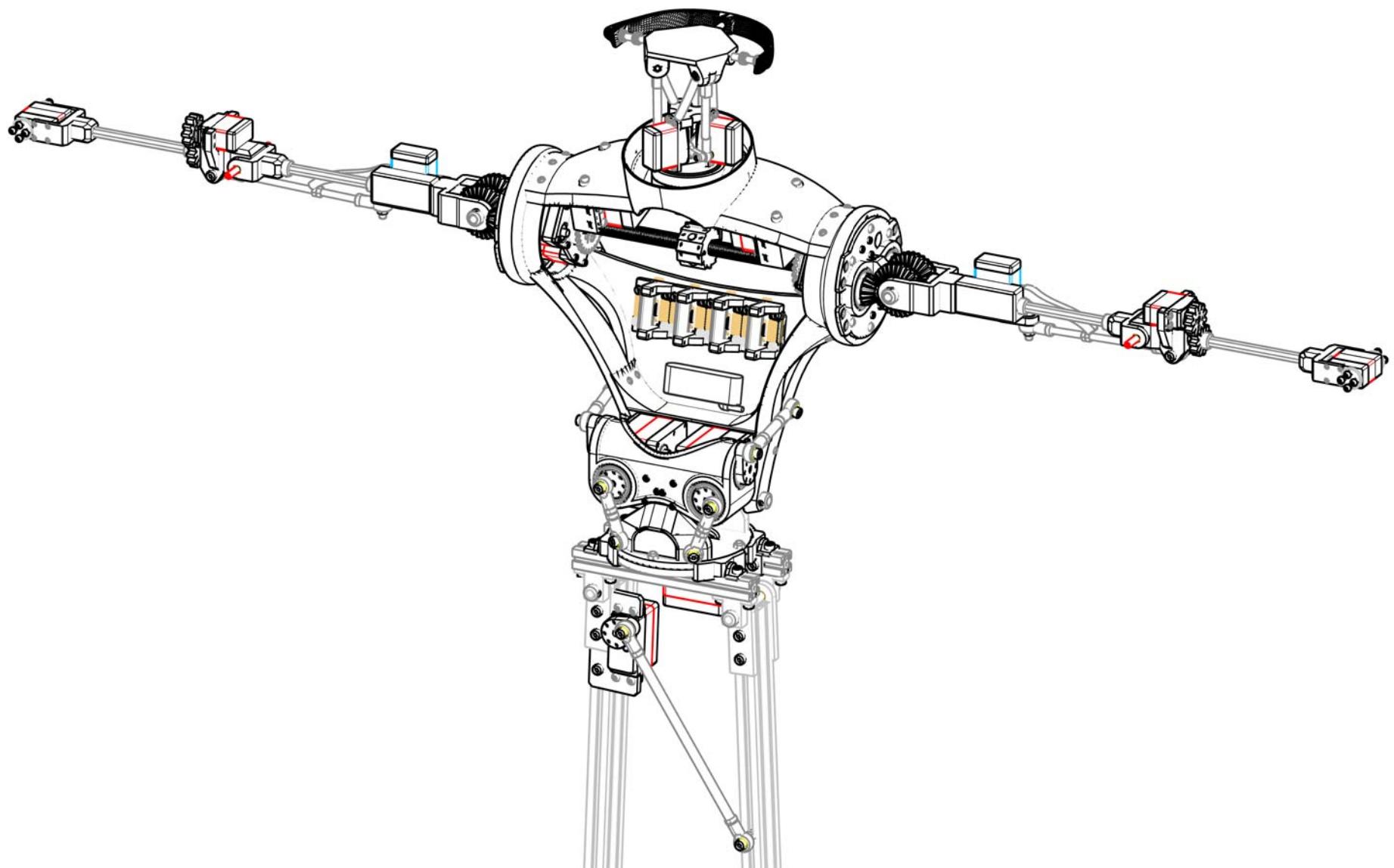


Animatronic C-3PO - Version 1 - 01/20/24
JesseM



Cutting Metal

The intent of this design is to make this available to a broad range of makers, not just those with advanced robotics experience. That said, this build does require some level of metal cutting capabilities. Preferred tools include the following, but a simply Dremel tool with cutoff wheel can perform all the required cutting if that is all you have.

- Bandsaw or hacksaw
- Grinder w/ cutoff wheel
- Bench vise
- Bench sander

No portion of the metal fabrication for this build requires high precision.

Use a cutoff wheel to cut the hardened steel shafts, tubing and all-thread rod for this build.



Use a hacksaw or bandsaw to cut the aluminum extrusions and flat bar only for this build. Do not use a hacksaw or bandsaw to cut the hardened steel shafts. The blades will not be able to cut the hardened steel and you will damage your blades.

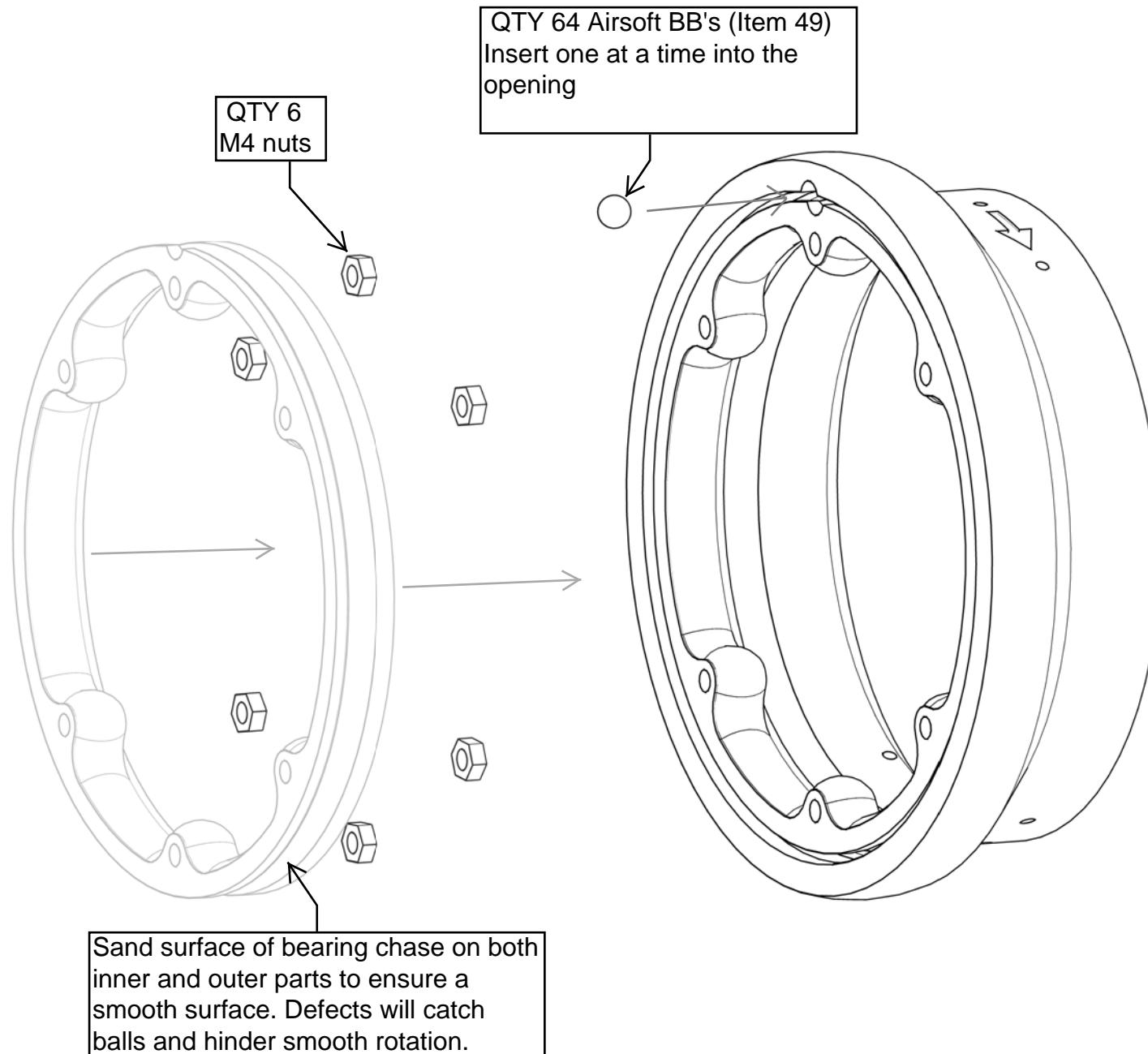


This build uses various sized 8mm sleeve bushings that are press fit into components. Sleeve bushings may require drilling to widen the openings after being press fit into place. Press fitting bushings will slightly compress them and prevent the adjoining shaft from being inserted or rotating inside the bushing properly. Test fit each bushing after pressing it in place. If the 8mm shaft does not properly insert or rotates with too much friction, then use a 8mm drill bit to slowly open the hole to allow smooth rotation of the shaft.



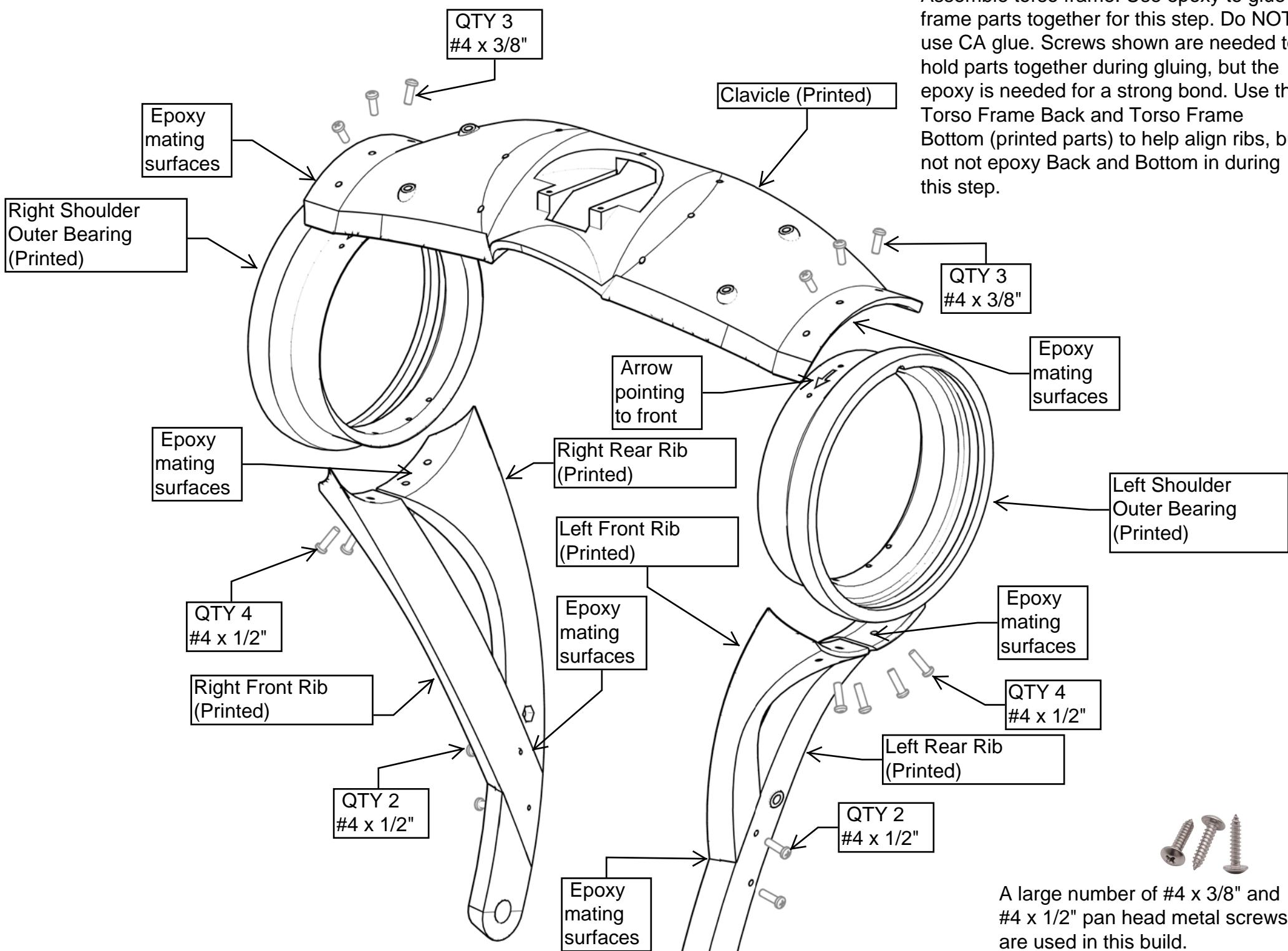
Step 0

Prepare Shoulder Bearings. Install Inner Bearing to Outer Bearing and insert BBs as noted. Test rotation for smooth operation. Disassembly not required if bearing is guarded during glue up in next step. If disassembly is desired, BBs can be pushed out of the opening from the gap on the opposite side.



Step 1

Assemble torso frame. Use epoxy to glue frame parts together for this step. Do NOT use CA glue. Screws shown are needed to hold parts together during gluing, but the epoxy is needed for a strong bond. Use the Torso Frame Back and Torso Frame Bottom (printed parts) to help align ribs, but not not epoxy Back and Bottom in during this step.



A large number of #4 x 3/8" and #4 x 1/2" pan head metal screws are used in this build.

Step 2

Assemble Torso Frame Back and Torso Frame Bottom. Use epoxy to glue frame parts together for this step. Do NOT use CA glue. Screws shown are needed to hold parts together during gluing, but the epoxy is needed for a strong bond.

Torso Frame Back (Printed)

View from rear

Epoxy mating surfaces

Epoxy mating surfaces

Epoxy mating surfaces

QTY 9
#4 x 3/8"

Torso Frame Bottom (Printed)

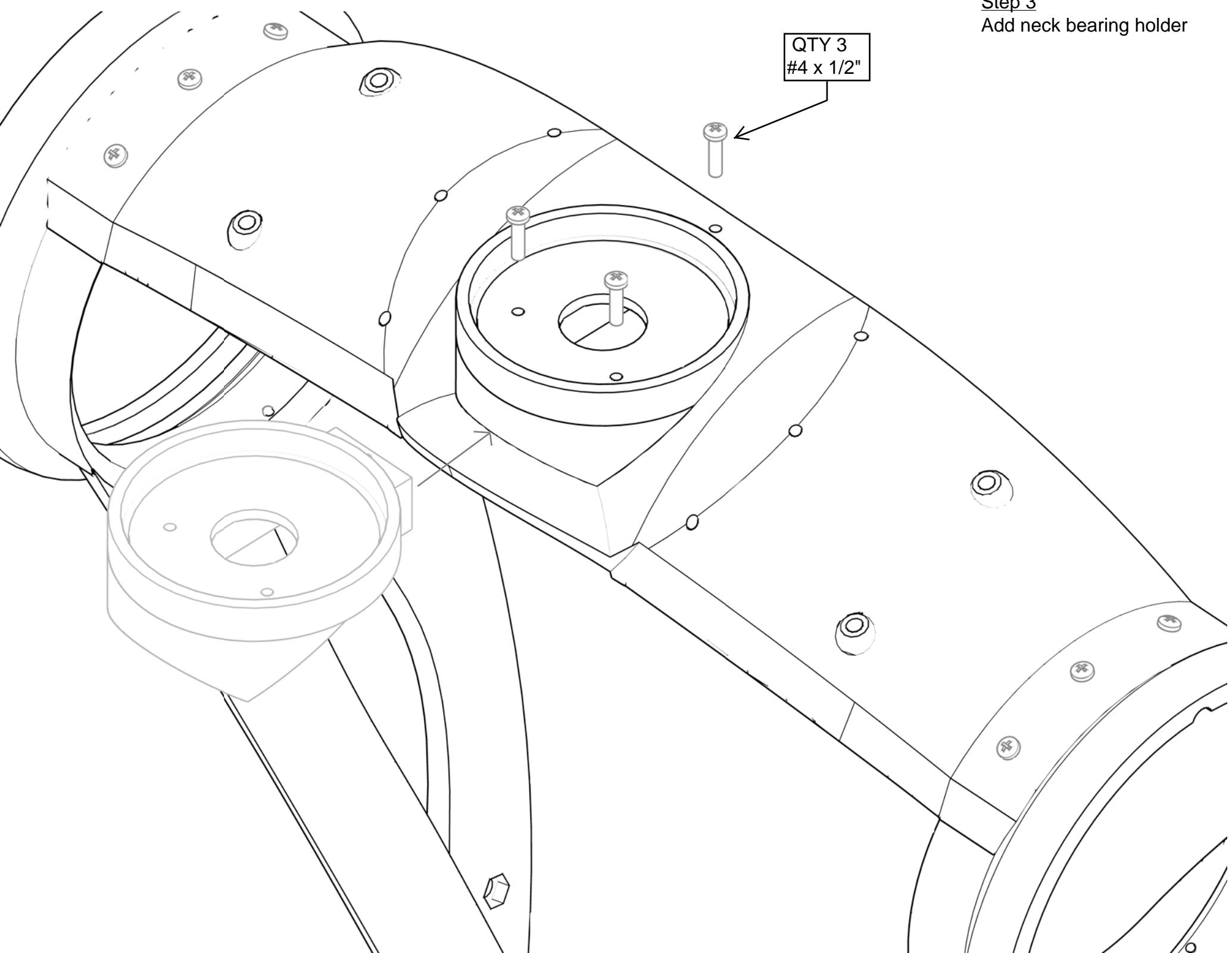
QTY 2, M5 nut

IMPORTANT, insert M5 nuts into ribs prior to glue up. Take care not to get epoxy into threads or into the adjoining hole in the Torso Frame Bottom. Recommend screwing a greased M5 screw into hole during glue up to prevent epoxy squeeze out from fouling the threads or hole.

View from front

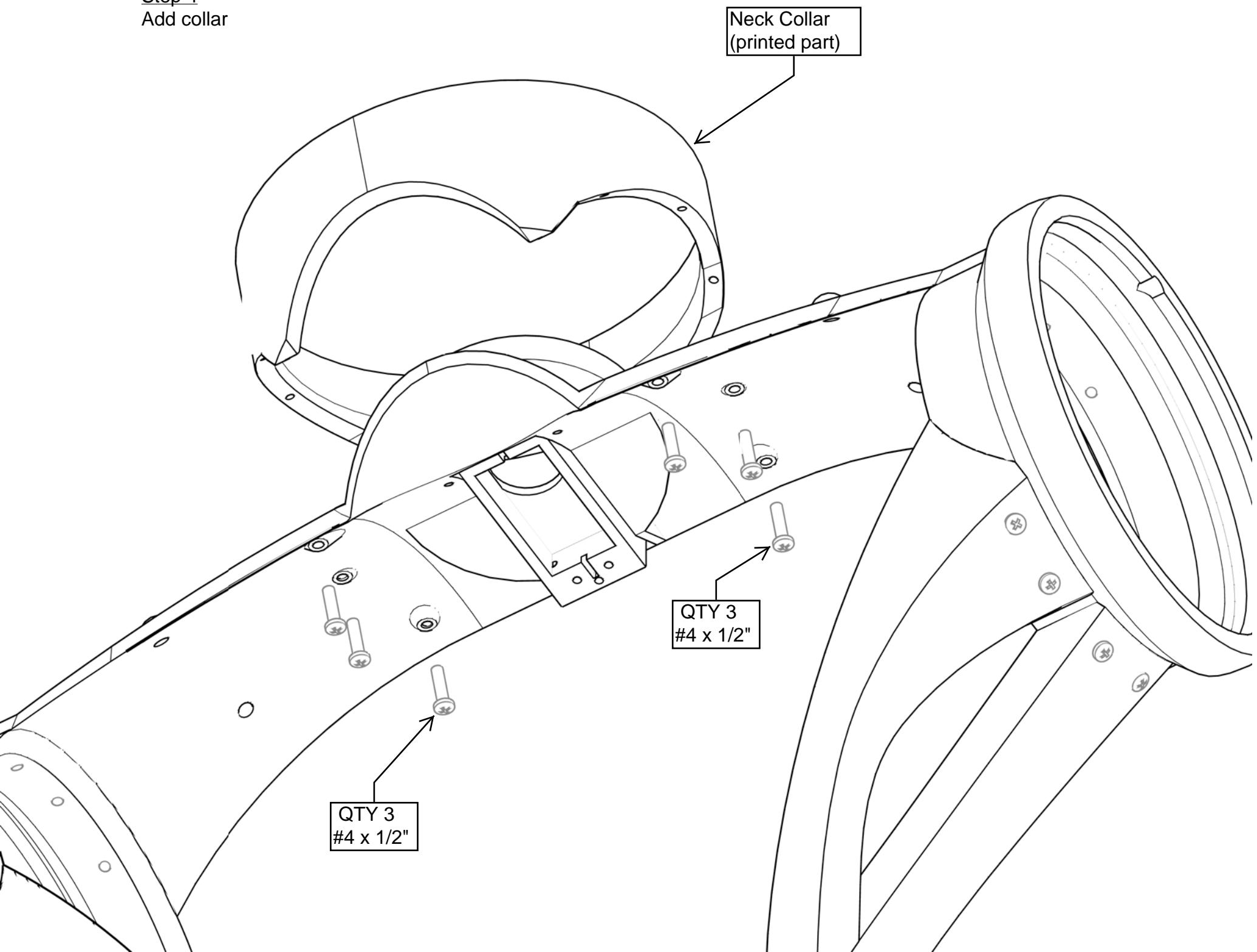
QTY 4
#4 x 3/8"

Step 3
Add neck bearing holder



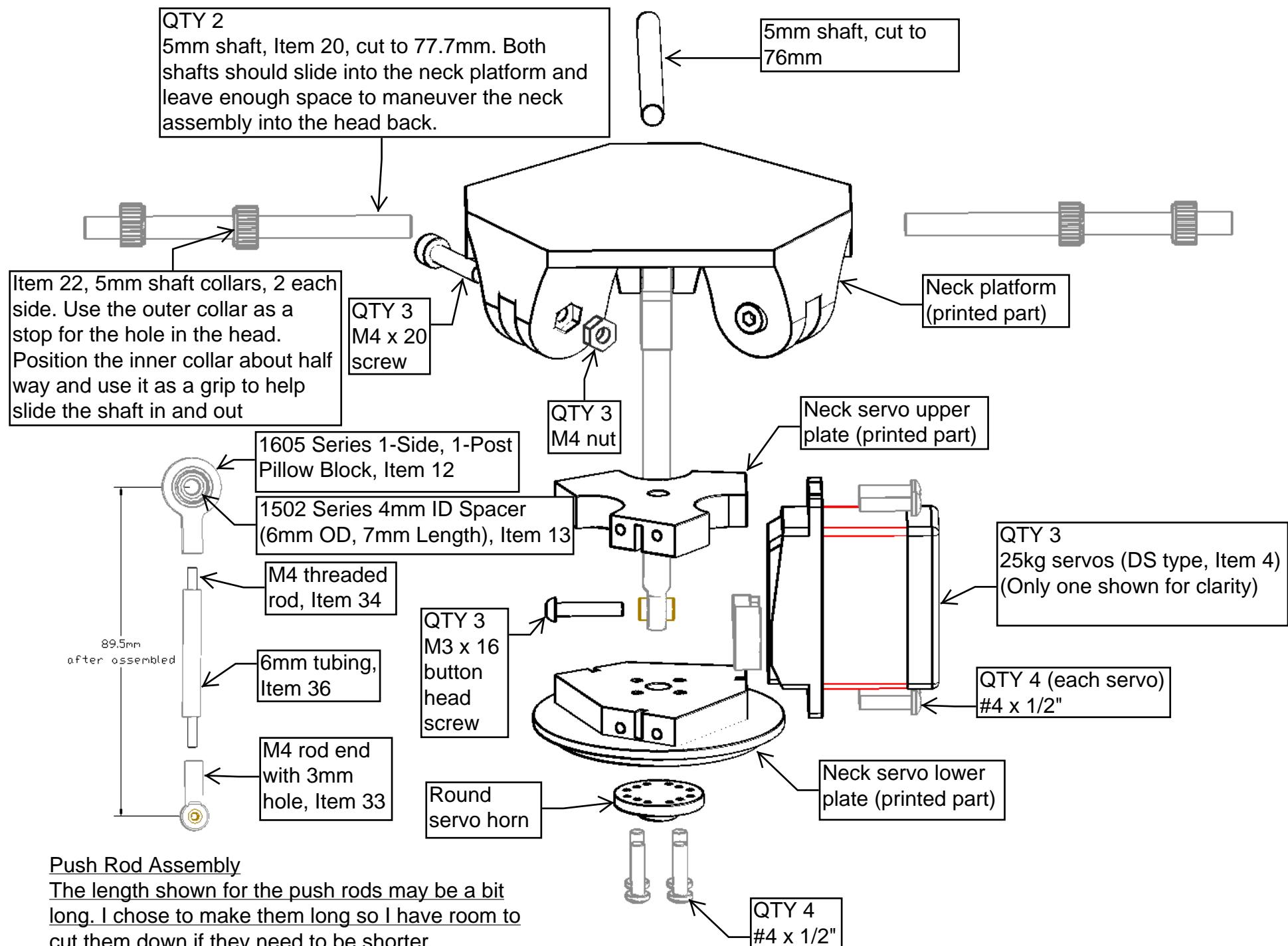
Step 4

Add collar



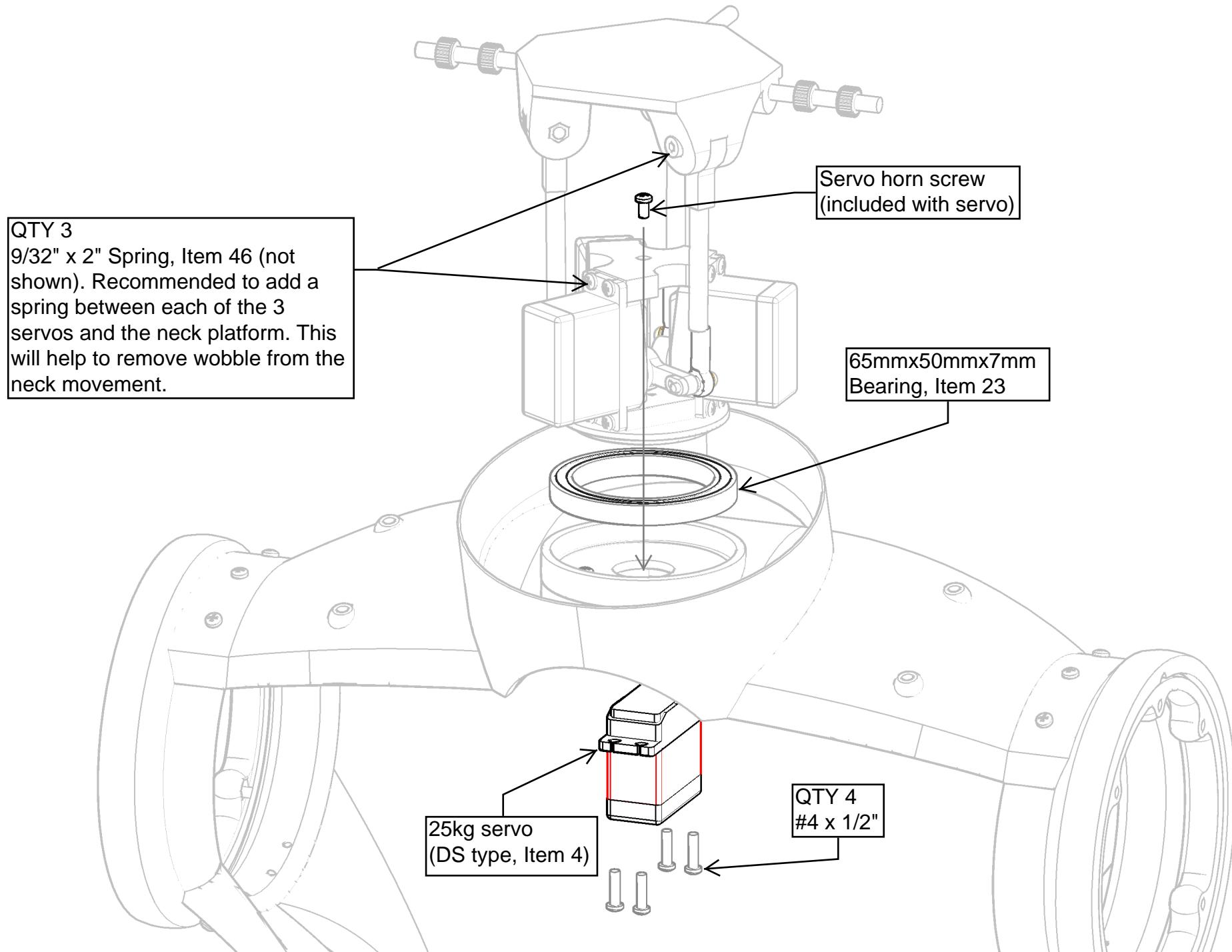
Step 5

Assemble neck assembly.



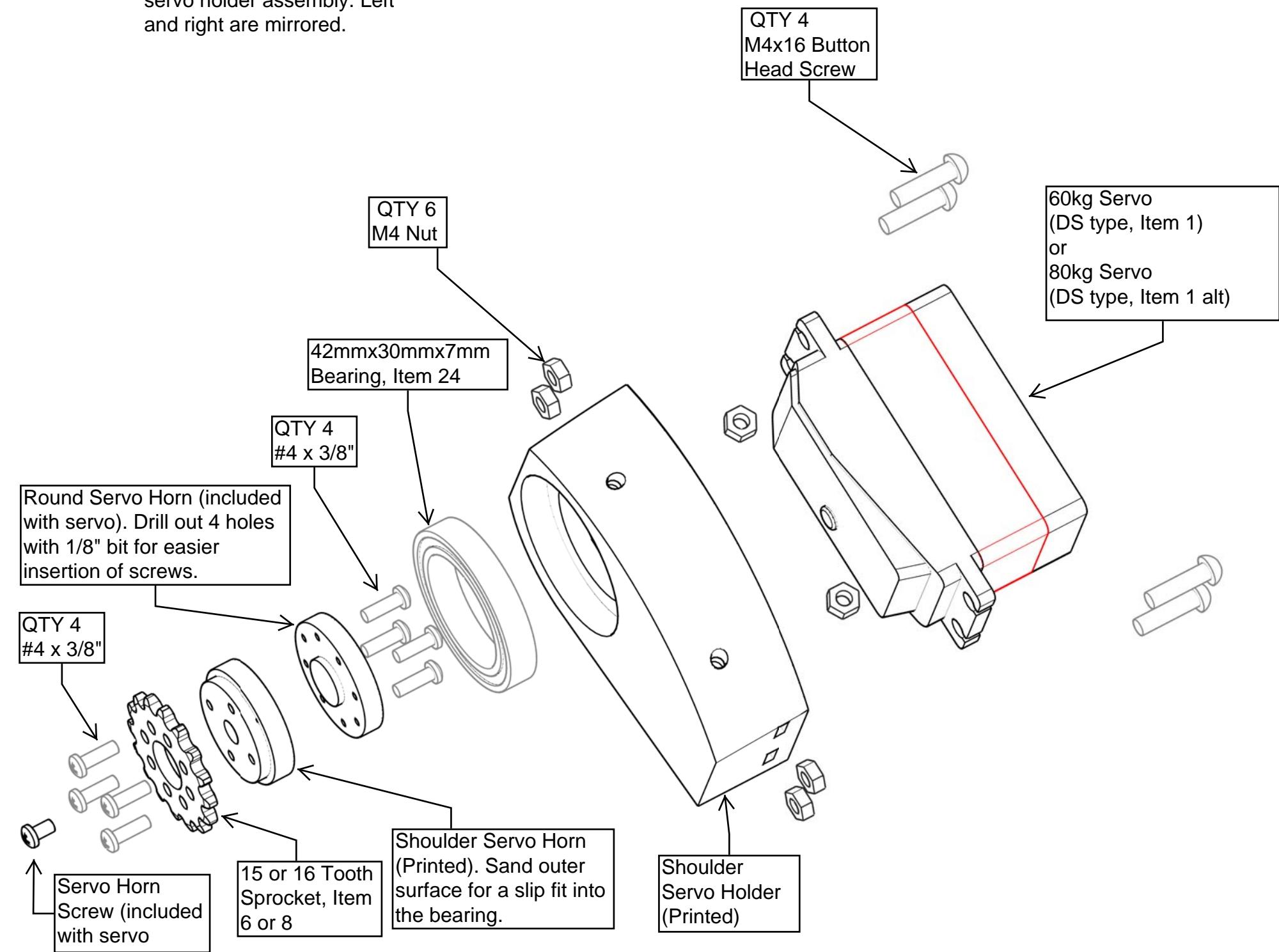
Step 6

Attach neck assembly to frame.



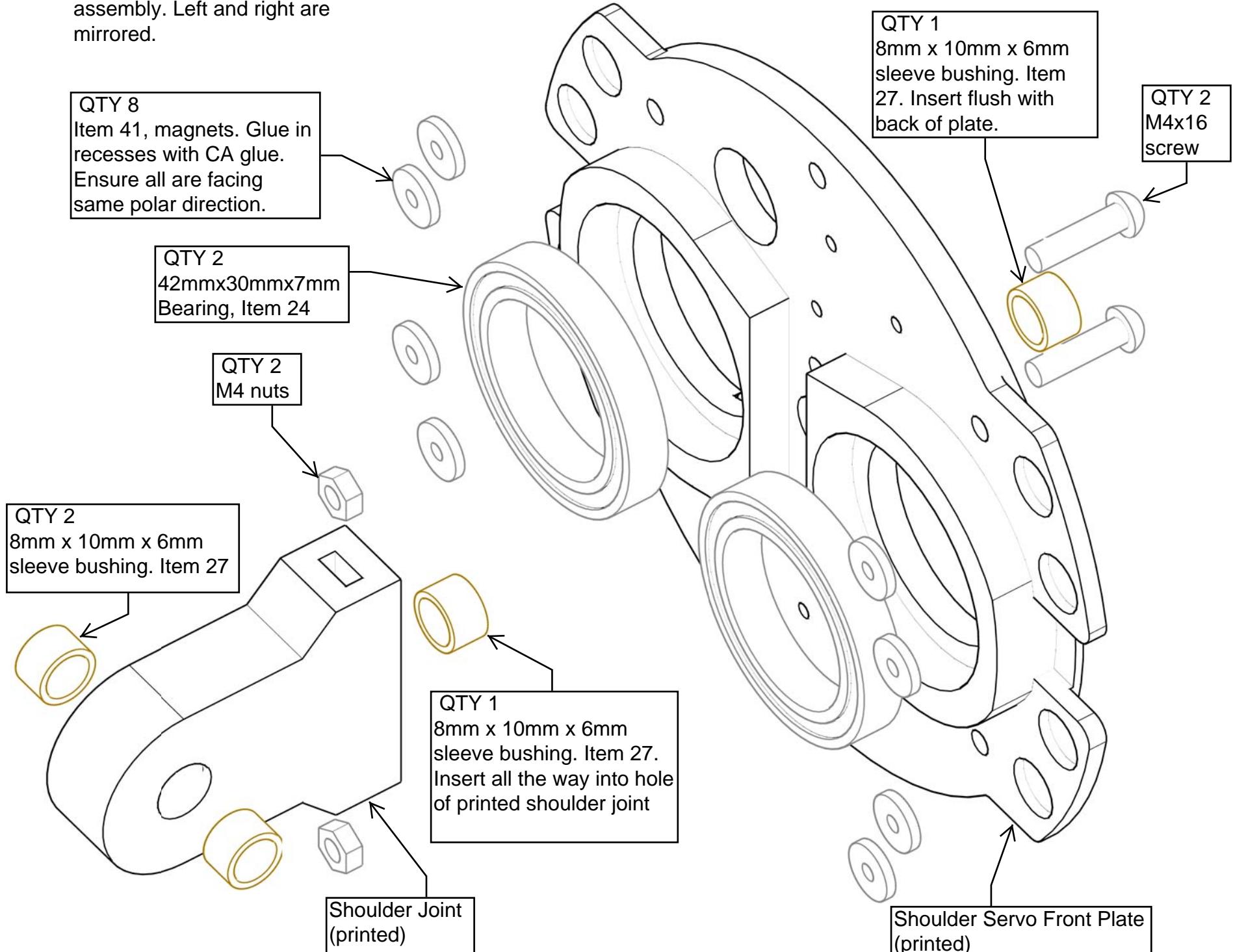
Step 7

Assemble shoulder rotation servo holder assembly. Left and right are mirrored.



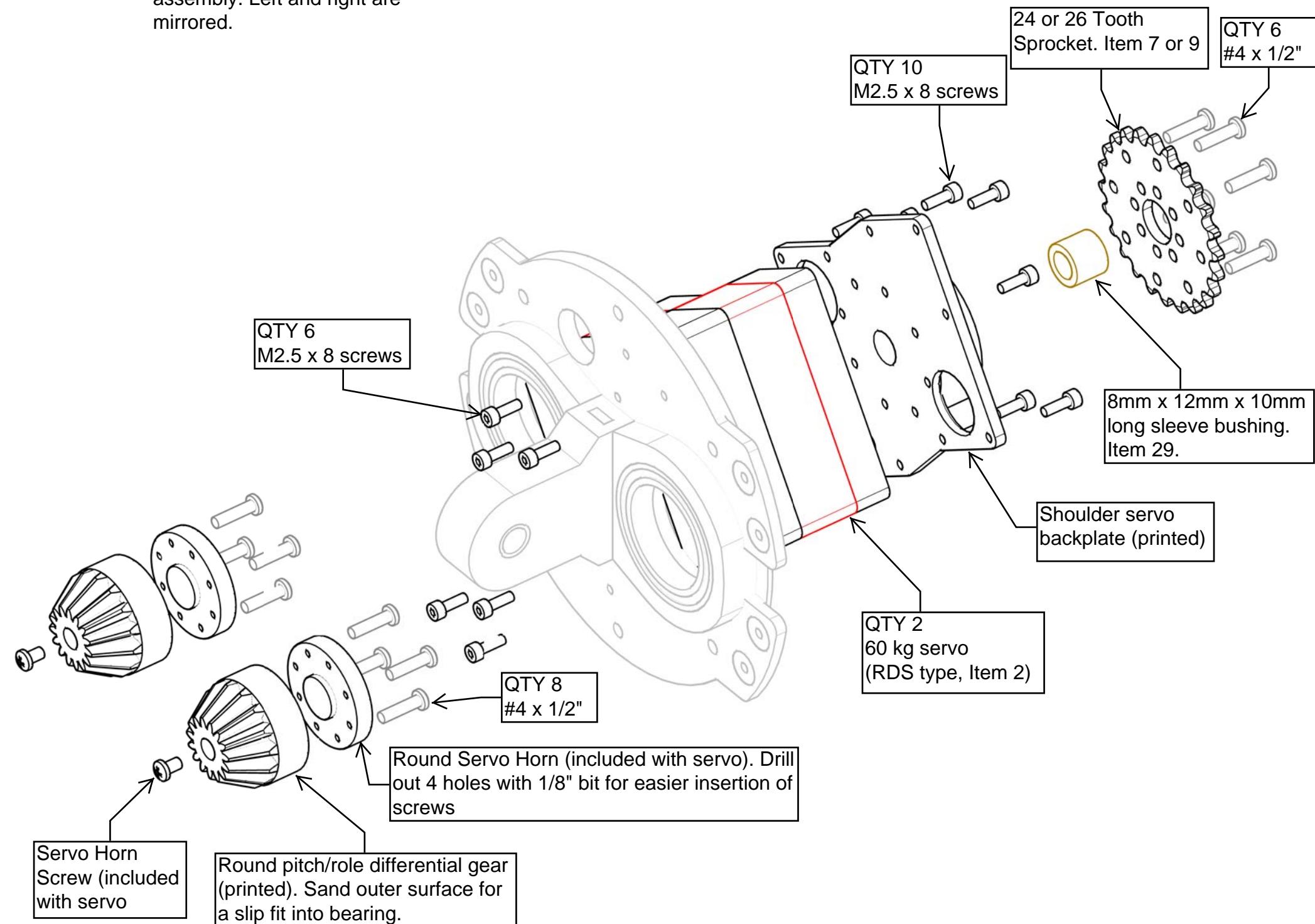
Step 8

Assemble shoulder front plate assembly. Left and right are mirrored.



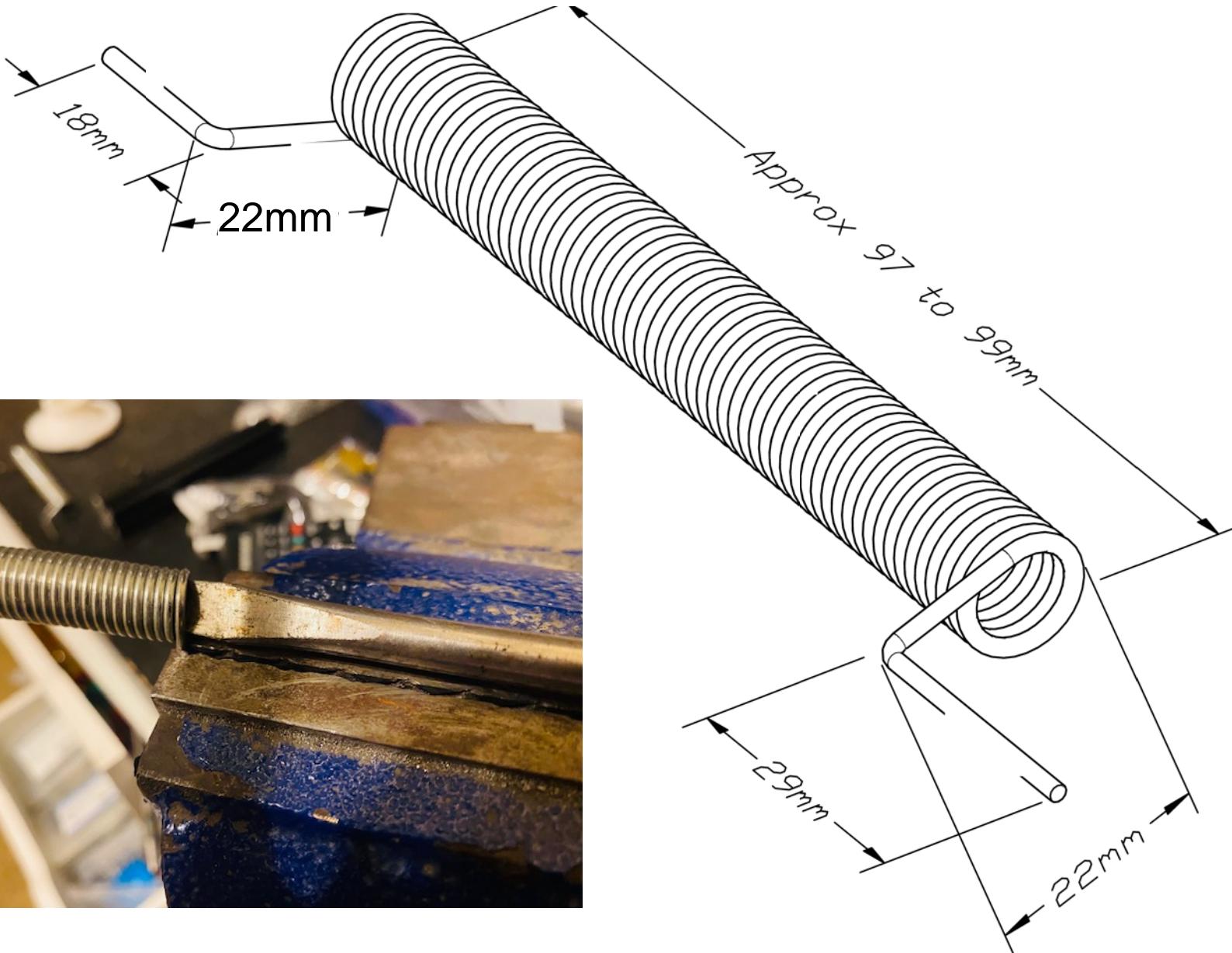
Step 9

Assemble shoulder rotation assembly. Left and right are mirrored.



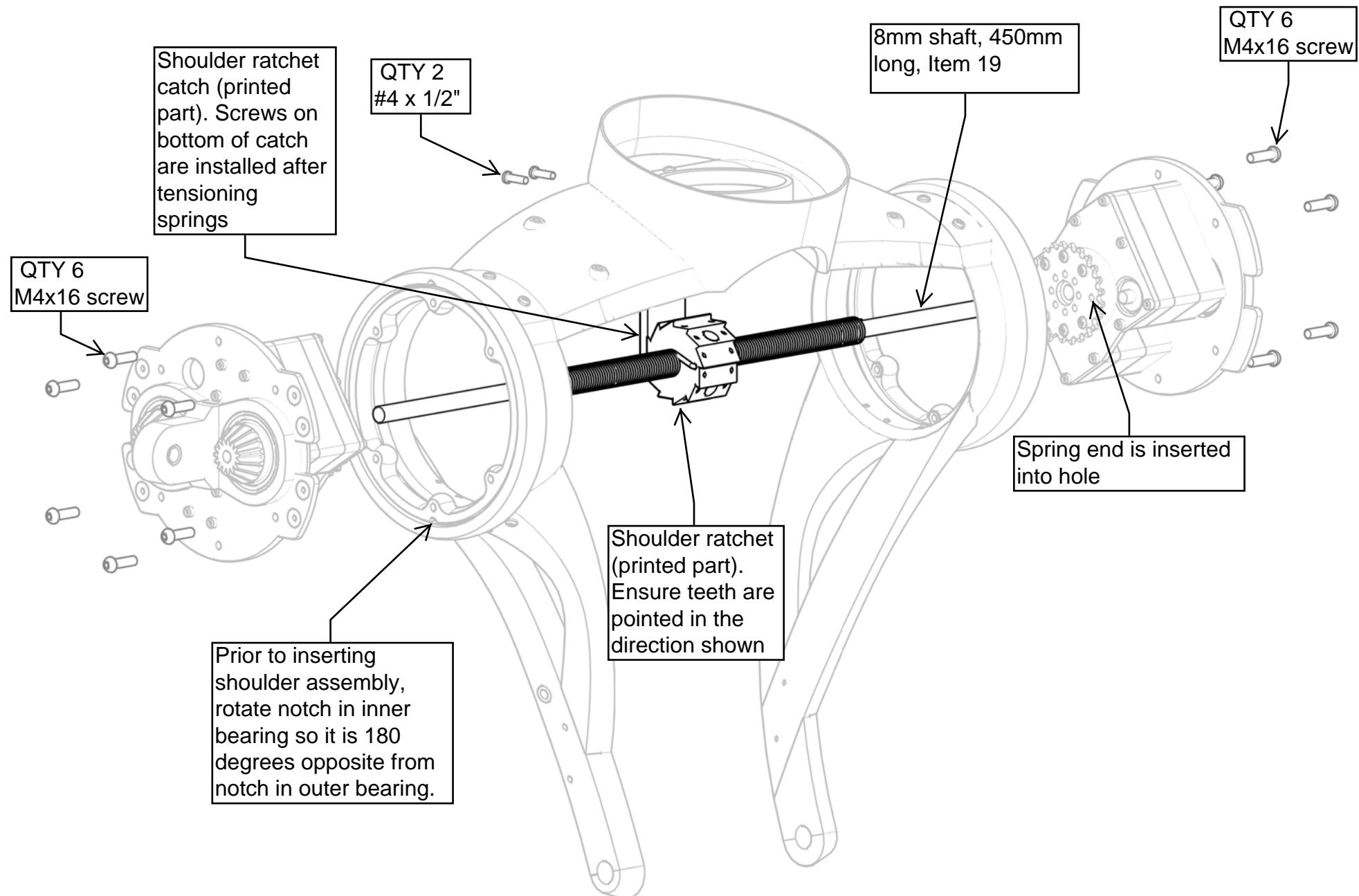
Step 10 Optional but Recommended

Fabricate torsion springs as follows. Cut a section of door spring (Item 42) to approximately 104mm long. Use a bench vise to hold the tip of one cut end securely. Insert a large, flat head screwdriver into the end and twist the screwdriver and spring to unwind a short section of spring wire (about 2mm). Reposition the spring end in the vise to grip the newly straighten section and repeat the process with the screwdriver. Unwind a total of 53mm of spring wire from one end and 60mm of spring wire from the opposite end. Measure and mark the dimensions for the 90 degree bend for each end and bend by hand. The spring wire is hard and can break if the bend is too sharp. Finally, cut off the excess from each end to the final dimension.

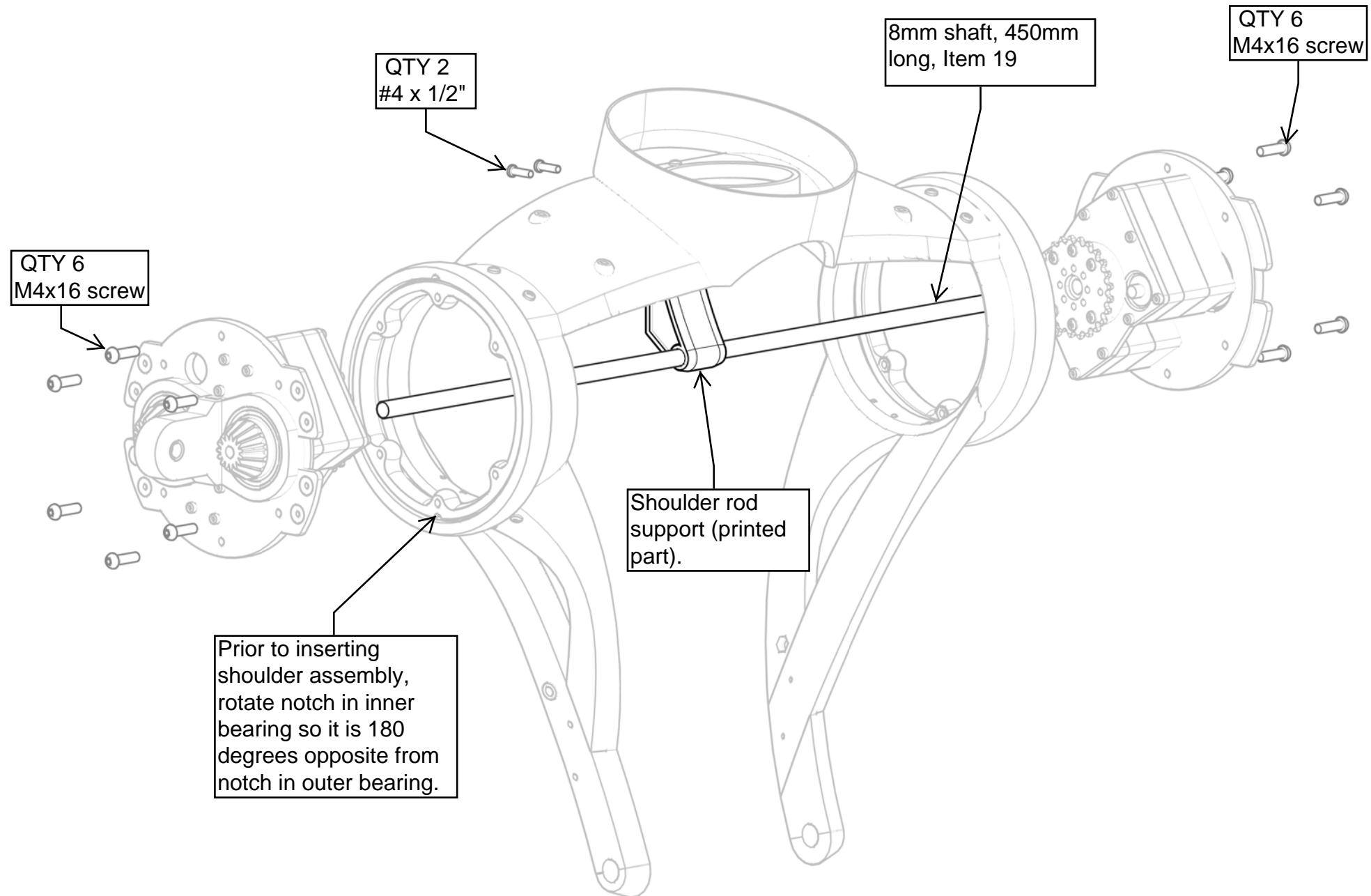


Step 11 (With Spring)

Assemble shoulders onto rotation axis.



Step 12 (Without Spring)
Assemble shoulders onto
rotation axis.



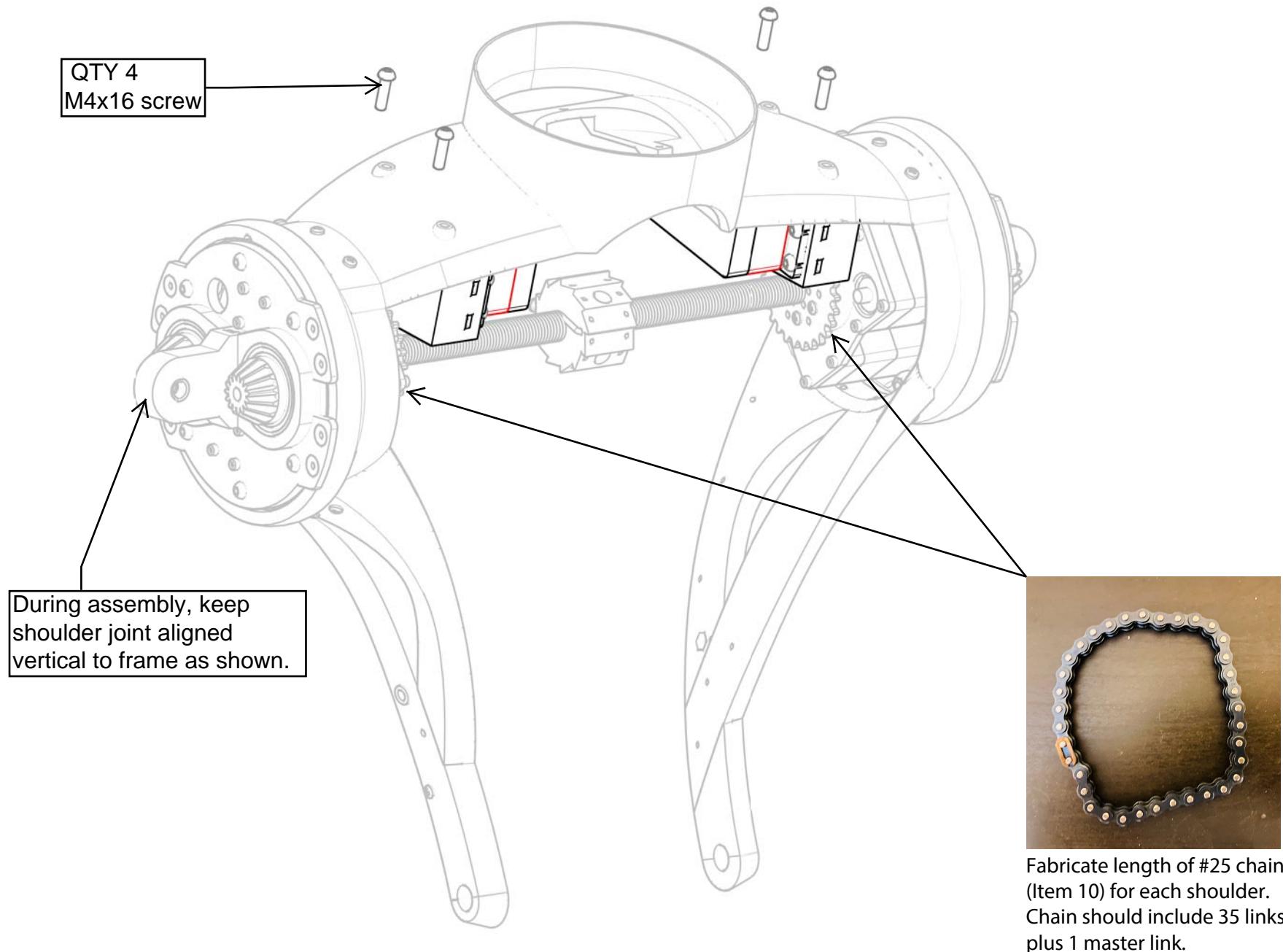
Step 13

Install Shoulder Rotation Servo Holder Assemblies into frame.

Position servos as shown in the table to the right. Place chain over sprockets prior to tightening screws.

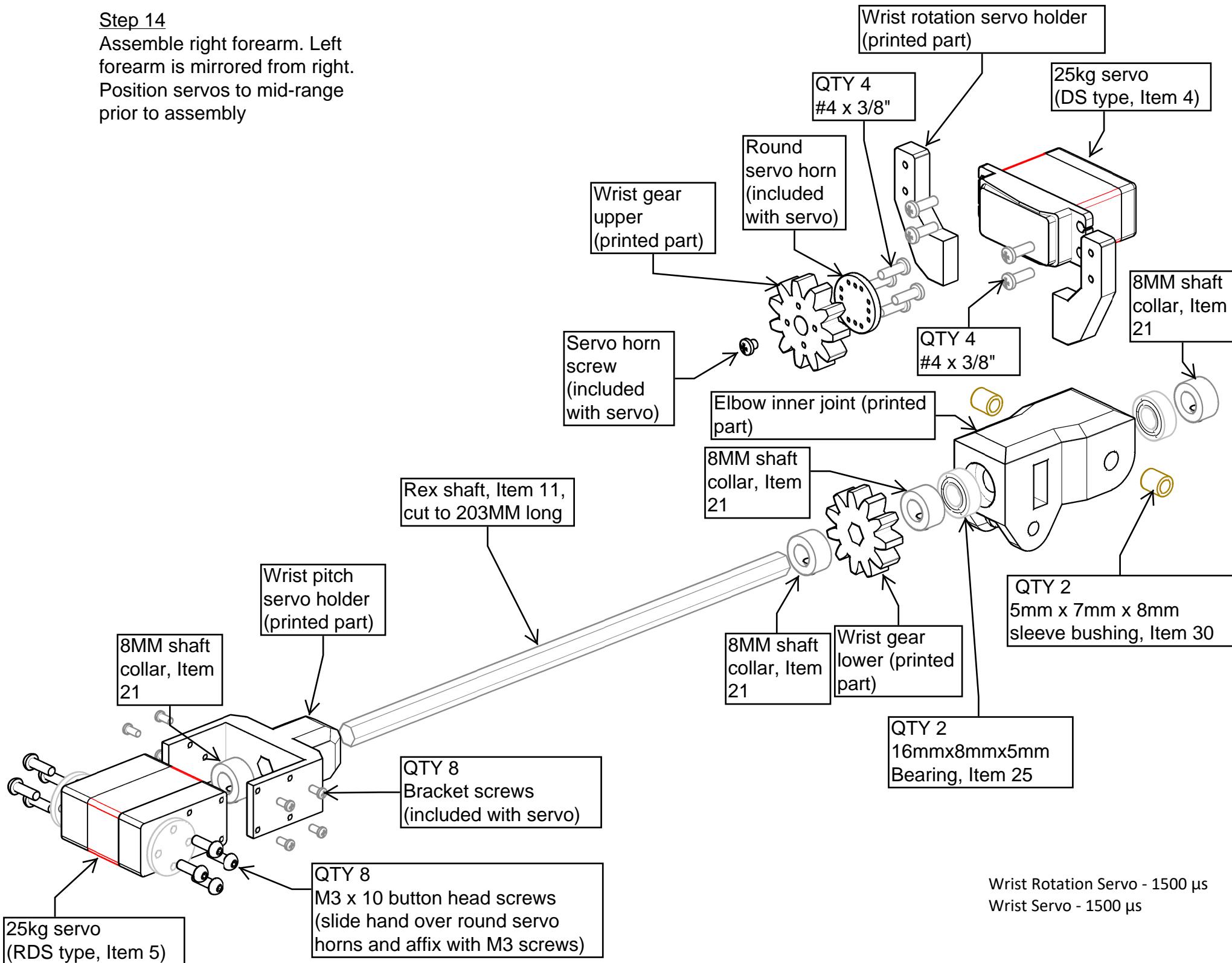
Right Shoulder Rotation Servo - 2100 µs

Left Shoulder Rotation Servo - 700 µs



Step 14

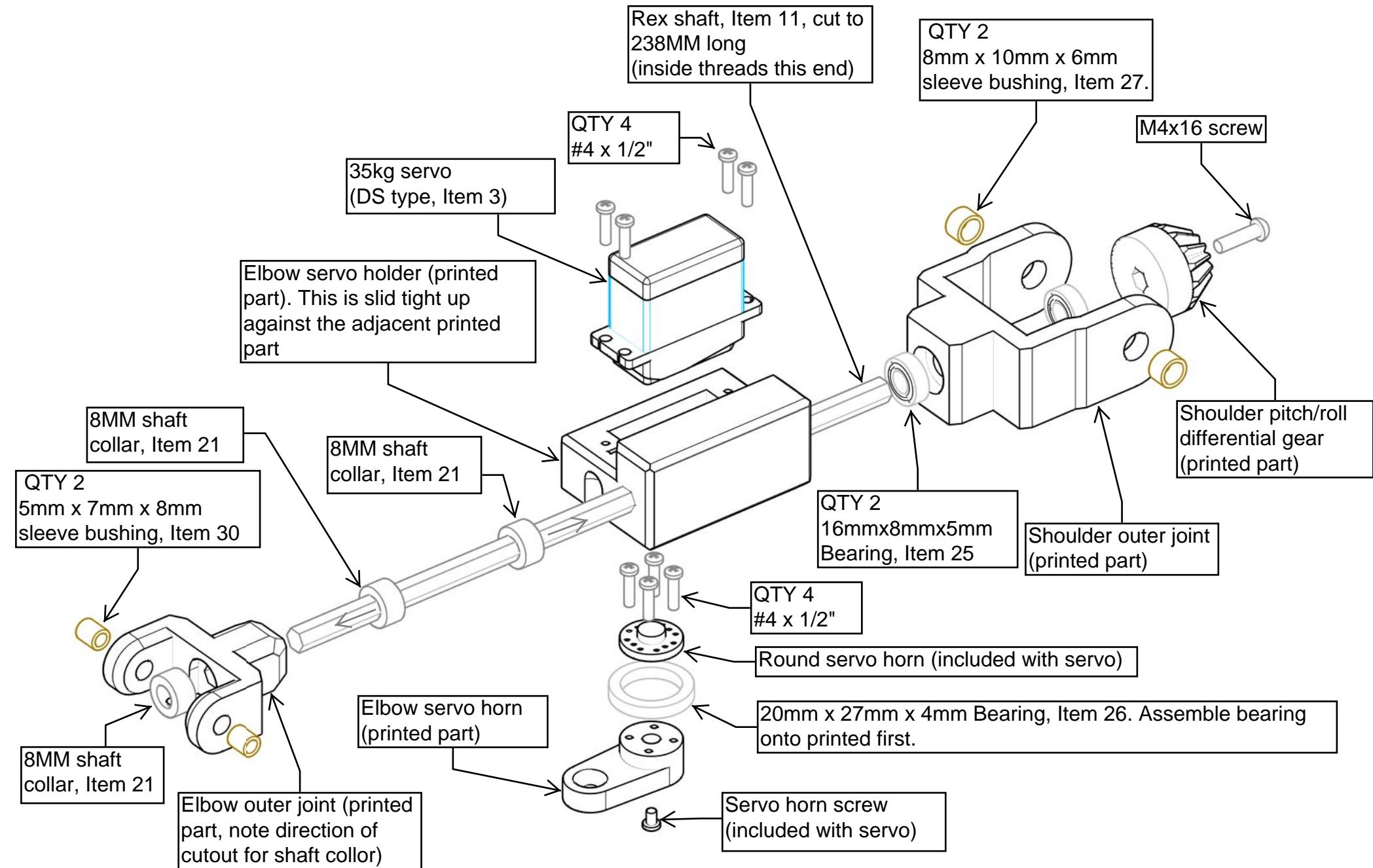
Assemble right forearm. Left forearm is mirrored from right. Position servos to mid-range prior to assembly



Step 15

Assemble right bicep. Left bicep is mirrored from right. Before securing the servo horn, position servo to 0 degrees for right bicep or 180 degrees for left bicep.

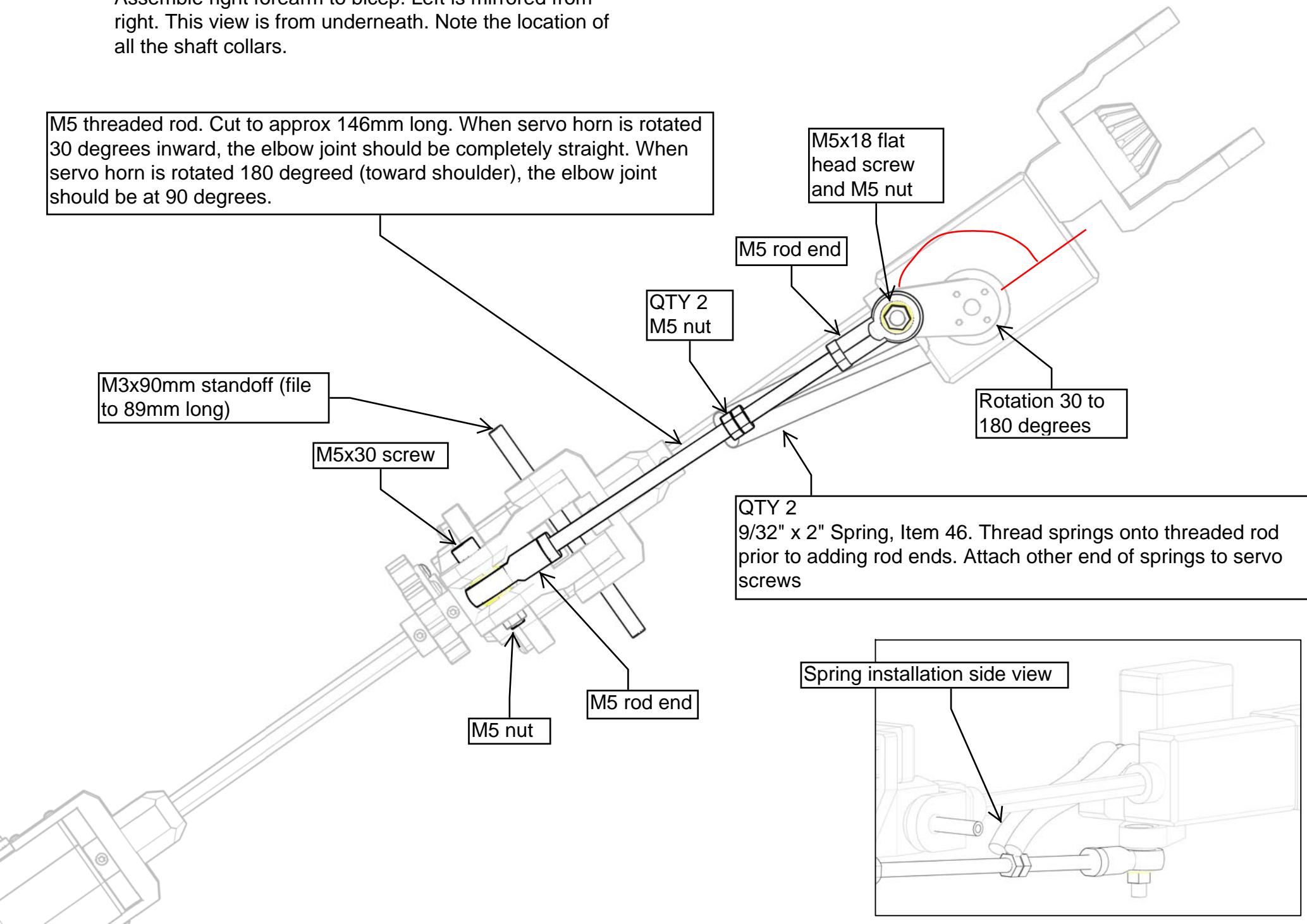
Left Bicep Servo - 500 μ s
Right Bicep Servo - 2500 μ s



Step 16

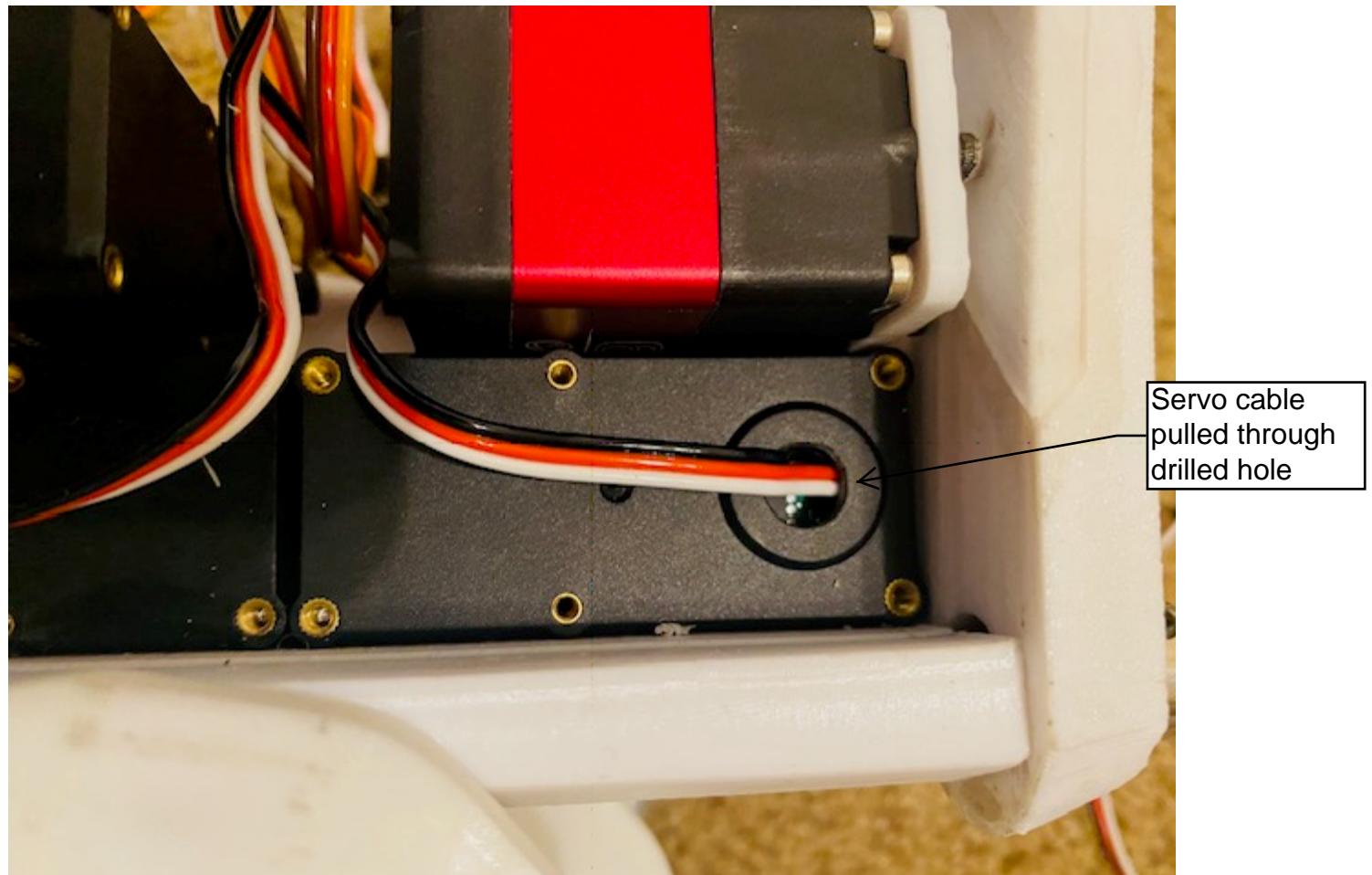
Assemble right forearm to bicep. Left is mirrored from right. This view is from underneath. Note the location of all the shaft collars.

M5 threaded rod. Cut to approx 146mm long. When servo horn is rotated 30 degrees inward, the elbow joint should be completely straight. When servo horn is rotated 180 degreeed (toward shoulder), the elbow joint should be at 90 degrees.



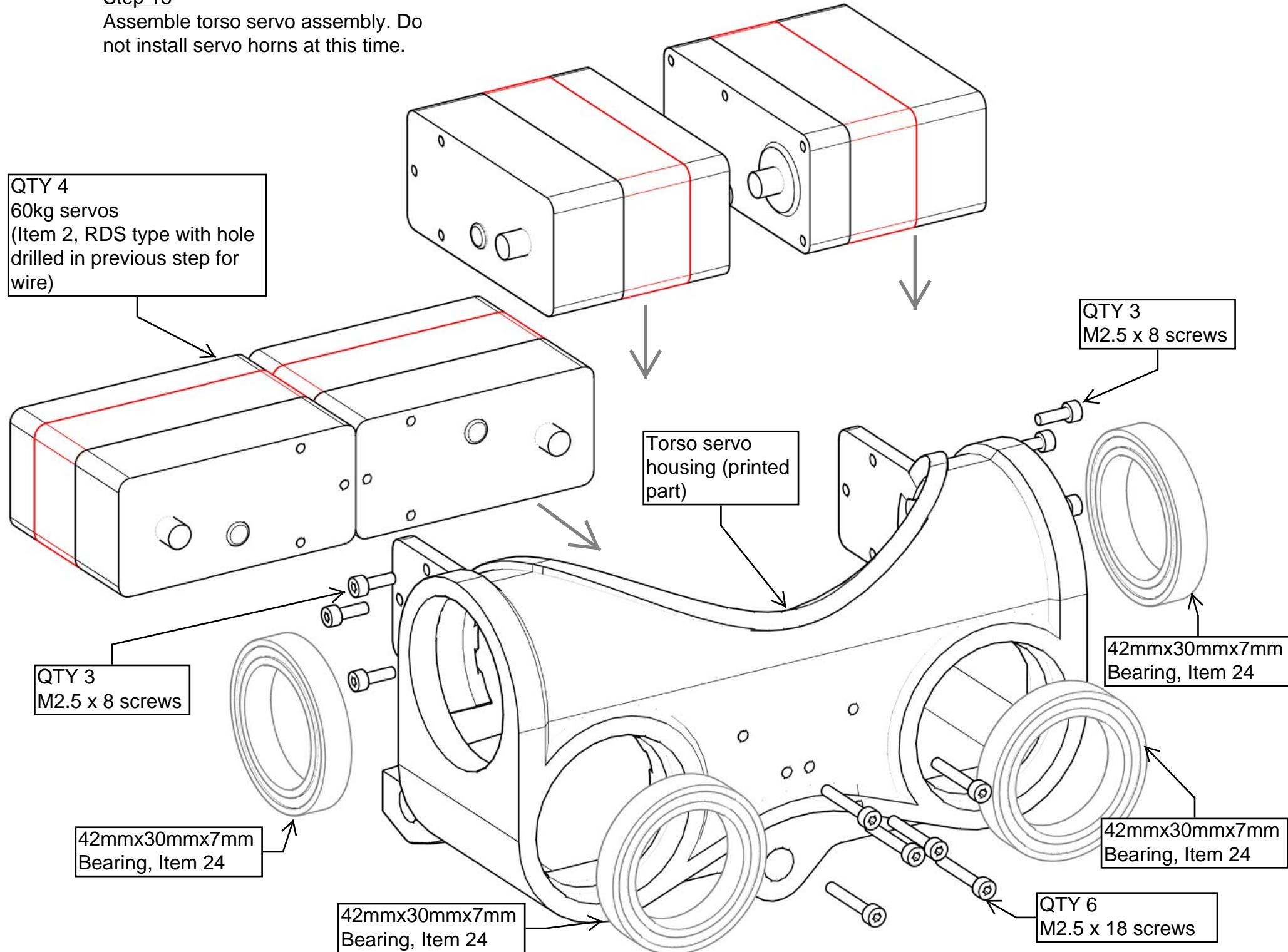
Step 17

Prepare servos for mounting in torso servo assembly. In this step, you will modify the torso servos to change where the servo wires exit the servo. Unscrew and remove the bottom housing of four (4) of the RDS style, 60kg servos. Drill out the plastic post with a 8mm or larger drill bit. Reassemble the bottom housing taking note to pull the servo cable through hole as you reassemble.



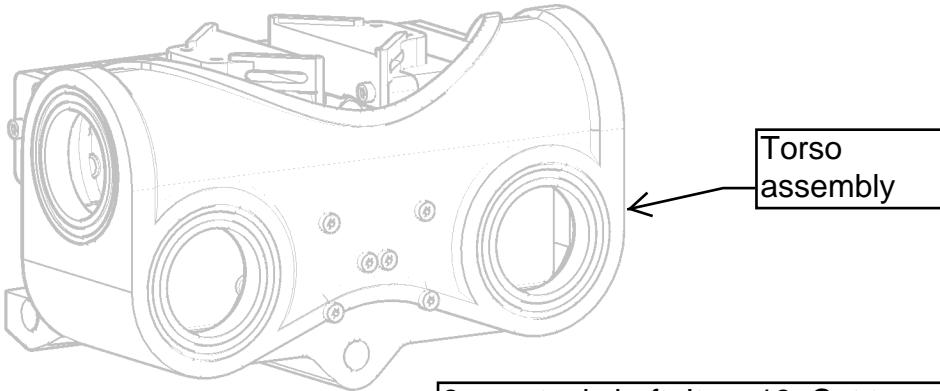
Step 18

Assemble torso servo assembly. Do not install servo horns at this time.



Step 19

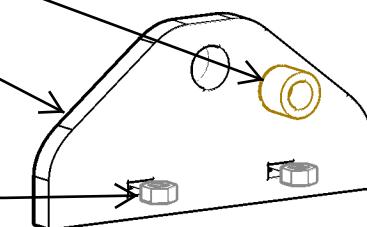
Assemble hip assembly with torso assembly.



8mm x 12mm x 10mm long sleeve bushing, Item 29.

Torso back base (printed part)

QTY 2
M5 nut



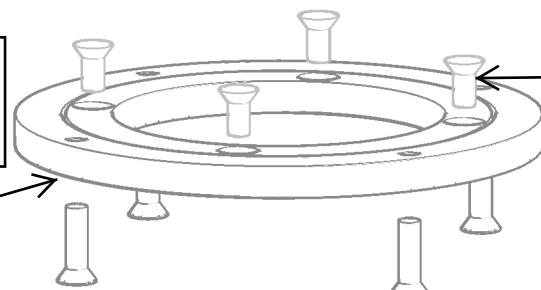
8mm steel shaft, Item 19. Cut to 95.4mm long. Place shaft through hole in torso assembly prior to affixing the torso base to the bearing

8mm x 12mm x 10mm long sleeve bushing, Item 29

Torso base plate (printed part)
Note that the flat surface is facing up and the face with the slight raised lip is facing down.

QTY 4
M5 x 20 flat head screw

QTY 4
M5 nut

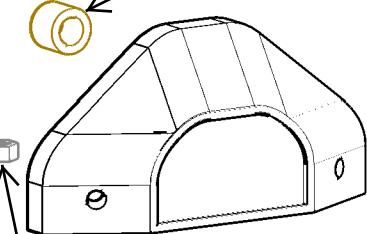


140mm Lazy Susan Bearing, Item 40

QTY 2
M5 nut

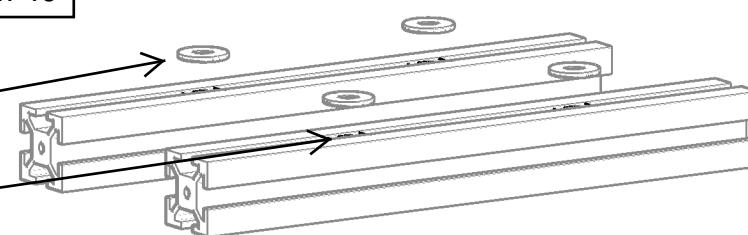
QTY 4
M5 x 16 flat head screw

Torso front base (printed part, note that the front base part has holes in front)



QTY 4
5mm washer

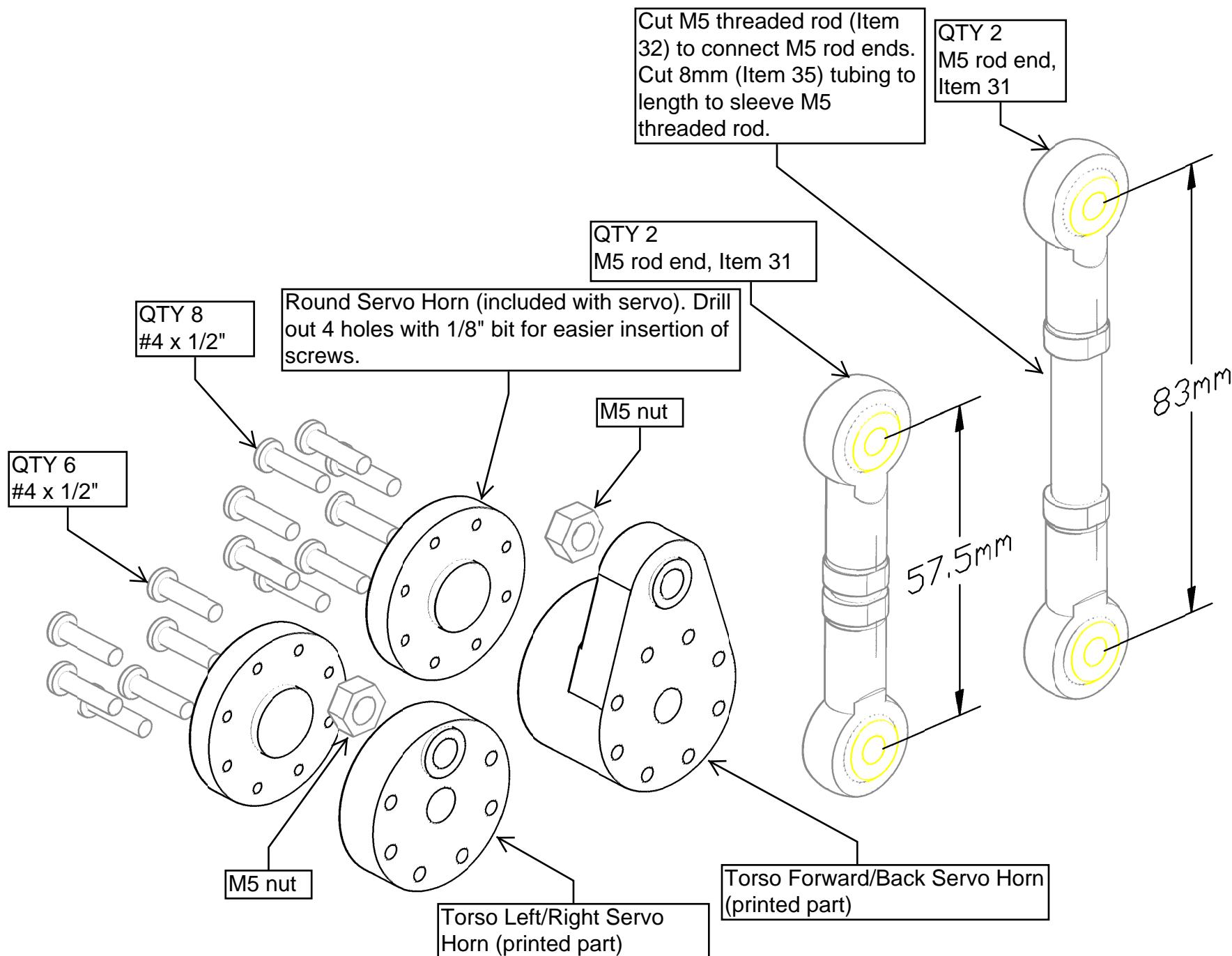
QTY 4
5mm T-Nut



QTY 2
2020 Extrusion, Item 39, cut to 196 mm length

Step 20

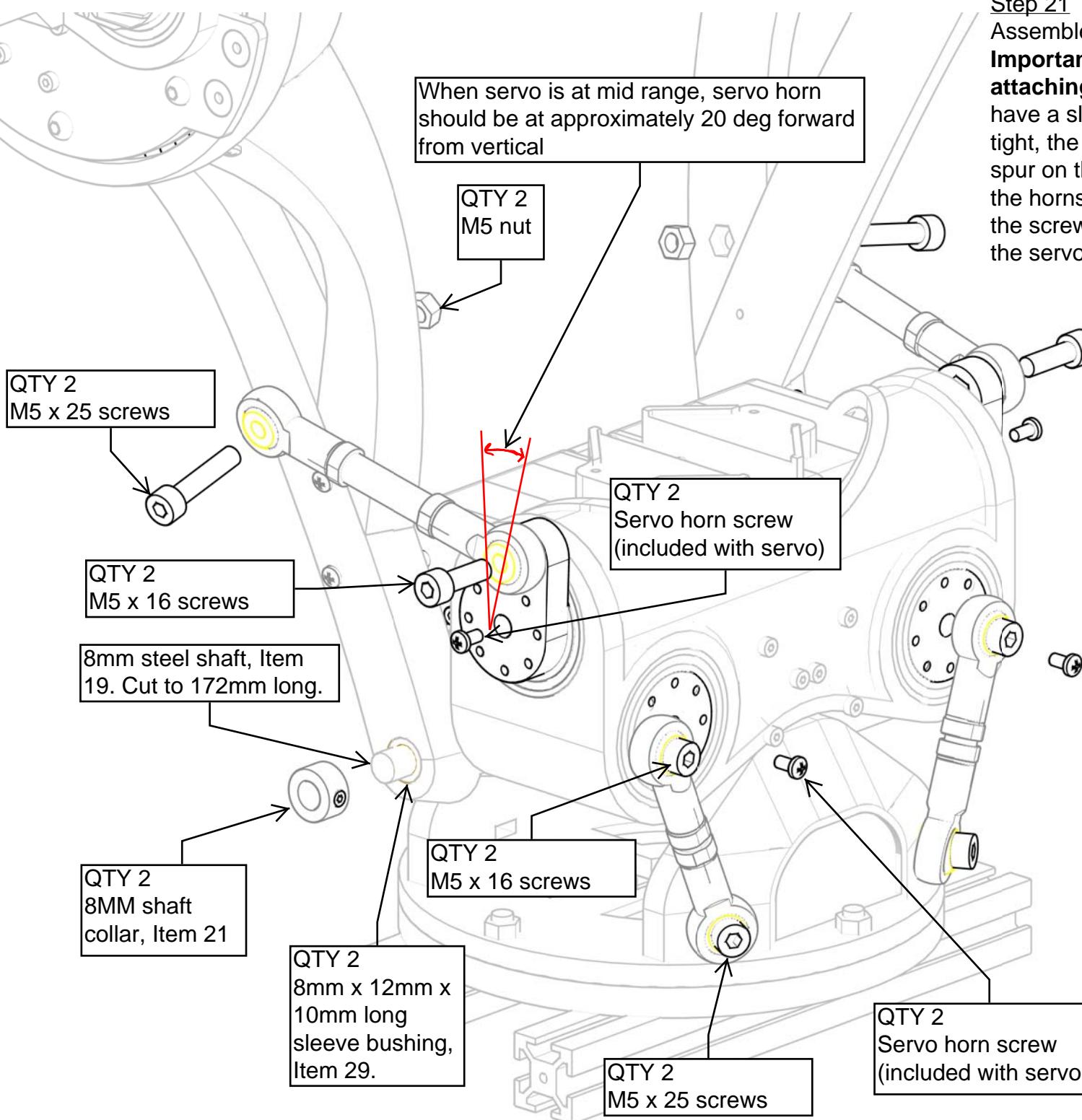
Assemble torso servo horns and linkages.
QTY 2 each below are required.
Sand outer surface of servo horns for a slip fit
into bearings.



Step 21

Assemble upper torso to lower torso.

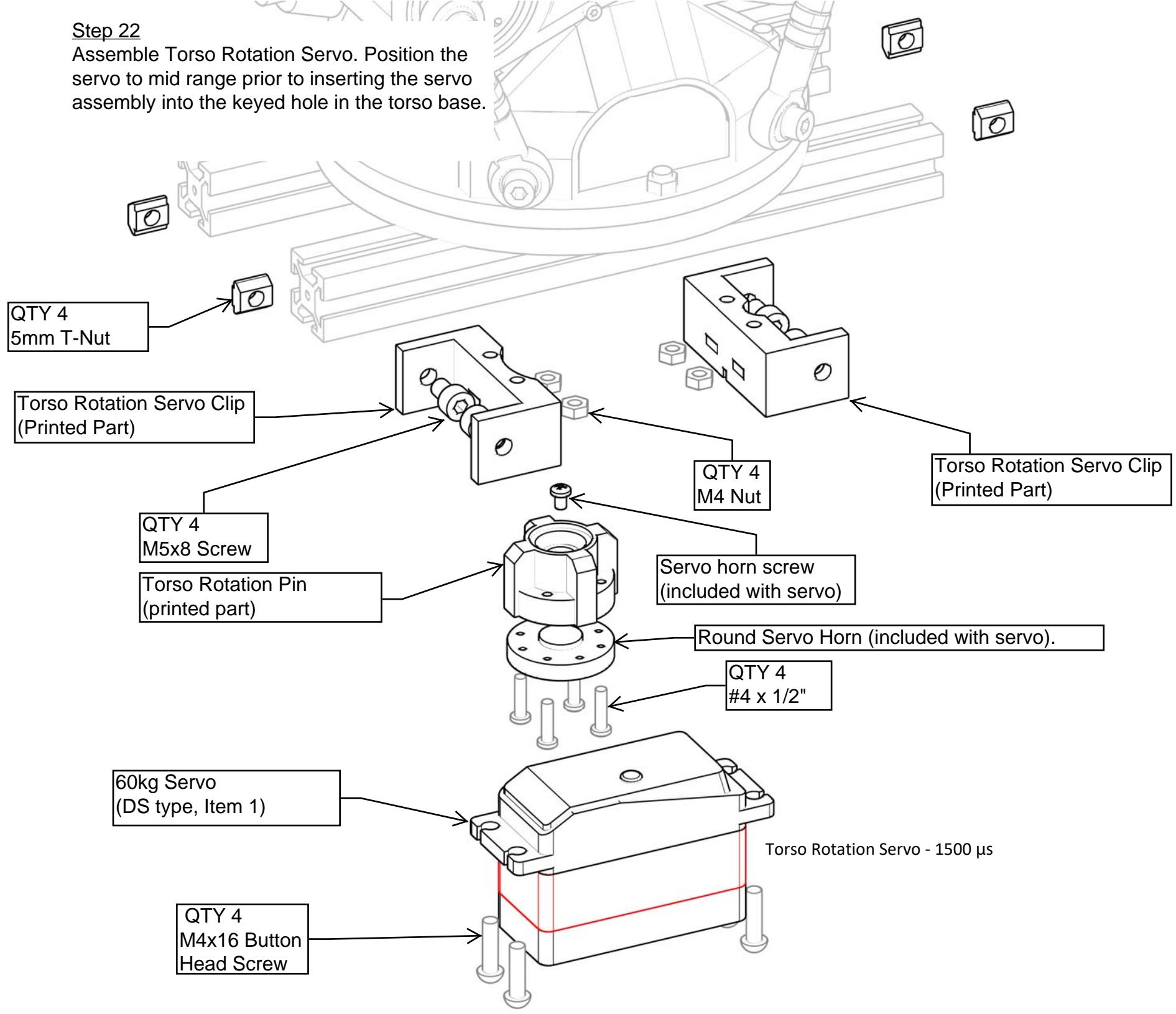
Important, set servos to mid range prior to attaching servo horns. Servo horns should have a slip fit into the bearings. If the fit is too tight, the horns will have trouble mating with the spur on the servo. If you have trouble getting the horns to mate with the servos, try loosening the screws holding the servo in place to allow the servos to move around slightly.



Torso L/R Lean Servos - 1500 µs
Torso F/B Lean Servos - 1500 µs

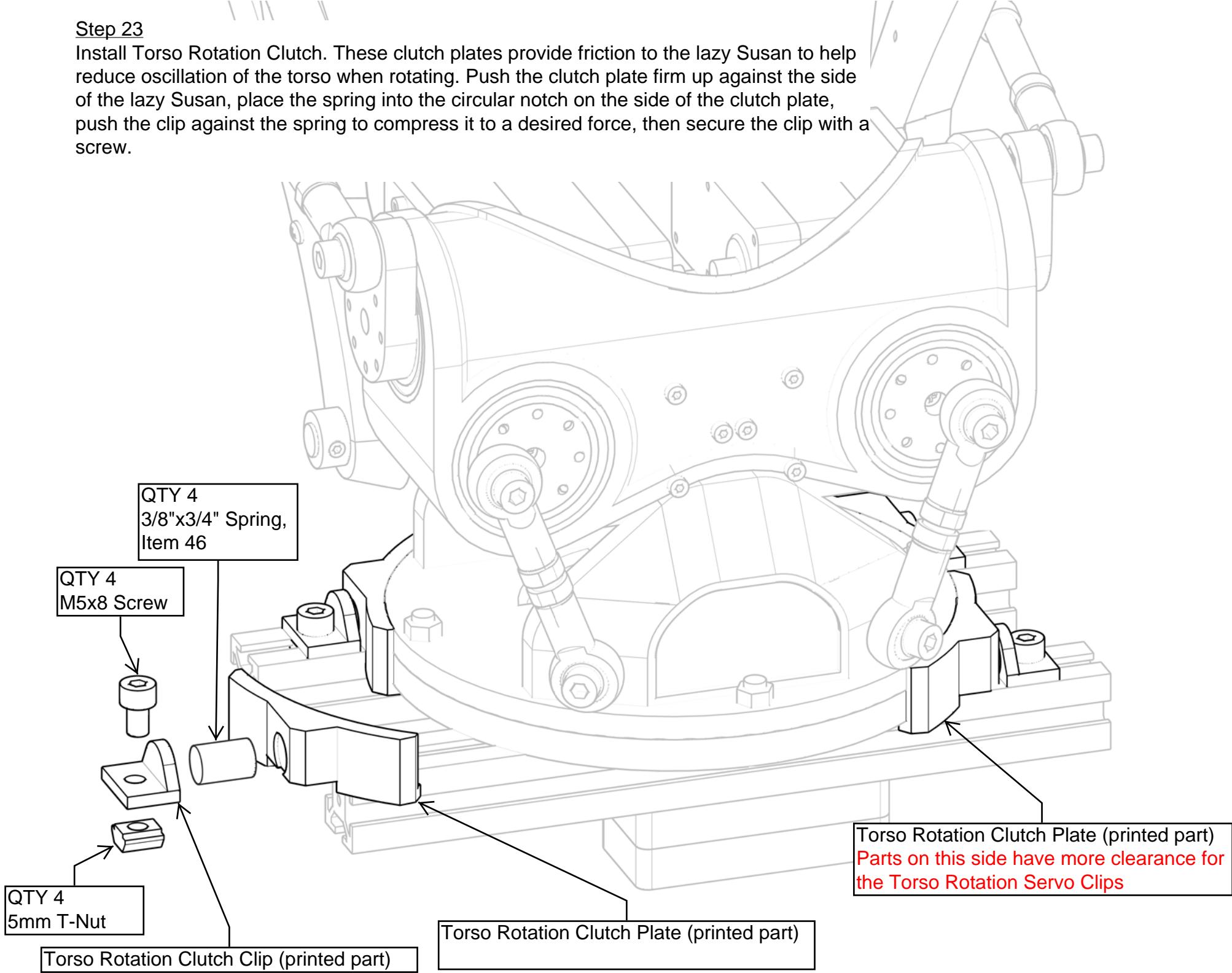
Step 22

Assemble Torso Rotation Servo. Position the servo to mid range prior to inserting the servo assembly into the keyed hole in the torso base.



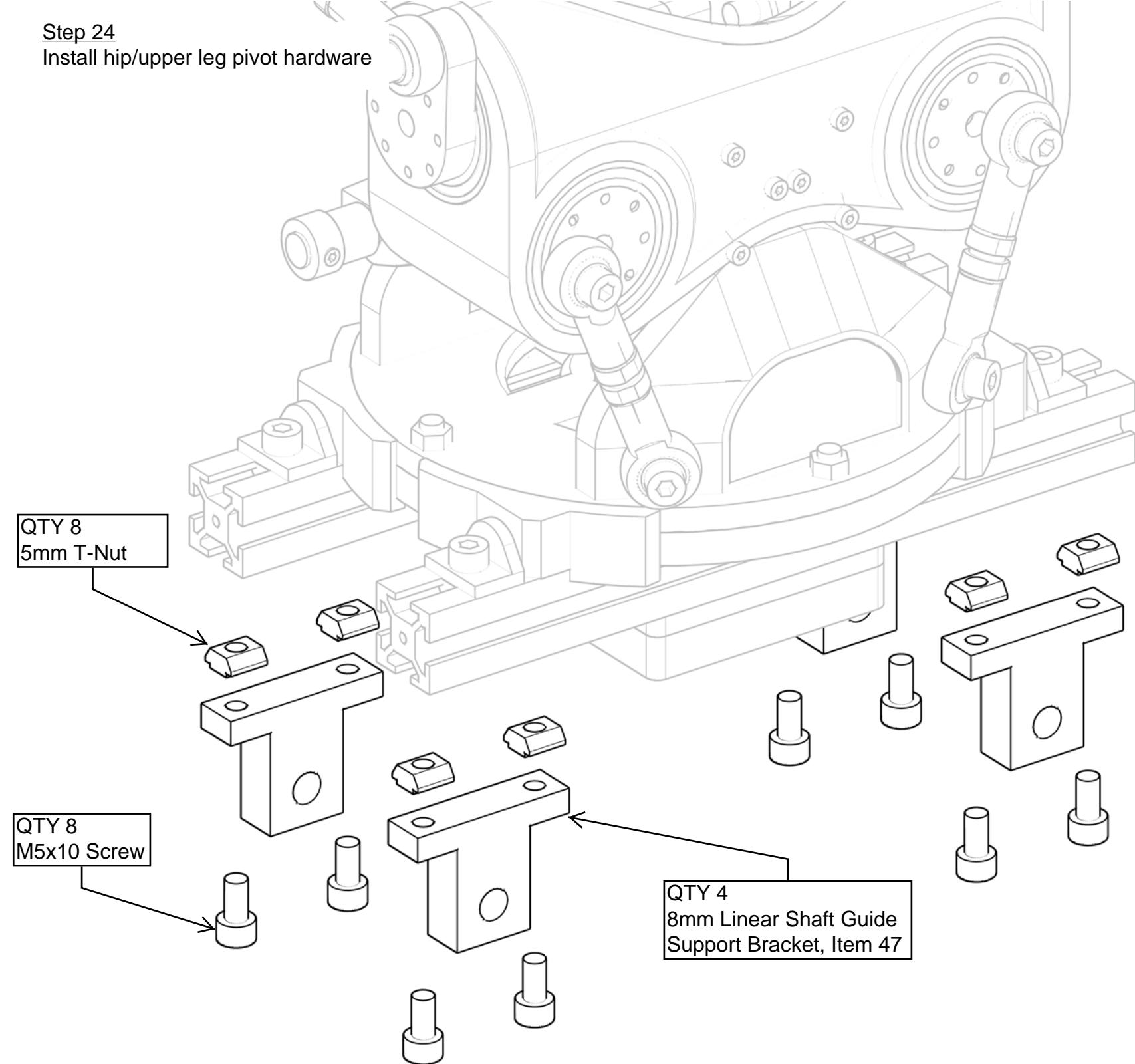
Step 23

Install Torso Rotation Clutch. These clutch plates provide friction to the lazy Susan to help reduce oscillation of the torso when rotating. Push the clutch plate firm up against the side of the lazy Susan, place the spring into the circular notch on the side of the clutch plate, push the clip against the spring to compress it to a desired force, then secure the clip with a screw.



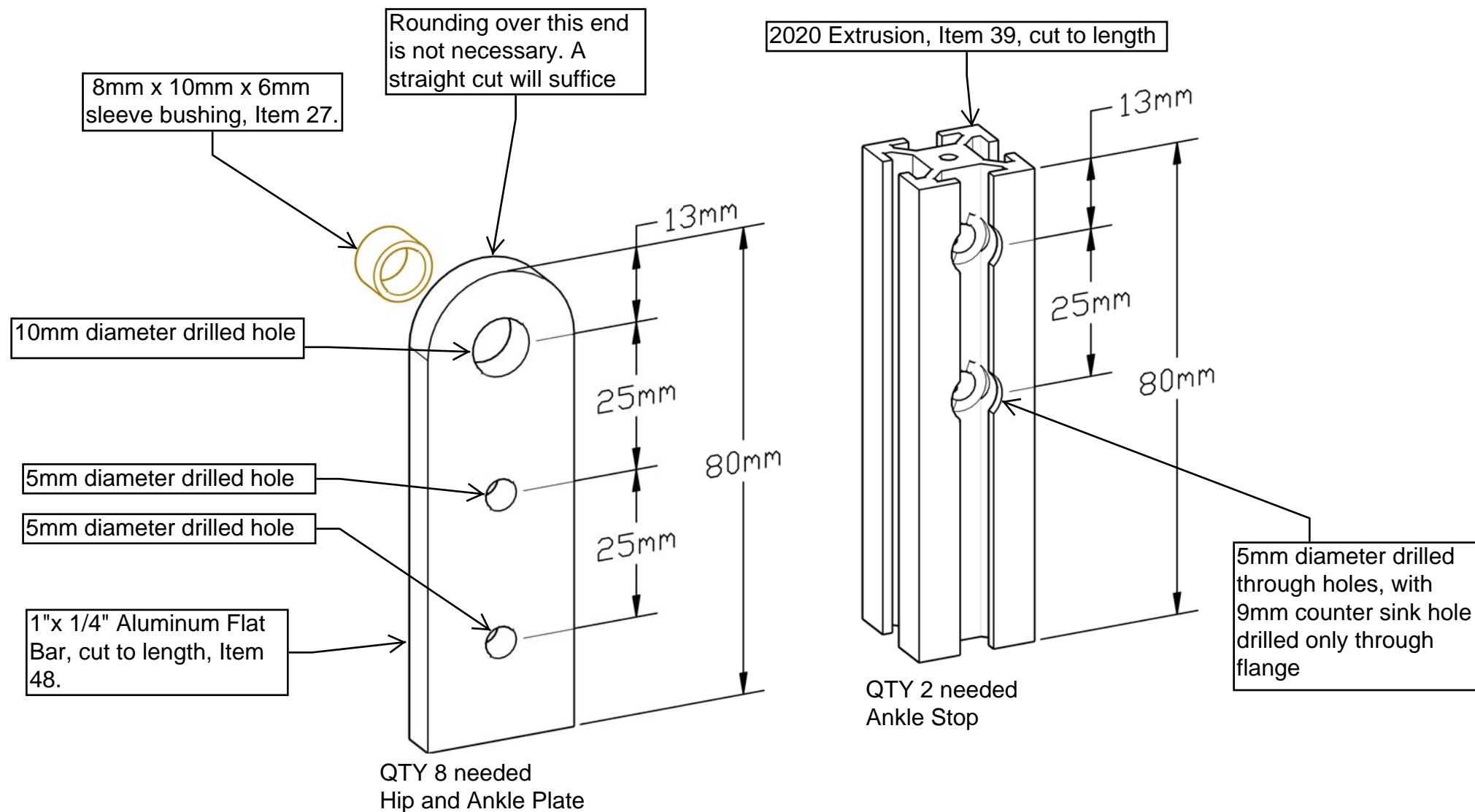
Step 24

Install hip/upper leg pivot hardware



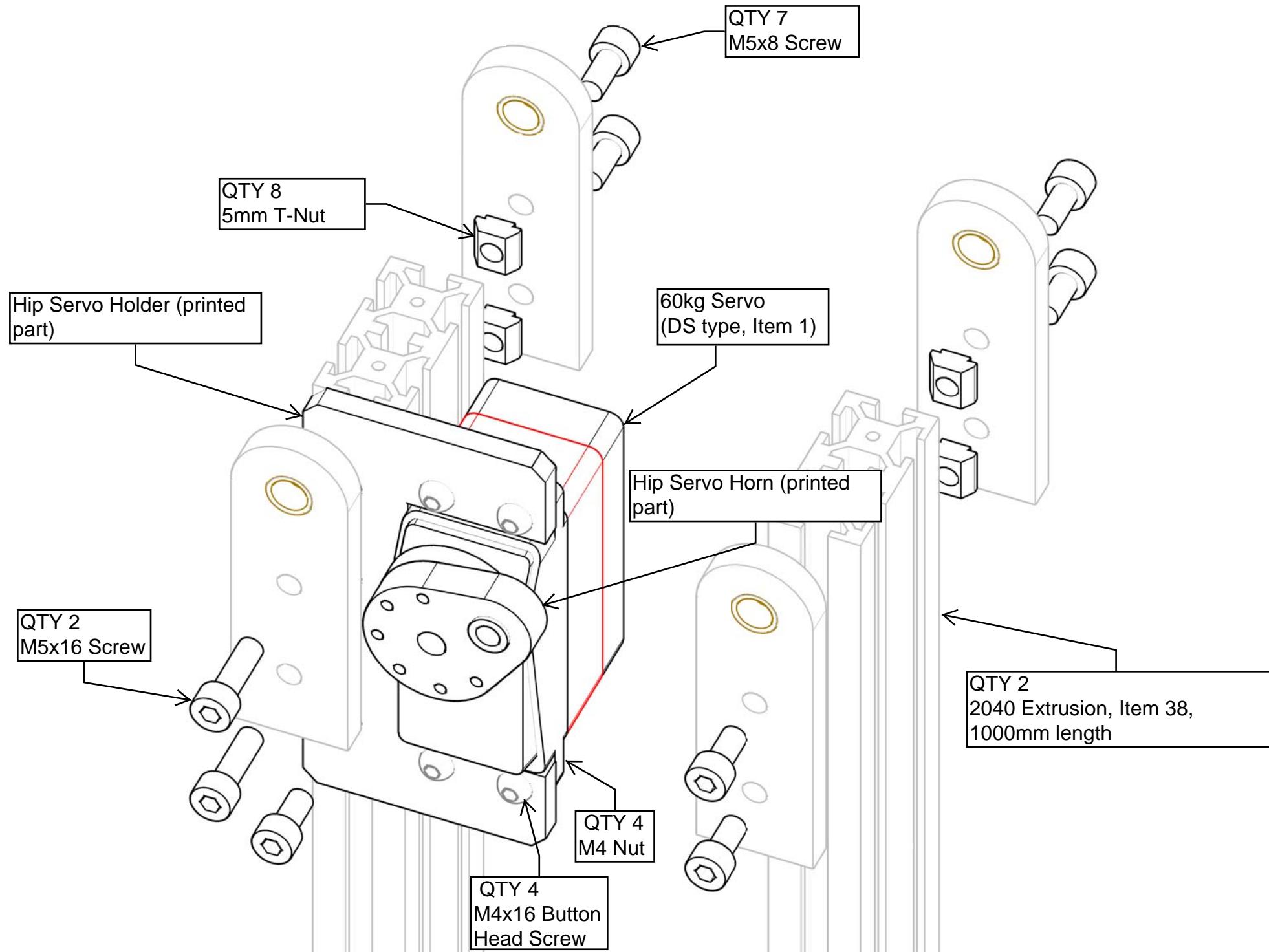
Step 25

Fabricate Hip and Ankle Plates and Ankle Stops. The fabrication dimensions shown are not extremely critical. Ankle Stops are highly recommended to prevent the whole body from falling over in the event that the Hip Servo linkage comes loose.



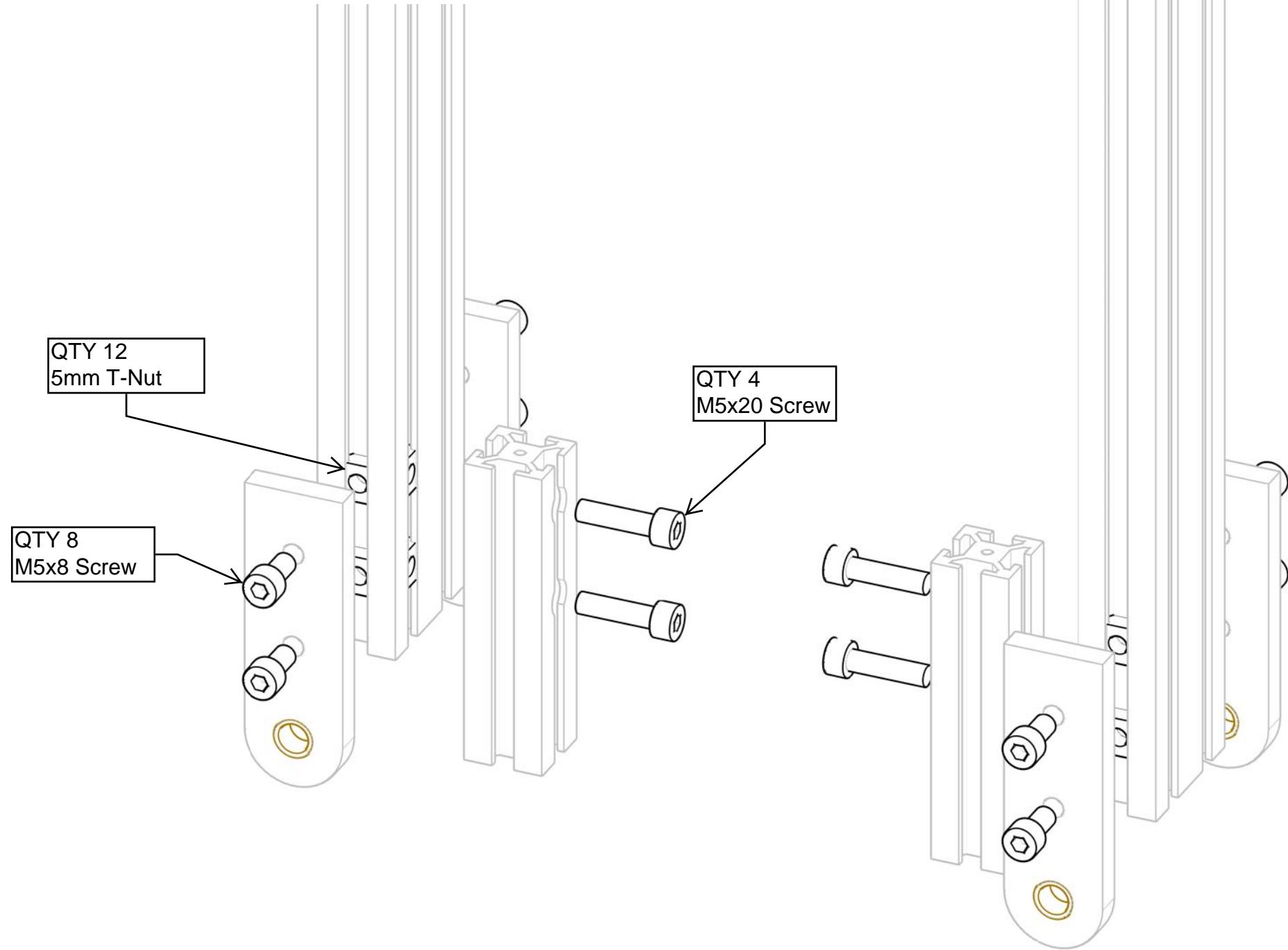
Step 26

Install Hip Plates and Hip Servo to upper legs



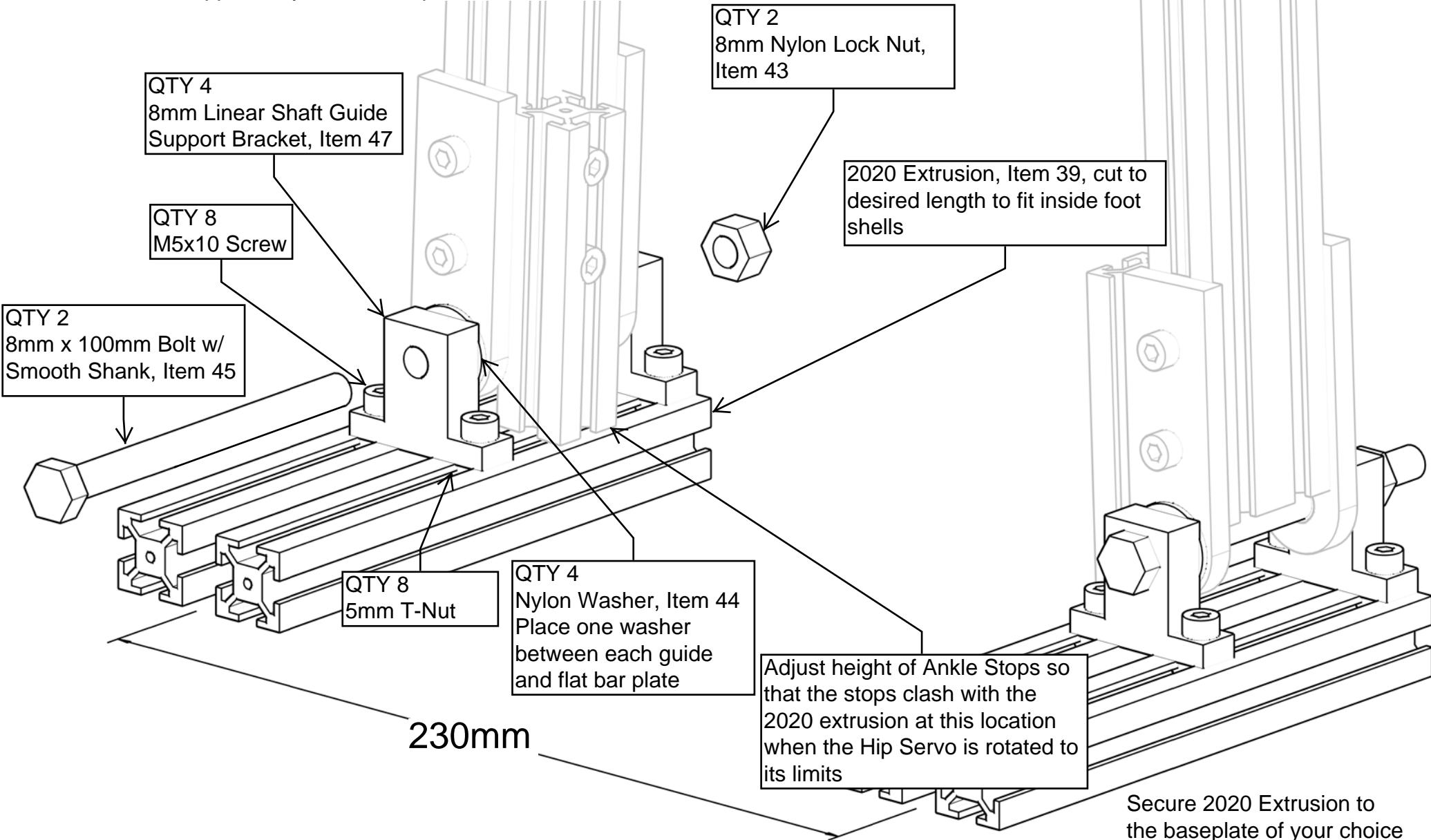
Step 27

Install Ankle Plates and Ankle Stops to lower legs



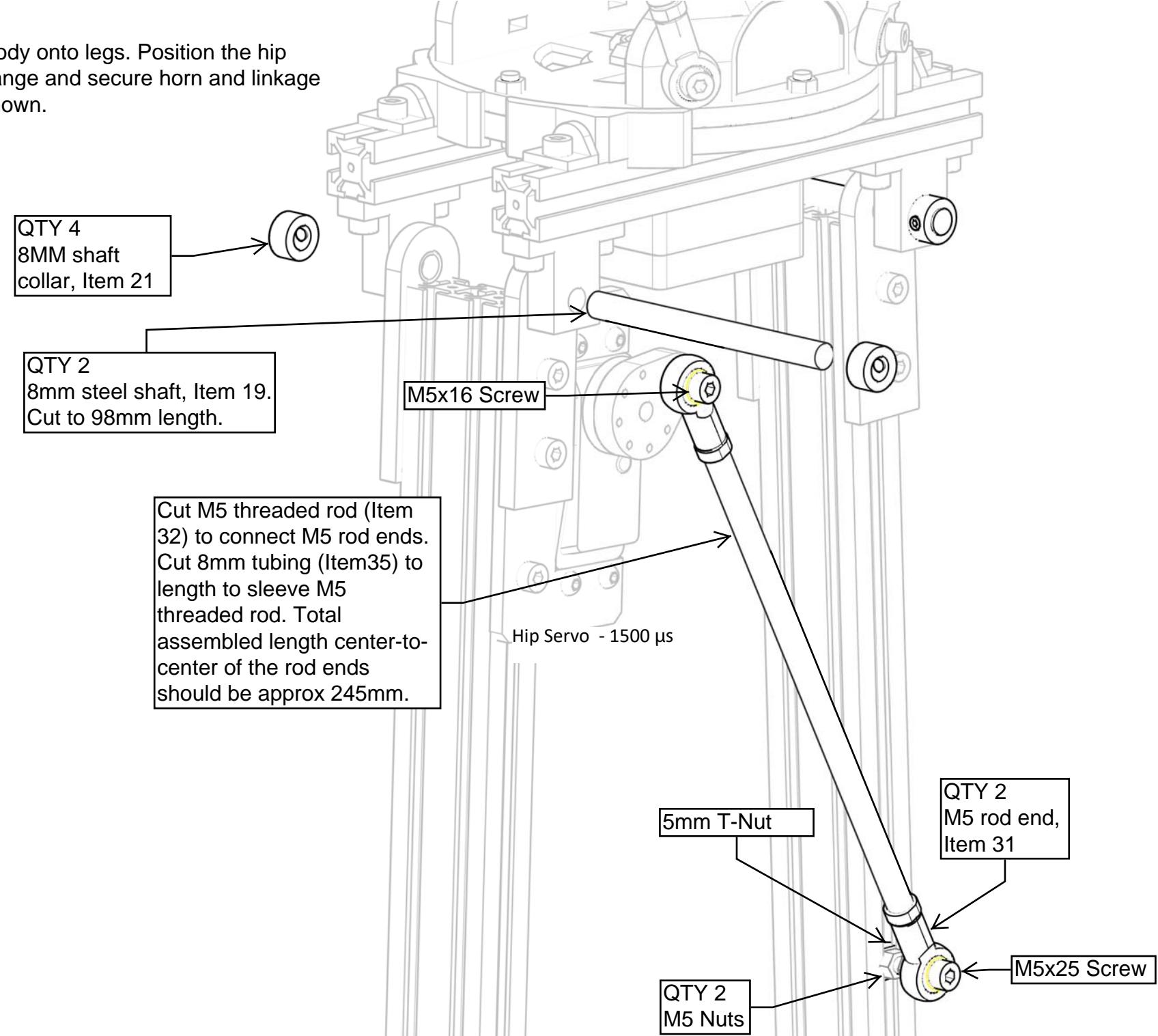
Step 28

Assemble feet components and secure feet to base. Tighten ankle bolts sufficiently to provide resistance but still allow ankles to rotate. Tightening these bolts will reduce the amount of wobble in the upper body when the hips move from side to side.



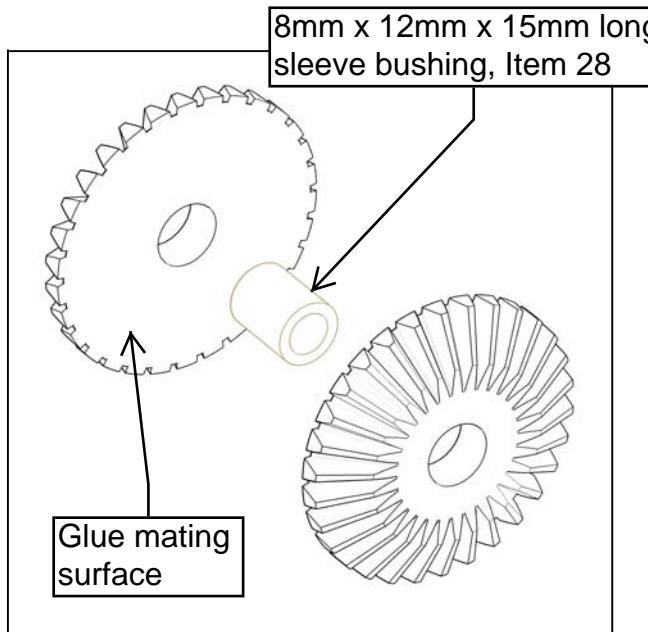
Step 29

Install upper body onto legs. Position the hip servo to mid range and secure horn and linkage at the angle shown.

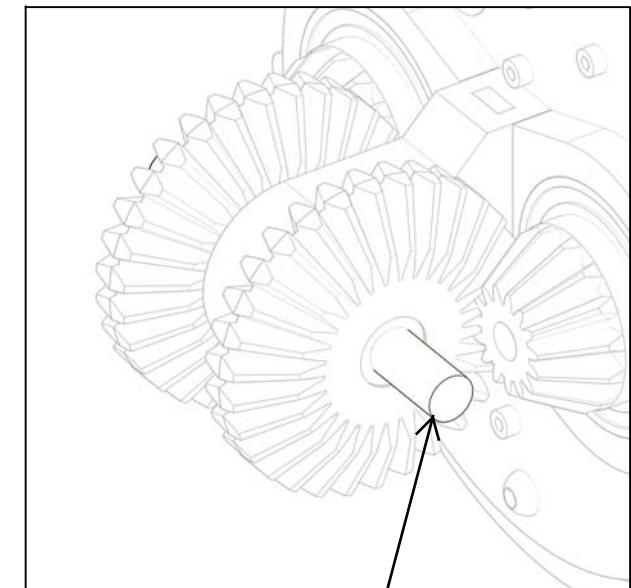
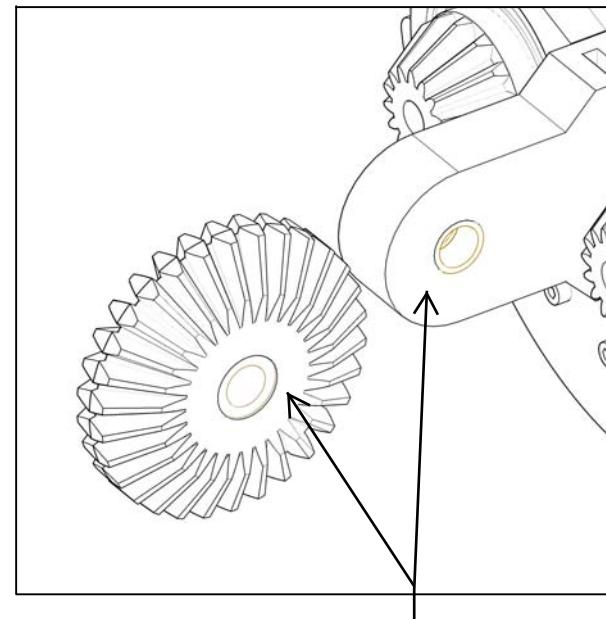


Step 30

Glue up and fit up Shoulder Gears. Glue the Large Shoulder Gear halves together with CA glue. Use the sleeve bushing to align parts during glue up. Once dry, test fit the gears into their position. Sand surfaces as required so that each gear slots straight into place.



QTY 4 Required
Large Shoulder Gear



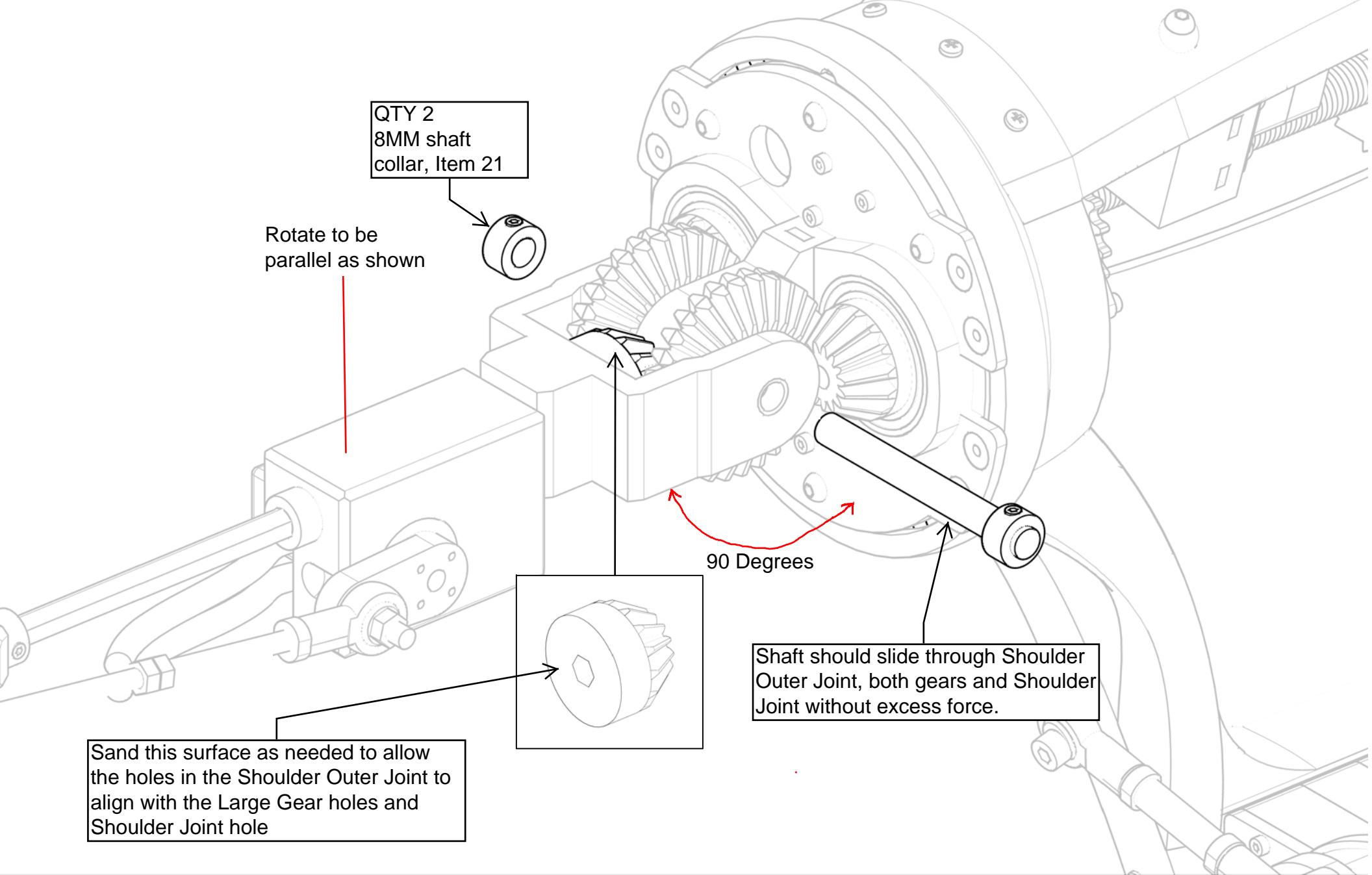
8mm steel shaft, Item 19. Cut to 76mm long. Test fit with shaft in this step. Shaft should slide through both gears without excess force.

Step 31

Assemble arms to torso. Position the Shoulder Servos as shown in the table to the right before mounting the arms. Align arms so they are parallel to the shoulder axis and rotate the biceps to have the threaded rod face forward.

Shoulder Servos

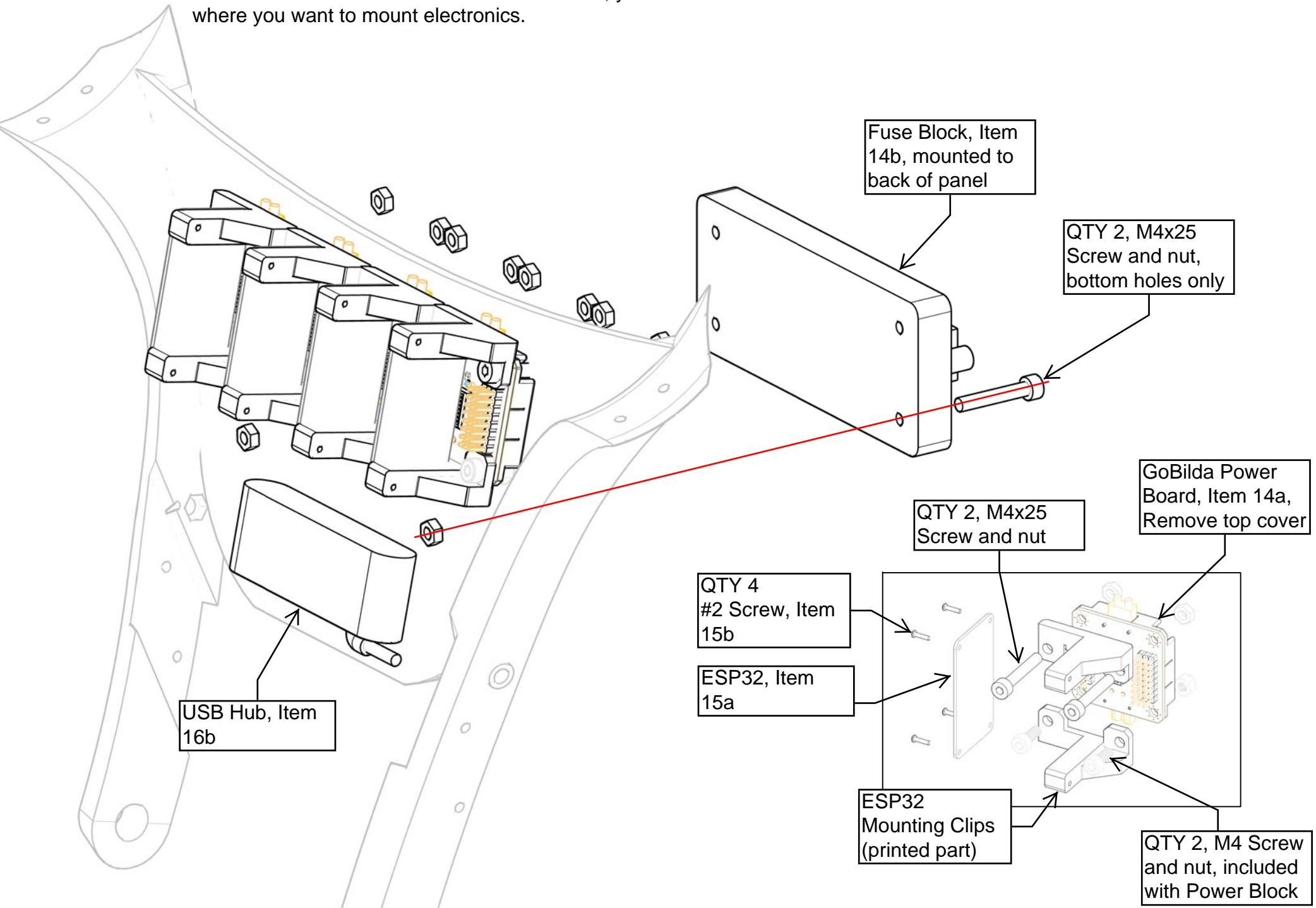
- Right Front - 2080 µs
- Right Rear - 860 µs
- Left Front - 1040 µs
- Left Rear - 2020 µs



Sand this surface as needed to allow the holes in the Shoulder Outer Joint to align with the Large Gear holes and Shoulder Joint hole

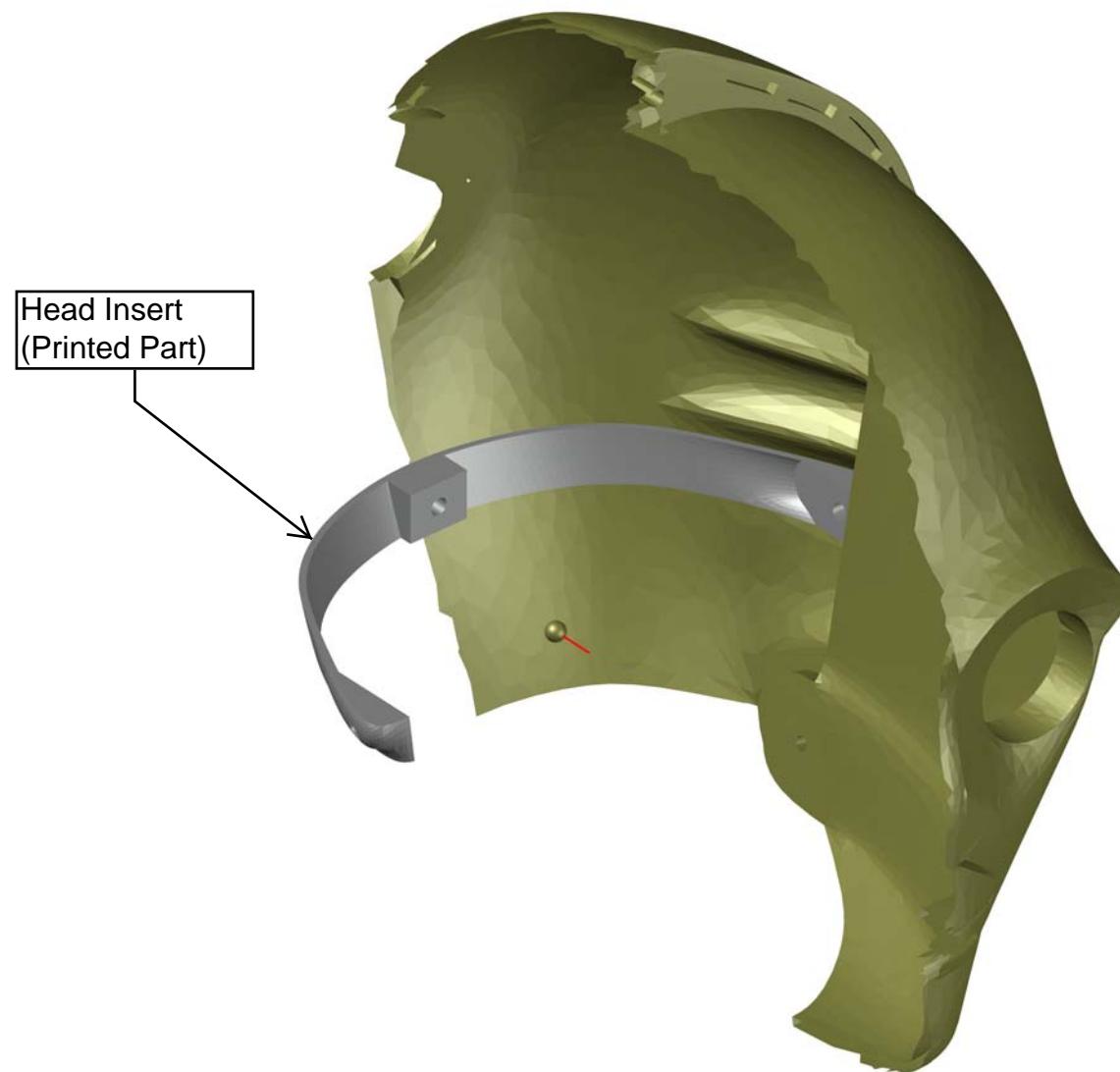
Step 32

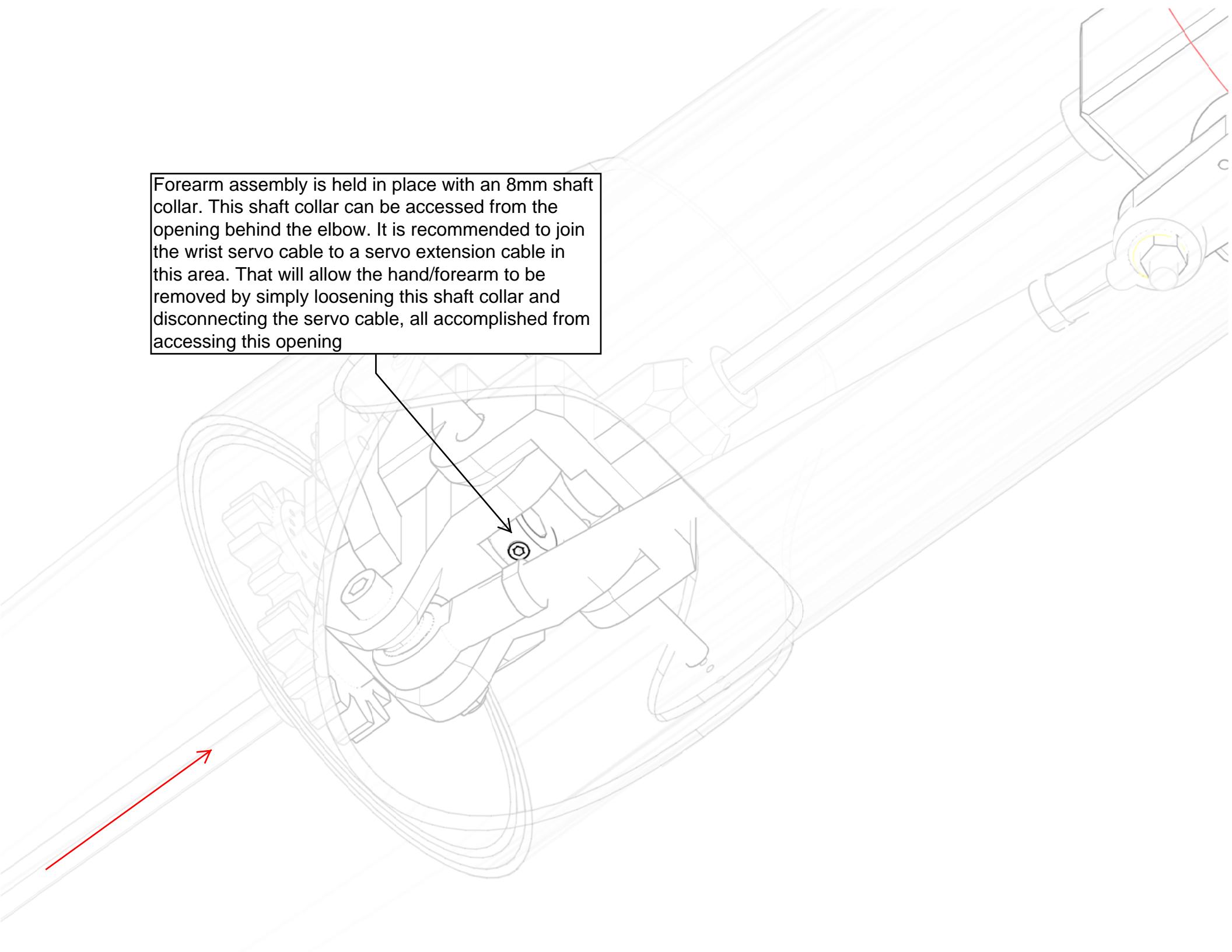
Suggested power and controls mounting. The back panel of the torso has been left blank to allow user customization. As such, you will need to drill holes where you want to mount electronics.



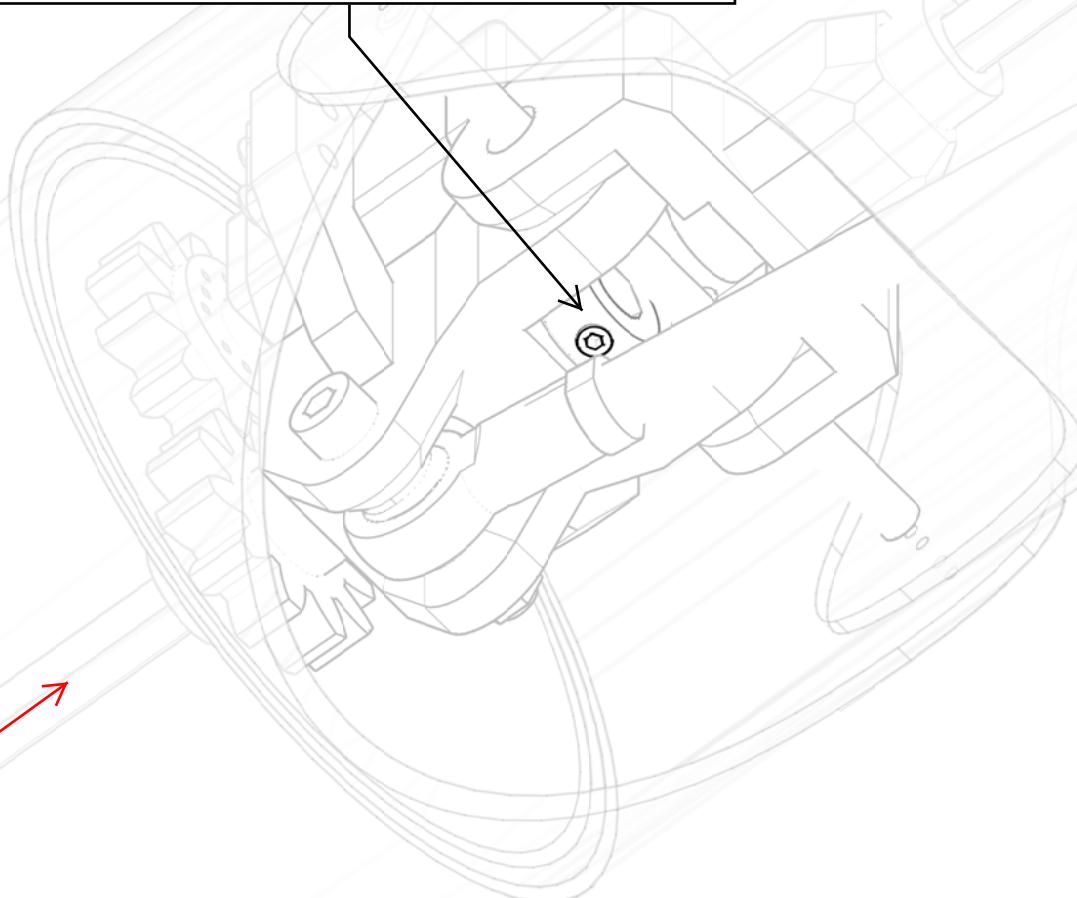
Step 33

Glue Head Insert. Two versions of the Head Insert part are included, corresponding to the version of head you have printed. I recommend using hot glue rather than another type of permanent glue to adhere the Insert into the head. This will allow for removal later if desired. The head insert should fit perfectly into the lower notch of the back of the head as shown here.





Forearm assembly is held in place with an 8mm shaft collar. This shaft collar can be accessed from the opening behind the elbow. It is recommended to join the wrist servo cable to a servo extension cable in this area. That will allow the hand/forearm to be removed by simply loosening this shaft collar and disconnecting the servo cable, all accomplished from accessing this opening



@



Step 34

Glue magnets into shoulder bearing. This design allows the animatronic to rotate the shoulder bells along with the arms. It also allows the shoulder bells to be pulled away from the torso without needing to take the arms off. This makes it easier to take the torso front and back off. You can take the torso front and back off without removing the arms.

QTY 8
Item 41, magnets. Glue in recesses with CA glue.
Ensure all are facing the proper direction to attract to the magnets in the shoulder bearing

