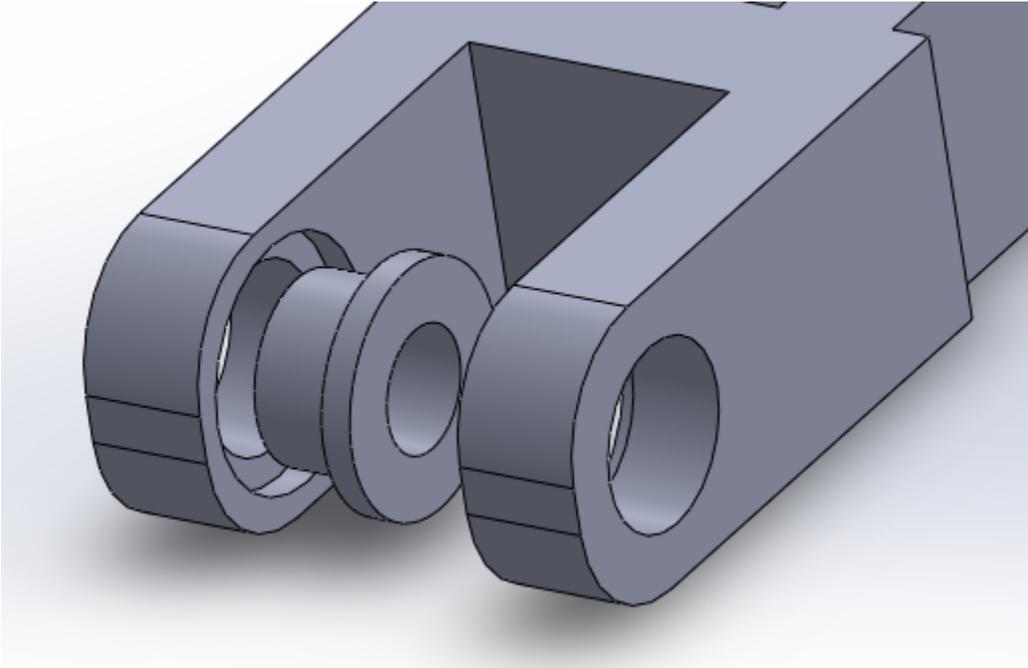
\$70.73

# Bill of Materials for Head

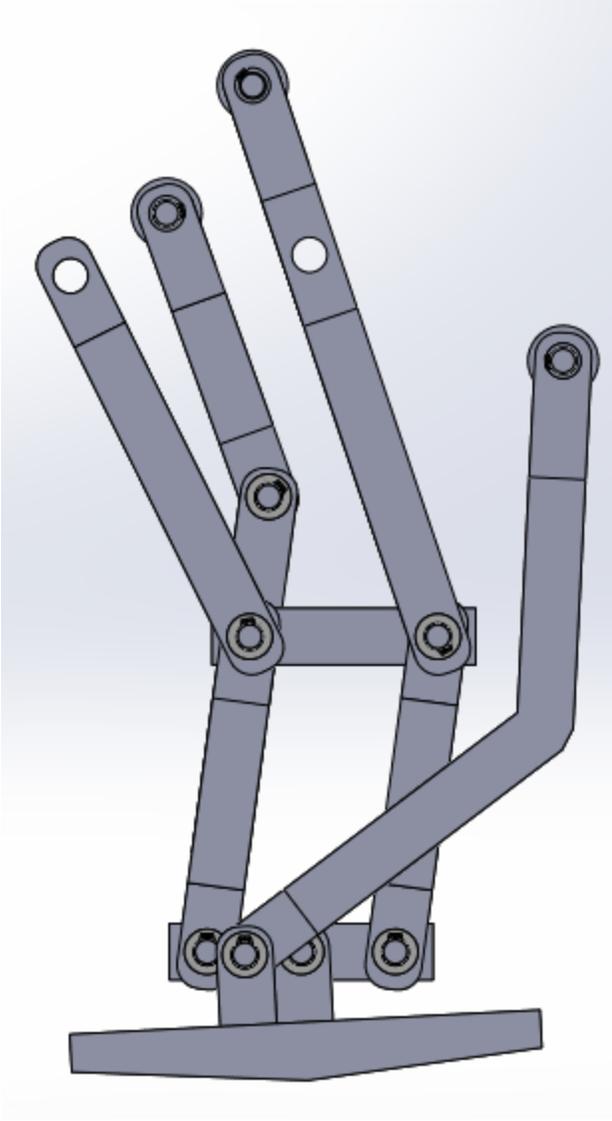
Description	Supplier	Part #	Cost (\$)	Quantity	Cost	Notes
neck	printed			1		
back of head	printed			1		
front of head	printed			1		
bevel gear for nodding (large)	printed			1		
motor turntable	printed			1		
4-40 screw	McMaster	91735A106	\$0.11	4	\$0.44	
chin	printed			1		
sleeve bearing	McMaster	6338K413	\$1.04	3	\$3.12	
chin/head coupler	printed			1		
ball bearing	McMaster	6383K213	\$3.17	1	\$3.17	
Dynamixel Motor	Robotis	MX-106R	\$500.00	1	\$500.00	Motor should be downsized to reduce cost
Small bevel gear	printed			1		
Tilt-control spur gear	printed			1		
tilt interface gear (large)	printed			1		
tilt interface gear (small)	printed			1		
Clutch sleeve	printed			3		
Driving transmission gear	printed			1		
Motor horn	printed			1		
Motor faceplate	printed			1		
Nylon washers	McMaster	90295A441	\$0.06	4	\$0.24	
1/16 x 3/4 in spring pin	McMaster	92373A113	\$0.07	1	\$0.07	
Collar-clutch coupler	printed			1		
M2 screw	McMaster	90116A022	\$0.10	8	\$0.84	
clutch tube	printed			1		
rotary clutch element	printed			1		
clutch button	printed			1		
clutch spring	McMaster	9657K680	\$0.57	1	\$0.57	
clutch mount	printed			1		
Transmission drive shaft	McMaster	1327K114	\$3.82	1	\$3.82	(modified part)

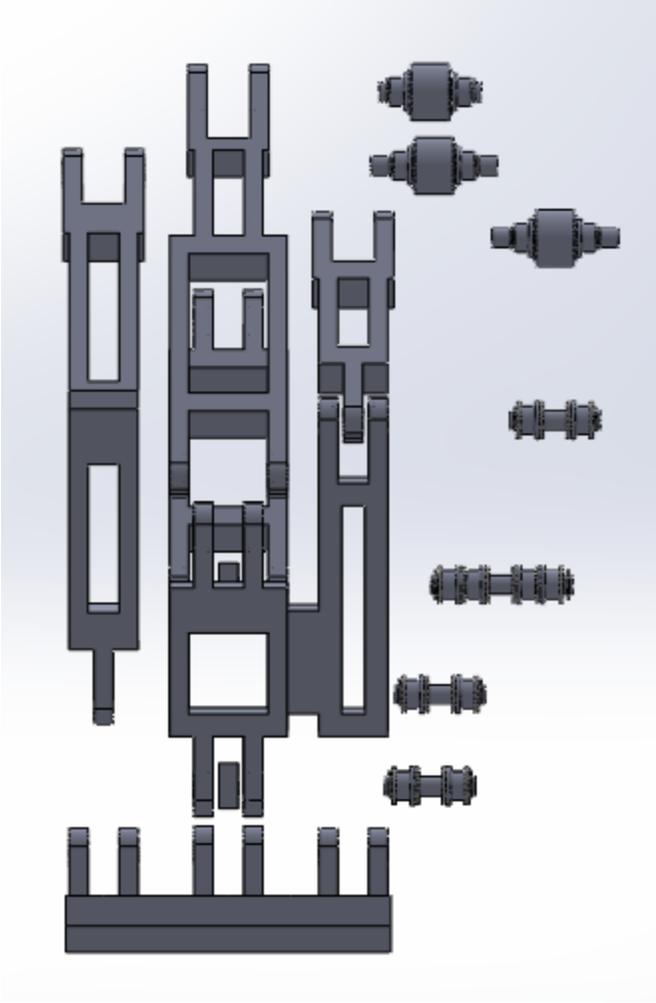
Description	Supplier	Part #	Cost (\$)	Quantity	Cost	Notes
1/16 x 9/16 in spring pin	McMaster	92373A110	\$0.05	1	\$0.05	
M2.5 x 25 mm screw	McMaster	92005A078	\$0.06	8	\$0.44	
M2.5 washer	McMaster	91166A190	\$0.01	16	\$0.24	
M2.5 nut	McMaster	90592A006	\$0.01	8	\$0.08	
screw	McMaster	92000A102	\$0.04	8	\$0.30	
electronics box	printed			1		
microcontroller	Trossen	ARBOTIX-M	\$39.95	1	\$39.95	
Lipo battery	Trossen		\$20.00	1	\$20.00	(11.1 V, 2200 milliamp-hours, 30 C)
Motor mount	printed			1		

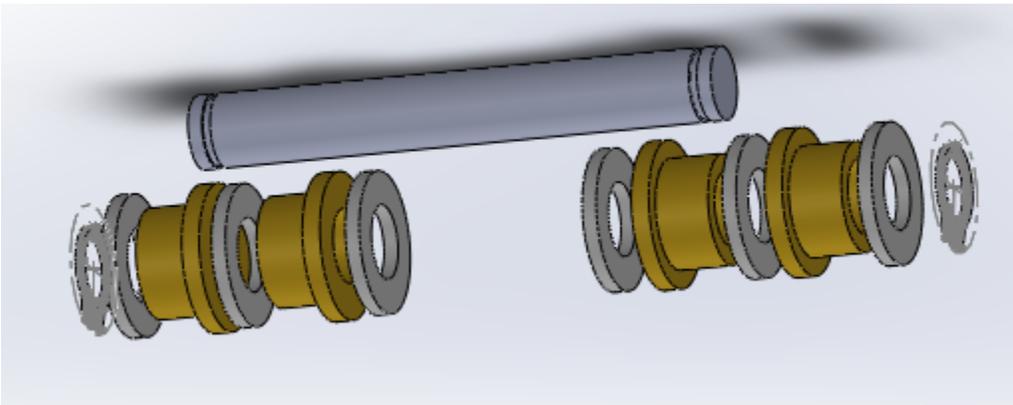
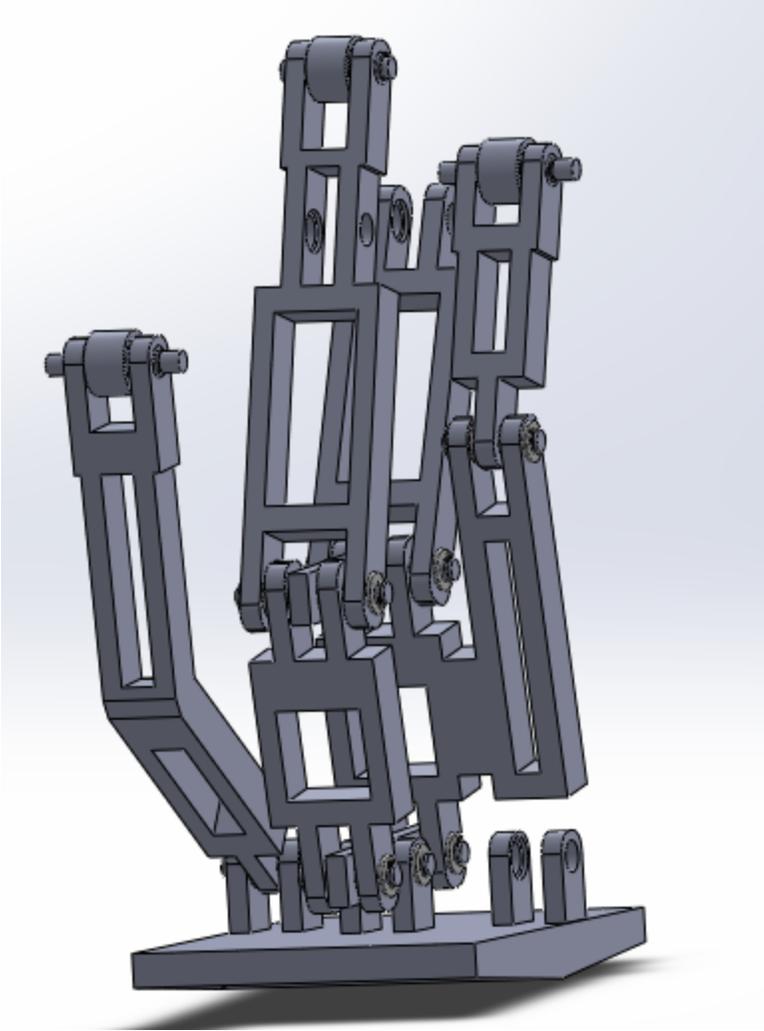
### Leg Assembly Instructions



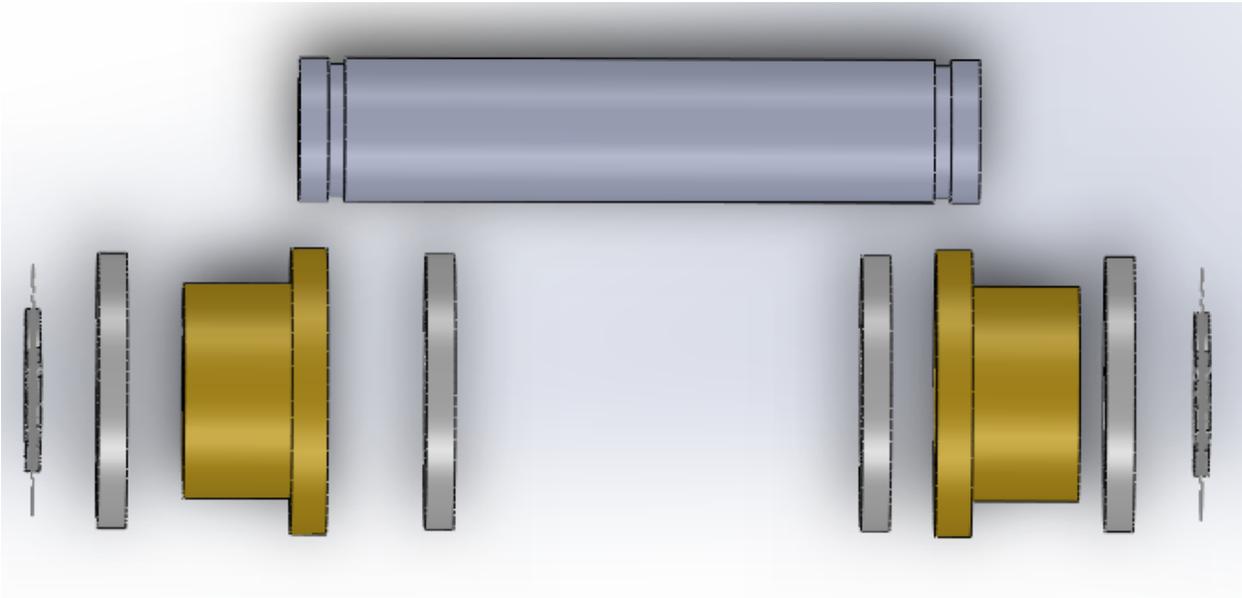
Put bearings in all countersunk holes. Then attach linkages together as shown. To attach two linkages, align the holes at the pivot. Slide the correct shaft through, then secure with retaining rings. Use washers as spacers as necessary. A few should do the trick. The following figures have been provided as reference. Afterwards, attach the cam followers to the end of the cam follower linkages.



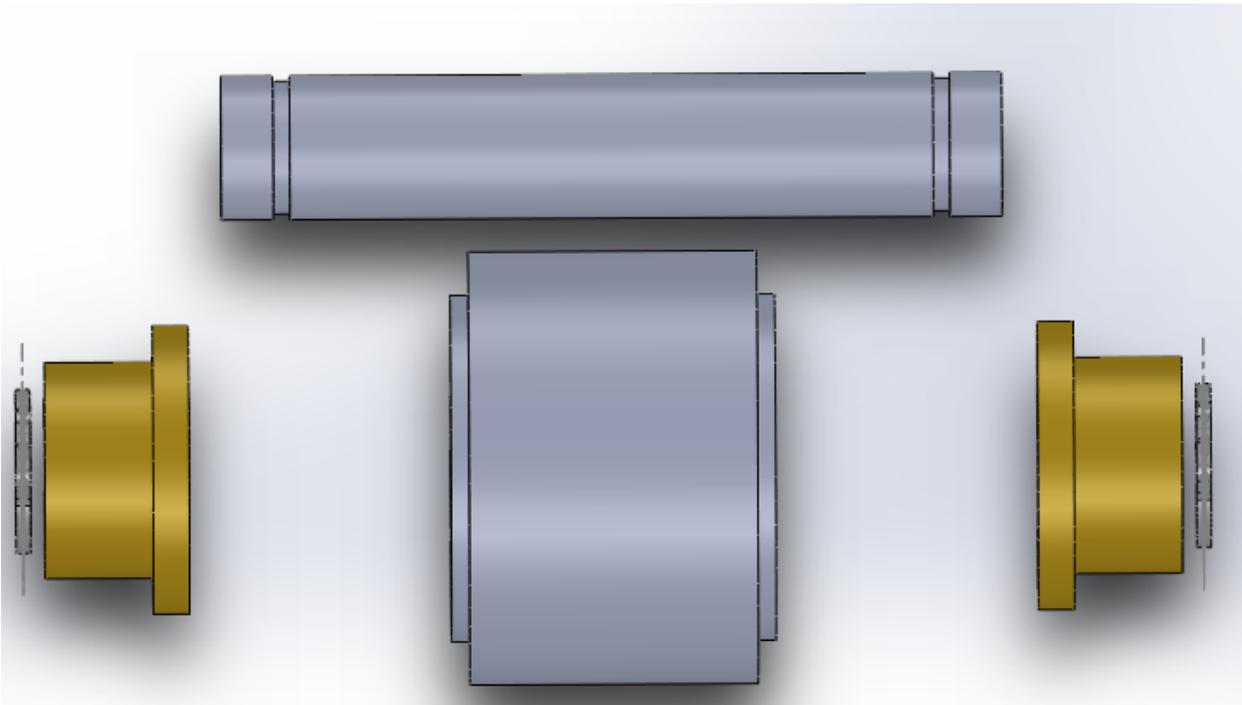




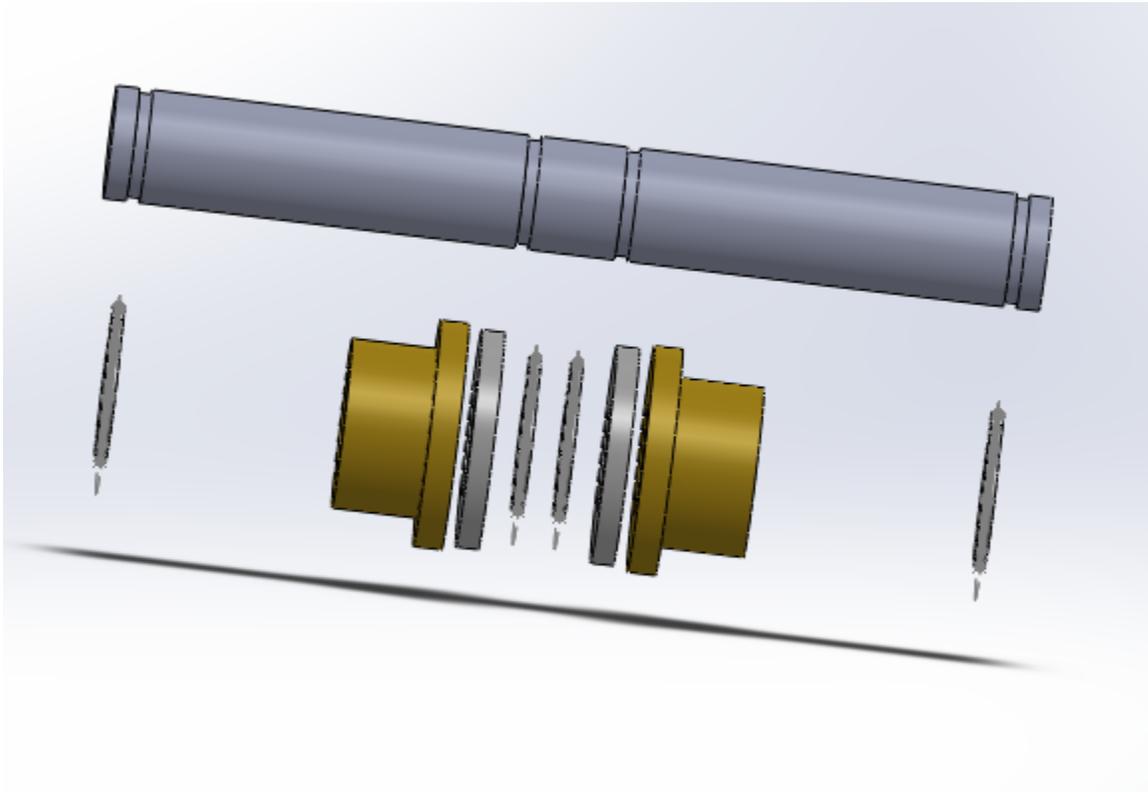
Long Pin Joint Washer Sequence



Short Pin Joint Washer Sequence



## Cam Follower Fastener Sequence

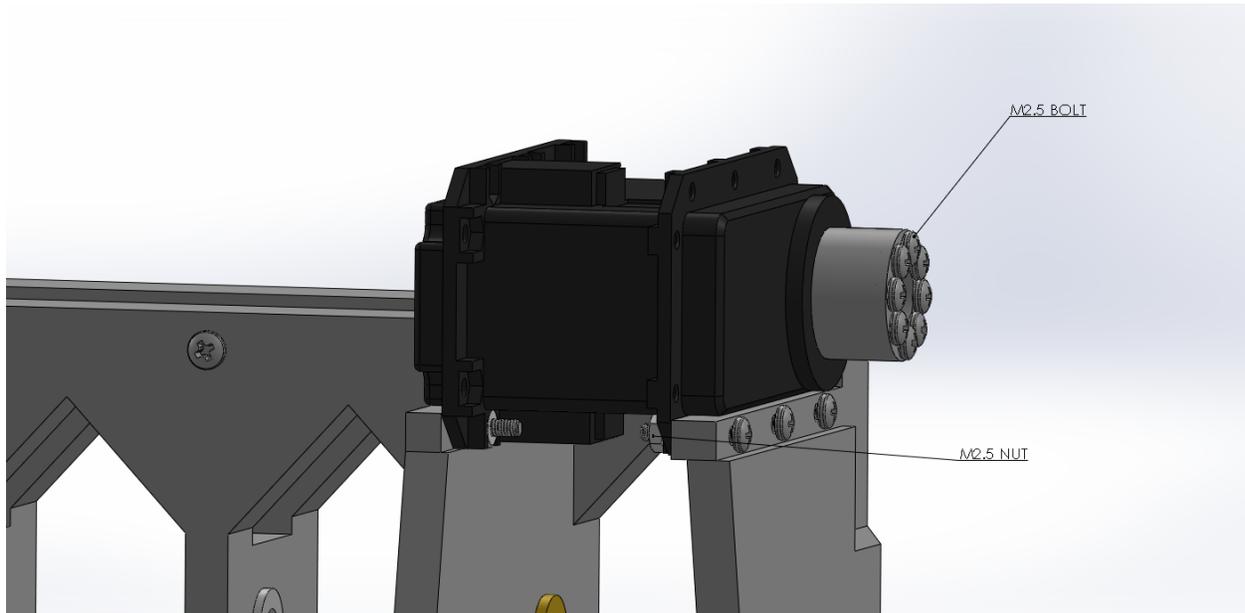


## Weird Pin Joint Fastener Order

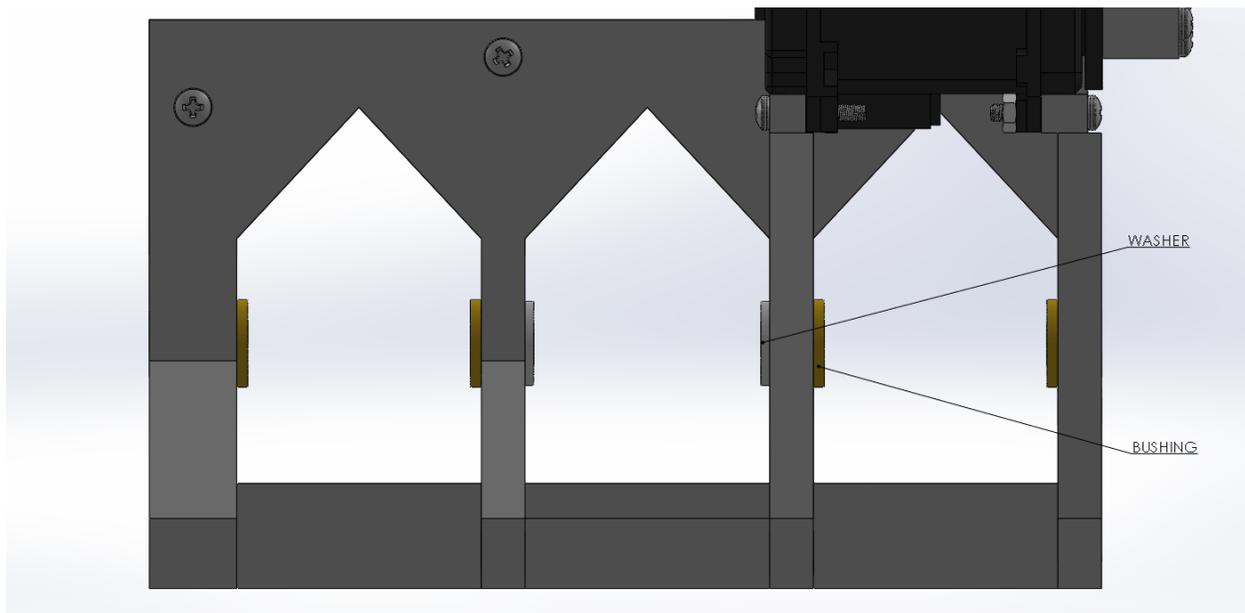
(OTAYLOR)

## Cradle Assembly

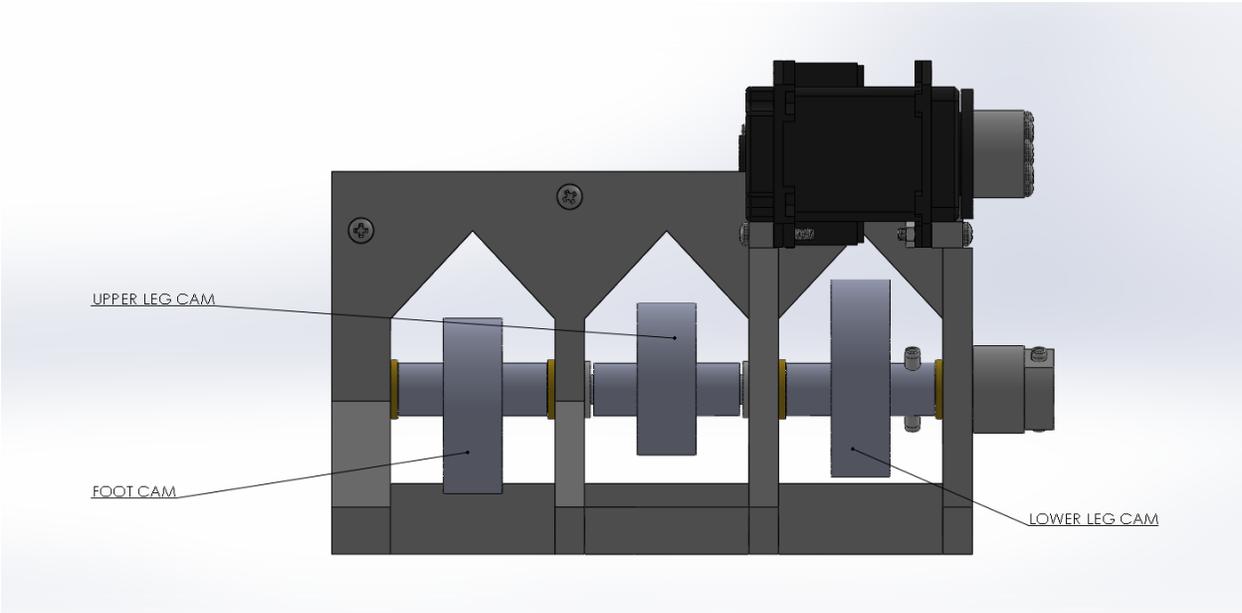
Attach Motor Pulley to MX-106 Dynamixel Motor via x8 M2.5 14mm bolts. Attach Dynamixel Motor to Cradle via x5 M2.5 14mm bolts.



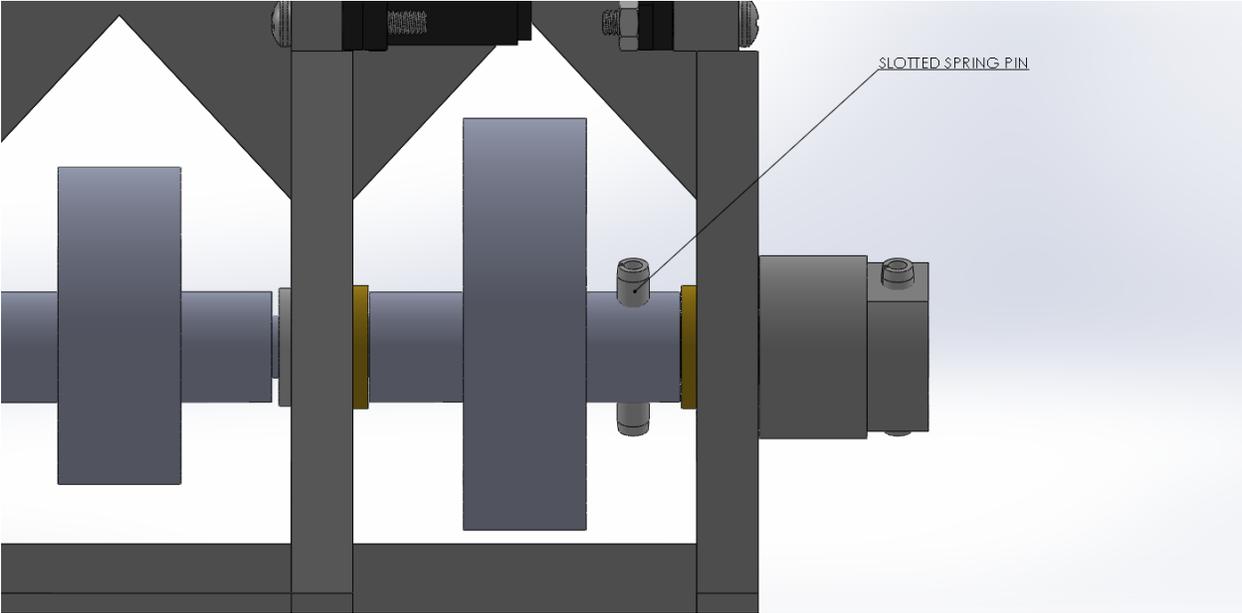
Insert  $\frac{1}{4}$ " Flange Bushings into holes in positions shown. Use  $\frac{1}{4}$ " Washers as spacers in positions shown.



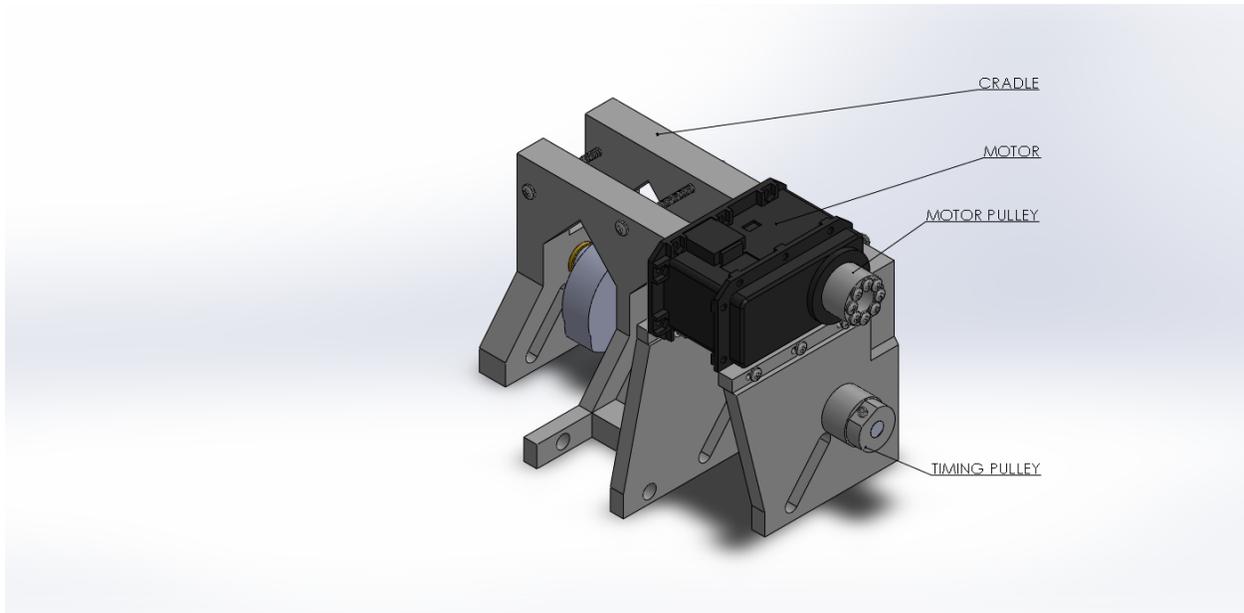
Fix the three unique pulleys in the locations shown using D Shaft.



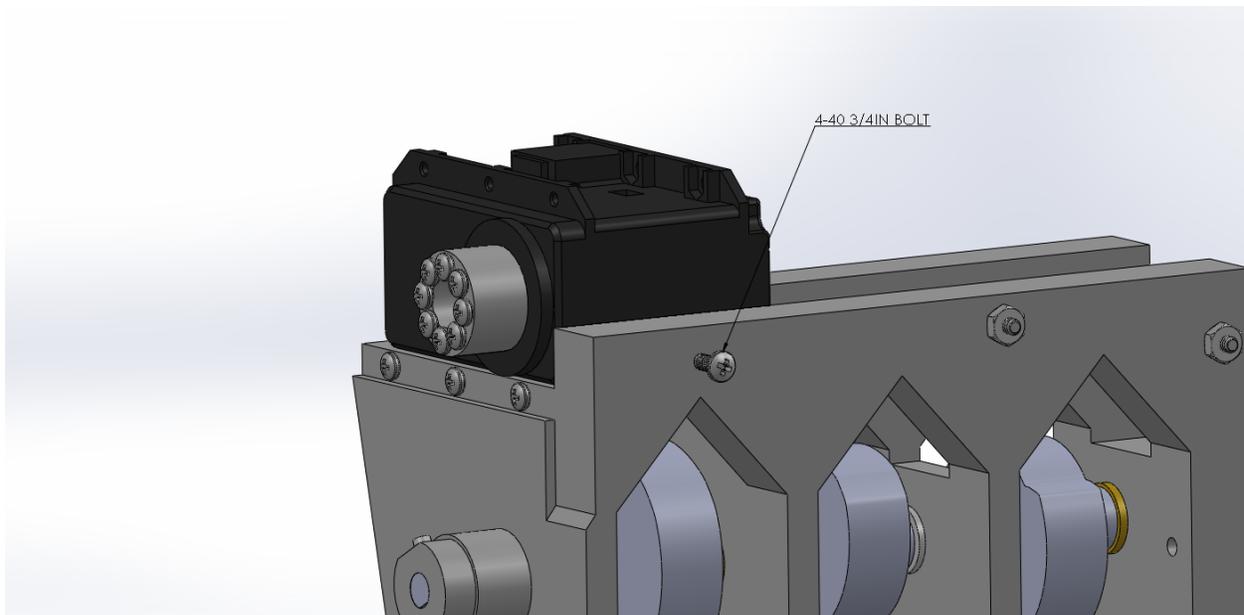
The D Shaft is axially constrained by Slotted Spring Pins in the Lower Leg Cam and Timing Pulley, as shown below.



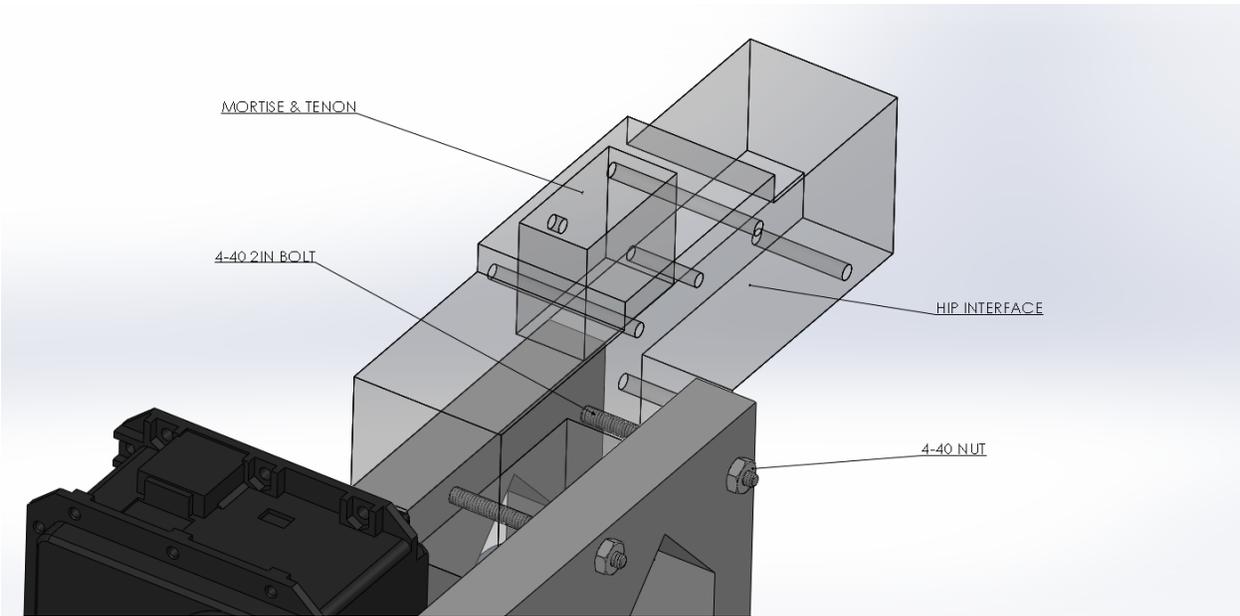
Connect Motor Pulley and Timing Pulley via 72 Tooth Timing Belt (not pictured)



Once the belt is attached, tension the belt via a 4-40  $\frac{3}{4}$ " Bolt threaded through the Cradle.

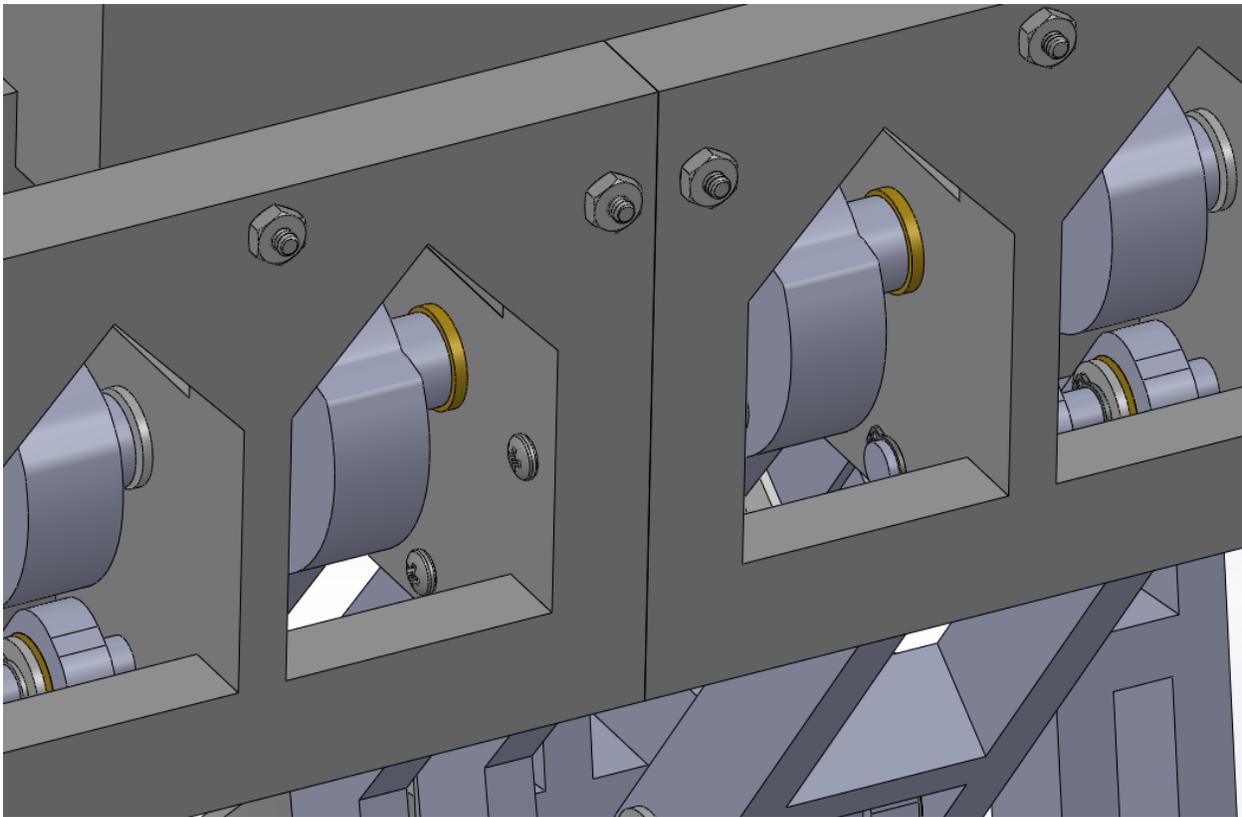


When Cradle is fully assembled, fix to the Hip Interface via two 4-40 2in Bolts – both left and right Cradles attach to the same structure.

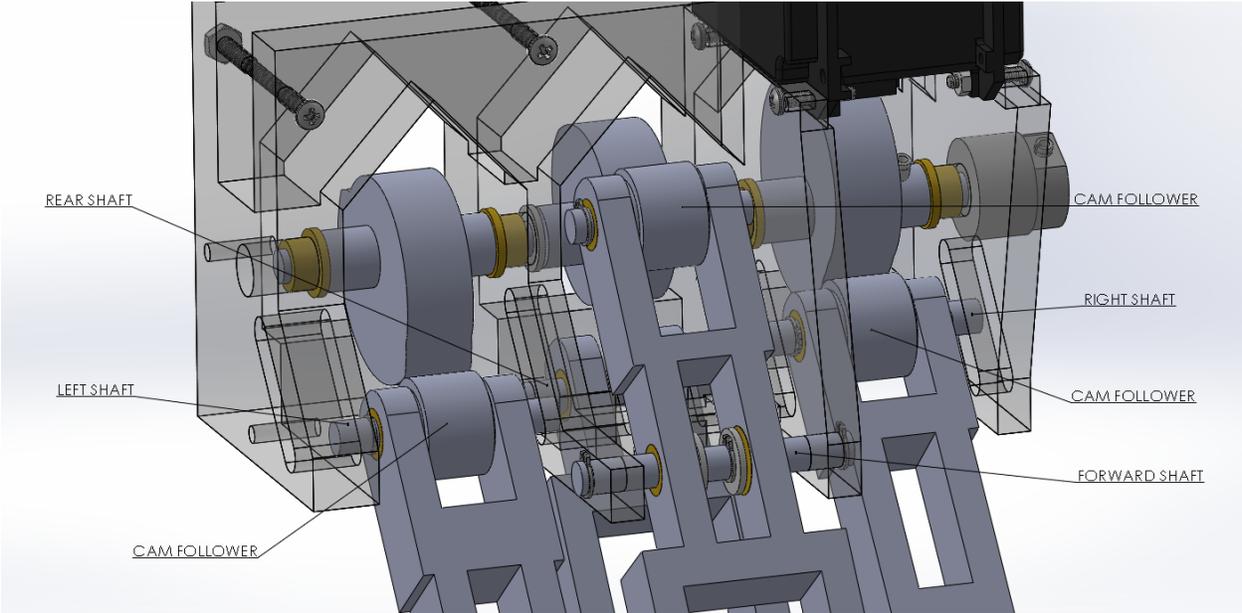


### Final Assembly

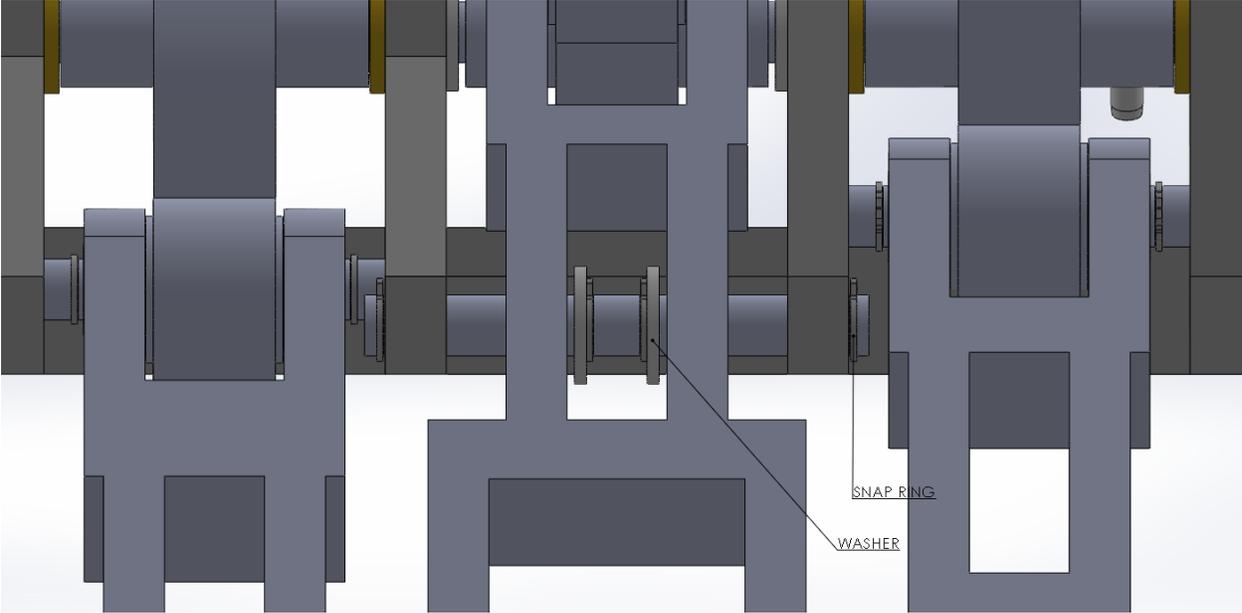
The two Cradles are then connected directly each other via x2 4-40 1-1/4" Bolts.



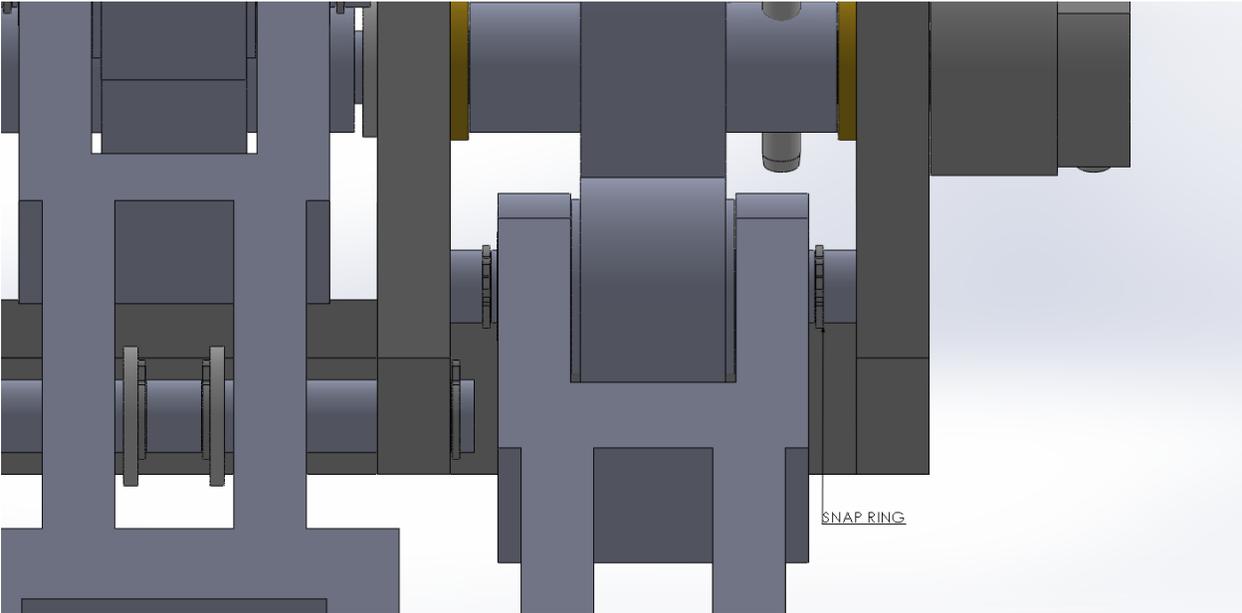
Once both legs have been assembled, connect them to the Cradle as follows.



The Forward and Rear Shafts are assembled using Snap Rings and Washers as shown below.

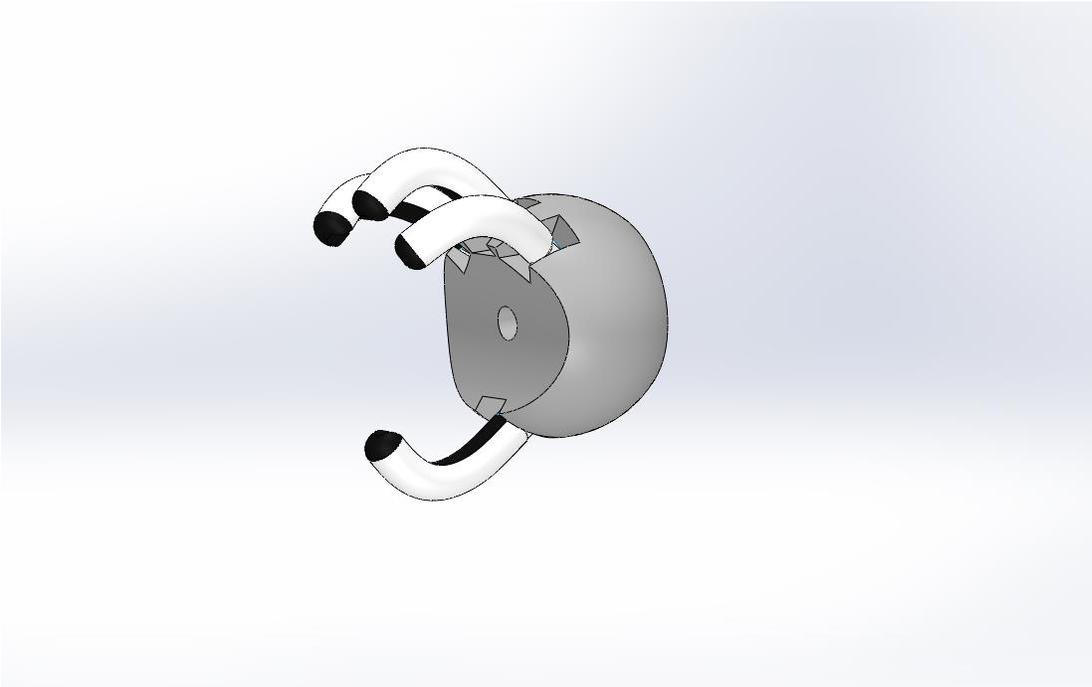


The Left and Right Shafts are assembled using only Snap Rings, as shown below.

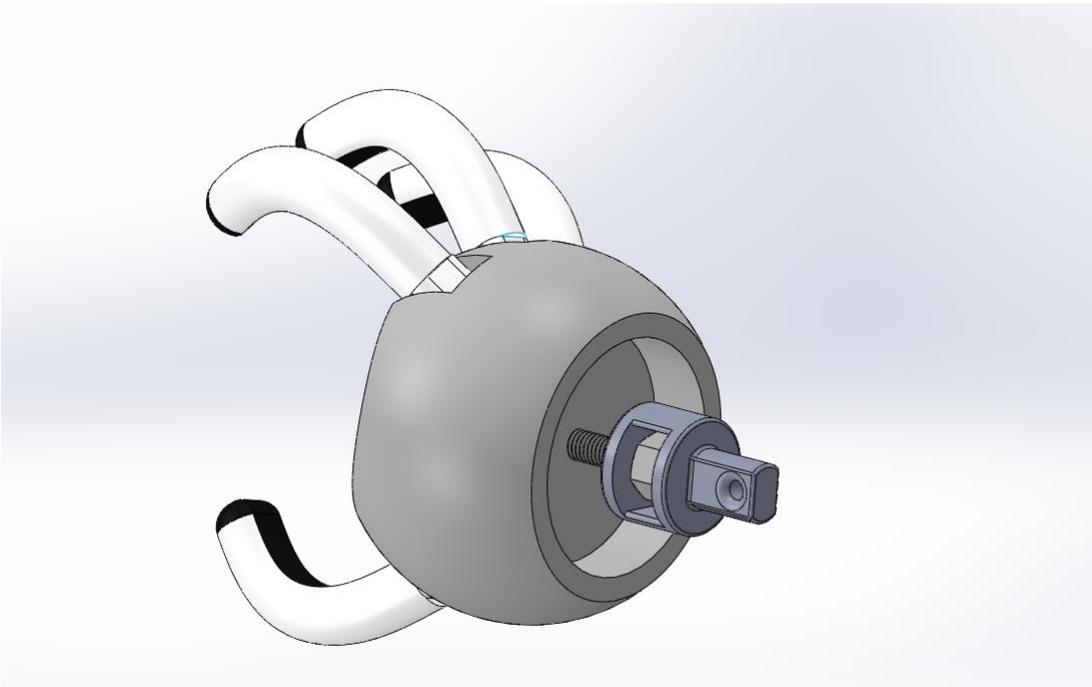


(ZDELROSARIO)

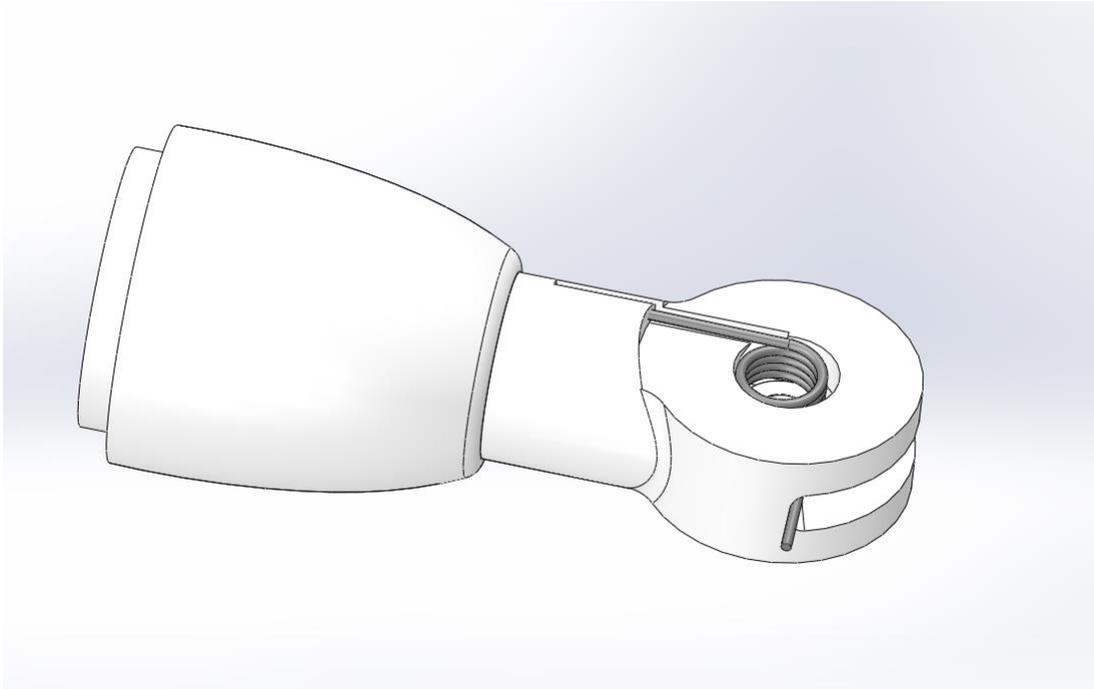
## Arm Assembly Instructions:



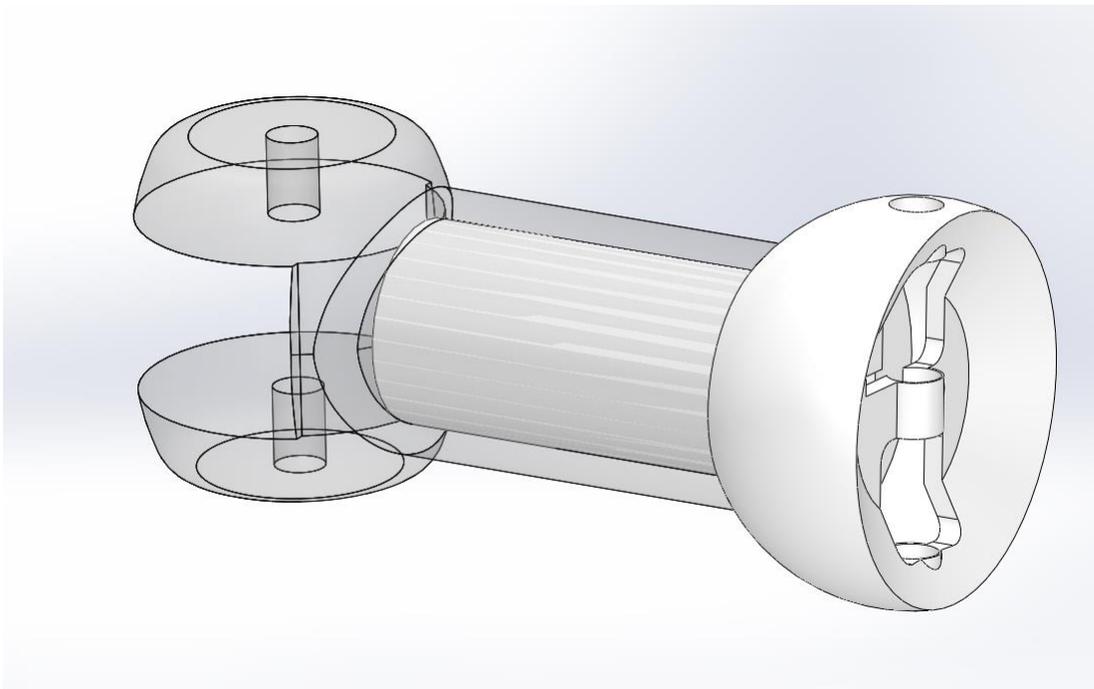
First glue fingers (JIMMYMA-2003) to the hand (JIMMYMA-2005). Use a glue that can act as a filler because the pieces do not mate firmly. Tap the small hole in the center of the palm with a 10-32 tap.



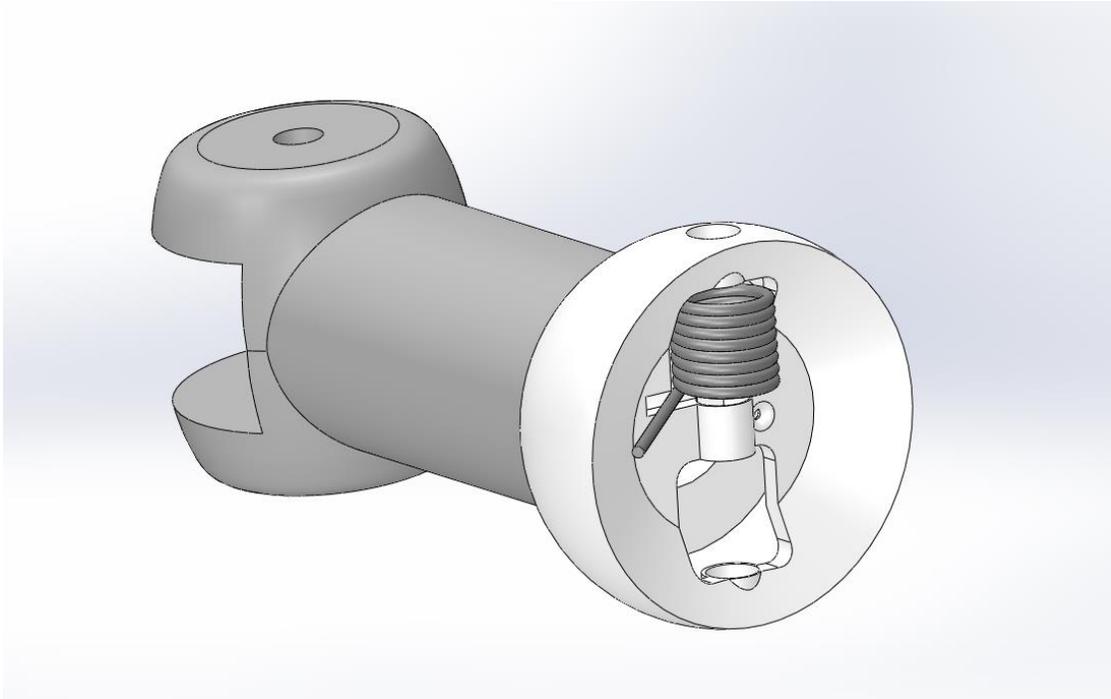
Screw the 1 inch 10-32 screw all the way into the palm and bolt the tensioner (JIMMYMA-2042) on with the nylock nut at the end.



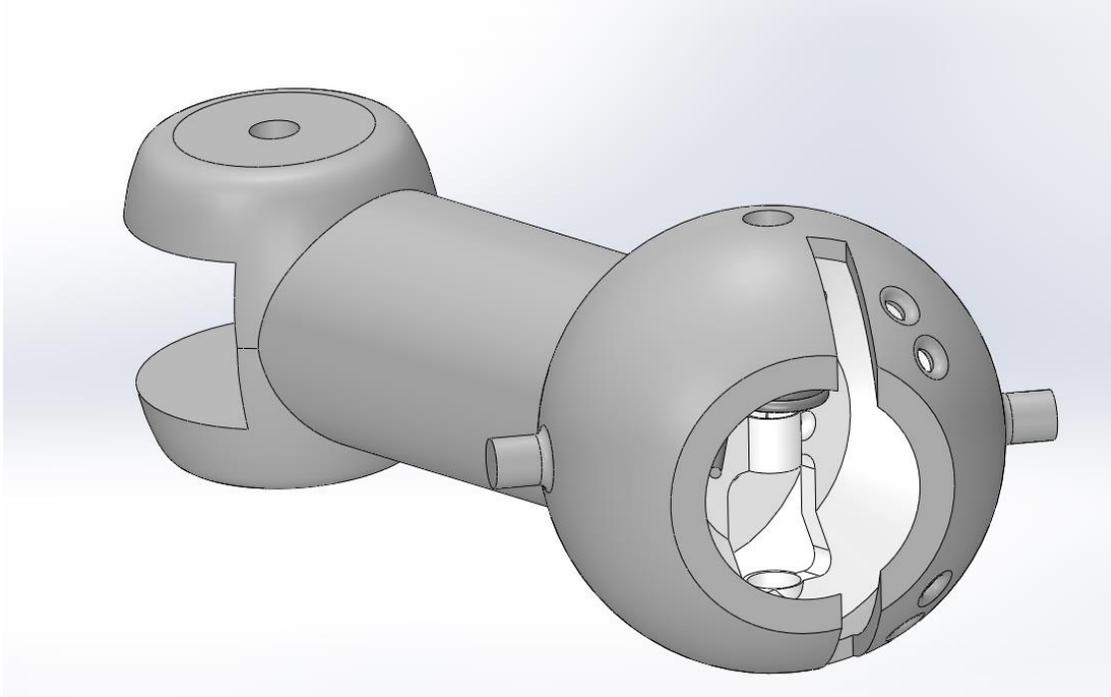
Place the elbow spring in the area cut for it in the FOREARM (JIMMYMA-2004).



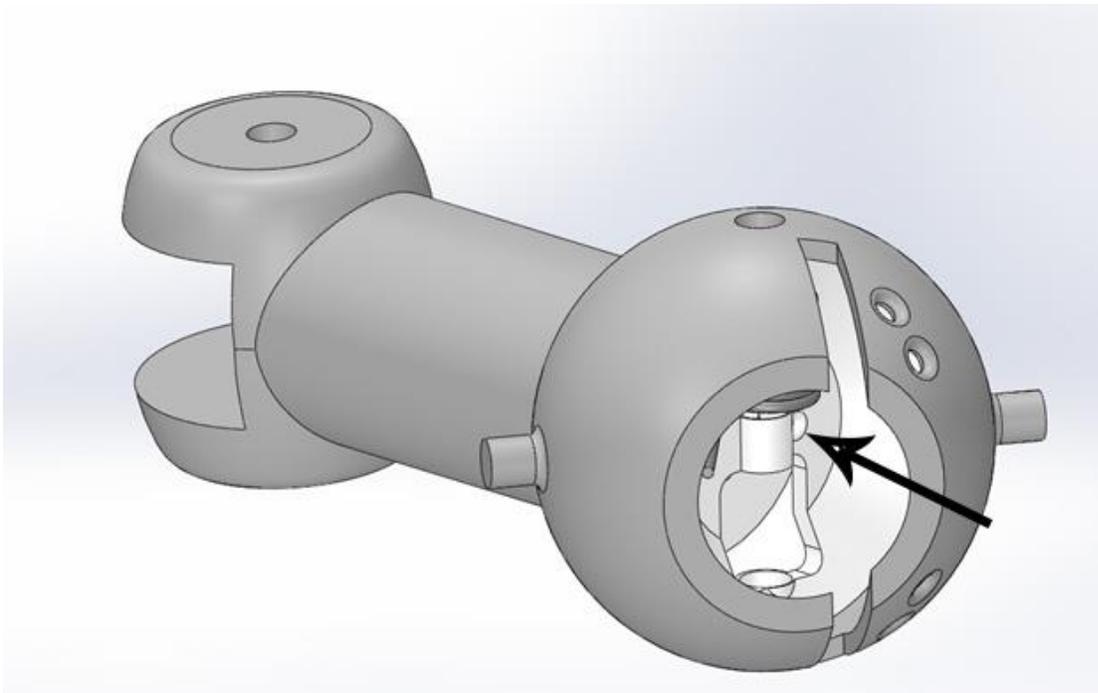
Glue the elbow (JIMMYMA-2002) to the upper arm (JIMMYMA-2006). There are no locating features so you can choose what angle Jimmy's arm will be at. However, we recommended that the holes in the two pieces be coplanar.



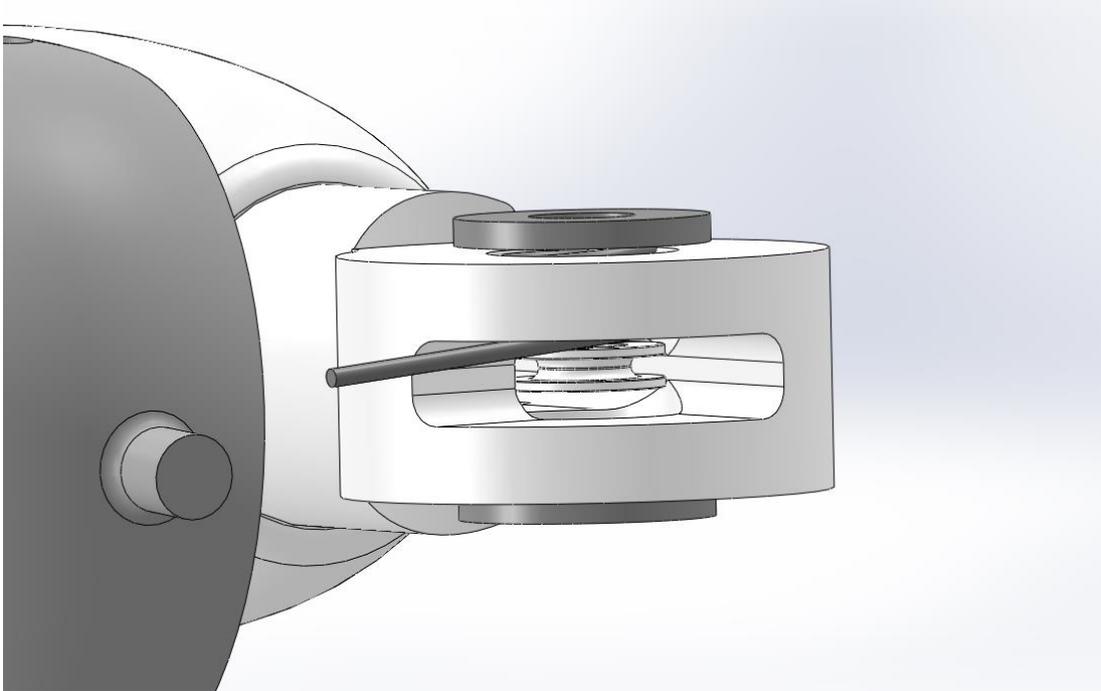
Cut the shoulder spring (JIMMYMA-2032) to have legs of about 0.75 to 1 inch length. Bend one of them down toward the center of the spring about 0.5 inches from where the coils start. Then place the shoulder spring in the position shown above.



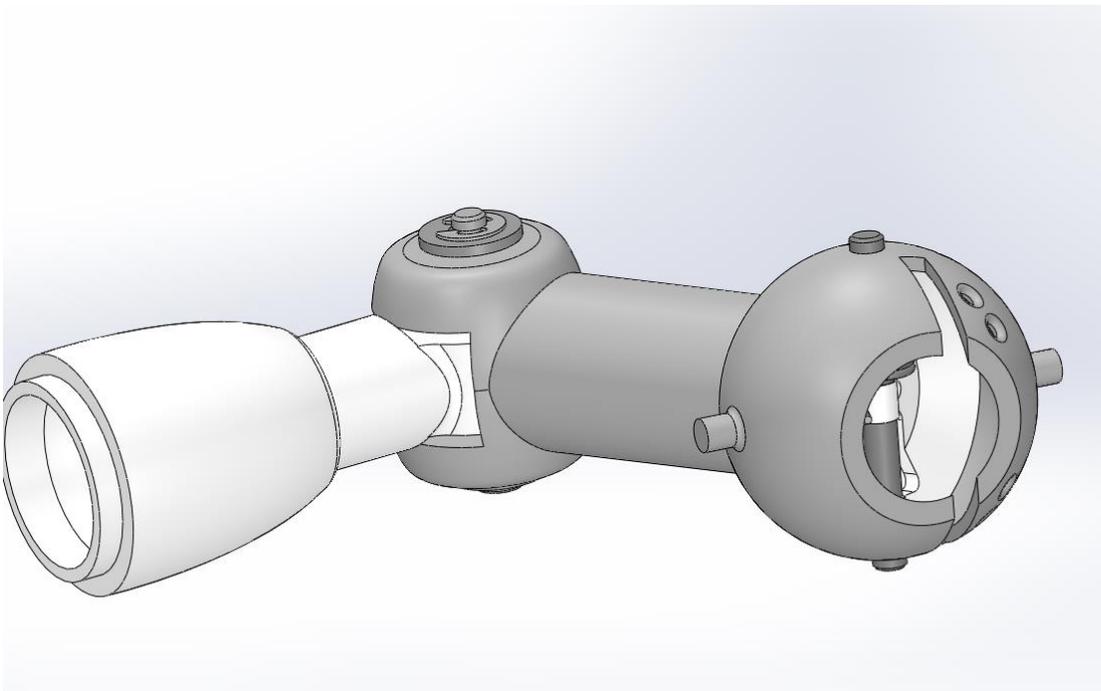
Glue the two shoulder gimbal shells (JIMMYMA-2001) together around the upper arm. The spring should be pushing against the gimbal so be sure to clamp the shells as they dry.



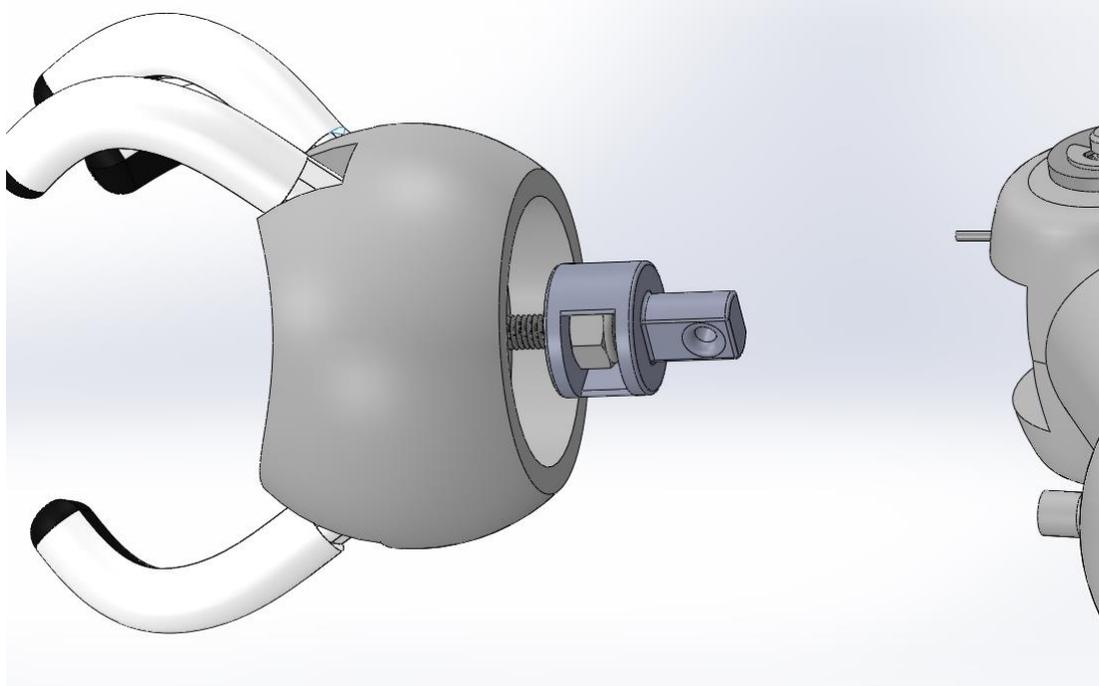
Thread the spectra cable from the hugging spool through the hole shown in the picture.



Add the spool (JIMMYMA-2008) and two washers to the elbow. Pull the cable through the upper arm and elbow and thread it around the outside of the spool.



Pull the spectra through the forearm, slide the halves of the elbow together and add the pin. Add the snap-ring to the end of the pin to secure it.



Pull the hand assembly as close as you can to the forearm and tie off the spectra cable with the know below:

### Improved Clinch Knot

Very popular general purpose knot for attaching a swivel or hook to the end of a line. Line can be doubled before tying the knot for improved strength.

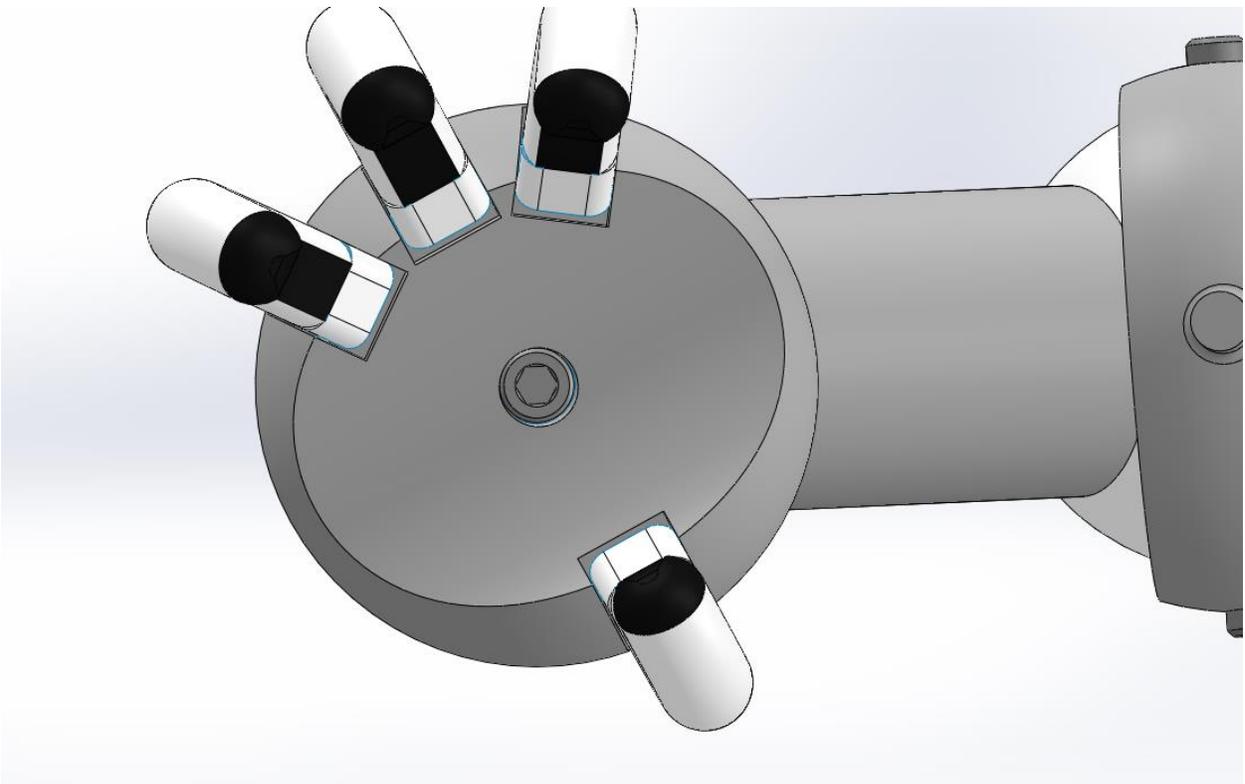
- 1** 

1. Pass the line through the eye of the hook, swivel, or lure. Double back and make five turns around the standing line.
- 2** 

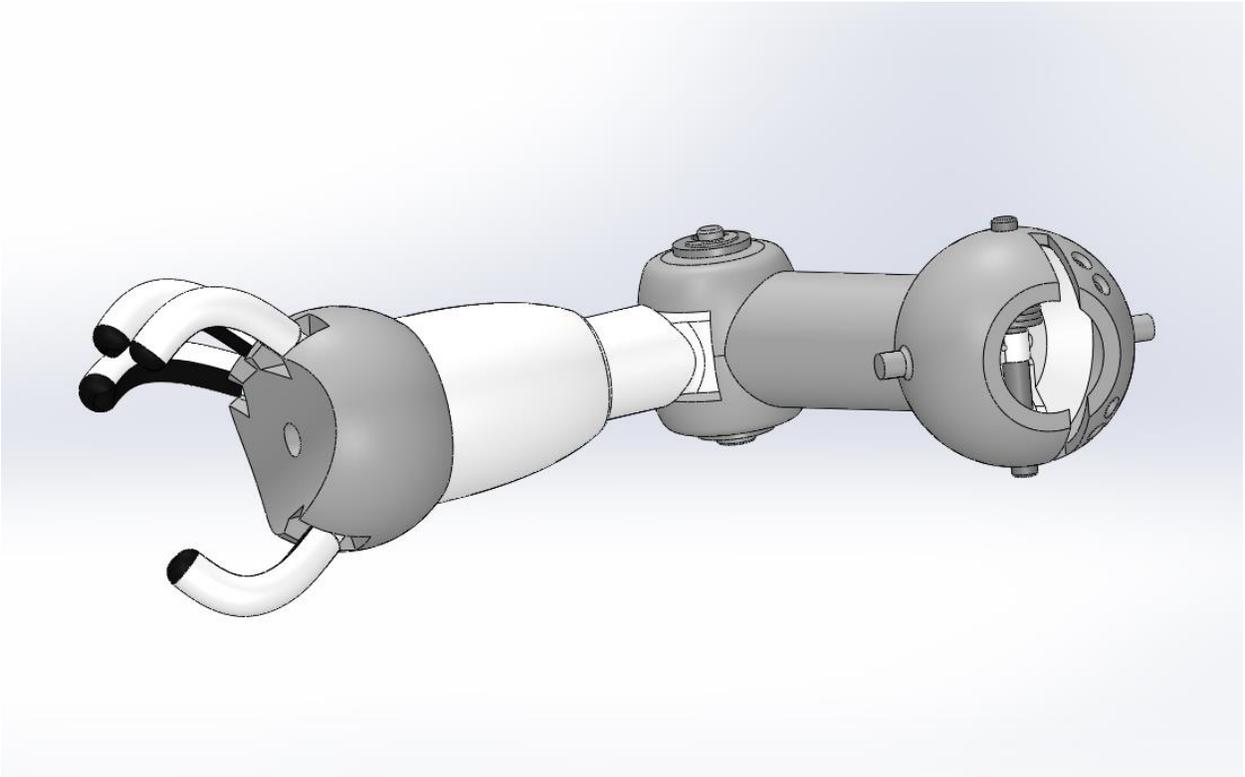
2. Holding the coils in place, thread the tag end of the first loop above the eye, then through the big loop.
- 3** 

3. Hold the tag end and standing line while pulling up the coils. Make sure the coils are in a spiral, not overlapping each other. Slide against the eye. Clip the tag end.

Once the knot is tied, the forearm and the hand can be glued together.



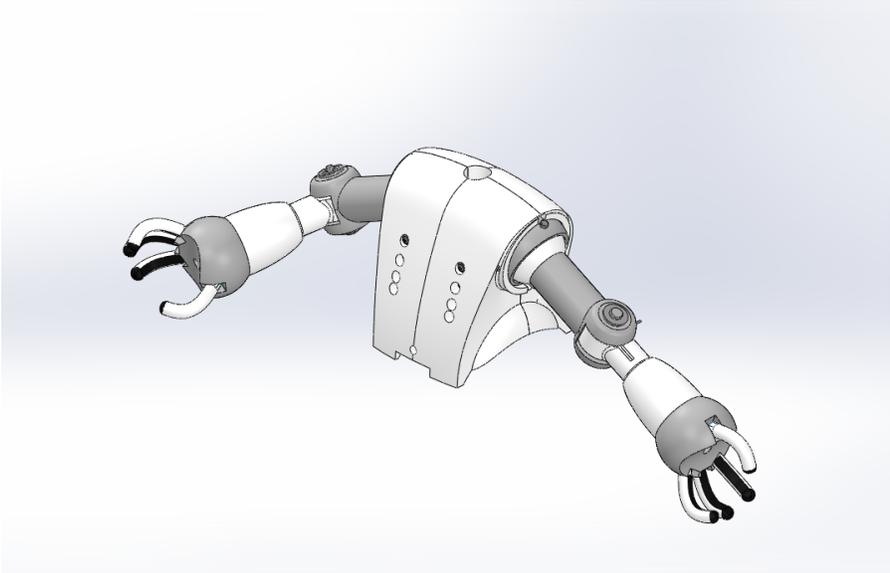
To tension the cable appropriately, first make sure the hug cam is not active. Then, unscrew the bolt in the palm until jimmy's arm is straight and under tension.

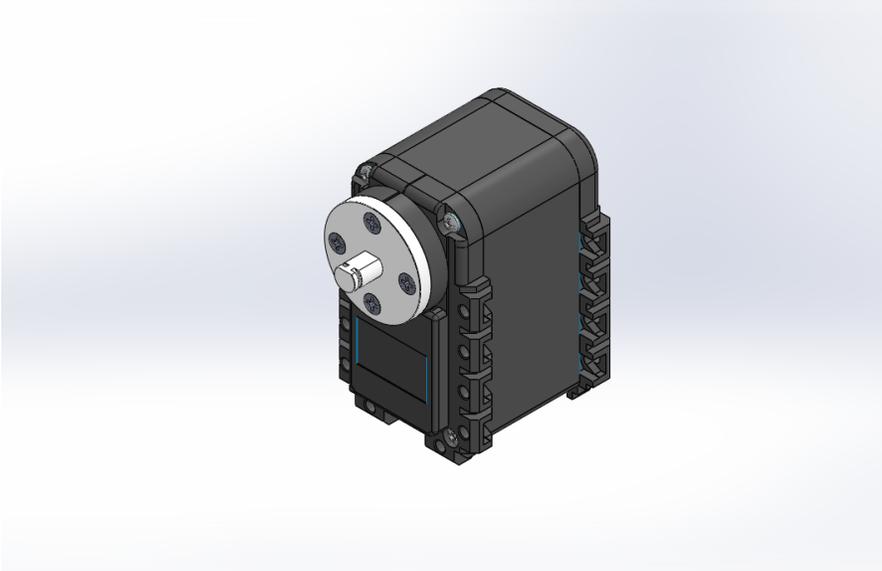


Now Jimmy's arm is complete!

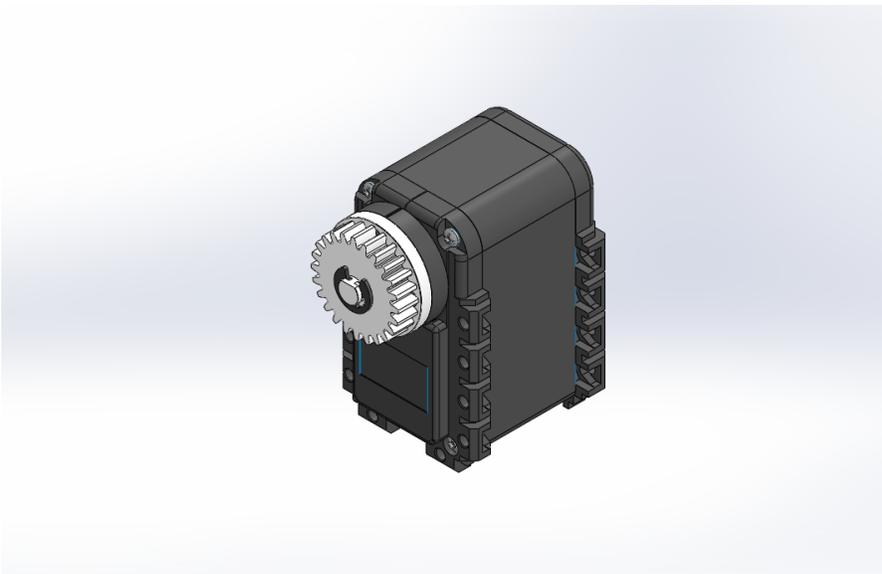
Elliott Donlon

Torso Assembly Instructions

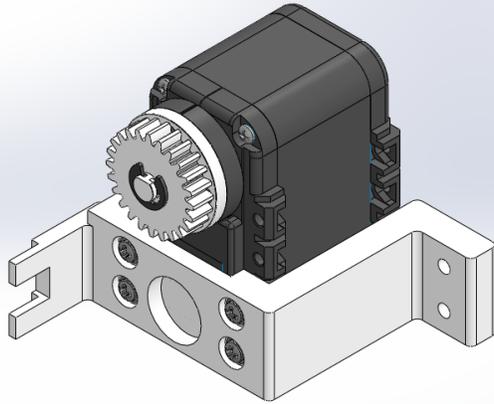




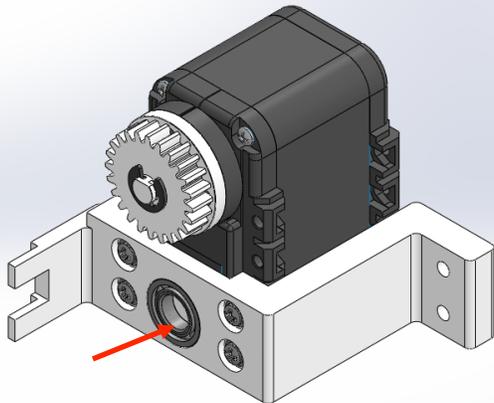
Take the motor (JIMMYMA-MOTOR-AX12A) and mount the servo horn (JIMMYMA-2013) to it using 4 machine screws (JIMMYMA-2037).



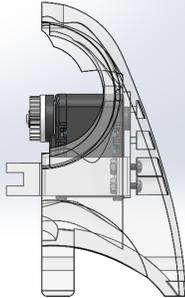
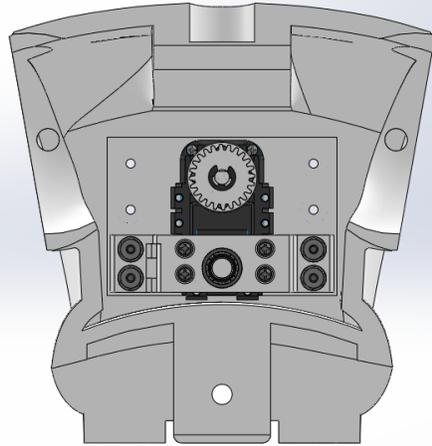
Slide the 24 tooth gear (JIMMYMA-2010) onto the servo horn d-shaft. Slip retaining ring (JIMMYMA-2030) into slot on the d-shaft. The gear should fit snugly onto the shaft and shouldn't wobble around.



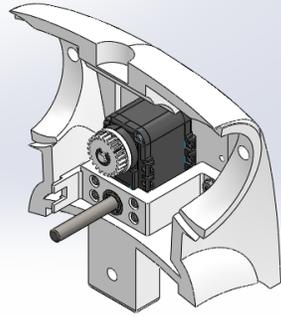
Take 4 M2 machine screws (JIMMYMA-2036) and 4 M2 flat washers (JIMMYMA-2038) and mount the motor on to the lower motor mount (JIMMYMA-2012). The washers should nest nicely in the counter sunk holes on the front face of the lower motor mount.



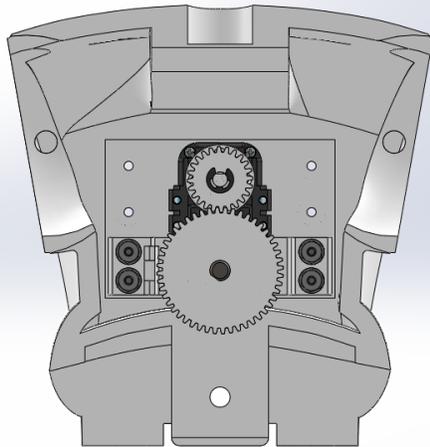
Press a bearing (JIMMYMA-2026) into the hole on the front of the lower motor mount until it is flush with the back of the hole.



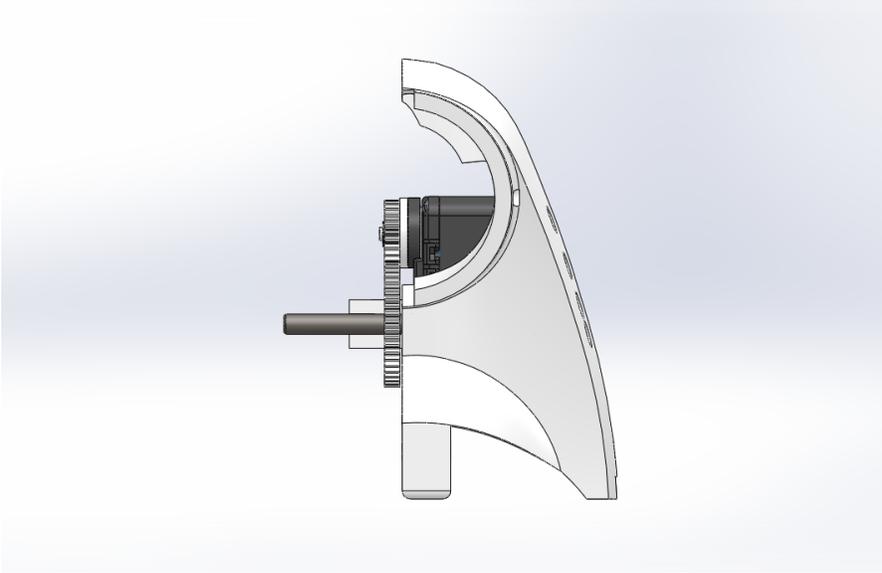
Place motor and mount into the front shell so the front of the motor faces out. Use 4 #4 machine screws (JIMMYMA-2041), 8 #4 flat washers (JIMMYMA-2039), and 4 #4 hex nuts (JIMMYMA-2040). The screws will be screwed in from the outside of Jimmy. There should be two washers on each screw; one on the outside in the counter sunk hole and the other between the motor mount and the nut.



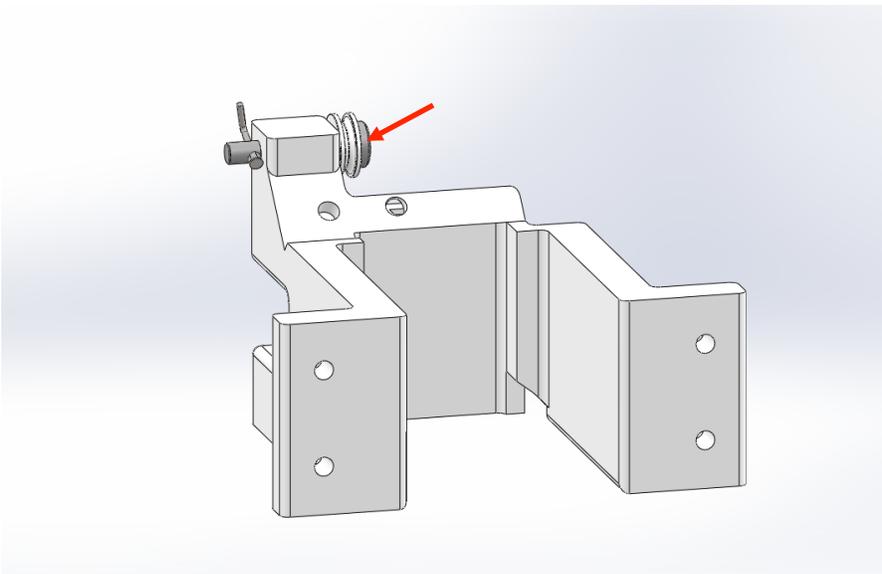
Press the d-shaft (JIMMYMA-2021) into the bearing that was pressed into the lower motor mount.



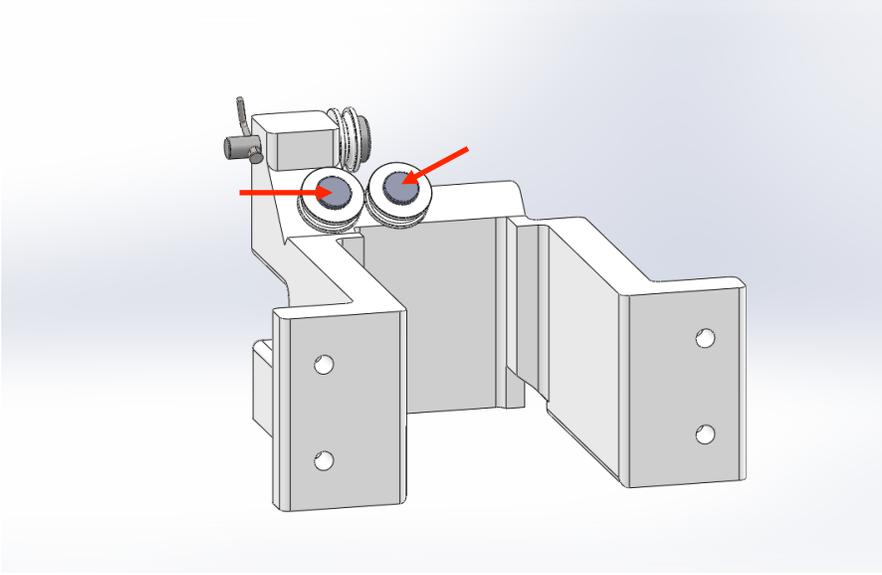
Press the 48 tooth gear (JIMMYMA-2011) onto the d-shaft. The gear should fit snugly onto the shaft and shouldn't wobble around.



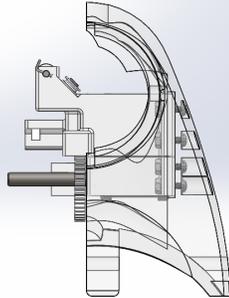
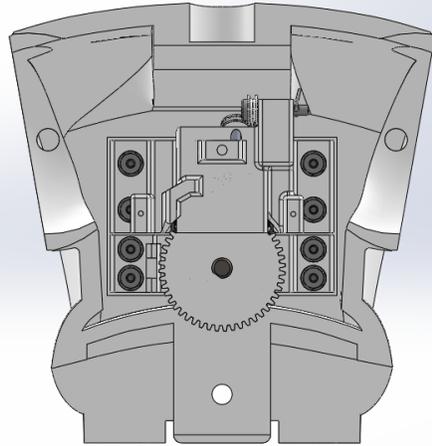
The 48 tooth gear needs to be moved far enough down the d-shaft that its teeth will interlock with the teeth of the 24 tooth gear that was mounted to the motor earlier.



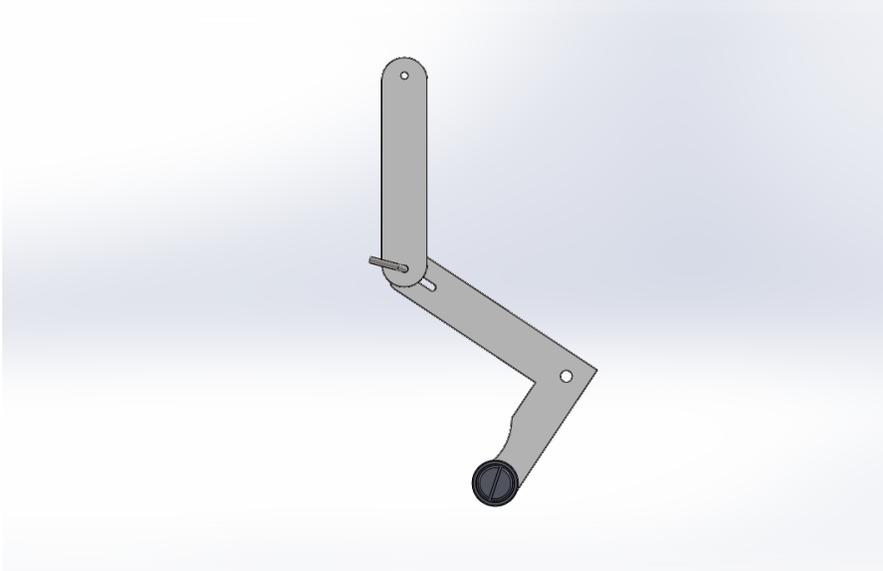
Take the upper motor mount (JIMMYMA-2031) and position it in the same orientation as the image. Slide a small cable pulley (JIMMYMA-2052) on to the clevis pin (JIMMYMA-2051). The pulley should be able to rotate on the shaft. If it doesn't then the hole in the center of the pulley will have to be widened until it does (rotate). The clevis pin will be pressed into the hole that is in the feature on the left (of the image). There is a hole in the end of the clevis pin that a straight cold formed pin (JIMMYMA-2022) needs to be slid into and bent to a right angle. Make sure not to press the pulleys tightly against the motor mount or it will not rotate.



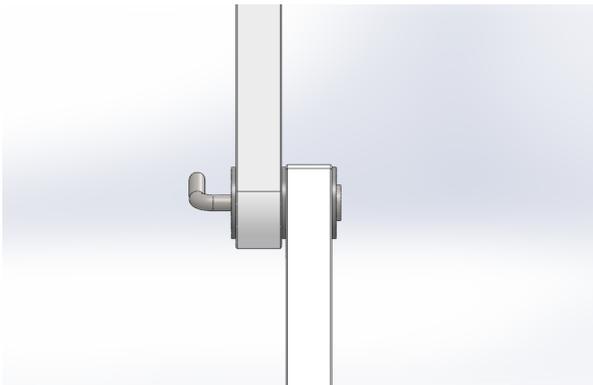
Take 2 more pulleys (JIMMYMA-2052) and 2 captive pins (JIMMYMA-2054) and slide the pulleys, one each, onto the pins. These pulleys should also rotate freely on the pins. Once they do the captive pins will be pressed into the two holes on the front of the upper motor mount. Make sure not to press the pulleys tightly against the motor mount or it will not rotate.



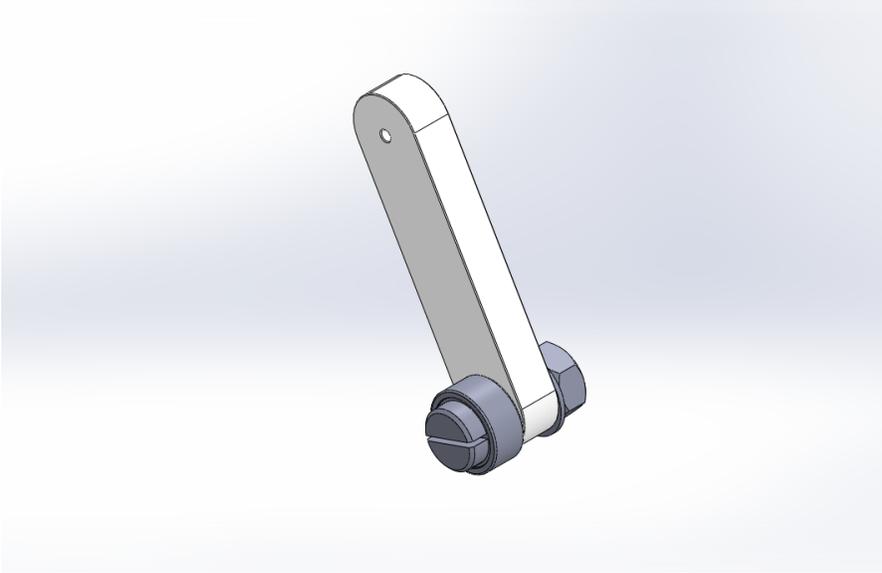
Take the upper motor mount and place it in the front shell above the lower motor mount. Use the remaining 4 #4 machine screws (JIMMYMA-2041), 8 #4 flat washers (JIMMYMA-2039), and 4 #4 hex nuts (JIMMYMA-2040) to attach the lower motor mount to the shell. The screws should be in the same orientation as the screws mounting the lower motor mount.



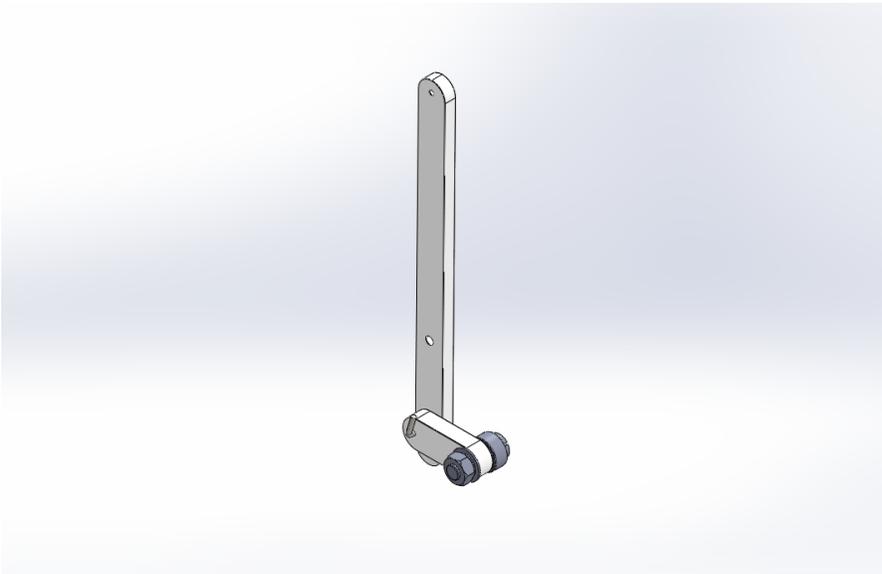
The cam followers need to be partially assembled before they are placed into the front shell. The cam follower (JIMMYMA-2009), in the bottom part of the image, is attached to the two arm lever (JIMMYMA-2016). The two arm lever is attached to the flux capacitor linkage (JIMMYMA-2024) using 3 #0 flat washers (JIMMYMA-2025) and a cold formed pin (JIMMYMA-2022).



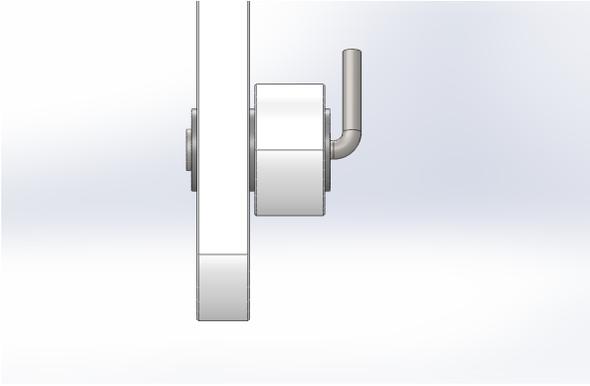
The order of the linkages, washers, and pin above. The left side of the image is the part of the assembly that is farthest out of the front shell.



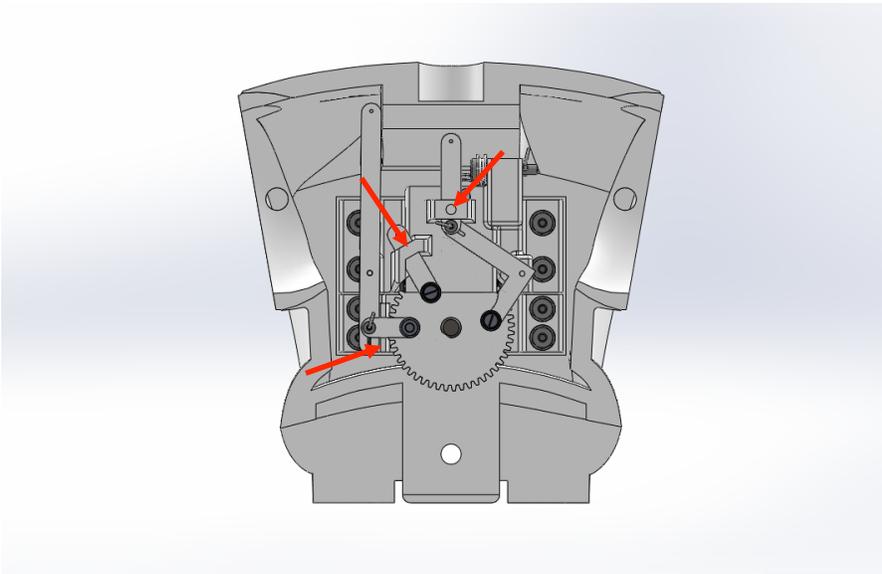
The hug holder (JIMMYMA-2029) and another cam follower (JIMMYMA-2009) attached in the same way as the follower for the two arm lever.



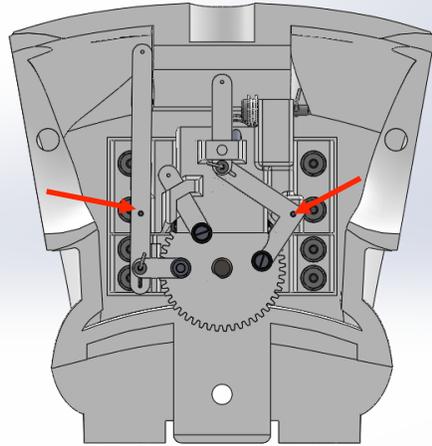
The one arm lever (JIMMYMA-2014) and the final cam follower (JIMMYMA-2009) attached in the same way as the follower for the two arm lever.



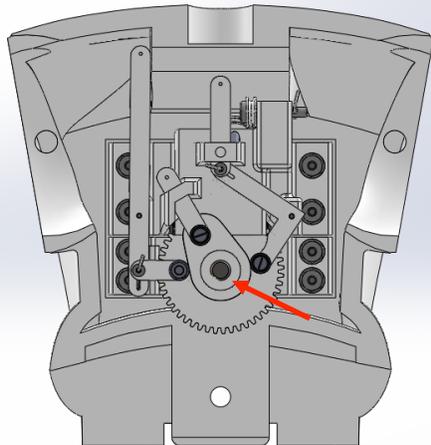
The order of the linkages, washers, and pin above. The right side of the image is the part of the assembly that is farthest out of the front shell.



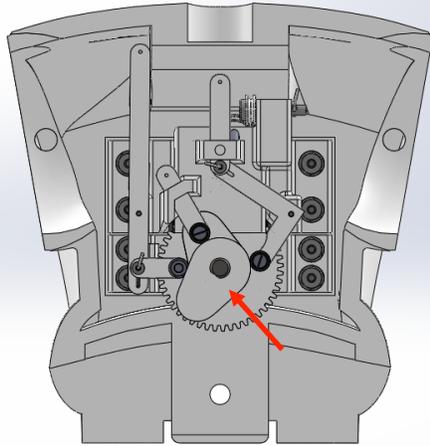
Slide the 3 cam followers assembled earlier into their corresponding “holders”



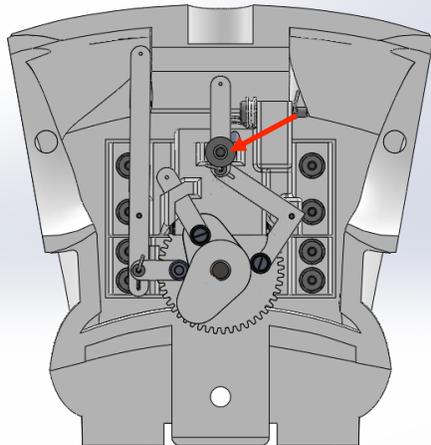
Press dowel pins (JIMMYMA-2028) into the upper motor mount. Be careful not to break the linkages. The linkages should now lie nearly flush against the portion of the upper motor mount that the pins were pressed into.



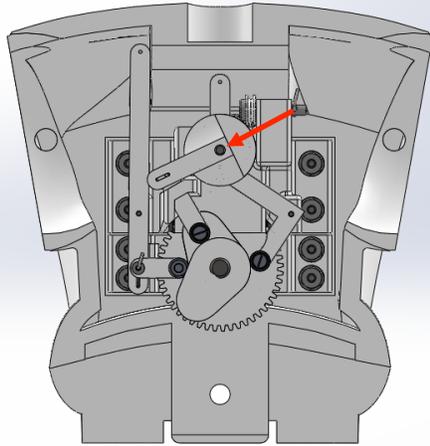
Take the arm raising cam (JIMMYMA-2017) and press it onto the d-shaft. The arm raising cam is the larger of the two cams and the cam followers may need to be moved slightly to allow the cam to go down the shaft. Make the back of the cam flush with the face of the 48 tooth gear.



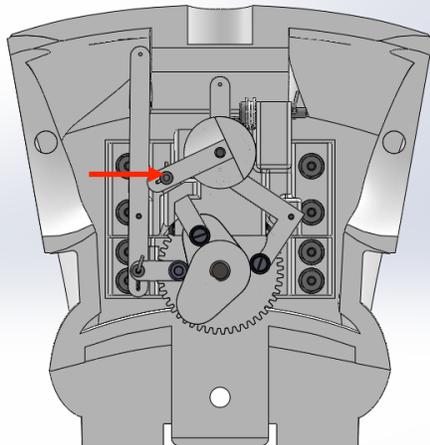
Fit the hugging cam (JIMMYMA-2018) onto the d-shaft so that its back face is flush with the front face of the arm raising cam. Once again the cam followers may need to be moved to allow the cam to fit onto the shaft.



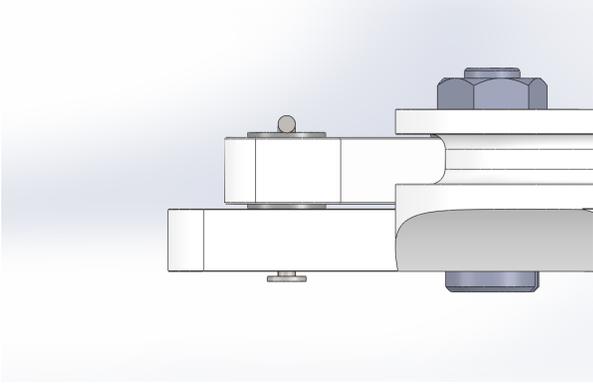
Press the dowel pin (JIMMYMA-2044) into the upper motor mount and then slide a flat washer (JIMMYMA-2045) onto it.



The spool gear (JIMMYMA-2015) goes after the washer onto the pin in the upper motor mount.

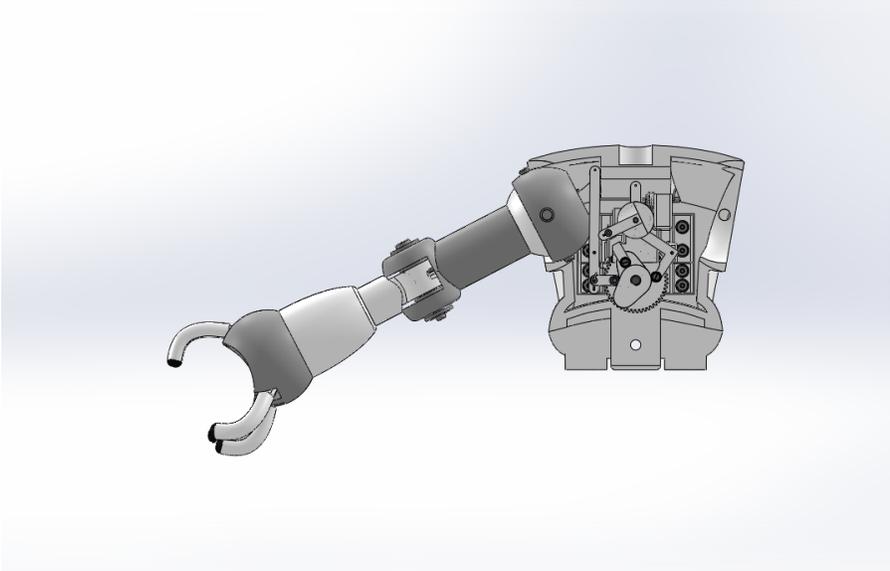


Connect the spool gear and the hug holder using 3 #0 flat washers (JIMMYMA-2025) and a cold formed pin (JIMMYMA-2022).

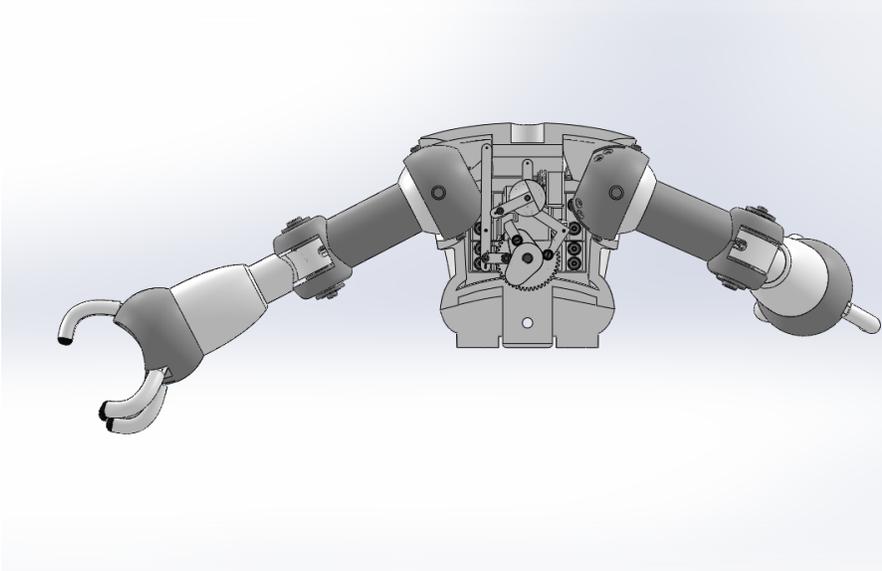


The order of the linkages, washers, and pin above. The left side of the image is the part of the assembly that is farthest out of the front shell.

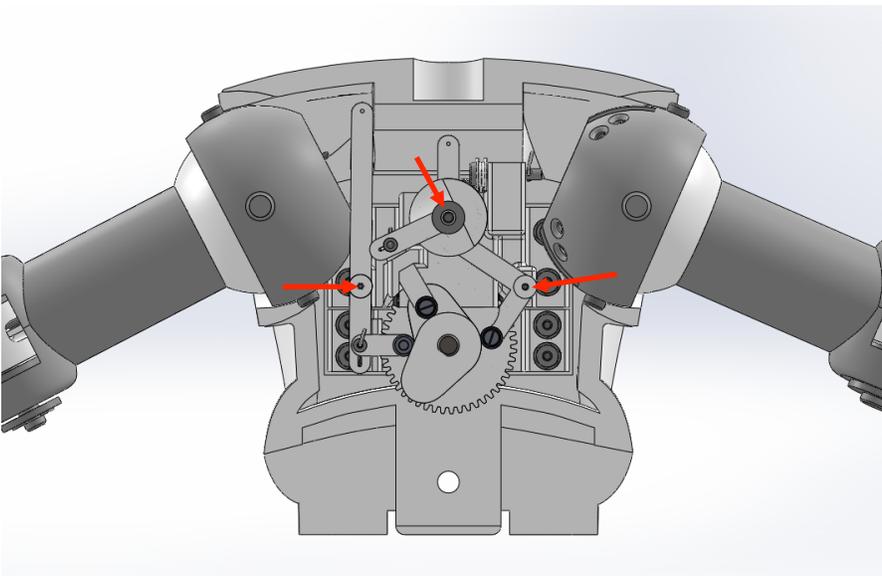
Refer to Arm Assembly Instructions for how to assemble arms



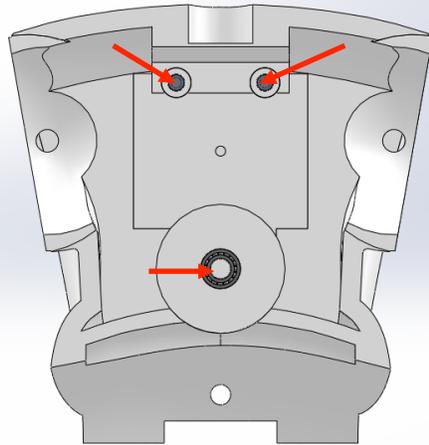
Press the left arm into the socket part of the front shell.



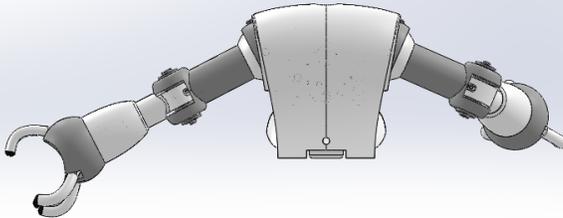
Press the right arm into the socket part of the front shell.



Slide the long spacer (JIMMYMA-2049) onto the left most dowel pin. Slide the short spacer (JIMMYMA-2028) on to the right most dowel pin. Slide another flat washer (JIMMYMA-2045) onto the dowel pin with the spool gear.



Take the back shell and press the bearing (JIMMYMA-2026) into the bottom hole. Take 2 pulleys (JIMMYMA-2052) and 2 captive pins (JIMMYMA-2054) and slide the pulleys onto each of the pins. These pulleys should also rotate freely on the pins. Once they do press the captive pins into the two holes on the top of the back shell.



Now the front and back shells can be pressed together.

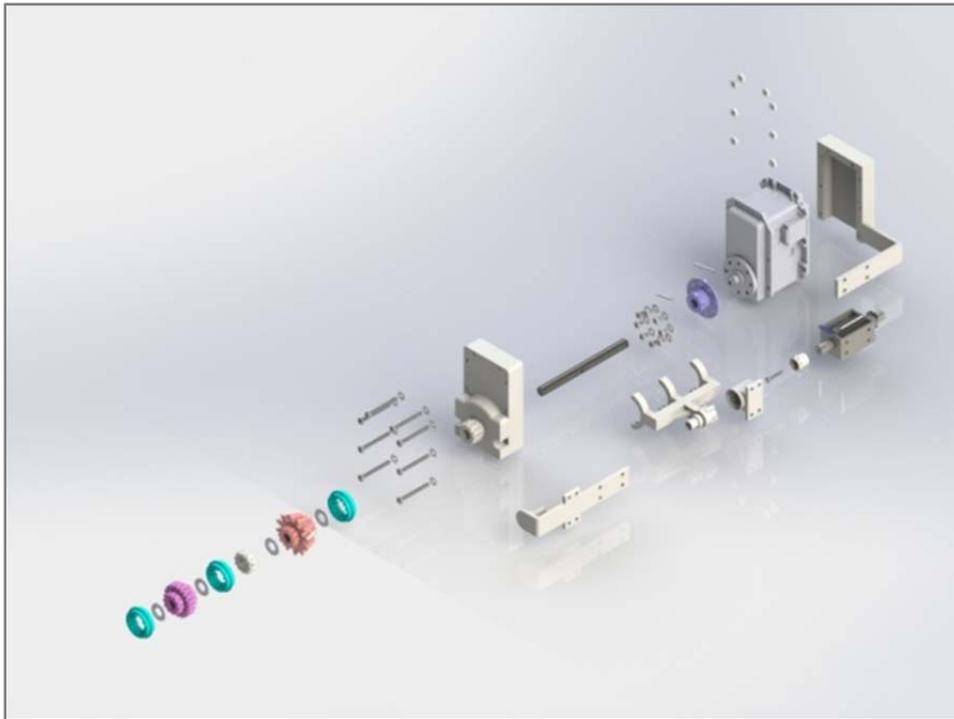
Portions of the torso are placed under large amounts of force. Parts like linkages may have to be fiber glassed and painted with a coat of epoxy in order to withstand the forces. Refer to the West System website for fiberglass information.

## Jimmy-M Transmission Assembly Instruction

The transmission subassembly in the Jimmy-M head assembly is responsible for driving both the “nod” and “tilt” motions and switching between the two, all while using a single motor. It utilizes a clutch mechanism based on a mechanical pen, driven by a solenoid.

Once the entire transmission subassembly has been put together, the entire system can be dropped into the head.

Herein we will refer to parts with a description and list their part number.



## 1. Assembling the transmission

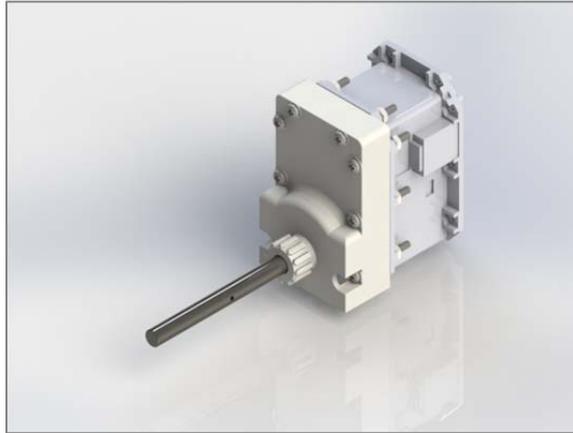
- a. Fasten the motor horn (1018) to the motor (1011) using 8 M2 x 0.45 mm screws (1034) and 8 M2.5 washers (1032). Note that while M2 washers may certainly be used, M2.5 should be functional and are used elsewhere in the assembly.



- b. Secure the drive shaft (1029) to the motor horn with a 1/16 x 3/4 in spring pin (1021).



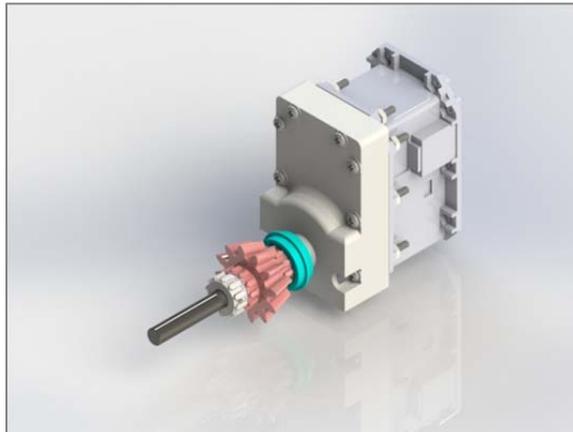
- c. Fasten the motor face plate (1019) to the motor with 8 M2.5 x 25 mm bolts (1031) along with their corresponding washers (1032) and nuts (1033).



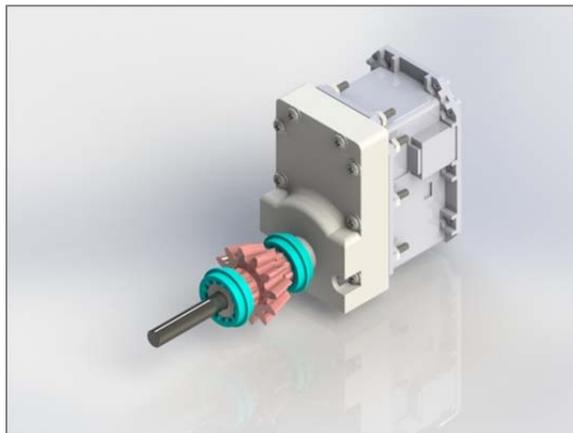
- d. Slide a collar (1016) onto the shaft, followed by a spacer (1020), the small bevel gear (1012), another spacer (1020), and the driving transmission gear (1017), in that order. Be sure to orient the small bevel gear such that the smaller gear face is facing toward the motor, as pictured. The bevel gear should be free to spin about the shaft, but the driving transmission gear should be tighter.



- e. Fasten the driving transmission gear to the shaft via a 1/16 x 9/16 in spring pin (1030).



- f. Slide another collar (1016) onto the shaft and onto the driving transmission gear. Orient the collar such that the “missing” teeth align with the spring pin.



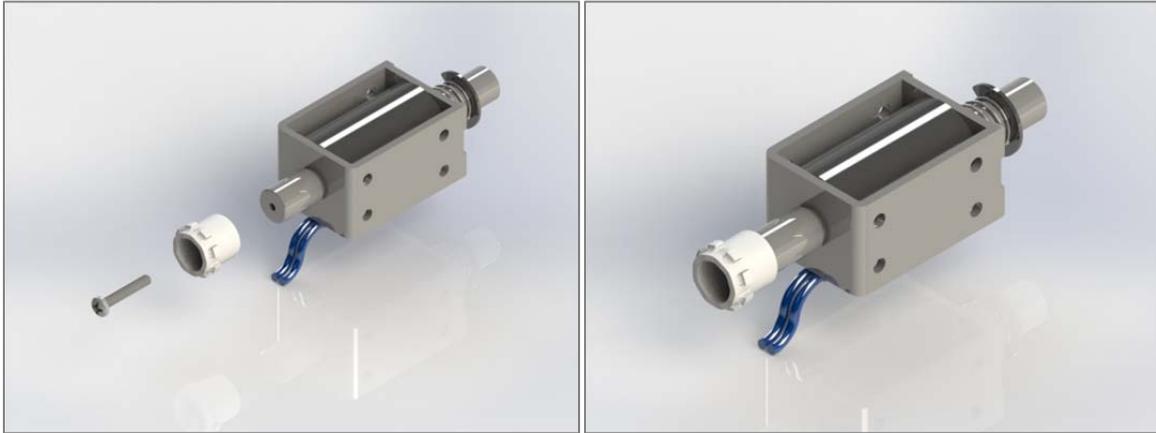
- g. Slide a spacer (1020), the small spur gear (1015), another spacer (1020), and another collar (1016) onto the shaft, in that order. The small spur gear should be free to spin about the shaft.



## 2. Assembling the solenoid pen-clutch



- a. Fasten the clutch button (1026) to the solenoid (1300) with an M2 x 12 mm screw (1023).



- b. Slide the clutch tube (1024) over the clutch button.



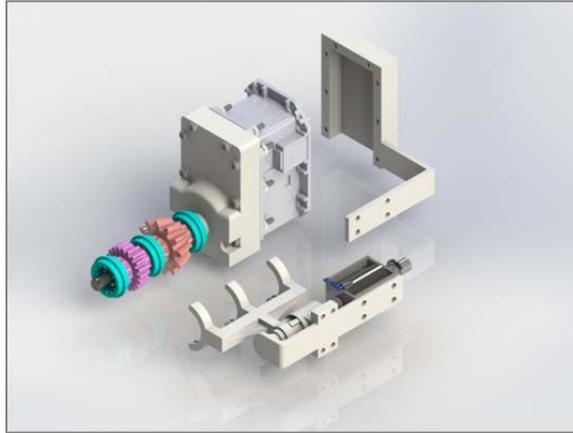
- c. Slide the compression spring (1027) into the rotary clutch element (1025) and slide this into the clutch tube (1024). Note that, while not shown, the rotary clutch element and the collar-clutch coupler (1022) are printed together as concentric pieces in this first-stage prototype; as such, the collar-clutch coupler is directly coupled with the rotary clutch element.



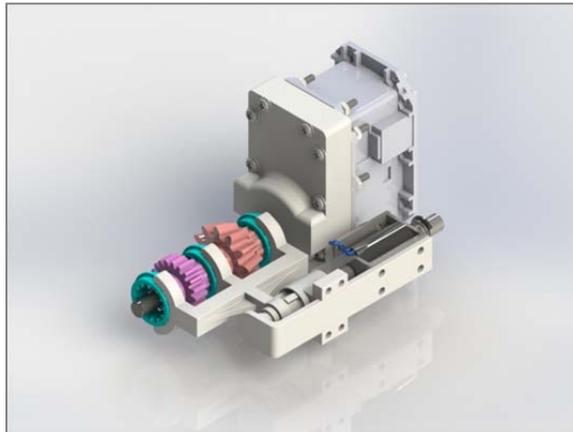
- d. Position the clutch mount (1028) such that the compression spring (1027) fits around the outside of the inner cylinder while resting within the outer cylinder. Fasten the clutch mount to the clutch tube with 4 4-40 screws (not included in CAD files).



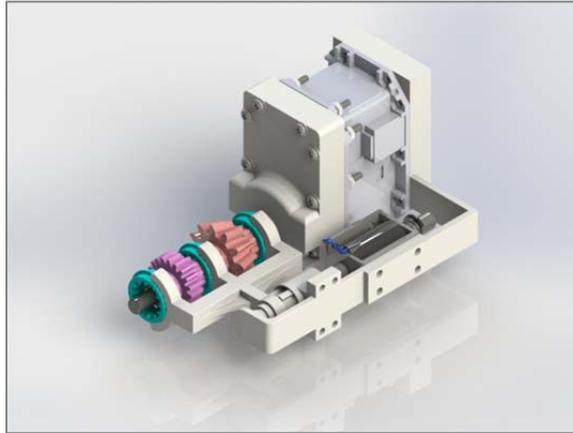
### 3. Joining the solenoid pen-clutch to the transmission



- a. Position each collar (1016) such that it rests in its corresponding guide channel in the collar-clutch coupler (1022).



- b. Fasten the solenoid (1300) and clutch mount to the motor mount (1038) with four M3 bolts, washers, and nuts (not included in CAD files).



- c. Fasten the motor mount (1038) to the rear of the motor (1011) with 4 M 2.5 bolts, washers, and nuts (not included in CAD files). Do not insert fasteners into the lower four holes at this time.

*Aaron Crenshaw*

## Head Assembly Instructions

By Laurel A. Kroo, Olin College of Engineering

We begin assembly with the neck piece. Fix the neck to the shoulders as shown with a high-strength epoxy such as the one suggested in our bill of materials. This piece is fixed and does not move with respect to the torso.

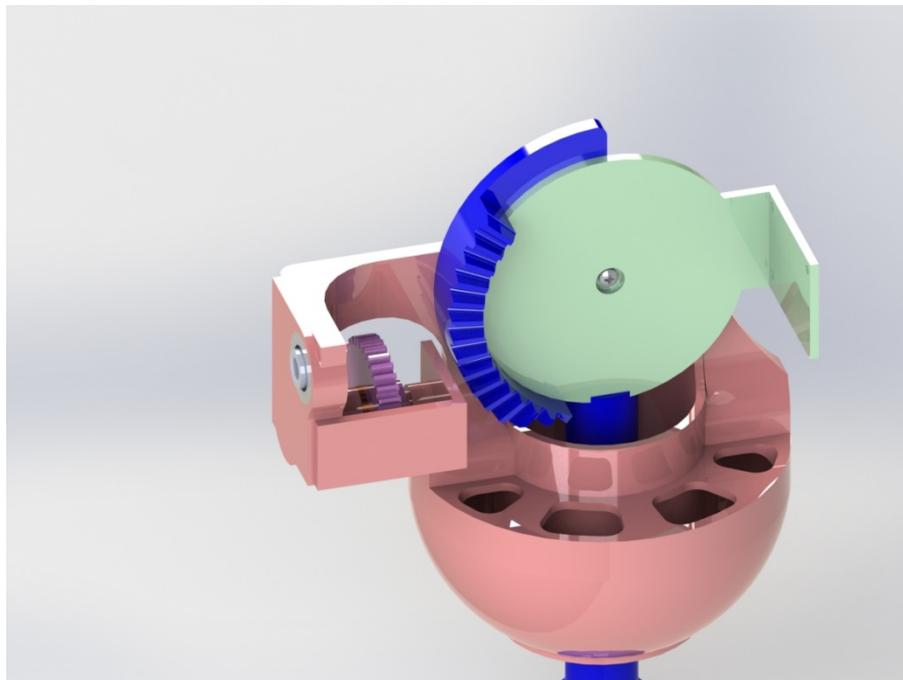
Next, we will assemble the head nodding and tilting mechanisms. Begin by taking the chin piece (denoted in red) and inserting appropriate bearing surfaces. In the bottom part, press-fit two flange sleeve bearings (McMaster part number 6338K413) into the chin bottom axis. Press fit a flanged ball bearing (McMaster part number 6383K213) into the cantilevered upper structure, rotating about an axis perpendicular to the bottom axis. These three bearings are shown in place below:



Next, take the printed gear with part number JIMMYMA-1014 and press fit a flanged sleeve bearing into its bore. This gear and bearing piece should then be threaded onto the RP rod which is part of the chin piece, coming out below parallel to the axis through the ball bearing on this piece. Finish this pre-assembly with gluing part JIMMYMA-1038 around this mounted gear to support the end of the shaft.

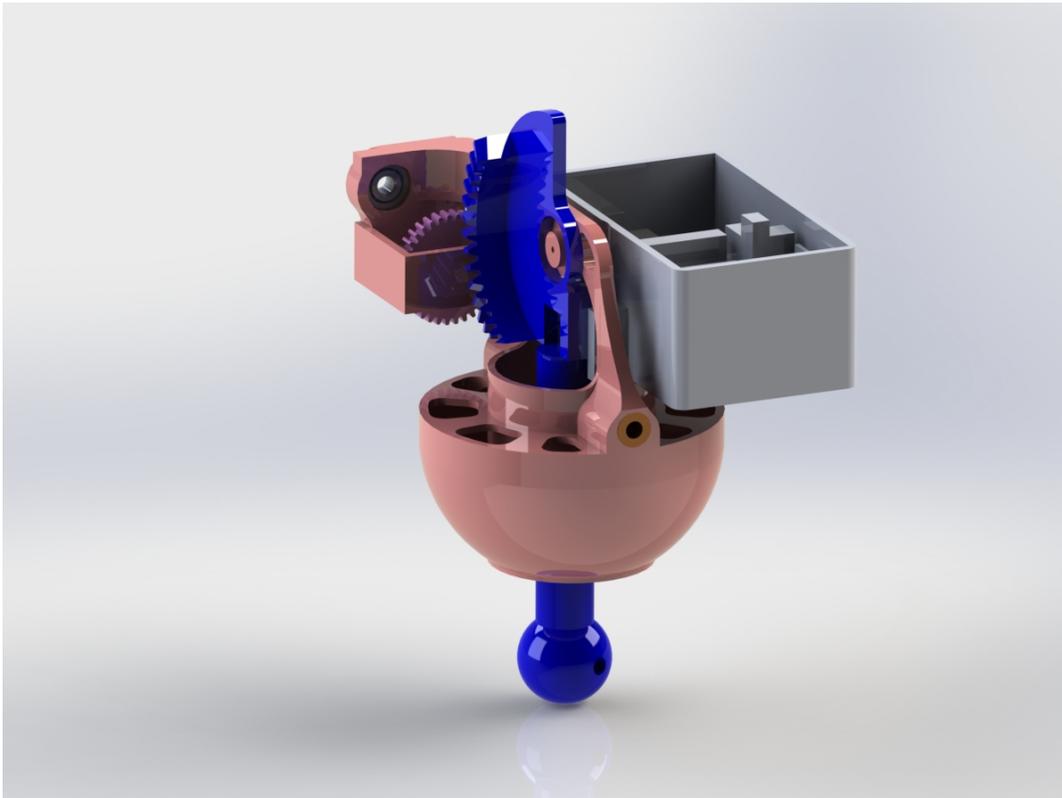


We will now integrate this piece with the rest of the robot. Carefully place this entire assembly over the neck as shown. Attach the large bevel gear shown in blue to the neck d-shaft and thread the short attachment rod on the chin piece through the center of the blue bevel gear. Finally, add the motor plate (notated in green) on the other side of the bevel gear. This motor plate has a counter bore that faces away from the bevel gear piece, into which a 4-40 screw should be used to fix the chin piece to the motor plate. The chin assembly and motor plate should rotate together and freely with respect to the head (this will eventually become Jimmy's nodding expression). This will resemble a turntable design, where the motor plate rotates within the blue bevel gear.

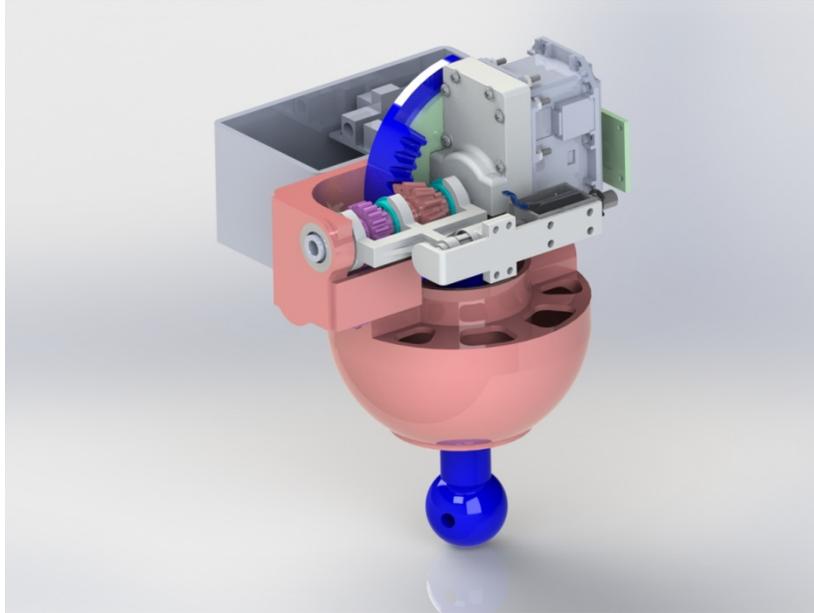


### Picture of chin with neck and turntable

Next, take all electronics and place in the electronics mounting box. This box should be glued directly to the opposite side of the neck shaft to the turntable. Note that some simple CAD modifications will need to be done to the neck to allow for wires to be routed to lower body. It is noted that the electronics constitute substantial weight, thus are mounted rigidly to the neck. This essentially means all nodding and tilting expressions will be only bearing the loads of the motor and transmission elements – not the weight of the entire power and controls system.



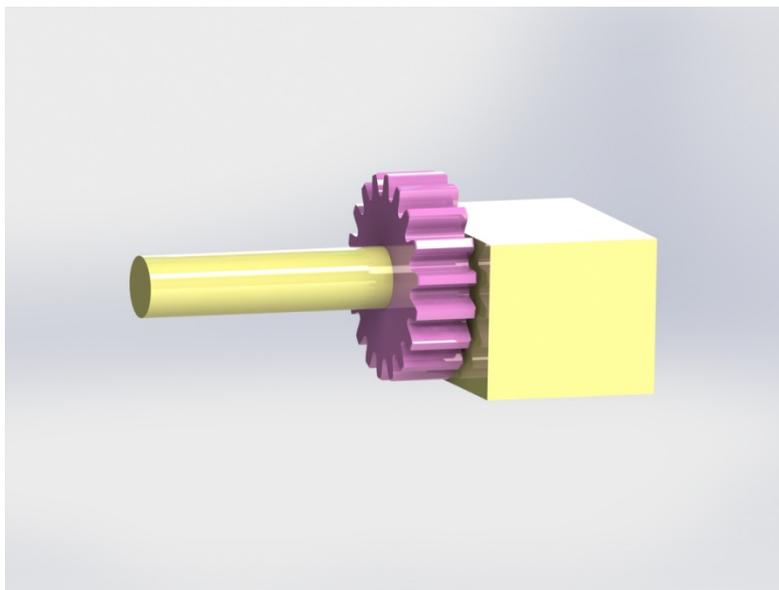
In the previous section, you will have assembled a complex transmission system, powered by a DYNAMIXEL servo motor and triggered with a Trossen Robotics solenoid. Take this motor-transmission sub assembly and mount it directly to the motor mounting plate (part number JIMMYMA-1005).



The small bevel gear (red) in the transmission should couple perfectly with the large bevel gear (blue) attached rigidly to the neck. The small purple spur gear in the transmission should also couple to the large purple spur gear that was initially mounted to the chin (slightly loose gear mate to avoid over-constraining the motor mounting process).

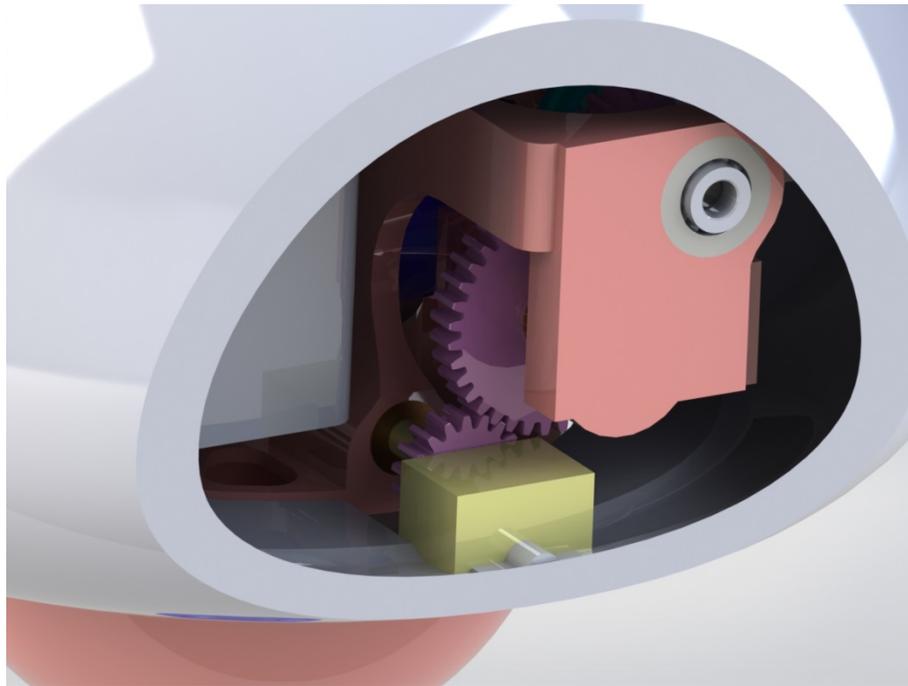
All wire routing needs to be done at or before this point in the assembly.

The next step is to take one of the two head-to-chin couplers (JIMMYMA-1009, depicted in yellow) and rigidly attach a spur gear (JIMMYMA-1015, smallest purple gear) to the RP shaft. We suggest using a high-strength epoxy and mounting the spur gear as far from the end of the shaft as possible.



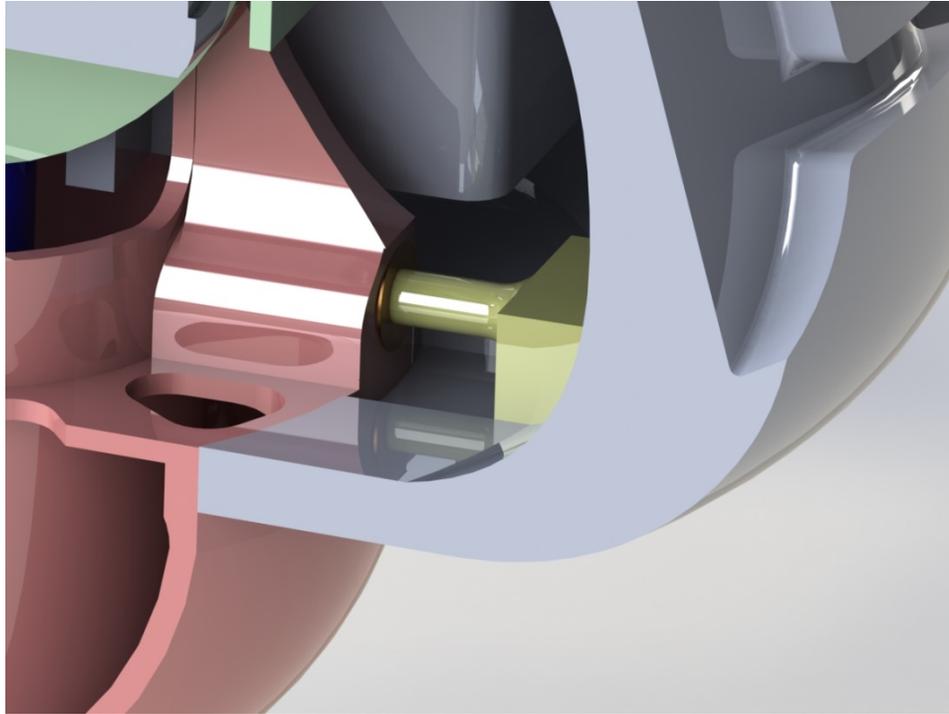
## Picture of coupler with spur gear

Our final step is to attach the head fairing, which is RP printed in 2 interlocking pieces. First, thread the coupler shaft (yellow piece) with the rigidly attached spur gear into the flanged sleeve bearing near the transmission. The spur gear should couple with the other two larger spur gears as pictured. Next, take the back head piece and slide the coupler shaft into the back of the head. Fasten the coupler to the head with four 4-40 bolts through the underside of the back of the head (fastener features may need to be added here in the CAD).

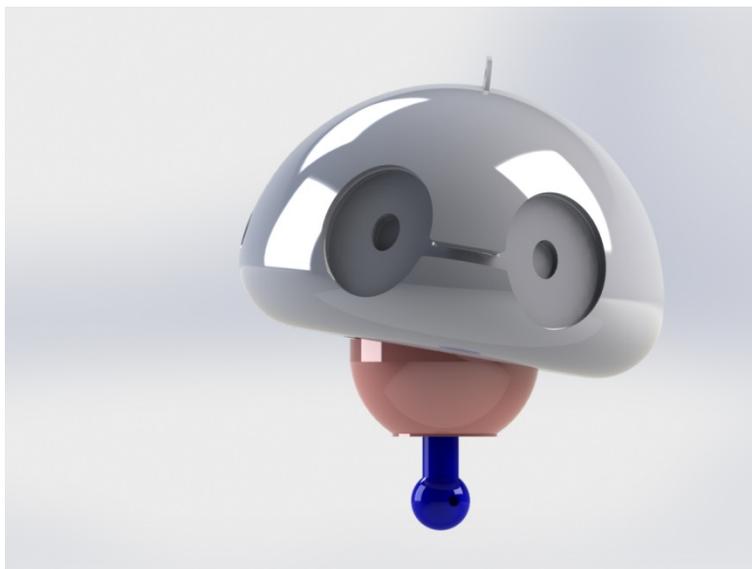


CUTAWAY Picture of back of head with back fairing attached

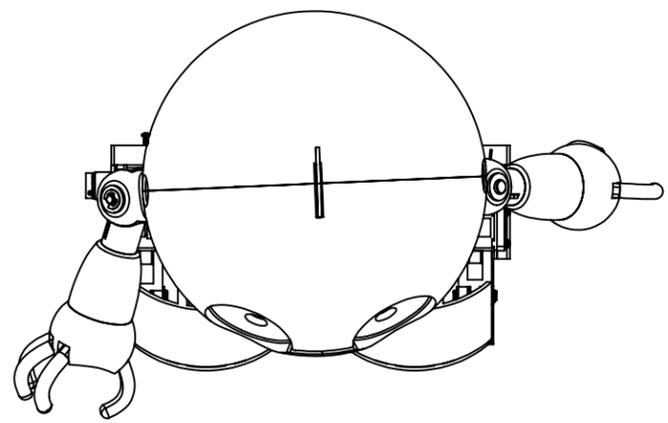
A similar technique is used for the front of the head. Slide the coupler shaft into the sleeve bearing in the front of the chin. Both couplers should rotate freely with respect to the chin. Slide the head fairing onto the coupler-chin structure and fasten again from the underside of the front of the head.



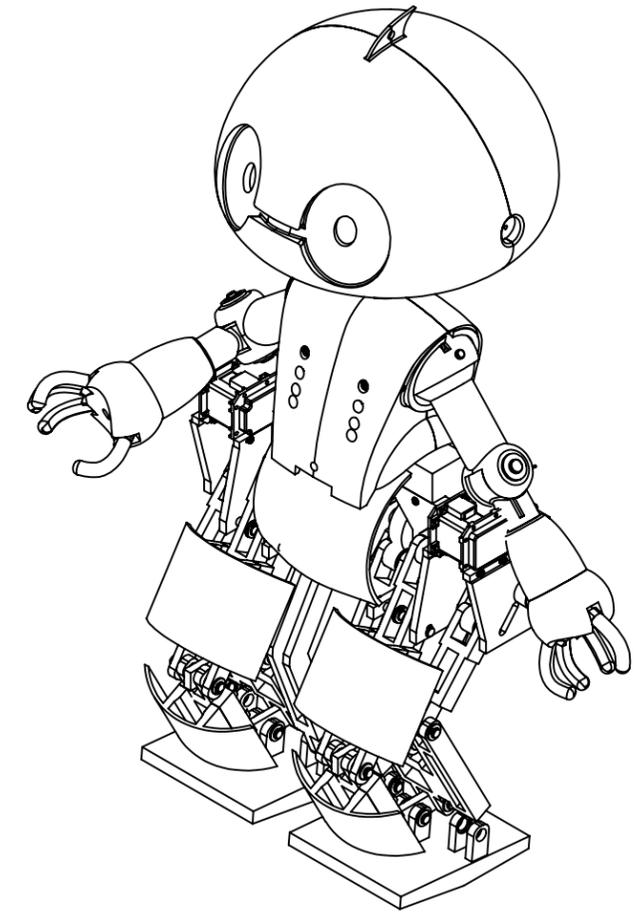
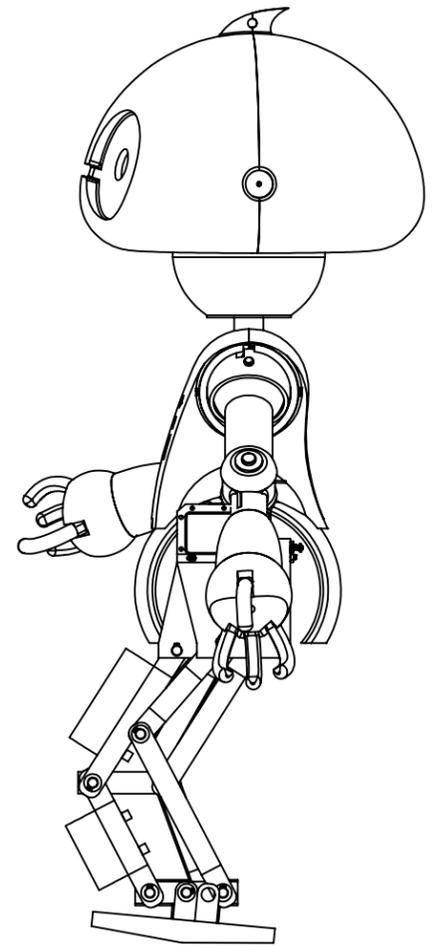
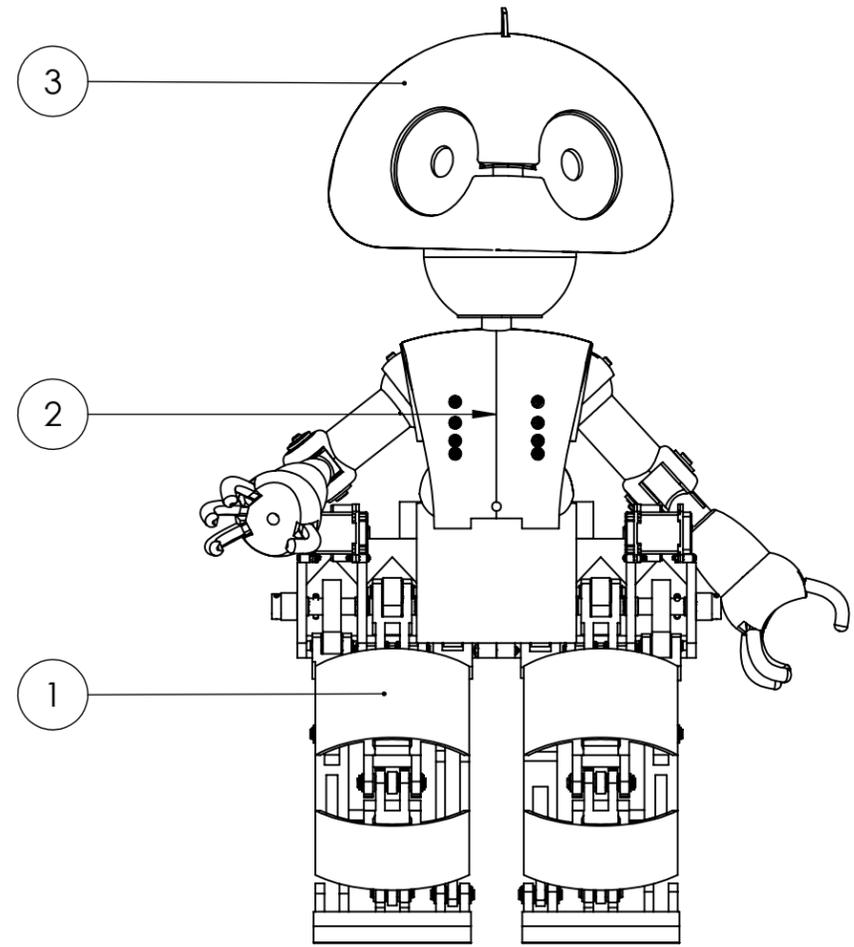
Finally, connect the front and back head fairings using 4-40 screws in the ears. Details for this final assembly fastening may need to be added to the fairing design CAD to complete this final step. With this final step, you have assembled Jimmy's head – allowing full control of two degrees of freedom in the head with the clutch. This leads to an enormous number of potential expressions with a single actuator – from an enthusiastic nod to an inquisitive head tilt.



8 7 6 5 4 3 2 1



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	JIMMYMA-3000	Legs Subassembly for locomotion	1
2	JIMMYMA-2000	Torso Subassembly for arm expressions	1
3	JIMMYMA-1000	Head Subassembly for nod and tilt mechanisms	1



**QTY: 1**

UNLESS OTHERWISE SPECIFIED:	
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.	PERPENDICULARITY: $\perp$ 0.001" / INCH
DIMENSIONS ARE IN INCHES.	CONCENTRICITY: $\odot$ 0.002" T.I.R.
DE-BURR AND BREAK ALL SHARP EDGES .003 MIN.	PARALLELISM: $\parallel$ 0.001" / INCH
TOLERANCES ARE: X.XX = $\pm 0.01$ X.XXX = $\pm 0.005$ X.XXXX = $\pm 0.001$ ANGLES: $\pm 0.5^\circ$	FLATNESS: $\square$ 0.001" / INCH
	ROUGHNESS: 125



TITLE: **JIMMY-MA**

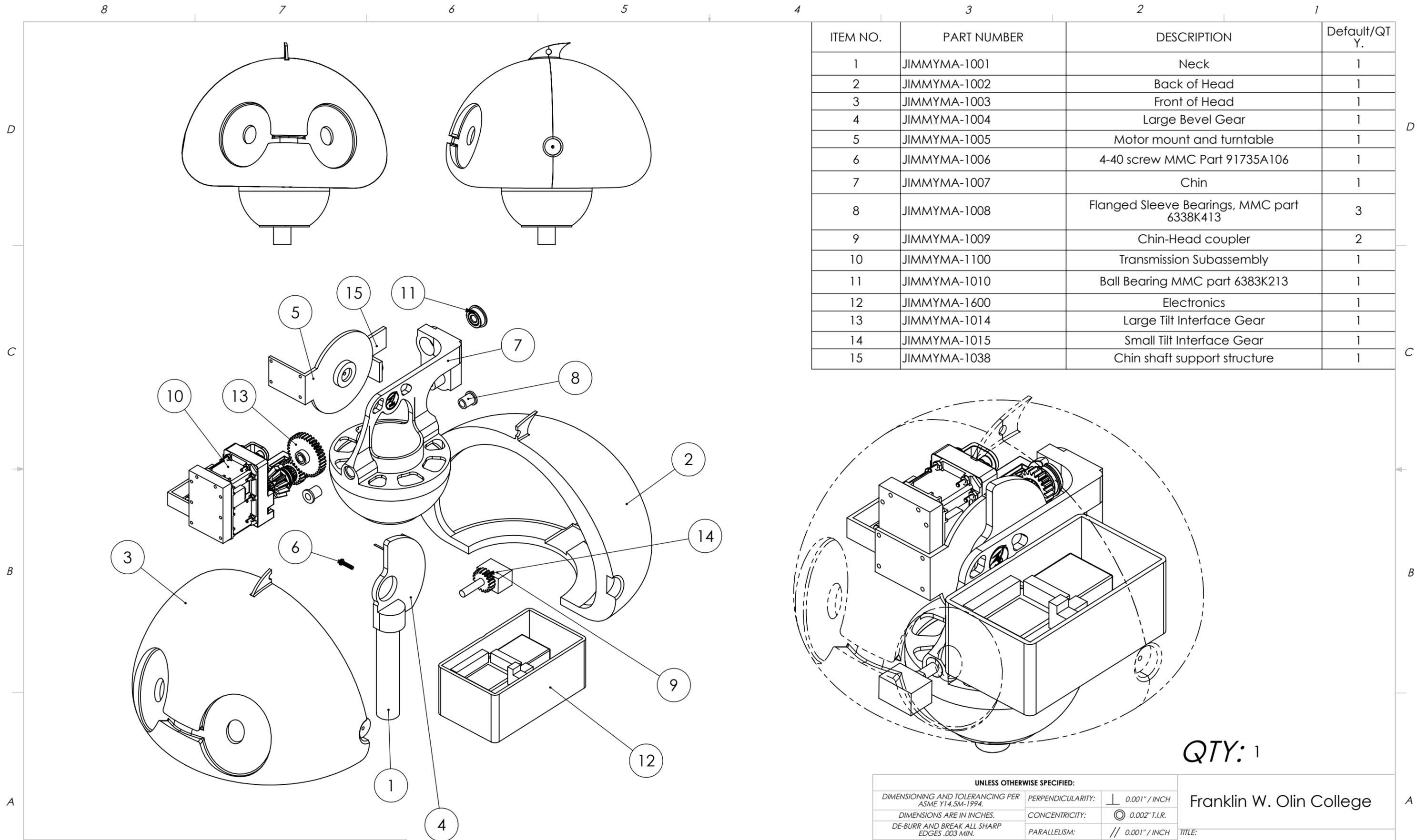
MATERIAL: **See Subassemblies and BOM**  
FINISH: **RP printed unless otherwise noted in BOM**

**NOTICE**  
THIS DRAWING IS FOR MECH-DESIGN USE AND CAN BE REDISTRIBUTED AND REUSED AT WILL.

	INIT.	DATE	SIZE	DWG. NO.	REV
ENGINEER	AC,LK,KL,ED,ZDR,OT	12/10/13	<b>B</b>	<b>JIMMYMA-0000</b>	<b>A</b>
DRAWN	LK	12/10/13			
CHECKED	AC	12/10/13			

SCALE: 1:5	DO NOT SCALE PRINT	SHEET 1 OF 1
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8 7 6 5 4 3 2 1



ITEM NO.	PART NUMBER	DESCRIPTION	Default/QT Y.
1	JIMMYMA-1001	Neck	1
2	JIMMYMA-1002	Back of Head	1
3	JIMMYMA-1003	Front of Head	1
4	JIMMYMA-1004	Large Bevel Gear	1
5	JIMMYMA-1005	Motor mount and turntable	1
6	JIMMYMA-1006	4-40 screw MMC Part 91735A106	1
7	JIMMYMA-1007	Chin	1
8	JIMMYMA-1008	Flanged Sleeve Bearings, MMC part 6338K413	3
9	JIMMYMA-1009	Chin-Head coupler	2
10	JIMMYMA-1100	Transmission Subassembly	1
11	JIMMYMA-1010	Ball Bearing MMC part 6383K213	1
12	JIMMYMA-1600	Electronics	1
13	JIMMYMA-1014	Large Tilt Interface Gear	1
14	JIMMYMA-1015	Small Tilt Interface Gear	1
15	JIMMYMA-1038	Chin shaft support structure	1

**QTY: 1**

UNLESS OTHERWISE SPECIFIED:	
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.	PERPENDICULARITY: $\perp$ 0.001" / INCH
DIMENSIONS ARE IN INCHES.	CONCENTRICITY: $\odot$ 0.002" T.I.R.
DE-BURR AND BREAK ALL SHARP EDGES .003 MIN.	PARALLELISM: $\parallel$ 0.001" / INCH
TOLERANCES ARE:	FLATNESS: $\square$ 0.001" / INCH
X.XX = $\pm 0.01$	ROUGHNESS: 125
X.XXX = $\pm 0.005$	
X.XXXX = $\pm 0.001$	
ANGLES: $\pm 0.5^\circ$	

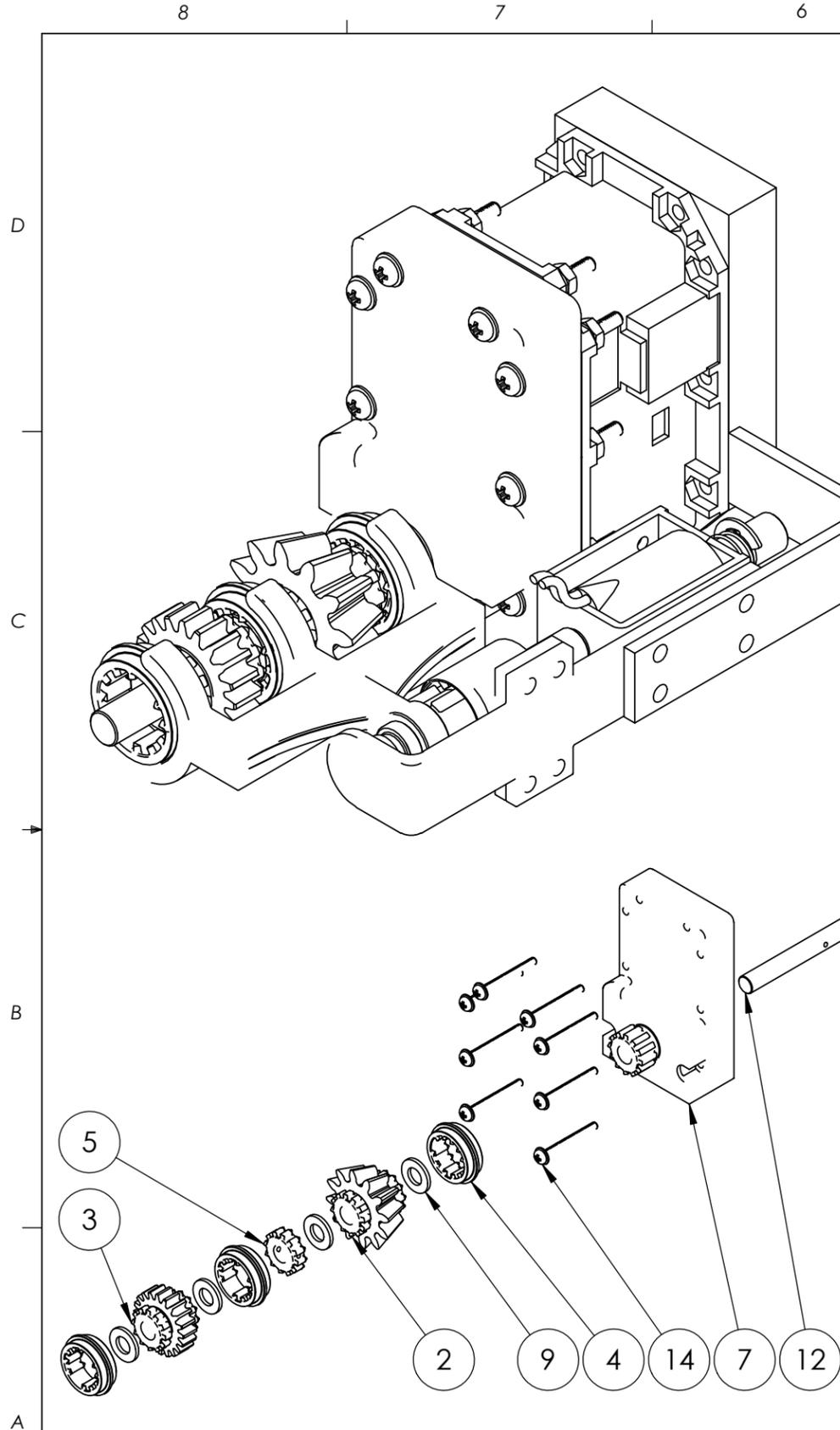
Franklin W. Olin College	
TITLE: <b>JIMMYMA</b>	

MATERIAL: **RP unless noted with MMC no. in BOM**  
 FINISH: none

**NOTICE**  
 THIS DRAWING IS FOR MECH-DESIGN USE AND CAN BE REDISTRIBUTED AND REUSED AT WILL.

	INIT.	DATE	SIZE	DWG. NO.	REV
ENGINEER	LK	12/10/13	<b>B</b>	<b>JIMMYMA-1000</b>	<b>A</b>
DRAWN	LK	12/10/13	SCALE: NONE	DO NOT SCALE PRINT	SHEET 1 OF 1
CHECKED	AC	12/10/13			

SCALE: NONE	DO NOT SCALE PRINT	SHEET 1 OF 1
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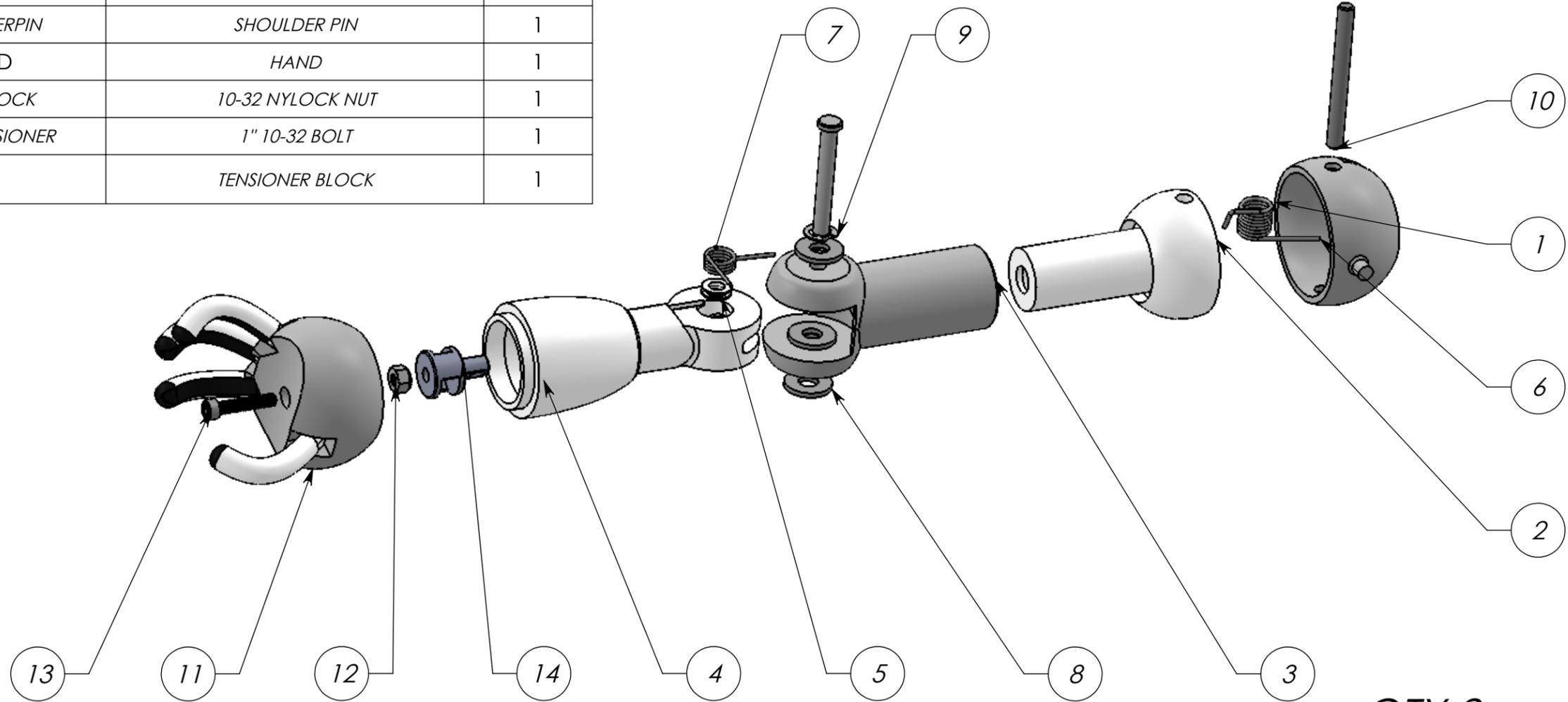
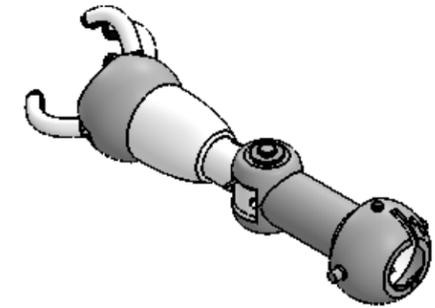


ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	JIMMYMA-1011-motor	Dynamixel MX-106R	1
2	JIMMYMA-1012-LittleBevelGear	Small bevel gear	1
3	JIMMYMA-1013-TiltSpurGear	Tilt-control spur gear	1
4	JIMMYMA-1016-clutchsleeve	Clutch sleeve	3
5	JIMMYMA-1017-transmissionDriveGear	Driving transmission gear	1
6	JIMMYMA-1018-motorhorn	Motor horn	1
7	JIMMYMA-1019-motorfaceplate	Motor faceplate	1
8	JIMMYMA-1200-solenoid_drive	Solenoid drive	1
9	JIMMYMA-1020-shaftSpacer	Nylon washer, McMaster-Carr 90295A441	4
10	JIMMYMA-1021-springPin	1/16 x 3/4 inch spring pin, McMaster-Carr 92373A113	1
11	JIMMYMA-1022-Pen_Collar_Coupling	Collar-clutch coupler	1
12	JIMMYMA-1029-transmission_drive_shaft	Transmission drive shaft	1
13	JIMMYMA-1030-spring2	1/16 x 9/16 inch spring pin, McMaster-Carr 92373A110	1
14	JIMMY-1400-M2pt5x25_with_washer	M2.5 x 25 mm screw with washer	8
15	JIMMYMA-1033-nut90592A006	M2.5 nut, McMaster-Carr 90592A006	8
16	JIMMYMA-1500-fasteners	M2.5 x 0.45 mm bolt with washer	8
17	JIMMYMA-1038-MotorMount	Motor mount	1

QTY: 1

UNLESS OTHERWISE SPECIFIED:		PERPENDICULARITY: $\perp$ 0.001" / INCH		
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.		CONCENTRICITY: $\odot$ 0.002" T.I.R.		
DIMENSIONS ARE IN INCHES.		PARALLELISM: $\parallel$ 0.001" / INCH		
DE-BURR AND BREAK ALL SHARP EDGES .003 MIN.		FLATNESS: $\square$ 0.001" / INCH		
TOLERANCES ARE:		ROUGHNESS: 125 $\sqrt{\text{ }}$		TITLE: <b>JIMMYMA</b>
MATERIAL: VARIOUS		NOTICE: THIS DRAWING IS FOR MECH-DESIGN USE AND CAN BE REDISTRIBUTED AND REUSED AT WILL.		INIT. DATE SIZE DWG. NO. REV
FINISH: NONE		ENGINEER AC 12/10/13		<b>B</b> <b>JIMMYMA-1100</b> <b>A</b>
		DRAWN AC 12/10/13		SCALE: 1:2 DO NOT SCALE PRINT SHEET 1 OF 1
		CHECKED ZDR 12/10/13		

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	JIMMYMA-2001-RIGHTARMSHOULDERGIMBAL	SHOULDER GIMBAL	1
2	JIMMYMA-2006-RIGHTUPPERARM	UPPER ARM	1
3	JIMMYMA-2002-ELBOW	ELBOW	1
4	JIMMYMA-2004-FOREARM	FOREARM	1
5	JIMMYMA-2008-CABLEPULLEY	PULLEY	1
6	JIMMYMA-2032-SHOULDERSPRING	SHOULDER SPRING	1
7	JIMMYMA-2033-ELBOWSPRING	ELBOW SPRING	1
8	JIMMYMA-2027-0.25SSFLATWASHER	WASHER	4
9	JIMMYMA-2035-ELBOWPIN	ELBOW PIN	1
10	JIMMYMA-2050-SHOULDERPIN	SHOULDER PIN	1
11	JIMMYMA-2053-HAND	HAND	1
12	JIMMYMA-2047-1032NYLOCK	10-32 NYLOCK NUT	1
13	JIMMYMA-2046-1032TENSIONER	1" 10-32 BOLT	1
14	JIMMYMA-2042-TENSIONERBLOCK	TENSIONER BLOCK	1



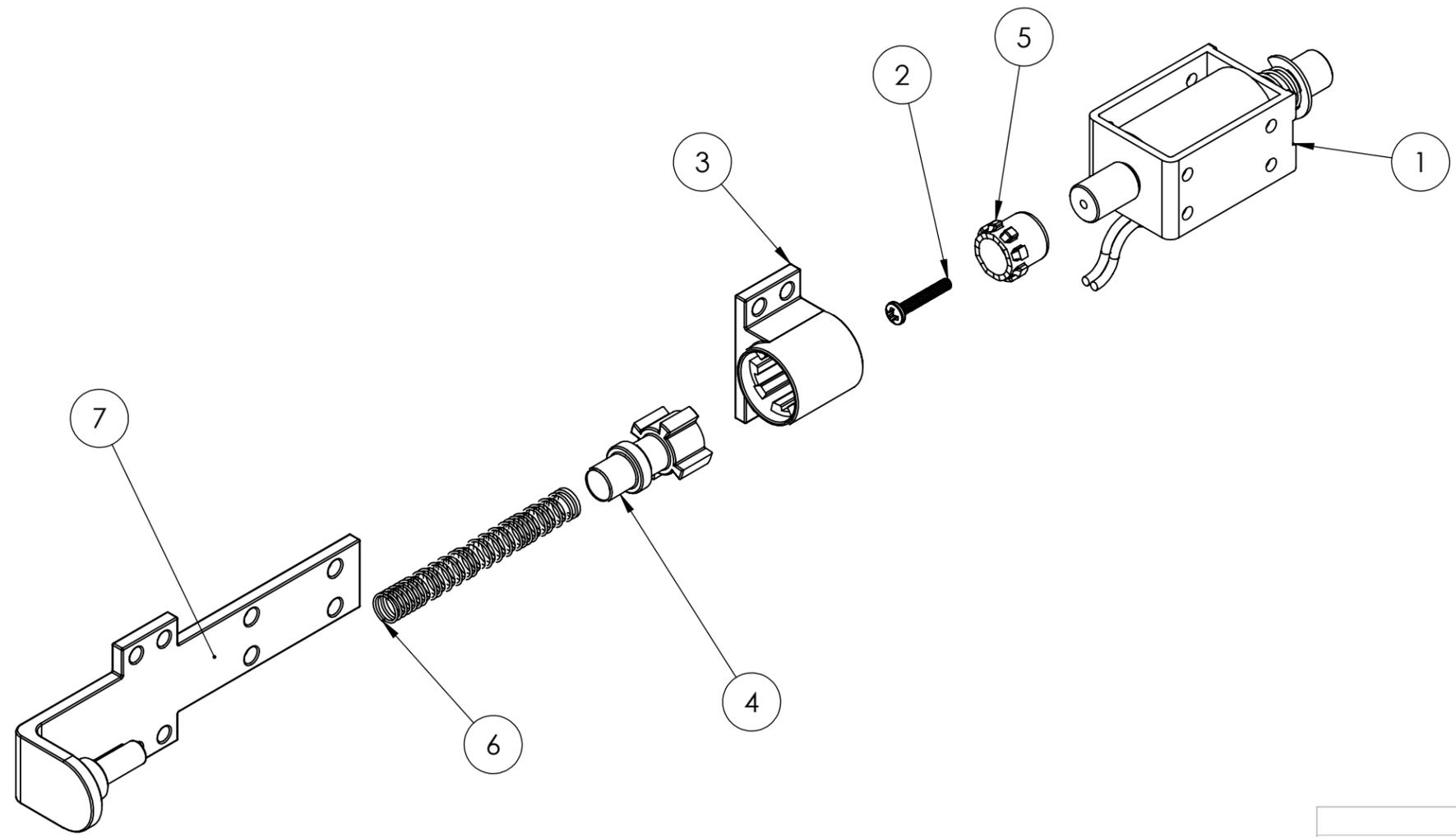
**QTY:2**

UNLESS OTHERWISE SPECIFIED:				Franklin W. Olin College of Engineering	
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.	PERPENDICULARITY:	$\perp$ 0.001" / INCH	TITLE: <b>JIMMY-MA</b>		
DIMENSIONS ARE IN INCHES.	CONCENTRICITY:	$\odot$ 0.002" T.I.R.			
DE-BURR AND BREAK ALL SHARP EDGES .003 MIN.	PARALLELISM:	$\parallel$ 0.001" / INCH			
TOLERANCES ARE:	FLATNESS:	$\square$ 0.001" / INCH			
X.XX = $\pm 0.01$	ROUGHNESS:	125 $\sqrt{\text{ }}$	MATERIAL: <b>VARIOUS</b>		
X.XXX = $\pm 0.005$	NOTICE THIS DRAWING IS FOR MECH-DESIGN USE AND CAN BE REDISTRIBUTED AND REUSED AT WILL.		ENGINEER	INIT.	DATE
X.XXXX = $\pm 0.001$			DRAWN	ED	12/10
ANGLES: $\pm 0.5^\circ$			CHECKED	ZDR	12/10
FINISH: <b>VARIOUS</b>			SIZE	DWG. NO.	REV
			<b>B</b>	<b>JIMMYMA-2300-RIGHTARMASSM</b>	<b>A</b>
			SCALE: 1:1	DO NOT SCALE PRINT	SHEET 1 OF 1

8 7 6 5 4 3 2 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	JIMMYMA-1300-solenoid	Trossen Robotics, solenoid, ASM-SOL-SM	1
2	JIMMYMA-1023-m2Bolt	M2x12mm screw, 90116A022	1
3	JIMMYMA-1024-Pen_Tube_Large	clutch tube	1
4	JIMMYMA-1025-PenBottom	rotary clutch element	1
5	JIMMAYMA-1026-Jimmy_Pen_Button	clutch button	1
6	JIMMYMA-1027-spring	McMaster spring, 9657K68	1
7	JIMMYMA-1028-Pen_end	clutch mount	1

D  
C  
B  
A



**QTY: 1**

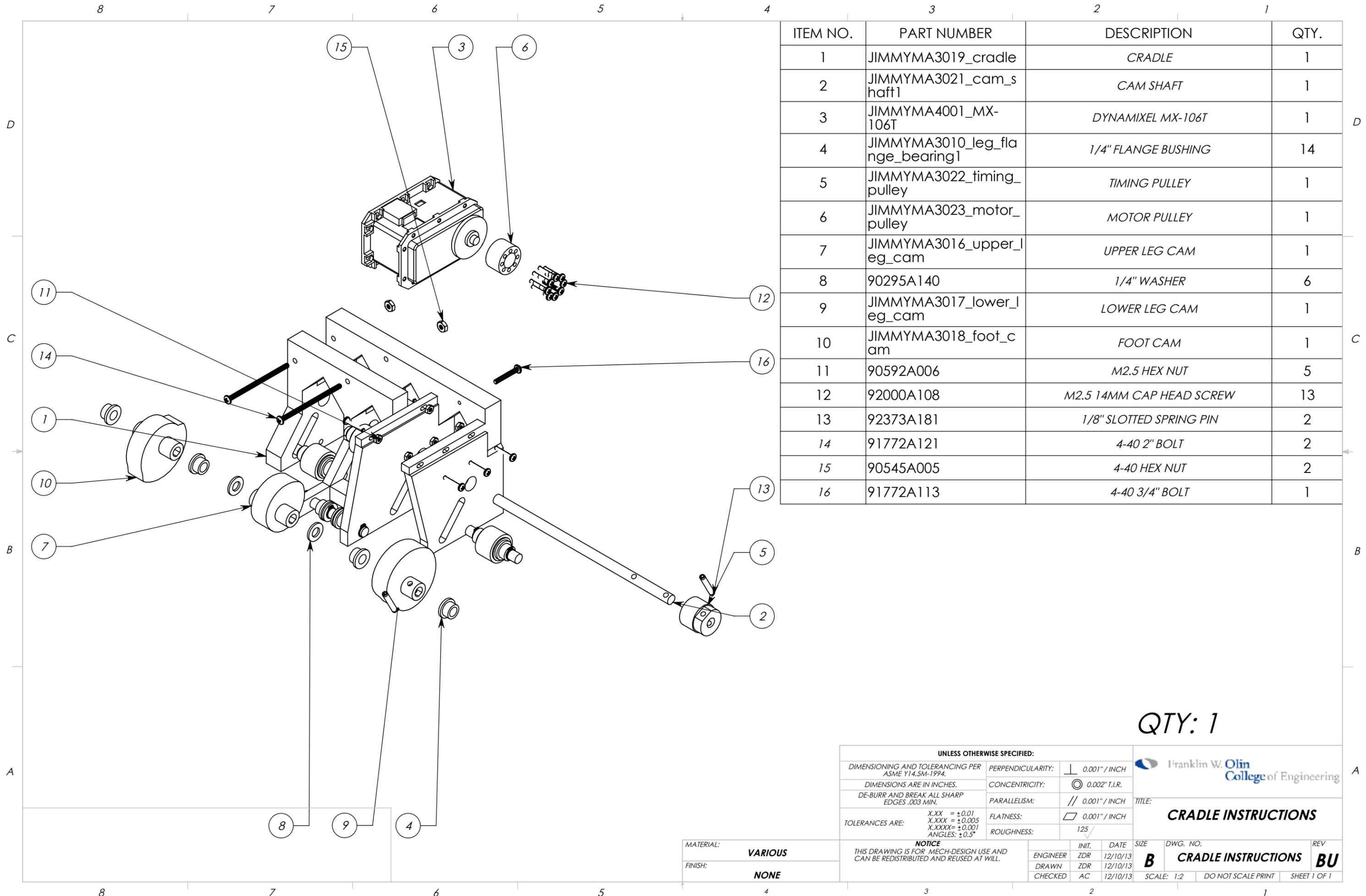
UNLESS OTHERWISE SPECIFIED:	
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.	PERPENDICULARITY: $\perp$ 0.001" / INCH
DIMENSIONS ARE IN INCHES.	CONCENTRICITY: $\odot$ 0.002" T.I.R.
DE-BURR AND BREAK ALL SHARP EDGES .003 MIN.	PARALLELISM: $\parallel$ 0.001" / INCH
TOLERANCES ARE: X.XX = $\pm 0.01$ X.XXX = $\pm 0.005$ X.XXXX = $\pm 0.001$ ANGLES: $\pm 0.5^\circ$	FLATNESS: $\square$ 0.001" / INCH
	ROUGHNESS: 125 $\sqrt{\text{ }}$



TITLE: **JIMMY-MA**

MATERIAL: <b>VARIOUS</b>	<b>NOTICE</b> THIS DRAWING IS FOR MECH-DESIGN USE AND CAN BE REDISTRIBUTED AND REUSED AT WILL.	INIT.	DATE	SIZE	DWG. NO.	REV	
FINISH:		ENGINEER	AC	12/10/13	<b>B</b>	<b>JIMMYMA-1200-solenoid_drive</b>	<b>A</b>
		DRAWN	KL	12/10/13	SCALE: 1:1	DO NOT SCALE PRINT	SHEET 1 OF 1
		CHECKED	ED	12/10/13			

8 7 6 5 4 3 2 1



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	JIMMYMA3019_cradle	CRADLE	1
2	JIMMYMA3021_cam_shaft1	CAM SHAFT	1
3	JIMMYMA4001_MX-106T	DYNAMIXEL MX-106T	1
4	JIMMYMA3010_leg_flange_bearing1	1/4" FLANGE BUSHING	14
5	JIMMYMA3022_timing_pulley	TIMING PULLEY	1
6	JIMMYMA3023_motor_pulley	MOTOR PULLEY	1
7	JIMMYMA3016_upper_leg_cam	UPPER LEG CAM	1
8	90295A140	1/4" WASHER	6
9	JIMMYMA3017_lower_leg_cam	LOWER LEG CAM	1
10	JIMMYMA3018_foot_cam	FOOT CAM	1
11	90592A006	M2.5 HEX NUT	5
12	92000A108	M2.5 14MM CAP HEAD SCREW	13
13	92373A181	1/8" SLOTTED SPRING PIN	2
14	91772A121	4-40 2" BOLT	2
15	90545A005	4-40 HEX NUT	2
16	91772A113	4-40 3/4" BOLT	1

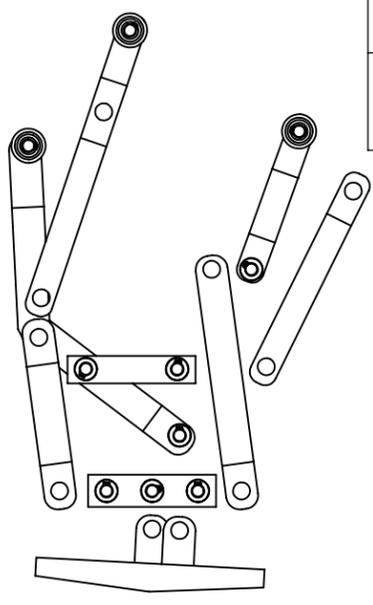
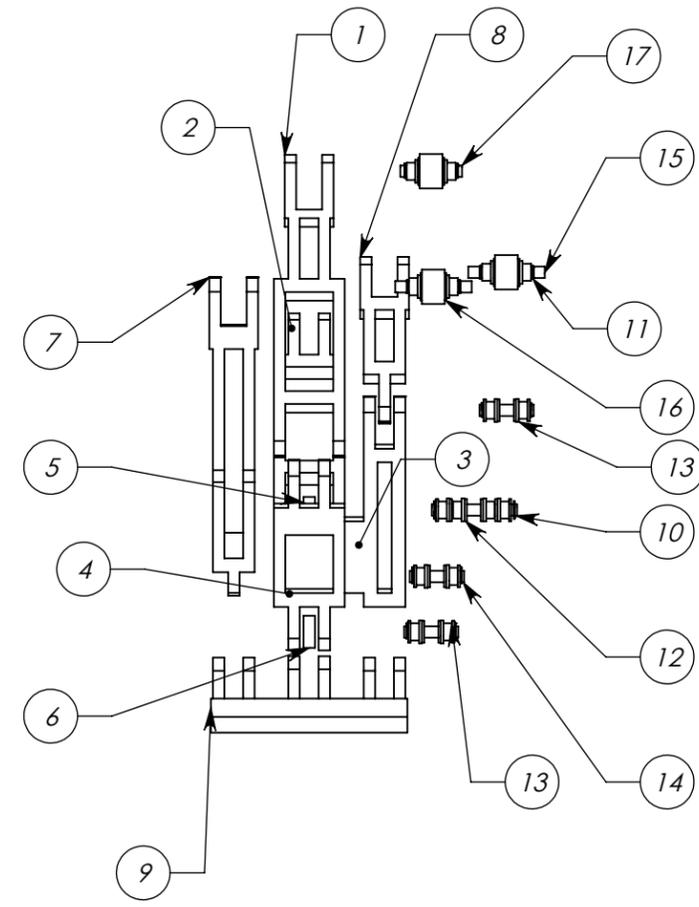
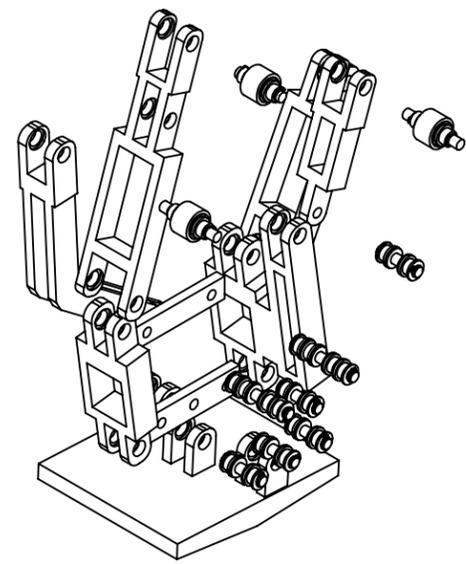
**QTY: 1**

UNLESS OTHERWISE SPECIFIED:	
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.	PERPENDICULARITY: $\perp$ 0.001" / INCH
DIMENSIONS ARE IN INCHES.	CONCENTRICITY: $\odot$ 0.002" T.I.R.
DE-BURR AND BREAK ALL SHARP EDGES .003 MIN.	PARALLELISM: $\parallel$ 0.001" / INCH
TOLERANCES ARE:	FLATNESS: $\square$ 0.001" / INCH
X.XX = $\pm 0.01$	ROUGHNESS: 125 $\sqrt{\text{ }}$
X.XXX = $\pm 0.005$	
X.XXXX = $\pm 0.001$	
ANGLES: $\pm 0.5^\circ$	



TITLE: **CRADLE INSTRUCTIONS**

MATERIAL:	<b>VARIOUS</b>	<b>NOTICE</b> THIS DRAWING IS FOR MECH-DESIGN USE AND CAN BE REDISTRIBUTED AND REUSED AT WILL.	INIT.	DATE	SIZE	DWG. NO.	REV	
FINISH:	<b>NONE</b>		ENGINEER	ZDR	12/10/13	<b>B</b>	<b>CRADLE INSTRUCTIONS</b>	<b>BU</b>
			DRAWN	ZDR	12/10/13	SCALE: 1:2	DO NOT SCALE PRINT	SHEET 1 OF 1
			CHECKED	AC	12/10/13			



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.	Unit Cost
1	JIMMYMA3004	Top Side Linkage with follower	1	2.29 in^3
2	JIMMYMA3004	Top Side Linkage no Follower	1	1.74 in^3
3	JIMMYMA3002	Bottom Side Linkage with Follower	1	4.31 in^3
4	JIMMYMA3002	Bottom Side Linkage No Follower	1	1.95 in^3
5	JIMMYMA3005	Leg Middle Cross Linkage	1	0.40 in^3
6	JIMMYMA3001	Leg Bottom Cross Linkage	1	0.45 in^3
7	JIMMYMA3006	Foot Follower linkage	1	3.02 in^3
8	JIMMYMA3008	Knee Follower Linkage	1	1.07 in^3
9	JIMMYMA3014	Foot	1	11.80
10	JIMMYMA3011	Long Pin Joint Shaft	2	0.09 in^3
11	97633A130	Retaining Ring	20	\$.0782
12	90295A140	Washer	32	\$.0595
13	JIMMYMA3010	Flange Bearing	24	\$.74
14	JIMMYMA3015	Short Pin Joint Shaft	5	0.08 in^3
15	JIMMYMA3020	Medium Pin Joint Shaft (long version)	2	0.08 in^3
16	JIMMYMA3009_leg_cam_follower	Leg Cam Follower	3	\$16.93
17	JIMMYMA3020_leg_pin_joint_shaft3_medium	Medium Pin Joint Shaft (short version)	1	0.07

**QTY: 2**

UNLESS OTHERWISE SPECIFIED:	
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.	PERPENDICULARITY: $\perp$ 0.001" / INCH
DIMENSIONS ARE IN INCHES.	CONCENTRICITY: $\odot$ 0.002" T.I.R.
DE-BURR AND BREAK ALL SHARP EDGES .003 MIN.	PARALLELISM: $\parallel$ 0.001" / INCH
TOLERANCES ARE: X.XX = $\pm 0.01$ X.XXX = $\pm 0.005$ X.XXXX = $\pm 0.001$ ANGLES: $\pm 0.5^\circ$	FLATNESS: $\square$ 0.001" / INCH
	ROUGHNESS: 125



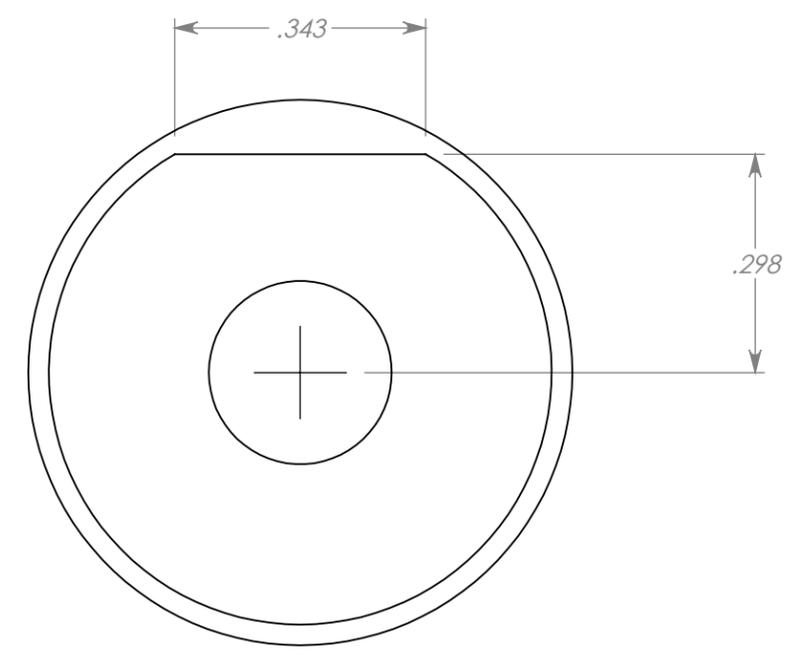
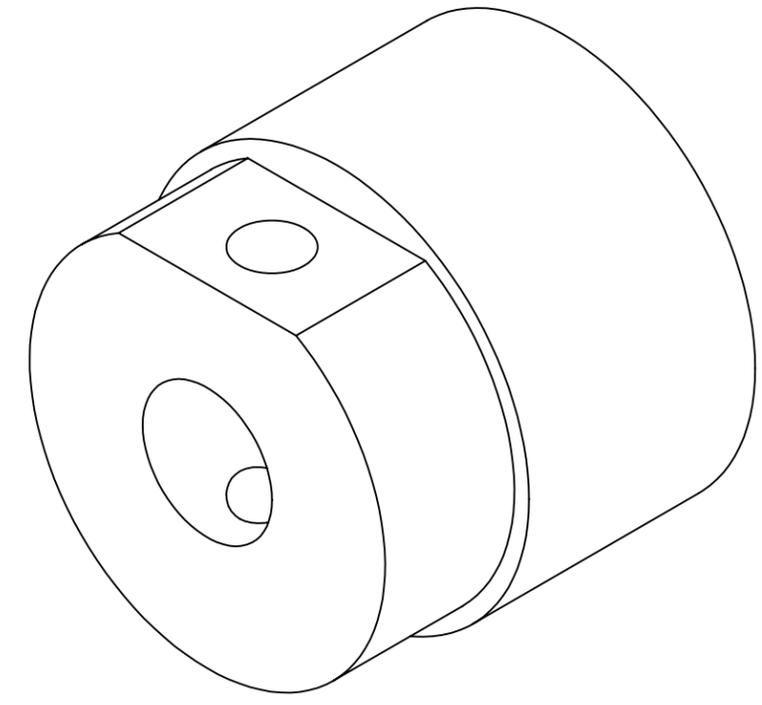
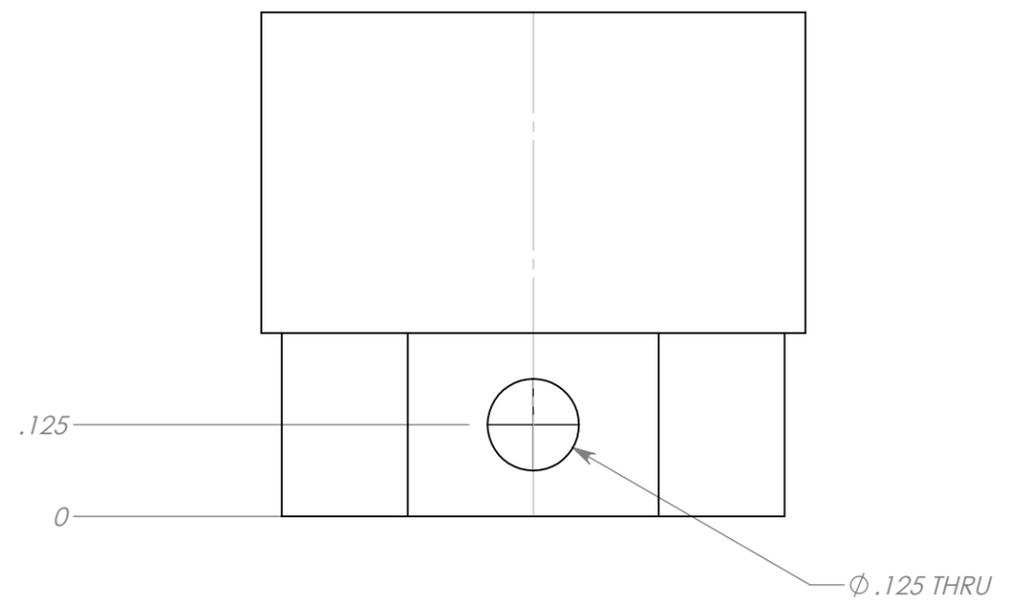
TITLE: **Leg Sub Assembly**

MATERIAL: STEEL	<b>NOTICE</b> THIS DRAWING IS FOR MECH-DESIGN USE AND CAN BE REDISTRIBUTED AND REUSED AT WILL.	INIT.	DATE	SIZE	DWG. NO.	REV	
FINISH:		ENGINEER	OT	12/10/13	<b>B</b>	<b>JIMMYMA3100</b>	<b>C</b>
		DRAWN	OT	12/10/13	SCALE: 1:4	DO NOT SCALE PRINT	SHEET 1 OF 1

8 7 6 5 4 3 2 1

D  
C  
B  
A

D  
C  
B  
A



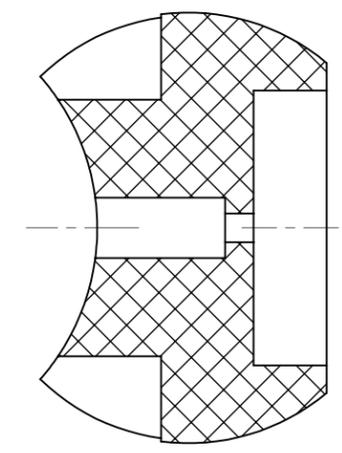
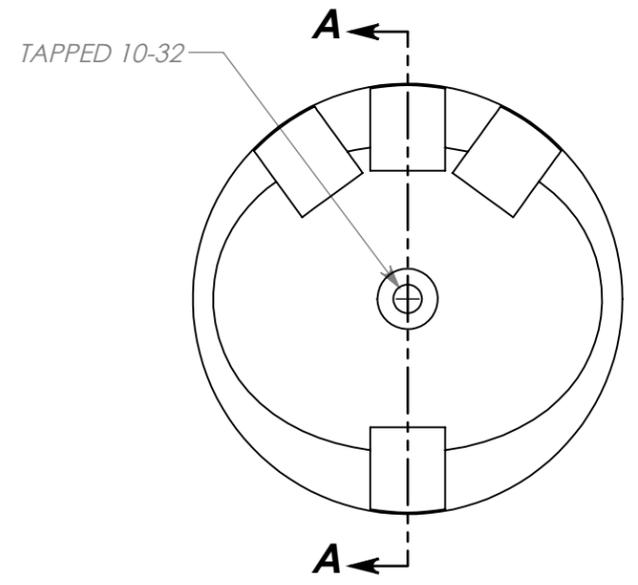
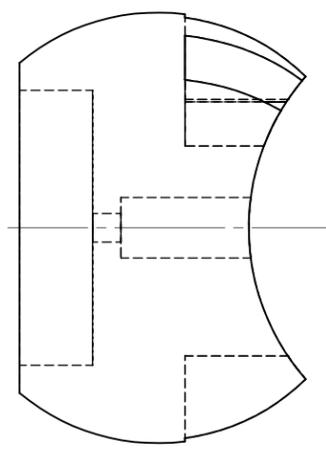
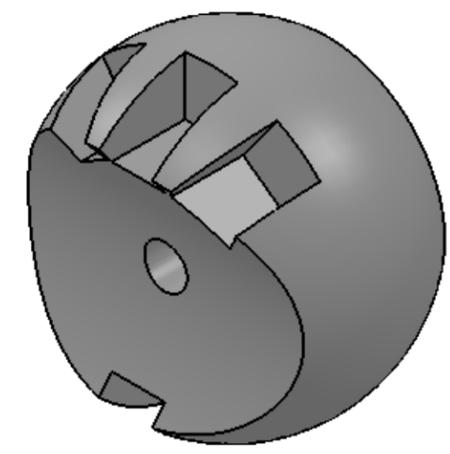
QTY: 2

<b>UNLESS OTHERWISE SPECIFIED:</b>			
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.	PERPENDICULARITY: $\perp$ 0.001" / INCH	TITLE: <b>TIMING PULLEY</b>	
DIMENSIONS ARE IN INCHES.	CONCENTRICITY: $\odot$ 0.002" T.I.R.		
DE-BURR AND BREAK ALL SHARP EDGES .003 MIN.	PARALLELISM: $\parallel$ 0.001" / INCH		
TOLERANCES ARE: X.XX = ±0.01 X.XXX = ±0.005 X.XXXX = ±0.001 ANGLES: ±0.5°	FLATNESS: $\square$ 0.001" / INCH		
	ROUGHNESS: 125 $\sqrt{\text{ }}$	SIZE: <b>B</b>	DWG. NO.: <b>JIMMYMA3022</b>
MATERIAL: PLA	<b>NOTICE</b> THIS DRAWING IS FOR MECH-DESIGN USE AND CAN BE REDISTRIBUTED AND REUSED AT WILL.		REV: <b>B</b>
FINISH:	ENGINEER: ZDR	INIT: ZDR	DATE: 12/10/13
	DRAWN: ZDR	INIT: AC	DATE: 12/10/13
	CHECKED: AC	INIT: AC	DATE: 12/10/13
		SCALE: 4:1	DO NOT SCALE PRINT
			SHEET 1 OF 1

8 7 6 5 4 3 2 1

D  
C  
B  
A

D  
C  
B  
A



SECTION A-A

QTY:2

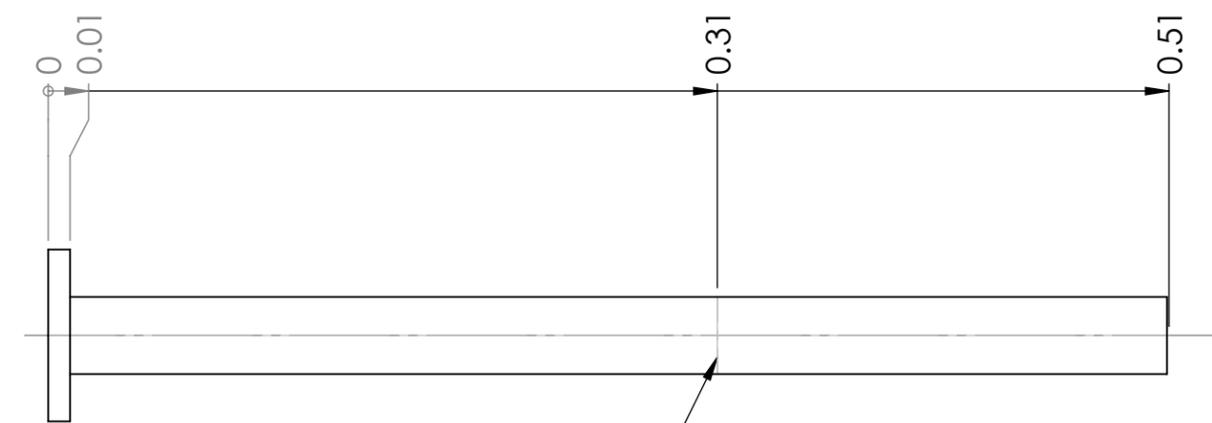
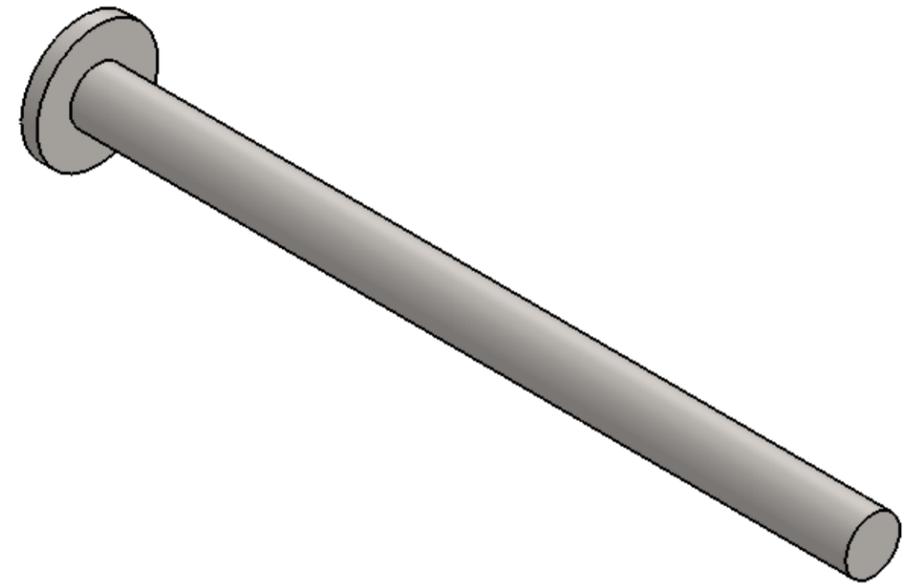
Hole is centered in part.

<b>UNLESS OTHERWISE SPECIFIED:</b>					
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.	PERPENDICULARITY:	$\perp$	0.001" / INCH	TITLE: <b>JIMMY-MA</b>	
DIMENSIONS ARE IN INCHES.	CONCENTRICITY:	$\odot$	0.002" T.I.R.		
DE-BURR AND BREAK ALL SHARP EDGES .003 MIN.	PARALLELISM:	//	0.001" / INCH		
TOLERANCES ARE:	FLATNESS:	$\square$	0.001" / INCH		
			ROUGHNESS:	125	
MATERIAL: <b>PLA</b>	<b>NOTICE</b>		INIT.	DATE	SIZE
FINISH: <b>3-D Printed</b>	THIS DRAWING IS FOR MECH-DESIGN USE AND CAN BE REDISTRIBUTED AND REUSED AT WILL.		ED	12/10	DWG. NO. <b>B JIMMYMA-2005-HAND A</b>
			DRAWN	ED	12/10
			CHECKED	ZDR	12/10
					SCALE: 1:1 DO NOT SCALE PRINT SHEET 1 OF 1

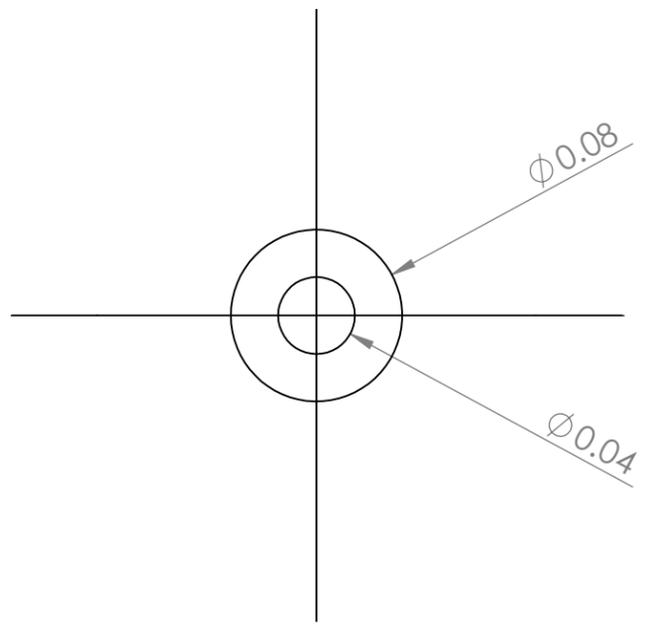
8 7 6 5 4 3 2 1

D  
C  
B  
A

D  
C  
B  
A



90 DEGREE BEND  
± 4 DEGREES



QTY: 3

UNLESS OTHERWISE SPECIFIED:	
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.	PERPENDICULARITY: $\perp$ 0.001" / INCH
DIMENSIONS ARE IN INCHES.	CONCENTRICITY: $\odot$ 0.002" T.I.R.
DE-BURR AND BREAK ALL SHARP EDGES .003 MIN.	PARALLELISM: $\parallel$ 0.001" / INCH
TOLERANCES ARE: X.XX = ±0.01 X.XXX = ±0.005 X.XXXX = ±0.001 ANGLES: ±0.5°	FLATNESS: $\square$ 0.001" / INCH
	ROUGHNESS: 125 $\sqrt{\text{ }}$



TITLE: **JIMMY-MA**

MATERIAL:	<b>ABS</b>
FINISH:	<b>NONE</b>

**NOTICE**  
THIS DRAWING IS FOR MECH-DESIGN USE AND CAN BE REDISTRIBUTED AND REUSED AT WILL.

ENGINEER	INIT.	DATE
DRAWN	KL	12/09/13
CHECKED	ZDR	12/09/13

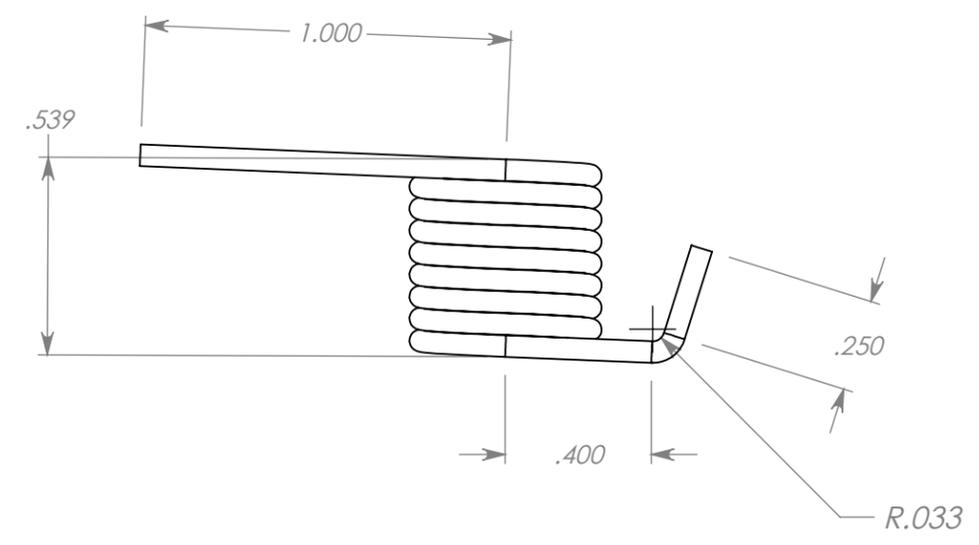
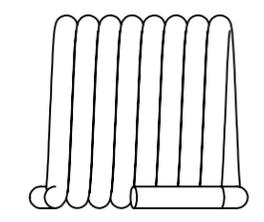
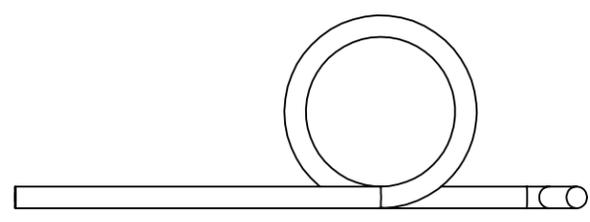
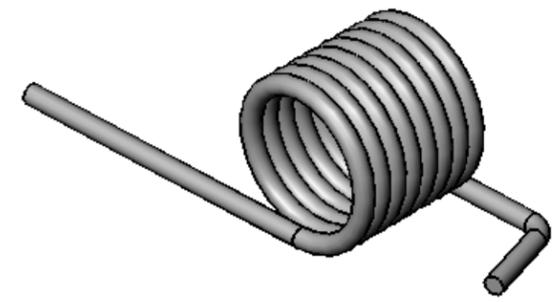
SIZE	DWG. NO.	REV
<b>B</b>	<b>JIMMYMA-2022-COLDFORMEDPIN</b>	<b>A</b>
SCALE: 16:1	DO NOT SCALE PRINT	SHEET 1 OF 1

8 7 6 5 4 3 2 1

8 7 6 5 4 3 2 1

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QTY: 2

McMaster-Carr #9271K642  
Right-handed music wire torsion spring

MATERIAL: **Spring Steel**  
FINISH: **Stock**

UNLESS OTHERWISE SPECIFIED:	
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.	PERPENDICULARITY: $\perp$ 0.001" / INCH
DIMENSIONS ARE IN INCHES.	CONCENTRICITY: $\odot$ 0.002" T.I.R.
DE-BURR AND BREAK ALL SHARP EDGES .003 MIN.	PARALLELISM: $\parallel$ 0.001" / INCH
TOLERANCES ARE:	FLATNESS: $\square$ 0.001" / INCH
X.XX = $\pm 0.01$	ROUGHNESS: 125 $\sqrt{\text{ }}$
X.XXX = $\pm 0.005$	
X.XXXX = $\pm 0.001$	
ANGLES: $\pm 0.5^\circ$	
<b>NOTICE</b> THIS DRAWING IS FOR MECH-DESIGN USE AND CAN BE REDISTRIBUTED AND REUSED AT WILL.	



TITLE: **JIMMY-MA**

ENGINEER	INIT.	DATE	SIZE	DWG. NO.	REV
DRAWN	ED	12/10	<b>B</b>	<b>JIMMYMA-2032-SHOULDERSPRING</b>	<b>A</b>
CHECKED	ZDR	12/10	SCALE: 2:1	DO NOT SCALE PRINT	SHEET 1 OF 1

8 7 6 5 4 3 2 1

8 7 6 5 4 3 2 1

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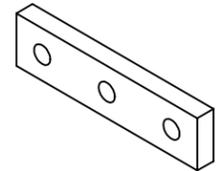
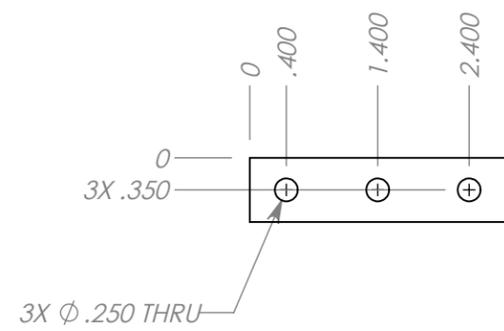
C

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QTY: 2

<b>UNLESS OTHERWISE SPECIFIED:</b>					
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.		PERPENDICULARITY:	$\perp$ 0.001" / INCH		
DIMENSIONS ARE IN INCHES.		CONCENTRICITY:	$\odot$ 0.002" T.I.R.	TITLE: <b>Bottom Cross Linkage</b>	
DE-BURR AND BREAK ALL SHARP EDGES .003 MIN.		PARALLELISM:	// 0.001" / INCH		
TOLERANCES ARE:		FLATNESS:	$\square$ 0.001" / INCH	SIZE: <b>B</b> DWG. NO. <b>JIMMYMA3001</b> REV <b>G</b>	
X.XX = ±0.01 X.XXX = ±0.005 X.XXXX = ±0.001 ANGLES: ±0.5°		ROUGHNESS:	125 $\sqrt{\text{ }}$		
MATERIAL: PLA		<b>NOTICE</b> THIS DRAWING IS FOR MECH-DESIGN USE AND CAN BE REDISTRIBUTED AND REUSED AT WILL.		ENGINEER	OT 12/10/13
FINISH:				DRAWN	OT 12/10/13
		CHECKED	ZDR 12/10/13	SCALE: 1:2	DO NOT SCALE PRINT
				SHEET 1 OF 1	

8 7 6 5 4 3 2 1

8 7 6 5 4 3 2 1

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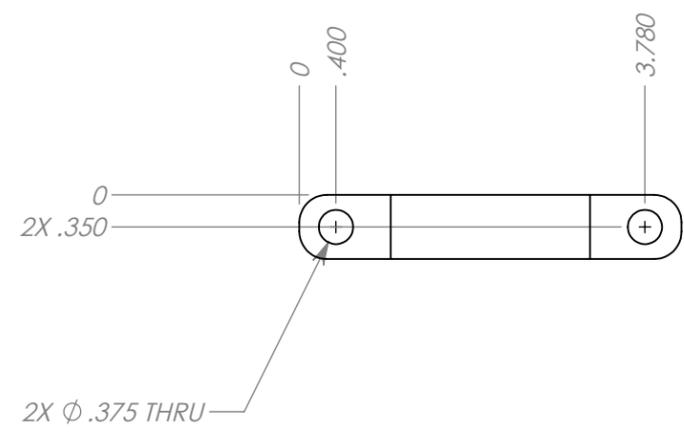
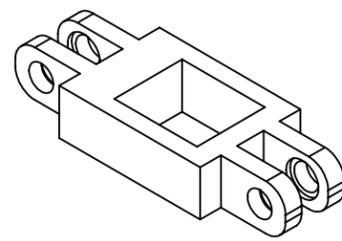
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QTY: 2

<b>UNLESS OTHERWISE SPECIFIED:</b>							
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994. DIMENSIONS ARE IN INCHES. DE-BURR AND BREAK ALL SHARP EDGES .003 MIN.		PERPENDICULARITY: $\perp$ 0.001" / INCH CONCENTRICITY: $\odot$ 0.002" T.I.R. PARALLELISM: $\parallel$ 0.001" / INCH	FLATNESS: $\square$ 0.001" / INCH ROUGHNESS: 125 $\sqrt{\text{ }}$				
TOLERANCES ARE: X.XX = $\pm 0.01$ X.XXX = $\pm 0.005$ X.XXXX = $\pm 0.001$ ANGLES: $\pm 0.5^\circ$		<b>NOTICE</b> THIS DRAWING IS FOR MECH-DESIGN USE AND CAN BE REDISTRIBUTED AND REUSED AT WILL.		ENGINEER: OT DRAWN: OT CHECKED: ZDR	DATE: 12/10/13 DATE: 12/10/13 DATE: 12/10/13	SIZE: <b>B</b> DWG. NO.: <b>JIMMYMA3002</b> SCALE: 1:2 DO NOT SCALE PRINT	REV: <b>P</b> SHEET 1 OF 1

MATERIAL: PLA  
 FINISH:

8 7 6 5 4 3 2 1

8 7 6 5 4 3 2 1

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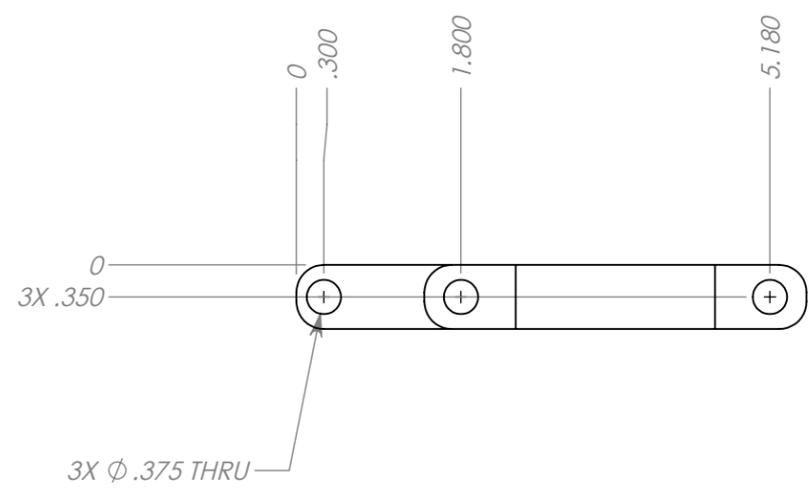
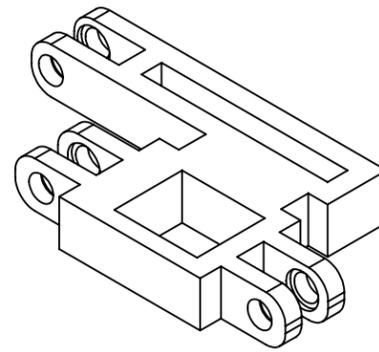
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QTY: 2

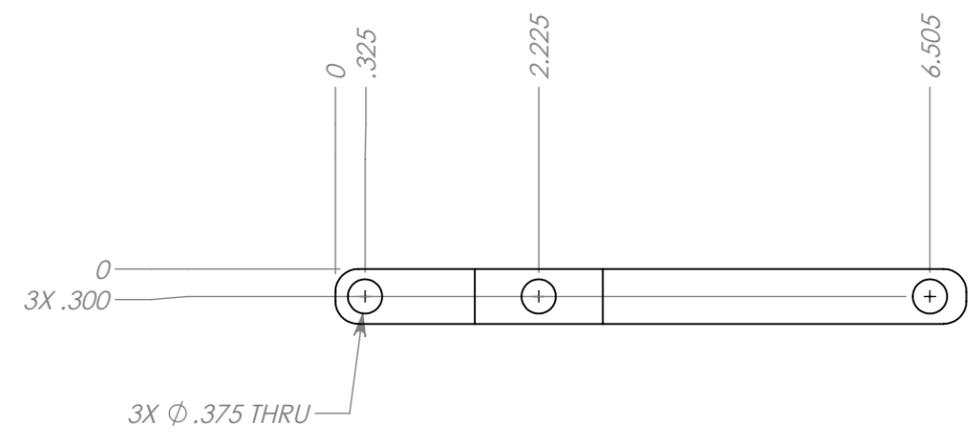
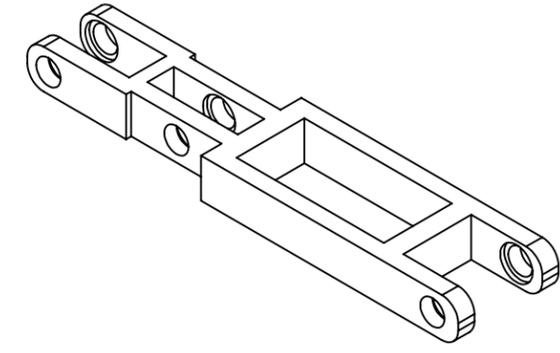
UNLESS OTHERWISE SPECIFIED:					
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.		PERPENDICULARITY:	⊥ 0.001" / INCH	TITLE: <b>Bottom Side Linkage with Follower</b>	
DIMENSIONS ARE IN INCHES.		CONCENTRICITY:	◎ 0.002" T.I.R.		
DE-BURR AND BREAK ALL SHARP EDGES .003 MIN.		PARALLELISM:	// 0.001" / INCH		
TOLERANCES ARE:		FLATNESS:	▭ 0.001" / INCH		
X.XX = ±0.01 X.XXX = ±0.005 X.XXXX = ±0.001 ANGLES: ±0.5°		ROUGHNESS:	125 /	SIZE DWG. NO. REV B JIMMYMA3002 P	
MATERIAL: PLA		NOTICE THIS DRAWING IS FOR MECH-DESIGN USE AND CAN BE REDISTRIBUTED AND REUSED AT WILL.		ENGINEER OT 12/10/13 DRAWN OT 12/10/13 CHECKED ZDR 12/10/13	SCALE: 1:2 DO NOT SCALE PRINT SHEET 1 OF 1

8 7 6 5 4 3 2 1

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QTY: 2



UNLESS OTHERWISE SPECIFIED:	
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.	PERPENDICULARITY: $\perp$ 0.001" / INCH
DIMENSIONS ARE IN INCHES.	CONCENTRICITY: $\odot$ 0.002" T.I.R.
DE-BURR AND BREAK ALL SHARP EDGES .003 MIN.	PARALLELISM: $//$ 0.001" / INCH
TOLERANCES ARE: X.XX = $\pm 0.01$ X.XXX = $\pm 0.005$ X.XXXX = $\pm 0.001$ ANGLES: $\pm 0.5^\circ$	FLATNESS: $\square$ 0.001" / INCH
	ROUGHNESS: 125 $\sqrt{\text{ }}$

TITLE: **Top Side Linkage with follower**

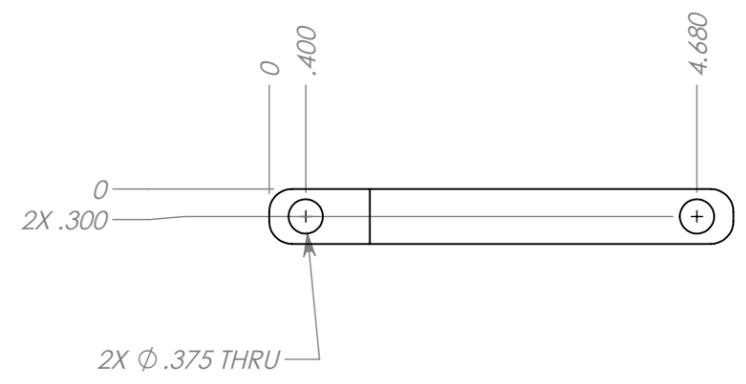
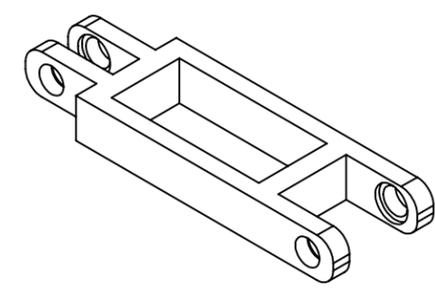
MATERIAL: PLA	<b>NOTICE</b> THIS DRAWING IS FOR MECH-DESIGN USE AND CAN BE REDISTRIBUTED AND REUSED AT WILL.	INIT.	DATE	SIZE	DWG. NO.	REV
FINISH:		ENGINEER	OT	12/10/13	<b>B</b> JIMMYMA3004	<b>N</b>
		DRAWN	OT	12/10/13		
	CHECKED	ZDR	12/10/13	SCALE: 1:2		

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QTY: 2

<b>UNLESS OTHERWISE SPECIFIED:</b>	
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.	PERPENDICULARITY: $\perp$ 0.001" / INCH
DIMENSIONS ARE IN INCHES.	CONCENTRICITY: $\odot$ 0.002" T.I.R.
DE-BURR AND BREAK ALL SHARP EDGES .003 MIN.	PARALLELISM: $\parallel$ 0.001" / INCH
TOLERANCES ARE:	FLATNESS: $\square$ 0.001" / INCH
X.XX = $\pm 0.01$	ROUGHNESS: 125 $\sqrt{\text{ }}$
X.XXX = $\pm 0.005$	
X.XXXX = $\pm 0.001$	
ANGLES: $\pm 0.5^\circ$	



TITLE: **Top Side Linkage without follower**

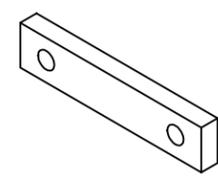
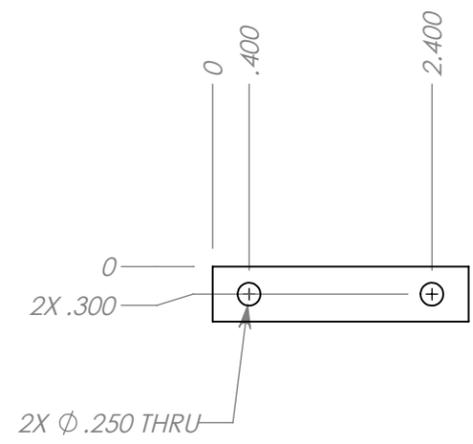
MATERIAL: PLA	<b>NOTICE</b> THIS DRAWING IS FOR MECH-DESIGN USE AND CAN BE REDISTRIBUTED AND REUSED AT WILL.	ENGINEER	INIT.	DATE	SIZE	DWG. NO.	REV
FINISH:		DRAWN	OT	12/10/13	<b>B</b>	<b>JIMMYMA3004</b>	<b>N</b>
		CHECKED	ZDR	12/10/13	SCALE: 1:2	DO NOT SCALE PRINT	SHEET 1 OF 1

8 7 6 5 4 3 2 1

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QTY: 2

UNLESS OTHERWISE SPECIFIED:					
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.		PERPENDICULARITY:	⊥	0.001" / INCH	
DIMENSIONS ARE IN INCHES.		CONCENTRICITY:	◎	0.002" T.I.R.	
DE-BURR AND BREAK ALL SHARP EDGES .003 MIN.		PARALLELISM:	//	0.001" / INCH	
TOLERANCES ARE:	X.XX = ±0.01	FLATNESS:	▭	0.001" / INCH	
	X.XXX = ±0.005	ROUGHNESS:	125	/	
X.XXXX = ±0.001	ANGLES: ±0.5°				
<b>NOTICE</b> THIS DRAWING IS FOR MECH-DESIGN USE AND CAN BE REDISTRIBUTED AND REUSED AT WILL.				INIT.	DATE
				ENGINEER	OT 12/10/13
				DRAWN	OT 12/10/13
				CHECKED	ZDR 12/10/13
MATERIAL: PLA		SIZE	DWG. NO.		REV
FINISH:		<b>B</b>	JIMMYMA3005		<b>K</b>
		SCALE: 1:2	DO NOT SCALE PRINT		SHEET 1 OF 1

8 7 6 5 4 3 2 1

8 7 6 5 4 3 2 1

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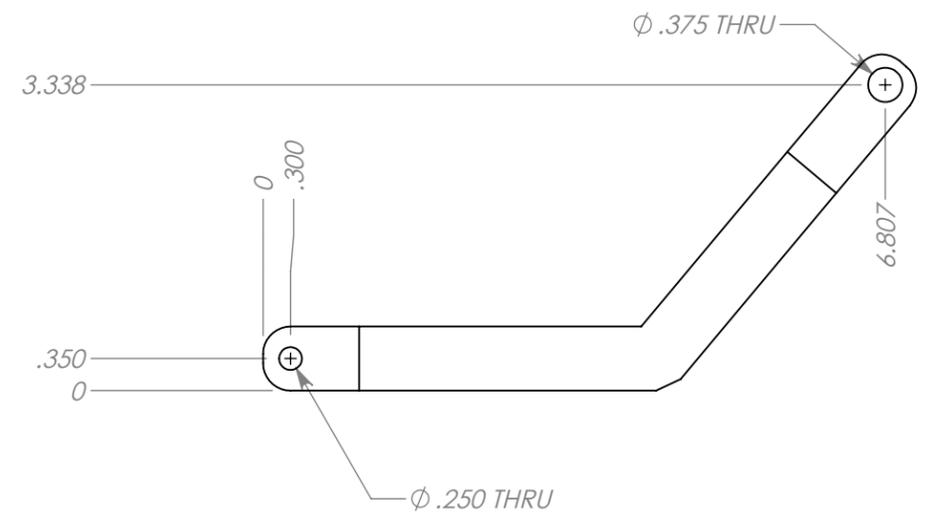
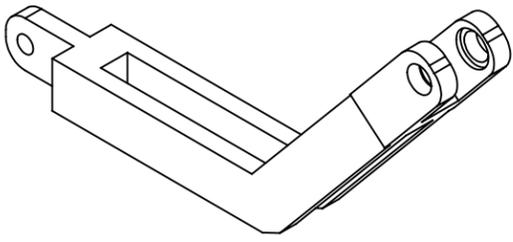
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QTY: 2

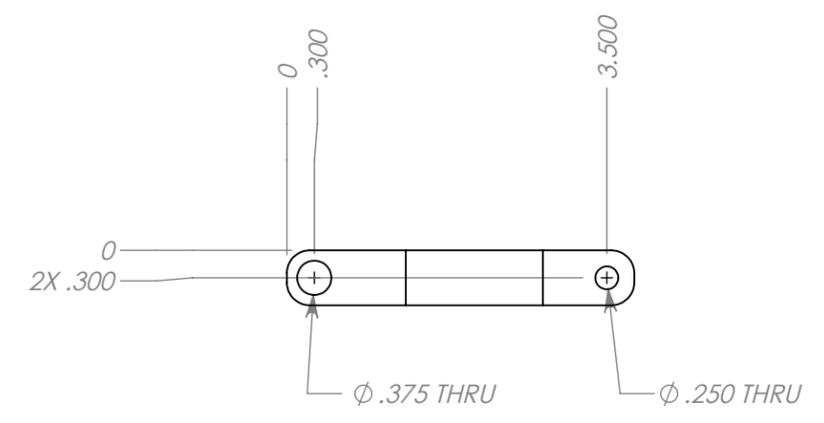
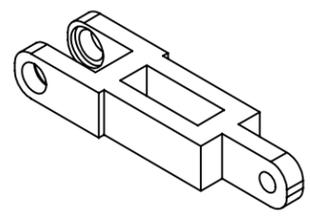
UNLESS OTHERWISE SPECIFIED:					
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.	PERPENDICULARITY:	$\perp$ 0.001" / INCH	TITLE: <b>Foot Follower Linkage</b> SIZE: <b>B</b> DWG. NO. <b>JIMMYMA3006</b> REV <b>L</b> SCALE: 1:2 DO NOT SCALE PRINT SHEET 1 OF 1		
DIMENSIONS ARE IN INCHES.	CONCENTRICITY:	$\odot$ 0.002" T.I.R.			
DE-BURR AND BREAK ALL SHARP EDGES .003 MIN.	PARALLELISM:	$\parallel$ 0.001" / INCH			
TOLERANCES ARE:	FLATNESS:	$\square$ 0.001" / INCH			
	ROUGHNESS:	125 $\sqrt{\text{ }}$			
MATERIAL: PLA		NOTICE THIS DRAWING IS FOR MECH-DESIGN USE AND CAN BE REDISTRIBUTED AND REUSED AT WILL.		INIT.	DATE
FINISH:		ENGINEER	OT	12/10/13	
		DRAWN	OT	12/10/13	
		CHECKED	ZDR	12/10/13	

8 7 6 5 4 3 2 1

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QTY: 2

UNLESS OTHERWISE SPECIFIED:		FRANKLIN W. OLIN College of Engineering	
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.	PERPENDICULARITY: $\perp$ 0.001" / INCH	TITLE: <b>Knee Follower Linkage</b>	
DIMENSIONS ARE IN INCHES.	CONCENTRICITY: $\odot$ 0.002" T.I.R.		
DE-BURR AND BREAK ALL SHARP EDGES .003 MIN.	PARALLELISM: $\parallel$ 0.001" / INCH	SIZE: <b>B</b> DWG. NO. <b>JIMMYMA3008</b> REV <b>E</b>	
TOLERANCES ARE: X.XX = $\pm 0.01$ X.XXX = $\pm 0.005$ X.XXXX = $\pm 0.001$ ANGLES: $\pm 0.5^\circ$	FLATNESS: $\square$ 0.001" / INCH		
MATERIAL: PLA	ROUGHNESS: 125 $\sqrt{\text{ }}$	ENGINEER: OT 12/10/13	DATE: 12/10/13
FINISH:	NOTICE: THIS DRAWING IS FOR MECH-DESIGN USE AND CAN BE REDISTRIBUTED AND REUSED AT WILL.		SCALE: 1:2 DO NOT SCALE PRINT SHEET 1 OF 1

8 7 6 5 4 3 2 1

8 7 6 5 4 3 2 1

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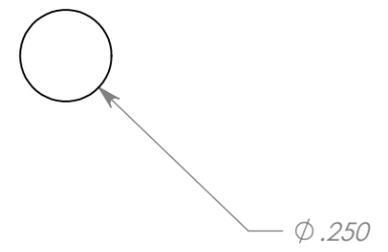
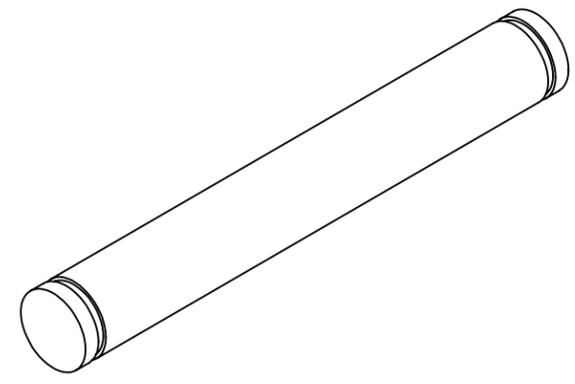
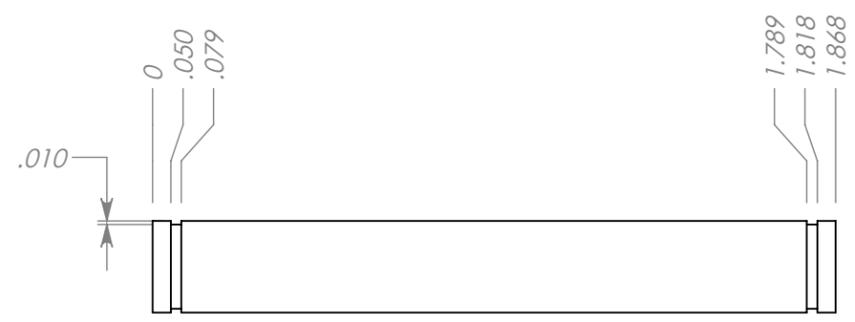
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QTY: 4

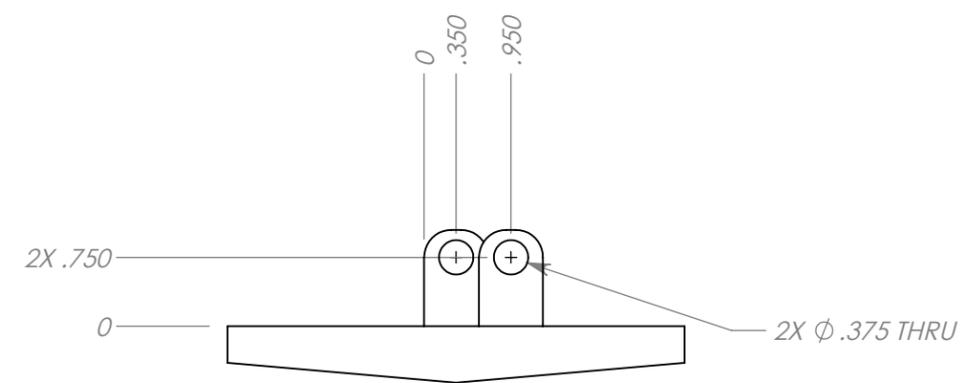
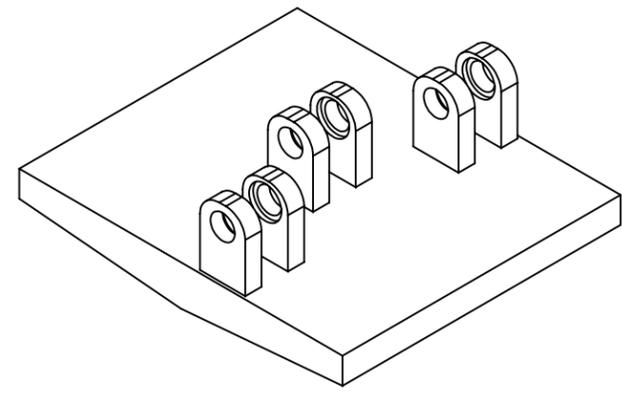
UNLESS OTHERWISE SPECIFIED:					
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.		PERPENDICULARITY:	$\perp$	0.001" / INCH	
DIMENSIONS ARE IN INCHES.		CONCENTRICITY:	$\odot$	0.002" T.I.R.	
DE-BURR AND BREAK ALL SHARP EDGES .003 MIN.		PARALLELISM:	$\parallel$	0.001" / INCH	
TOLERANCES ARE:		FLATNESS:	$\square$	0.001" / INCH	
X.XX = $\pm 0.01$		ROUGHNESS:	$\sqrt{\quad}$	125	
X.XXX = $\pm 0.005$		<b>NOTICE</b> THIS DRAWING IS FOR MECH-DESIGN USE AND CAN BE REDISTRIBUTED AND REUSED AT WILL.			
X.XXXX = $\pm 0.001$					
ANGLES: $\pm 0.5^\circ$					
MATERIAL: STEEL	ENGINEER	INIT.	DATE	SIZE	DWG. NO.
FINISH:	DRAWN	OT	12/10/13	<b>B</b>	<b>JIMMYMA3011</b>
	CHECKED	KL	12/10/13	SCALE: 2:1	DO NOT SCALE PRINT
					SHEET 1 OF 1

8 7 6 5 4 3 2 1

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QTY: 2

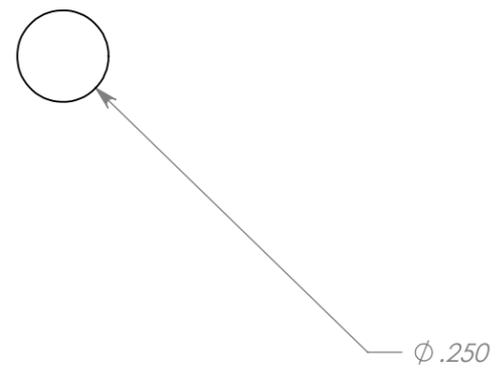
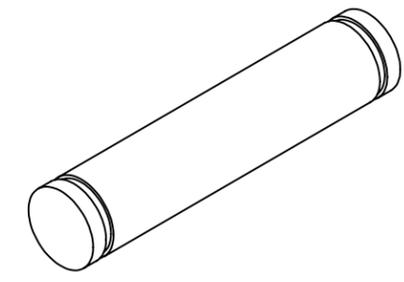
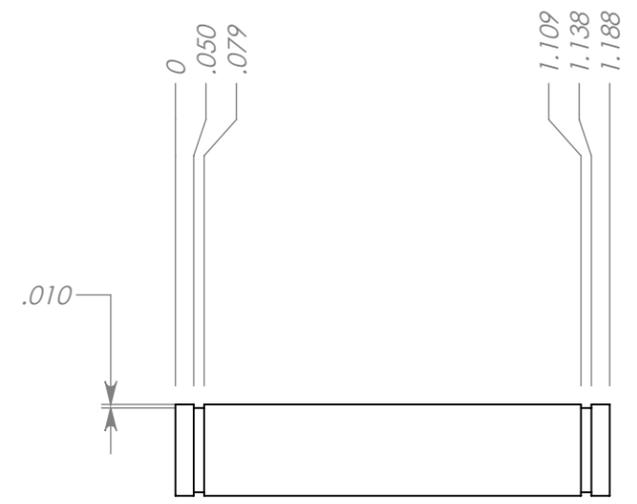
<b>UNLESS OTHERWISE SPECIFIED:</b>							
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.		PERPENDICULARITY:	$\perp$ 0.001" / INCH				
DIMENSIONS ARE IN INCHES.		CONCENTRICITY:	$\odot$ 0.002" T.I.R.	TITLE: <b>Foot</b>			
DE-BURR AND BREAK ALL SHARP EDGES .003 MIN.		PARALLELISM:	// 0.001" / INCH				
TOLERANCES ARE: X.XX = ±0.01 X.XXX = ±0.005 X.XXXX = ±0.001 ANGLES: ±0.5°		FLATNESS:	$\square$ 0.001" / INCH				
		ROUGHNESS:	125 $\sqrt{\text{ }}$	SIZE DWG. NO. REV			
MATERIAL: PLA		<b>NOTICE</b> THIS DRAWING IS FOR MECH-DESIGN USE AND CAN BE REDISTRIBUTED AND REUSED AT WILL.		ENGINEER	OT	12/10/13	<b>B</b> <b>JIMMYMA3014</b> <b>H</b>
FINISH:				DRAWN	OT	12/10/13	
				CHECKED	ZDR	12/10/13	
		SCALE: 1:2	DO NOT SCALE PRINT	SHEET 1 OF 1			

8 7 6 5 4 3 2 1

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QTY: 10

UNLESS OTHERWISE SPECIFIED:					
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.		PERPENDICULARITY:	$\perp$ 0.001" / INCH	TITLE: <b>Short Pin Joint Shaft</b>	
DIMENSIONS ARE IN INCHES.		CONCENTRICITY:	$\odot$ 0.002" T.I.R.		
DE-BURR AND BREAK ALL SHARP EDGES .003 MIN.		PARALLELISM:	// 0.001" / INCH		
TOLERANCES ARE: X.XX = $\pm 0.01$ X.XXX = $\pm 0.005$ X.XXXX = $\pm 0.001$ ANGLES: $\pm 0.5^\circ$		FLATNESS:	$\square$ 0.001" / INCH		
MATERIAL: STEEL		ROUGHNESS:	125 $\sqrt{\text{ }}$	SIZE	DWG. NO.
FINISH:		NOTICE THIS DRAWING IS FOR MECH-DESIGN USE AND CAN BE REDISTRIBUTED AND REUSED AT WILL.		ENGINEER DRAWN CHECKED	DATE 12/10/13 12/10/13 12/10/13
				SCALE: 2:1 DO NOT SCALE PRINT	REV JIMMYMA3015 SHEET 1 OF 1

8 7 6 5 4 3 2 1

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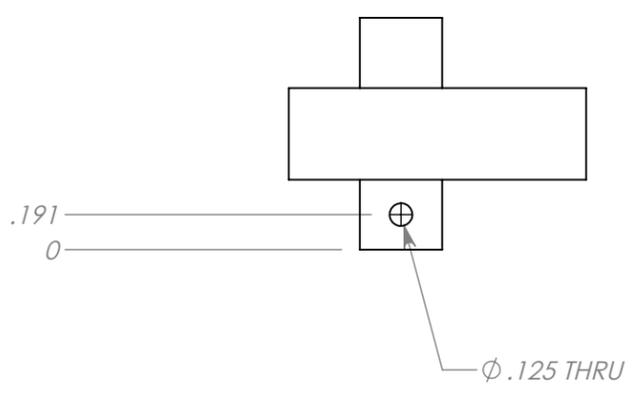
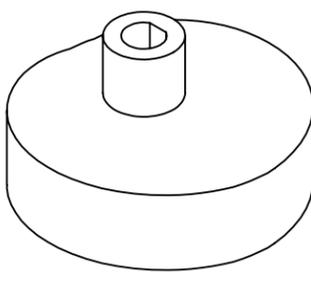
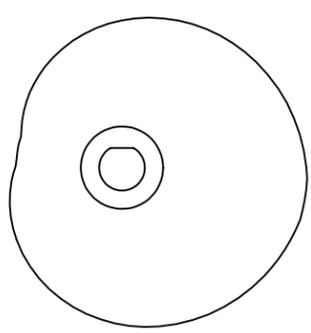
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QTY: 2

<b>UNLESS OTHERWISE SPECIFIED:</b>							
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994. DIMENSIONS ARE IN INCHES. DE-BURR AND BREAK ALL SHARP EDGES .003 MIN.		PERPENDICULARITY: $\perp$ 0.001" / INCH CONCENTRICITY: $\odot$ 0.002" T.I.R. PARALLELISM: $\parallel$ 0.001" / INCH	FLATNESS: $\square$ 0.001" / INCH ROUGHNESS: 125 $\sqrt{\text{ }}$				
TOLERANCES ARE: X.XX = $\pm 0.01$ X.XXX = $\pm 0.005$ X.XXXX = $\pm 0.001$ ANGLES: $\pm 0.5^\circ$		<b>NOTICE</b> THIS DRAWING IS FOR MECH-DESIGN USE AND CAN BE REDISTRIBUTED AND REUSED AT WILL.		ENGINEER: OT DRAWN: OT CHECKED: ZDR	INIT.: DATE: 12/10/13	SIZE: <b>B</b> DWG. NO.: <b>JIMMYMA3017</b> SCALE: 1:2 DO NOT SCALE PRINT	REV: <b>P</b> SHEET 1 OF 1

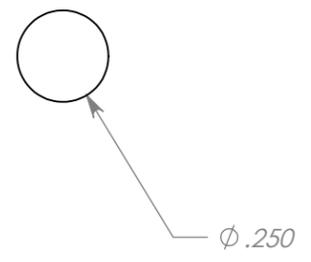
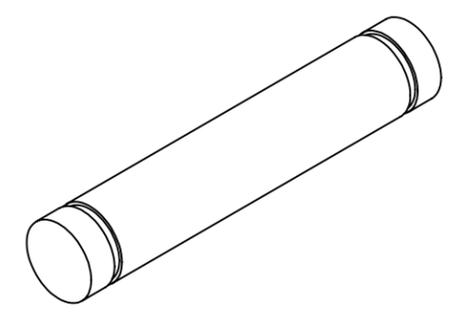
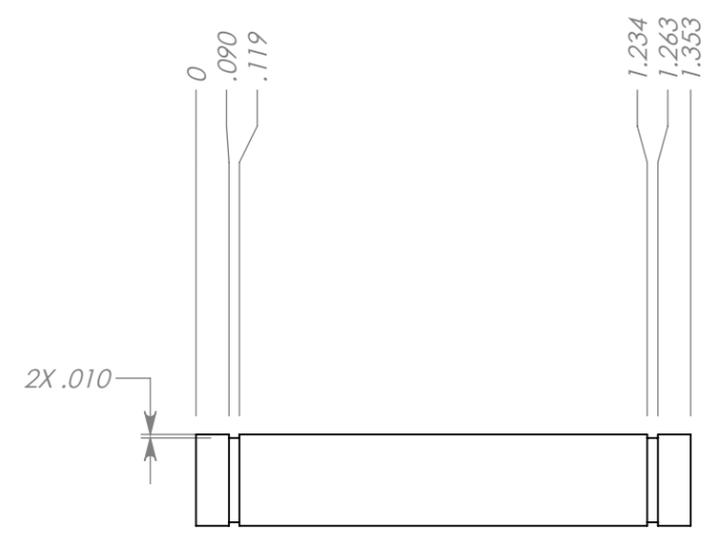
MATERIAL: PLA  
 FINISH:

8 7 6 5 4 3 2 1

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QTY: 2

UNLESS OTHERWISE SPECIFIED:	
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.	PERPENDICULARITY: $\perp$ 0.001" / INCH
DIMENSIONS ARE IN INCHES.	CONCENTRICITY: $\odot$ 0.002" T.I.R.
DE-BURR AND BREAK ALL SHARP EDGES .003 MIN.	PARALLELISM: $//$ 0.001" / INCH
TOLERANCES ARE:	FLATNESS: $\square$ 0.001" / INCH
X.XX = $\pm 0.01$	ROUGHNESS: 125 $\sqrt{\text{ }}$
X.XXX = $\pm 0.005$	
X.XXXX = $\pm 0.001$	
ANGLES: $\pm 0.5^\circ$	



TITLE: **Medium Pin Joint Shaft Chopped Ends**

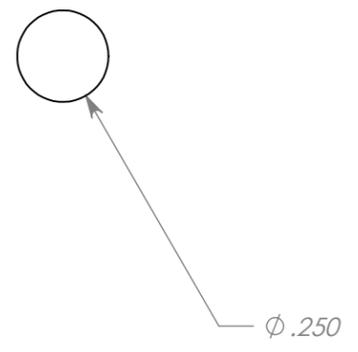
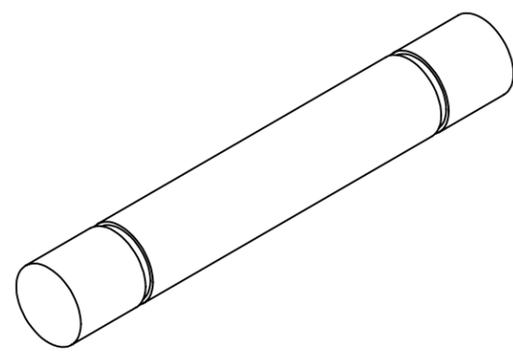
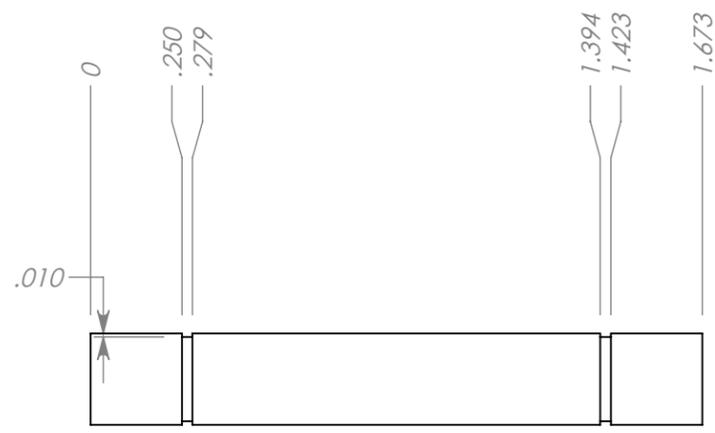
MATERIAL: STEEL	<b>NOTICE</b> THIS DRAWING IS FOR MECH-DESIGN USE AND CAN BE REDISTRIBUTED AND REUSED AT WILL.	INIT.	DATE	SIZE	DWG. NO.	REV
FINISH:		ENGINEER	OT	12/10/13	<b>B</b> JIMMYMA3020	<b>F</b>
		DRAWN	OT	12/10/13		
	CHECKED	KL	12/10/13	SCALE: 2:1		

8 7 6 5 4 3 2 1

8 7 6 5 4 3 2 1

D  
C  
B  
A

D  
C  
B  
A



**QTY: 4**

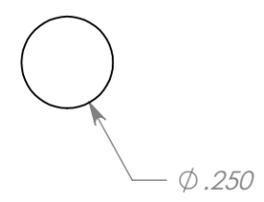
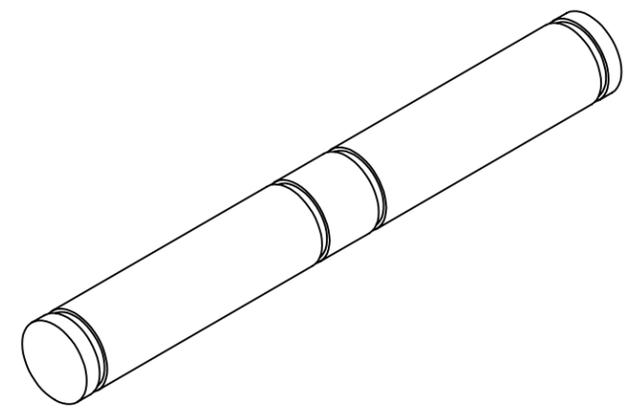
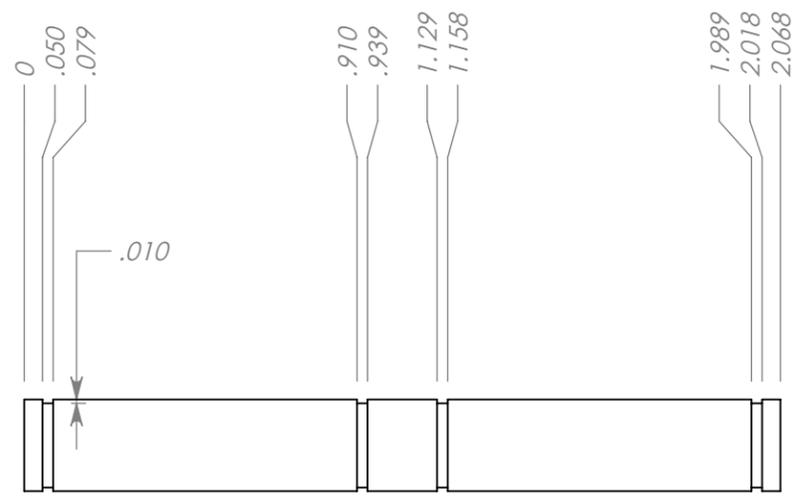
<b>UNLESS OTHERWISE SPECIFIED:</b>							
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994. DIMENSIONS ARE IN INCHES. DE-BURR AND BREAK ALL SHARP EDGES .003 MIN.		PERPENDICULARITY: $\perp$ 0.001" / INCH CONCENTRICITY: $\odot$ 0.002" T.I.R. PARALLELISM: $\parallel$ 0.001" / INCH	FLATNESS: $\square$ 0.001" / INCH ROUGHNESS: 125 $\sqrt{\text{ }}$				
TOLERANCES ARE: X.XX = $\pm 0.01$ X.XXX = $\pm 0.005$ X.XXXX = $\pm 0.001$ ANGLES: $\pm 0.5^\circ$		<b>NOTICE</b> THIS DRAWING IS FOR MECH-DESIGN USE AND CAN BE REDISTRIBUTED AND REUSED AT WILL.		ENGINEER: OT DRAWN: OT CHECKED: KL	INIT.: DATE: 12/10/13 DATE: 12/10/13 DATE: 12/10/13	SIZE: <b>B</b> DWG. NO.: <b>JIMMYMA3020</b> SCALE: 2:1 DO NOT SCALE PRINT	REV: <b>F</b> SHEET 1 OF 1

8 7 6 5 4 3 2 1

8 7 6 5 4 3 2 1

D  
C  
B  
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D  
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B  
A



QTY: 4

UNLESS OTHERWISE SPECIFIED:					
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.		PERPENDICULARITY:	$\perp$ 0.001" / INCH	TITLE: <b>Weird Joint Pin Shaft</b>	
DIMENSIONS ARE IN INCHES.		CONCENTRICITY:	$\odot$ 0.002" T.I.R.		
DE-BURR AND BREAK ALL SHARP EDGES .003 MIN.		PARALLELISM:	$\parallel$ 0.001" / INCH		
TOLERANCES ARE:		FLATNESS:	$\square$ 0.001" / INCH		
X.XX = $\pm 0.01$ X.XXX = $\pm 0.005$ X.XXXX = $\pm 0.001$ ANGLES: $\pm 0.5^\circ$		ROUGHNESS:	125 $\sqrt{\text{ }}$	SIZE: <b>B</b> DWG. NO. <b>JIMMYMA3030</b> REV <b>B</b>	
MATERIAL: STEEL		NOTICE THIS DRAWING IS FOR MECH-DESIGN USE AND CAN BE REDISTRIBUTED AND REUSED AT WILL.		ENGINEER: OT DATE: 12/10/13	SCALE: 2:1 DO NOT SCALE PRINT SHEET 1 OF 1
FINISH:		DRAWN: OT DATE: 12/10/13	CHECKED: KL DATE: 12/10/13		

8 7 6 5 4 3 2 1

# Revision Notes

## Legs

1. There are no springs to tension the cam followers against the cams – this is a large design flaw.
2. The placement of snap rings makes for difficult assembly; these should be moved to facilitate easier assembly.
3. The cams provided approximate the desired gait cycle, but are not as accurate as desired. Further optimization would be necessary for smoother movement.
4. The entire leg structure is very wide, which makes the legs look disproportional with the rest of the body. For better aesthetics the leg assembly should be compacted.
5. The leg structure could use more fairing work to cover up the linkages.

-- Zach Del Rosario

## Torso

The torso could be made larger to match the size of the legs and head. Also, adding springs to the cam followers so that gravity isn't the only thing bringing it back to its "rest" position. --Kathryn Lau

Currently, the cable is quite difficult to tension because of the way the hand mounts. In the future, the mounting of the hand could be split again to allow for easier access of the tensioner. The spool is also quite difficult to place and thread the cable over. In future versions, the spool could be supported better and possibly given easier access. Currently, the shoulder gimbal is mounted as one piece. In order to be completely assemble-able it needs to be in two pieces. The mounting of the shoulder spring could also be improved in future revisions. --Elliott Donlon

## Head

The neck needs to be hollowed out to allow for wire routing to the torso and legs. In general, wire routing is a problem we did not have the time to address. Additionally, there are some fastener features that need to be added - especially to the head fairing - before printing. These include the ear fastener holes and some of the fastener features on the underside of the head. Please triple check for interfering parts before printing -- because of the time limitations there may be subtle part interference that we did not catch. --Laurel Kroo

# Concluding Remarks

Although this design quite extensively addresses the mechanical implementation of an accessible, expressive humanoid robot, it is not a finished product. It needs revision before it would be reasonable to implement. Above is a list of notes our team has compiled regarding changes that need to be made for implementation to be effective.

From this project our team learned how to successfully synthesize a highly complex design from conception to detailed mechanical implementation. We learned a great deal about how mechanical design resourcefulness can be used to make a product more effective in the context of real-world constraints.