

2022-2023 *FIRST*® Tech Challenge

Basic ‘Bot Guide for TETRIX- Part 2 (Armature)

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Raytheon Technologies

Revision History		
Revision	Date	Description
1	11/7/2022	Initial Release

Contents

Contents.....	3
Introduction.....	5
What is FIRST® Tech Challenge?	5
<i>Gracious Professionalism</i> ®	5
Introduction to this Guide.....	6
Parts	6
Tips and Tricks.....	6
Computer Aided Design (CAD)	6
CAD Coloring Legend.....	6
Chassis Modifications	7
Step 1: Remove Screws & Nuts from Right Rail.....	7
Armature	7
Step 1: Add Tower Support.....	8
Step 2: Add Right Rail Screws & Nuts.....	9
Step 3: Add Channel Support.....	10
Step 4: Add Channel.....	11
Step 5: Add Additional Channel Support	12
Step 6: Add Lower Gear Set	13
Step 7: Add Upper Gear Set	14
Step 8: Add Motor Mount	16
Step 9: Add Motor and Gear	17
Step 10: Build Servo 1	18
Step 11: Add the Servo Mount	19
Step 12: Add Servo Standoffs	20
Step 13: Add Servo 1 to Arm.....	21
Step 14: Add Servo 1 Gear	22
Forearm.....	23
Step 15: Assemble forearm channel	23
Step 16: Assemble Forearm.....	24
Step 17: Add Servo Mount	25
Step 18: Attach Servo	26
Step 19: Attach Gear.....	27

Step 20: Add the Forearm Assembly to the Robot	28
Hand.....	30
Step 21: Assemble Hand	30
Step 22: Attach L Bracket	31
Step 23: Hand Assembly.....	32
Step 24: Hand Assembly.....	33
Step 25: Add Hand Assembly to the Robot	34
Final Steps	35
What's Next?	35
Appendix A – Resources	36
Game Forum Q&A	36
Volunteer Forum	36
<i>FIRST</i> Tech Challenge Game Manuals.....	36
<i>FIRST</i> Headquarters Pre-Event Support.....	36
<i>FIRST</i> Websites.....	36
<i>FIRST</i> Tech Challenge Social Media	36
Feedback.....	36
Appendix B: Examples of Proper and Improper Gear Meshing.....	37

Introduction

What is FIRST® Tech Challenge?

FIRST® Tech Challenge is a student-centered program that focuses on giving students a unique and stimulating experience. Each year, teams engage in a new game where they design, build, test, and program autonomous and driver operated robots that must perform a series of tasks. Participants and alumni of *FIRST* programs gain access to education and career discovery opportunities, connections to exclusive scholarships and employers, and a place in the *FIRST* community for life. To learn more about *FIRST®* Tech Challenge and other *FIRST®* Programs, visit www.firstinspires.org.

Gracious Professionalism®

FIRST® uses this term to describe our programs' intent.

Gracious Professionalism® is a way of doing things that encourages high-quality work, emphasizes the value of others, and respects individuals and the community.

Watch Dr. Woodie Flowers explain *Gracious Professionalism* in this [short video](#).

Introduction to this Guide

The Basic 'Bot Guide is designed to be a resource for teams looking for a step-by-step instructional for building a basic armature for the FIRST Tech Challenge competition. There are multiple versions of this guide, previously called the "Push Bot Guide", this version the **Basic 'Bot Guide for TETRIX-Part 2 (Armature)** has been created to use the new and differing parts in the 2020-2021 season's TETRIX kit of parts.

Parts

- TETRIX FTC Competition Set
 - Tools included with the TETRIX FTC Competition Set
- Electronics Modules and Sensors set
- Control & Communication Set 1 or 2
- (Optional) Only the tools included in the FTC Competition Set will be needed to build the chassis. The screws and nuts are a standard size and having more tools may allow more students to participate at the same time.
- (Optional) A ruler is not needed to build this robot, but it is necessary to make sure that the robot is competition ready

Tips and Tricks

- Make sure that set screws are installed in every axle hub, motor hub, and axle collar.
- Refer to the legend provided in the Kit of Parts, if any parts are unfamiliar.
- Make sure that all assemblies are square. It is hard to drive a crooked robot straight!
- The drive wheels are powered by two DC motors located on the back of the robot, which are relatively heavy. This weight is needed to help the wheels grip the surface better.
- Omni wheels should be located on the front of the robot, which allows the robot to turn more easily. The omni wheels can slide sideways with very little friction due to the rollers.
- Unless otherwise noted, the top image in each step shows the necessary parts; the lower image shows the completed assembly.

Computer Aided Design (CAD)

- The drawings in this document were generated using Creo Parametric Computer Aided Design (CAD) software.
 - By designing on the computer first, with CAD, the design can be tested to ensure everything will work together before actual construction.
- The Creo software is available for free to FIRST teams for use in designing robots. The CAD drawings color code the screws to help identify them (see table below).

CAD Coloring Legend

Pitsco Part Number	Part	Color
39098	5/16" socket head cap screw	red
39094	keps nut	blue
39111	3/8" button head cap screw	green
39097	1/2" socket head cap screw	yellow
39195	motor mount screw	orange

Chassis Modifications

Step 1: Remove Screws & Nuts from Right Rail

Parts Removed:

39098 - 5/16" socket head cap screw (4)

39094 - keps nut (4)

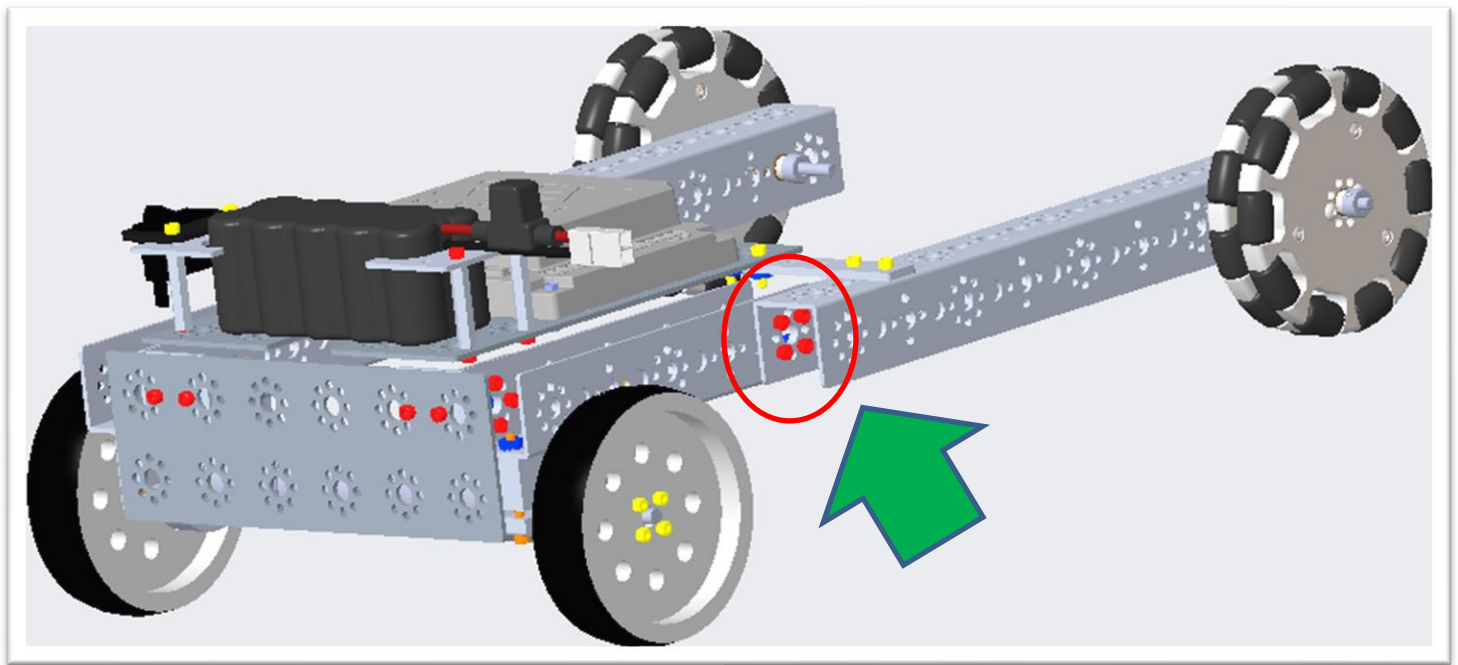


Figure 1-Assembled View of Robot Right Rail

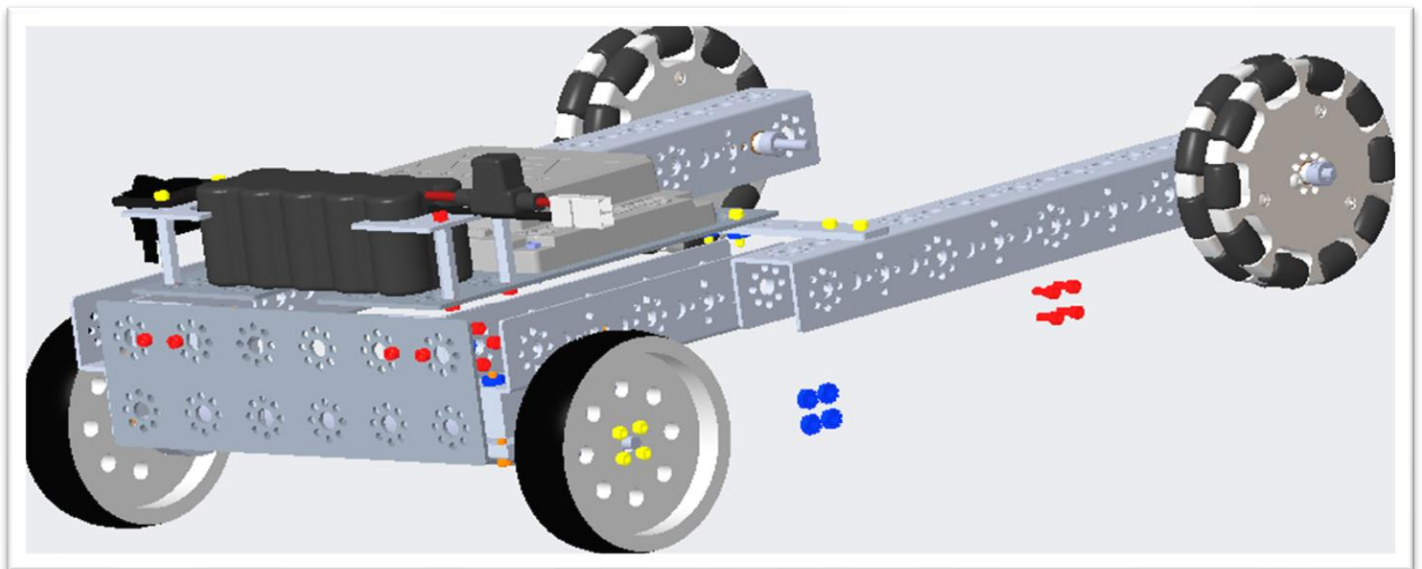


Figure 2- Disassembled View of of Robot Right Rail

Step 1: Add Tower Support

Parts Needed:

- 39270 - Inside C Connector (1)
- 39098 - 5/16" socket head cap screws (4)
- 39094 - keps nuts (4)

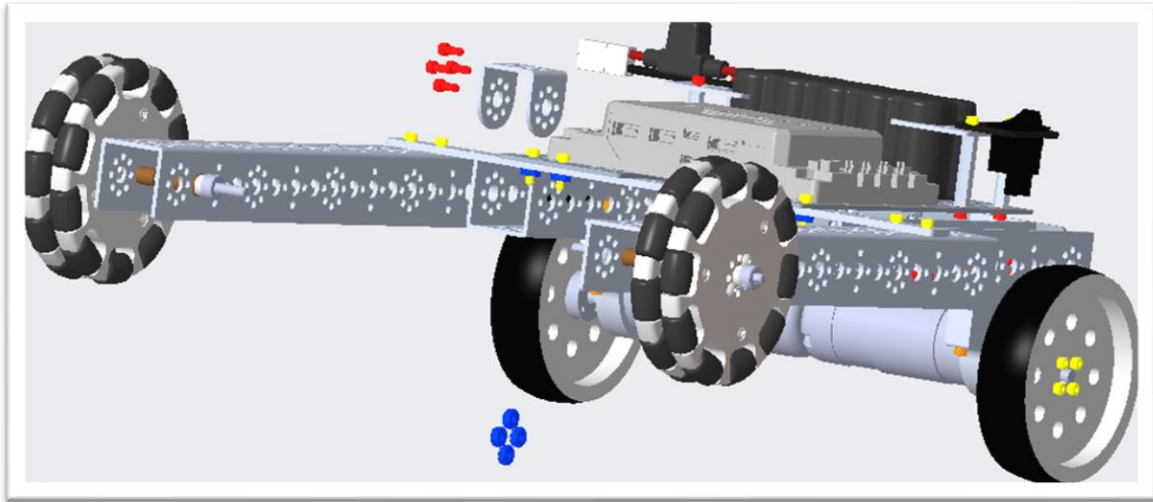


Figure 3-Disassembled View of Tower Support

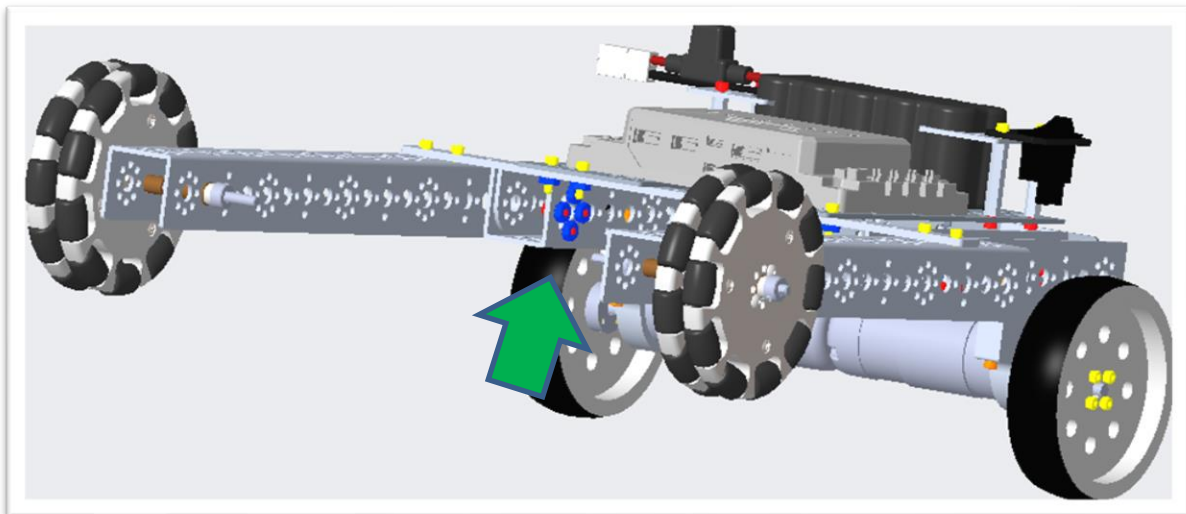


Figure 4- Assembled View of Tower Support

Step 2: Add Right Rail Screws & Nuts

Parts Needed:

39097 - 1/2" socket head cap screws (4)
39094 - keps nuts (4)

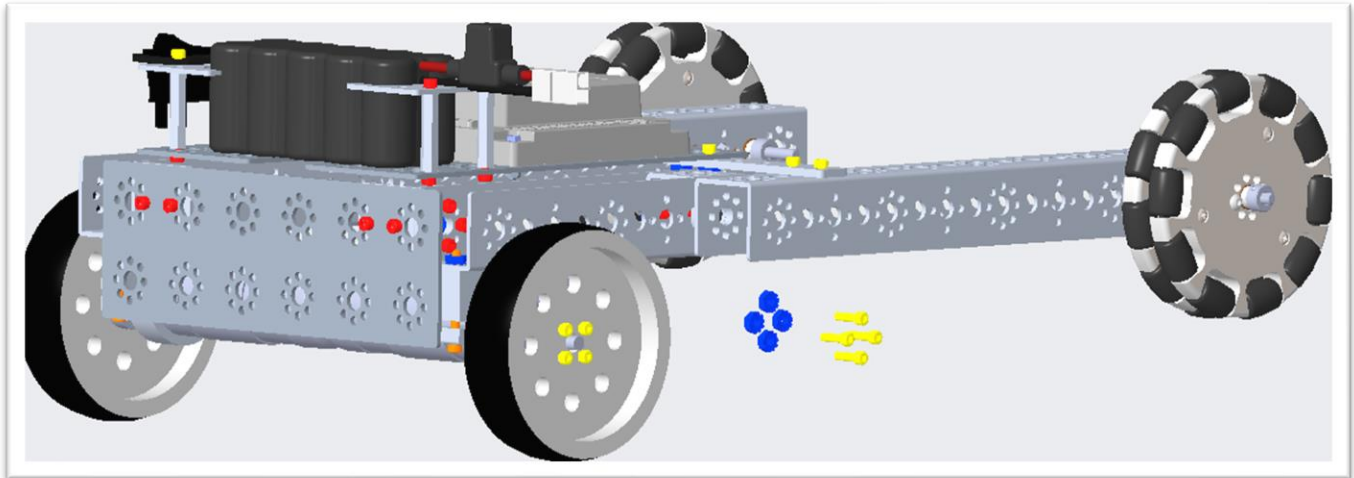


Figure 5- Disassembled View of Right Rail Screws and Nuts

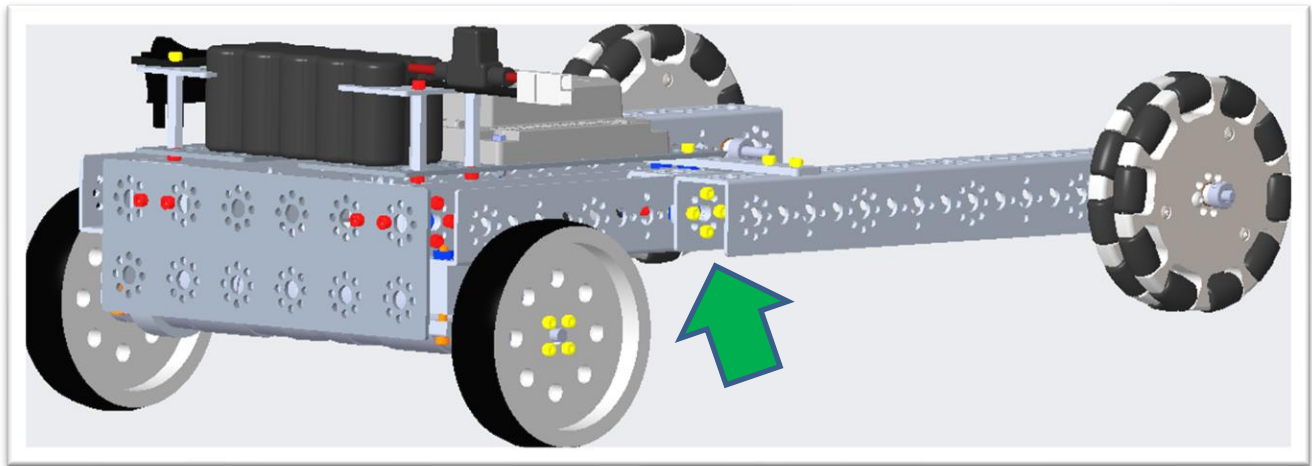


Figure 6-Assembled View of Right Rail Screws and Nuts

Helpful Hint:

The original screws need to be replaced with longer screws

Step 3: Add Channel Support

Parts Needed:

- 39270 - Inside C Connector (1)
- 39098 - 5/16" socket head cap screws (4)
- 39094 - keps nuts (4)

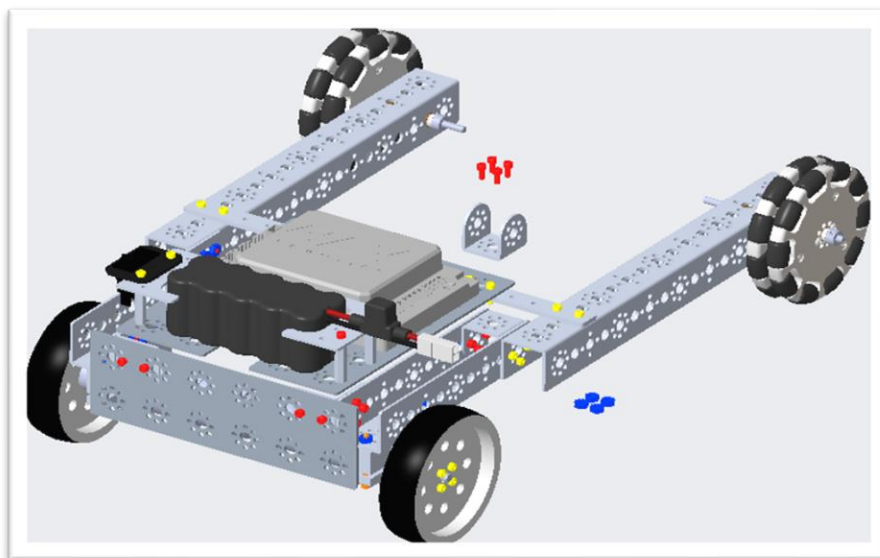


Figure 7-Disassembled View of Channel Support

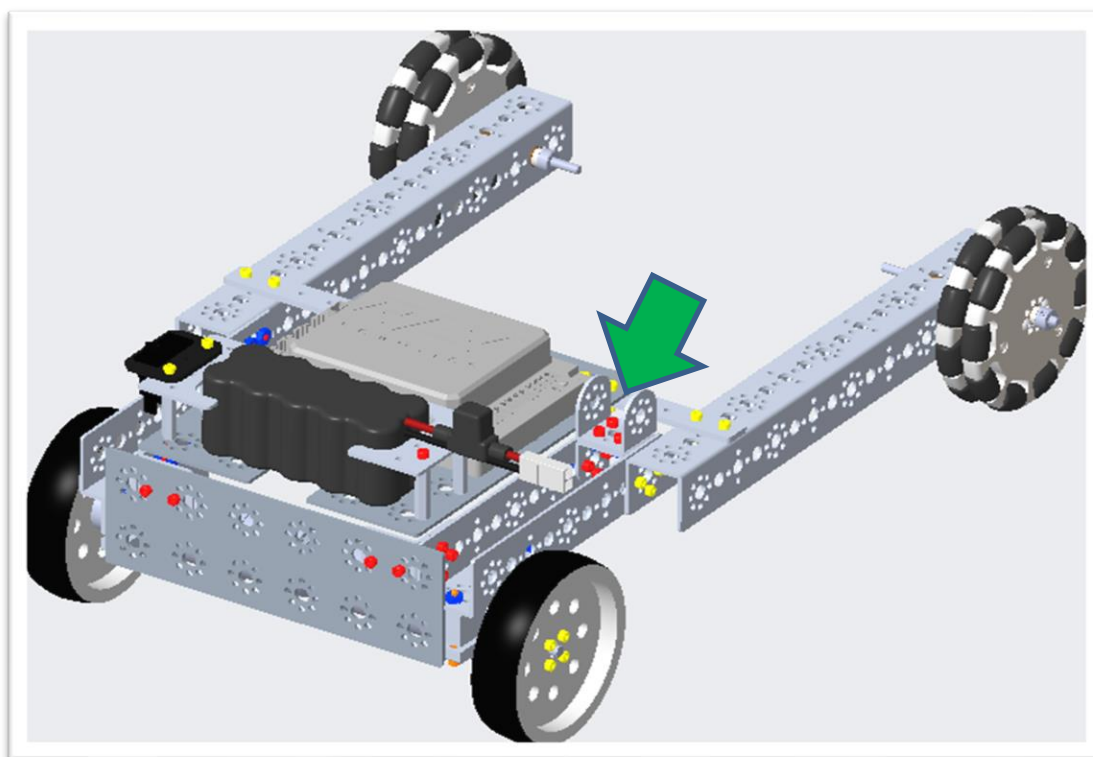


Figure 8- Assembled View of Channel Support

Step 4: Add Channel

Parts Needed:

39068 - 288 mm Channel (1)
39098 - 5/16" socket head cap screws (3)
39094 - keps nuts (3)

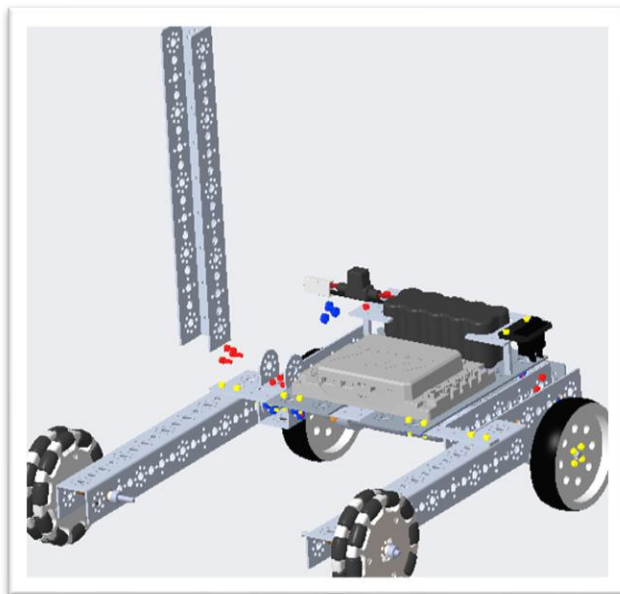


Figure 9- Disassembled View of Channel

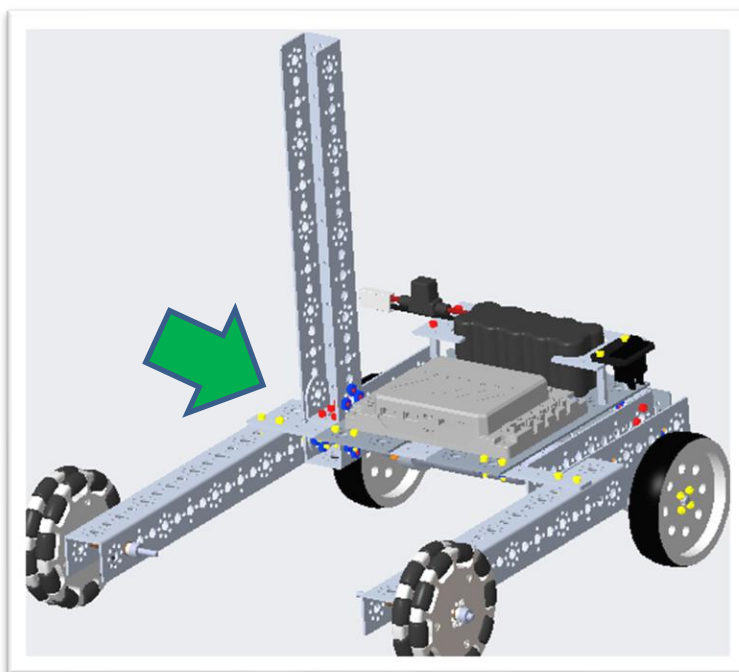


Figure 10- Assembled View of Channel

Step 5: Add Additional Channel Support

Parts Needed:

- 39281 - Inside Corner Bracket (1)
- 39098 - 5/16" socket head cap screws (3)
- 39097 - 1/2" socket head cap screws (3)
- 39094 - keps nuts (6)

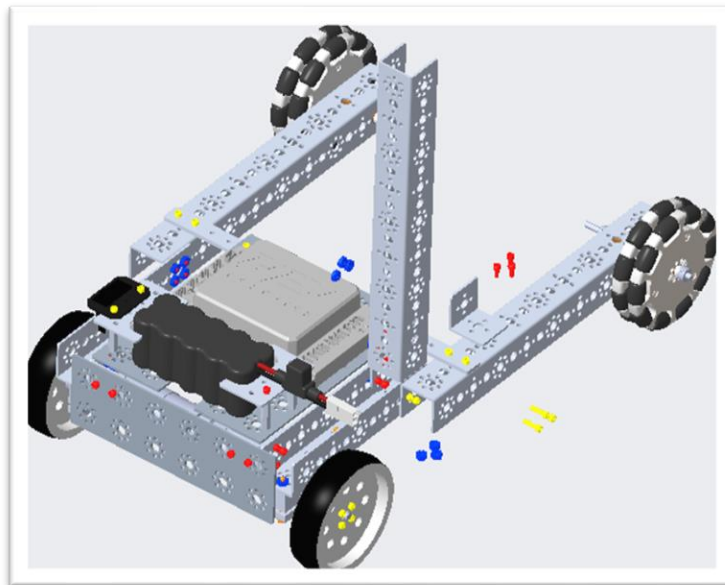


Figure 11- Disassembled View of Additional Channel Support

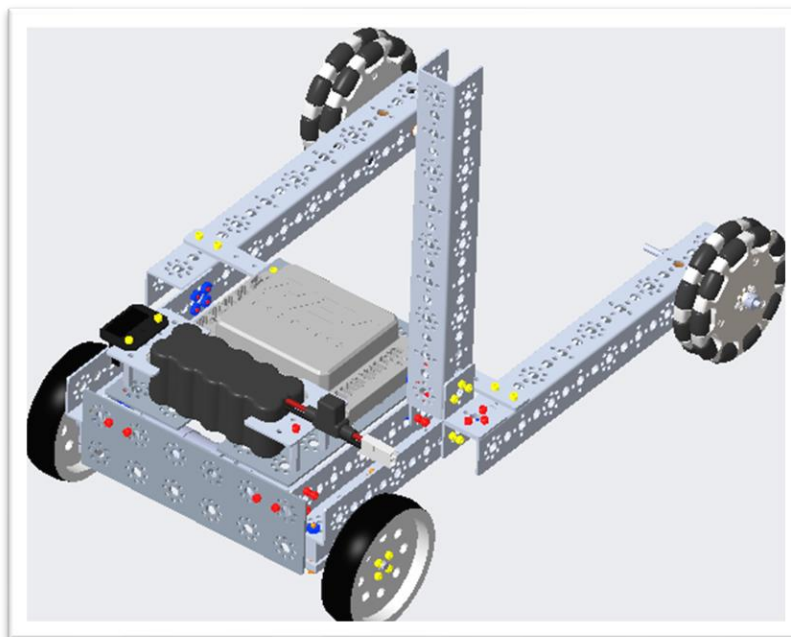


Figure 12- Assembled View of Additional Channel Support

Step 6: Add Lower Gear Set

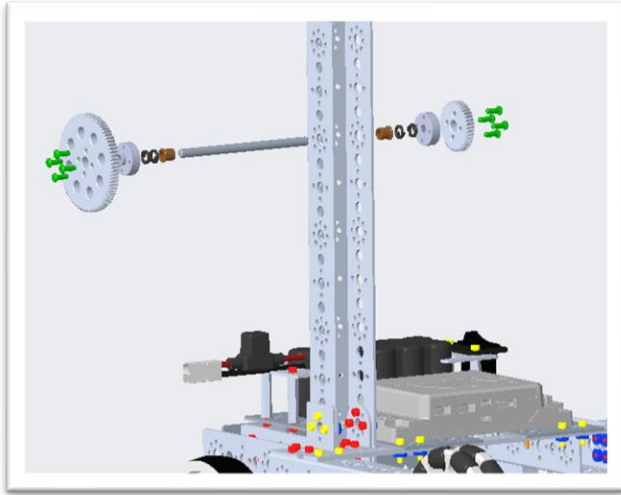


Figure 13- Disassembled View of Lower Gear Set

Parts Needed:

- 39111 - 3/8" button head cap screws (8)
- 39086 - Gear 80 Tooth (1)
- 39079 - Motor Hub (2)
- 41665 - 6mm Plastic Bushing Spacer (4)
- 40227 - 8mm x 6mm Bronze Bushing (2)
- 44708 - 100mm x 6mm xle (1)
- 39028 - Gear 40 Tooth (1)

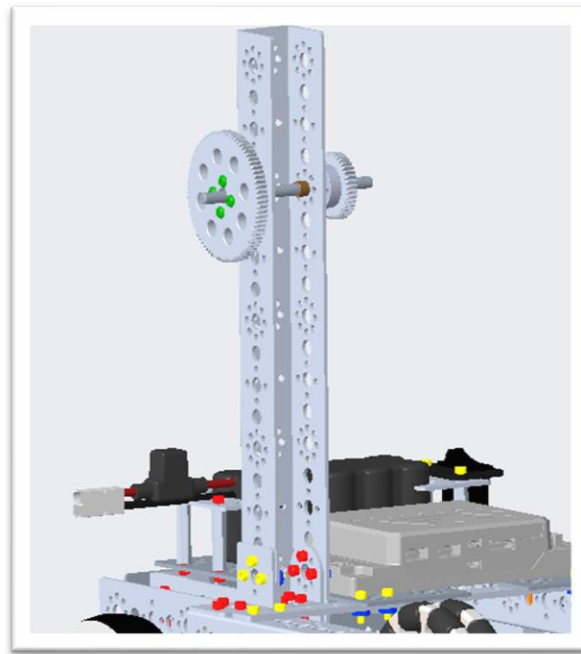


Figure 14- Assembled View of Lower Gear Set

Helpful Hint:

Order: 80 tooth gear, hub, spacers (2), bushing, channel, bushing, spacers (2), hub, 40 tooth gear

Step 7: Add Upper Gear Set

Parts Needed:

- 39079 - Motor Hub (2)
- 41665 - 6mm Plastic Bushing Spacer (4)
- 40227 - 8mm x 6mm Bronze Bushing (2)
- 44708 - 100mm x 6mm Axle (1)
- 39085 - Gear 120 Tooth (1)
- 39097 - 1/2" socket head cap screws (4)
- 39069 - 416mm Channel

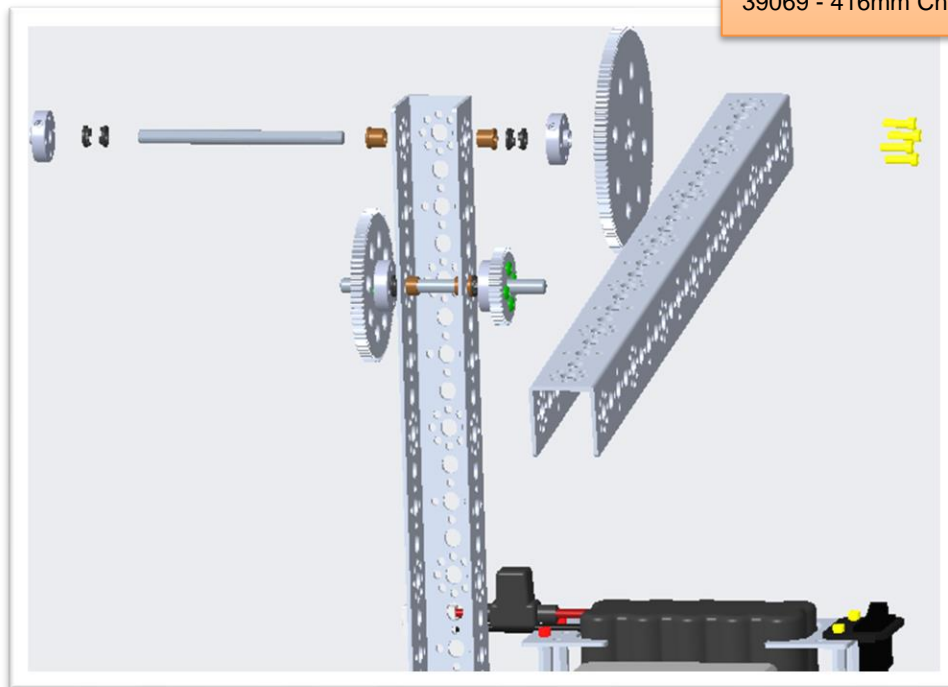


Figure 15-Disassembled View of Upper Gear Set



Figure 16- Assembled view of Upper Gear Set (Front Overview)

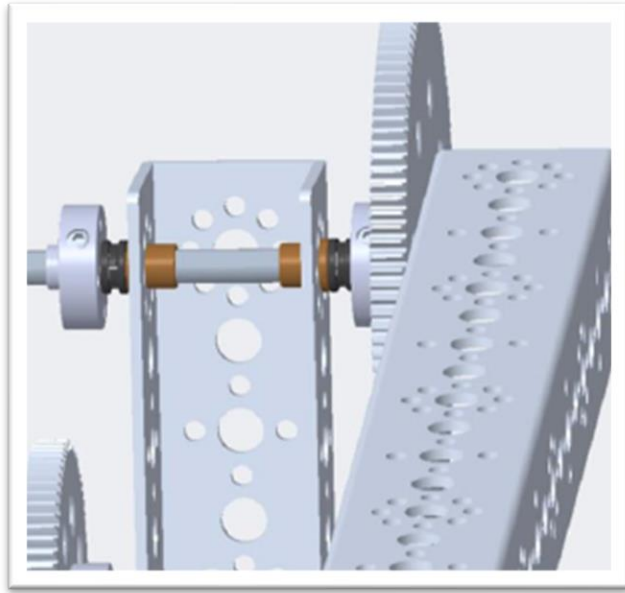


Figure 17- Assembled View of Upper Gear Set (Front Detail)

Helpful Hint:

Order (using the above image):

NO GEAR, hub, spacers (2), bushing, channel, bushing, spacers (2), hub, 120 tooth gear, channel

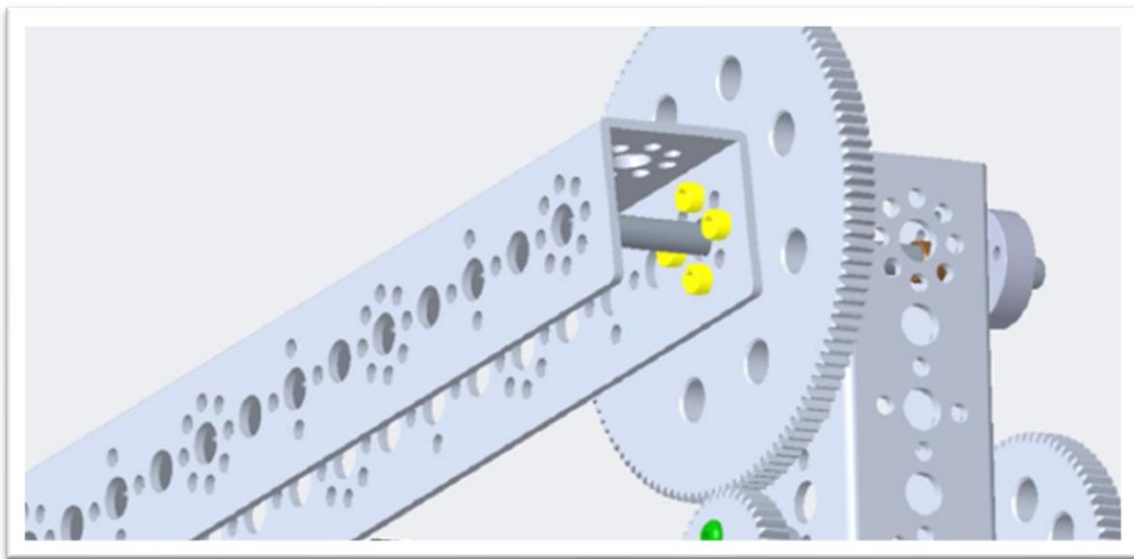


Figure 18- Assembled View of Upper Gear Set (Back Detail)

Step 8: Add Motor Mount

Parts Needed:
39089 - Motor Mount (1) (with included bolts and nuts)

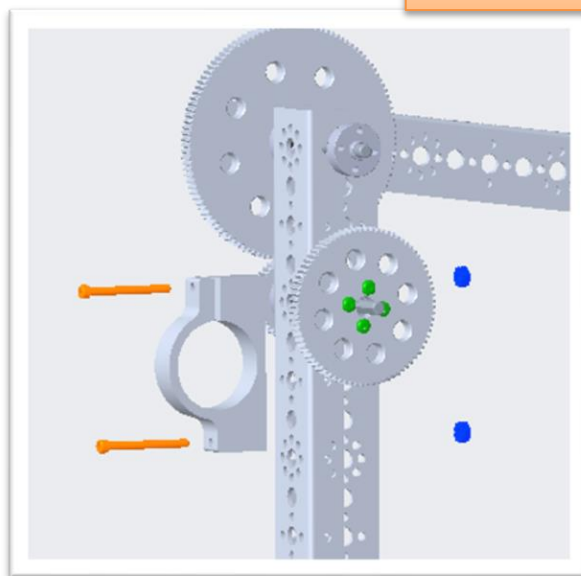


Figure 19- Disassembled View of Motor Mount

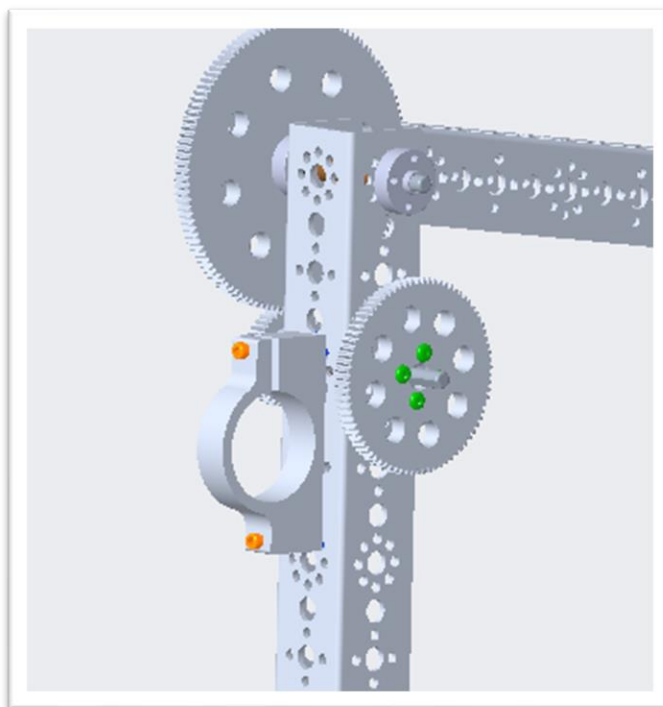


Figure 20- Assembled view of Motor Mount

Helpful Hint:

The mount is in the vertical center of the channel.

Step 9: Add Motor and Gear

Parts Needed:

- 44260 - TorqueNADO Motor (1)
- 39079 - Motor Hub (1)
- 39028 - Gear 40 Tooth (1)
- 39111 - 3/8" button head cap screws (4)

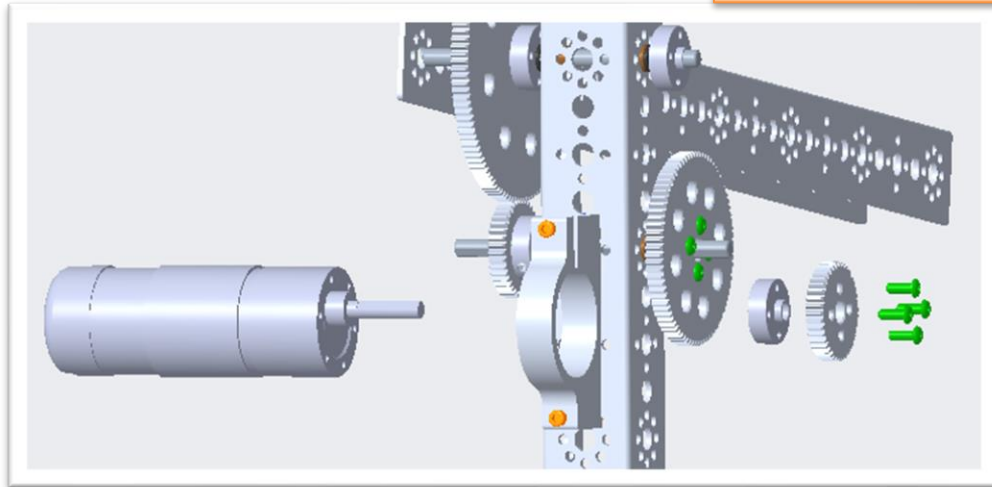


Figure 21- Disassembled View of Motor and Gear

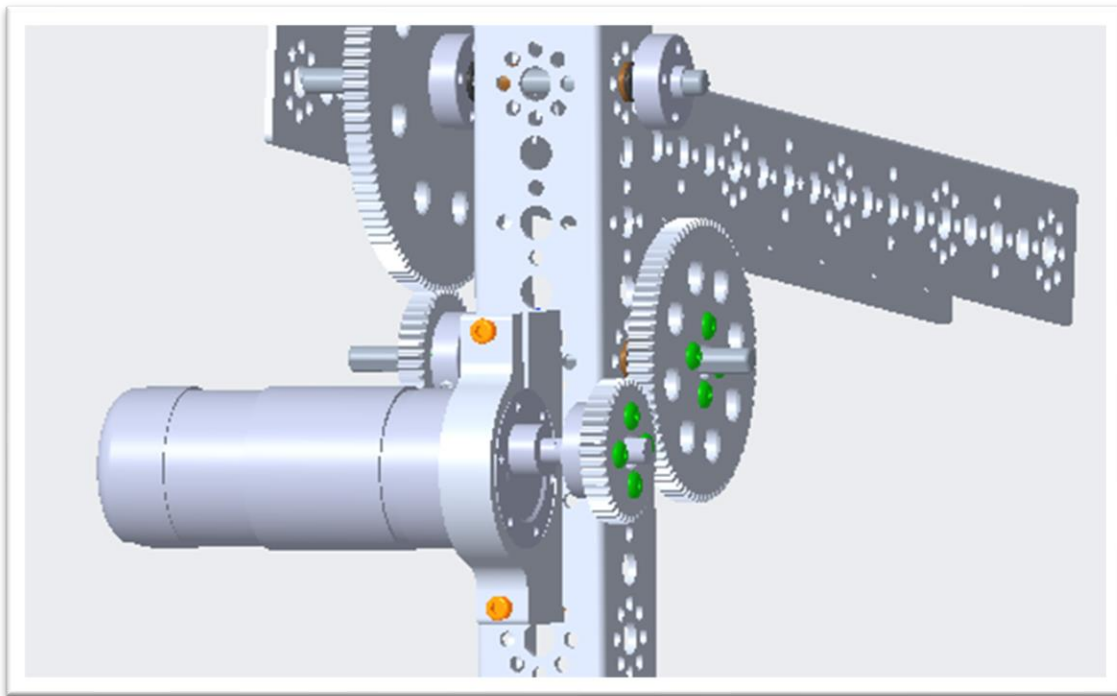


Figure 22- Assembled view of Motor and Gear

Helpful Hint

The next page shows how to properly mesh gears.
 The motor should be plugged into port 2.
 See [Appendix B](#) for examples of proper gear meshing

Step 10: Build Servo 1

Parts Needed:
43050 Servo Pack containing:
Servo
Servo to Shaft Coupler
60mm Axle D-Shaft

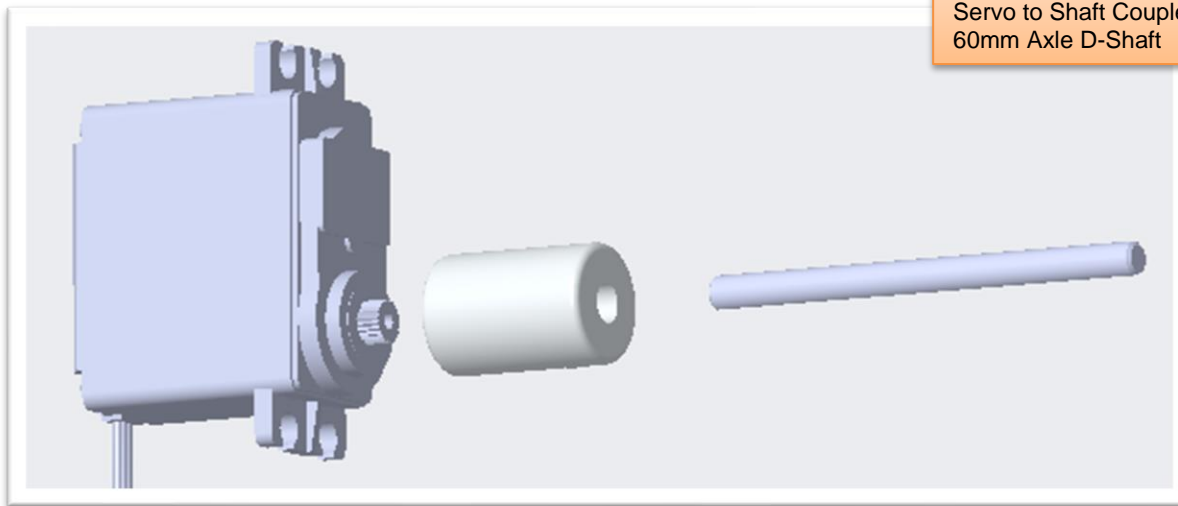


Figure 23- Disassembled View of Servo 1

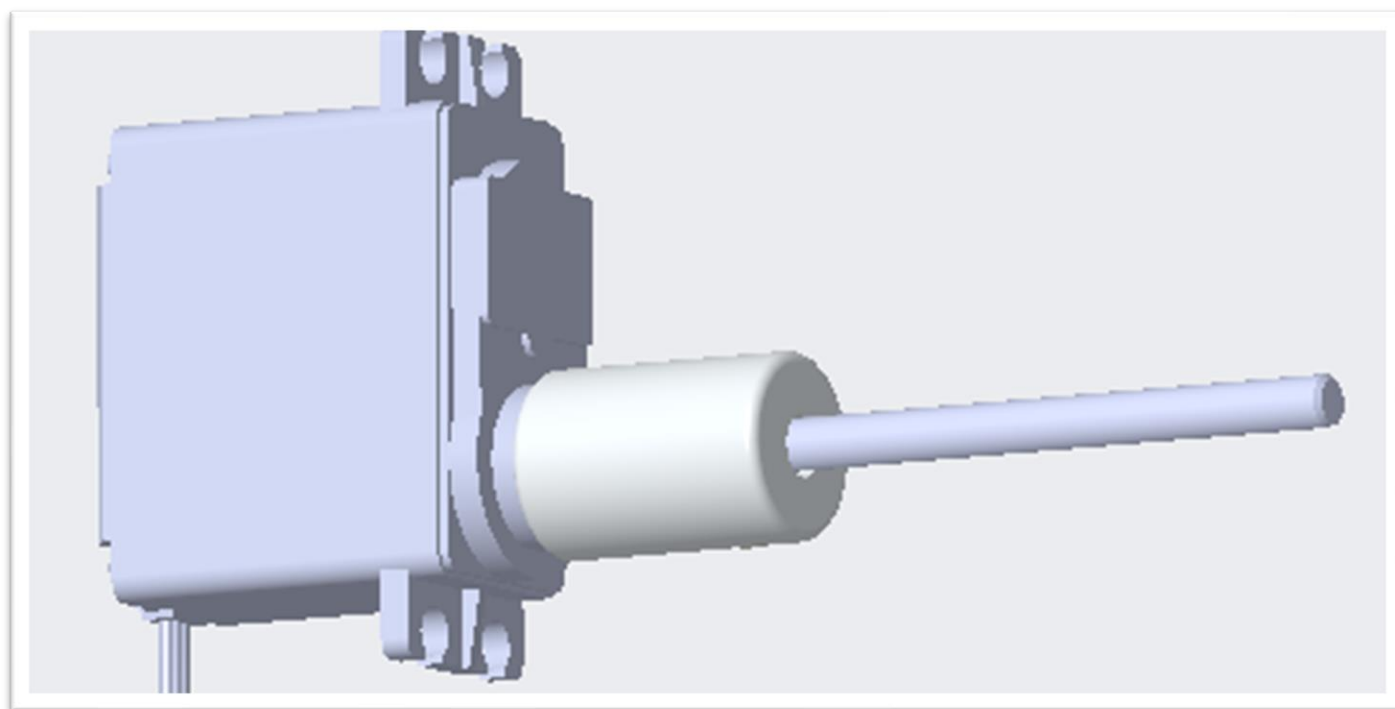


Figure 24- Assembled View of Servo 1

Step 11: Add the Servo Mount

Parts Needed:

41789 - Servo Mount from Mounting Kit (1)
39097 - 1/2" socket head cap screws (4)
39094 - keps nuts (4)

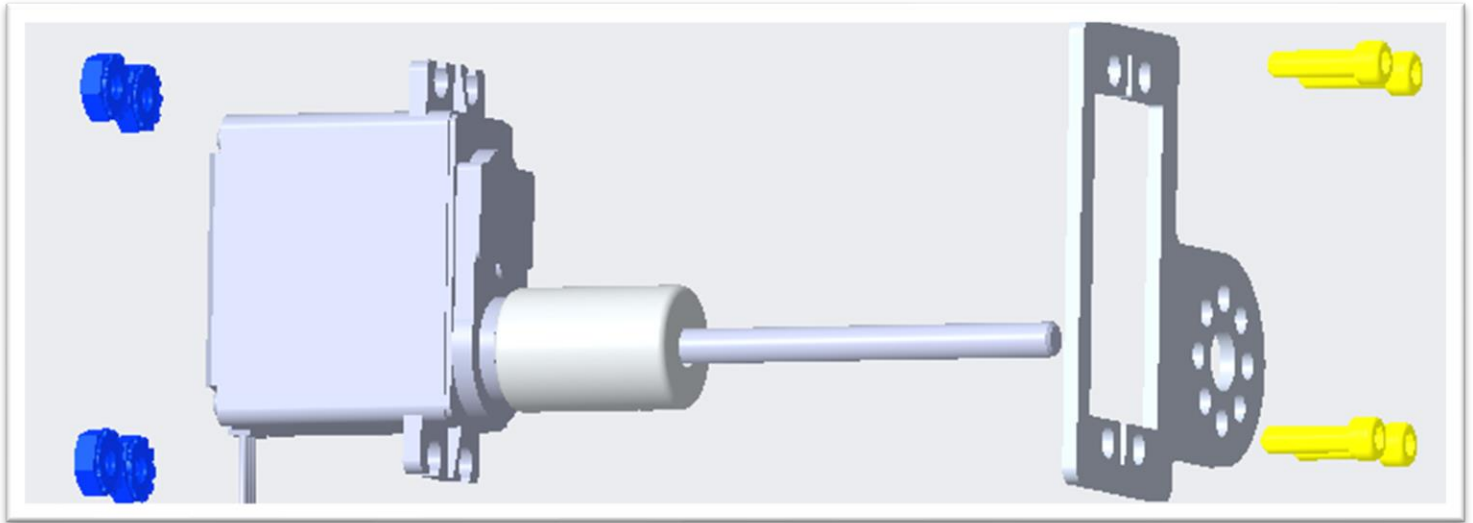


Figure 25-Disassembled View of Servo Mount

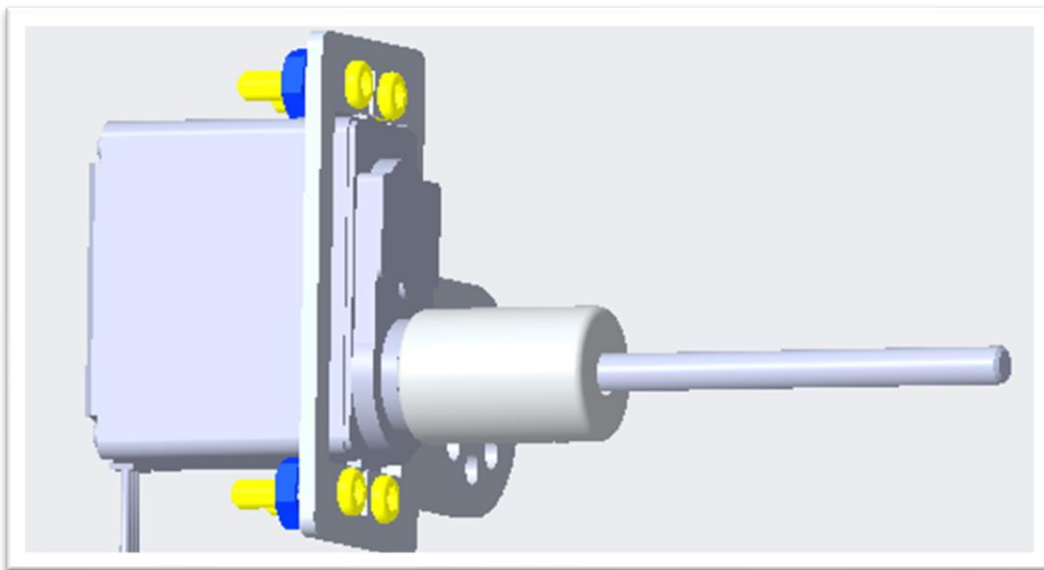


Figure 26- Assembled View of Servo Mount

Step 12: Add Servo Standoffs

Parts Needed:
39107 - Stand Off 32mm (4)
39111 - 3/8" button head cap screws (4)

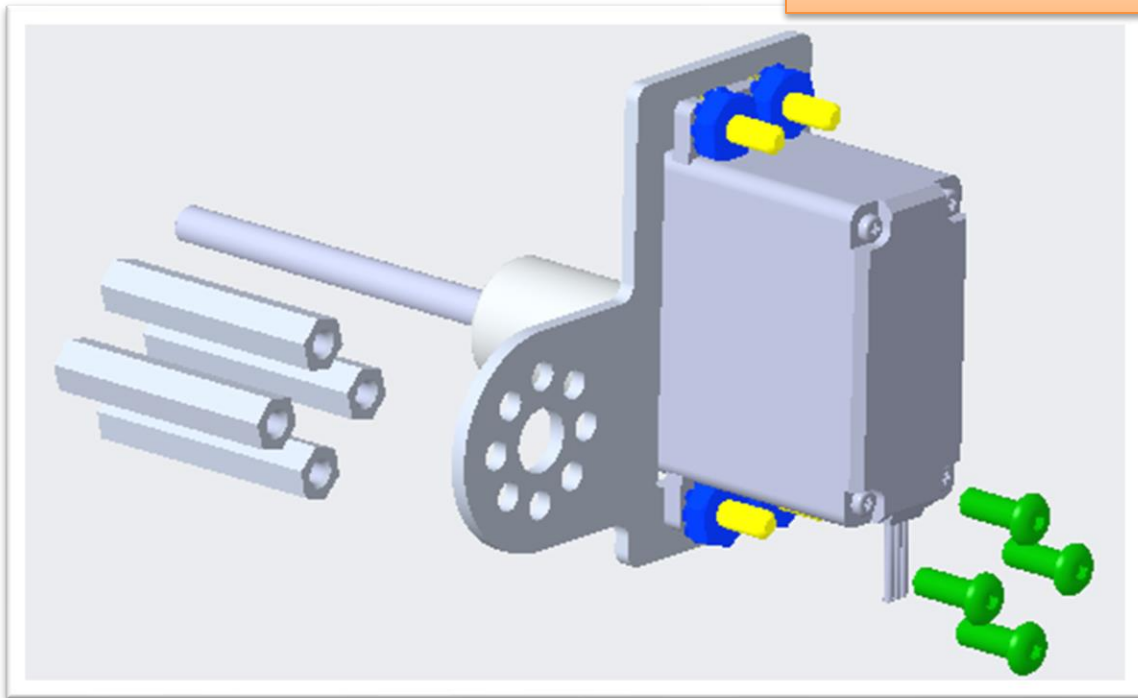


Figure 27- Disassembled View of Servo Standoffs

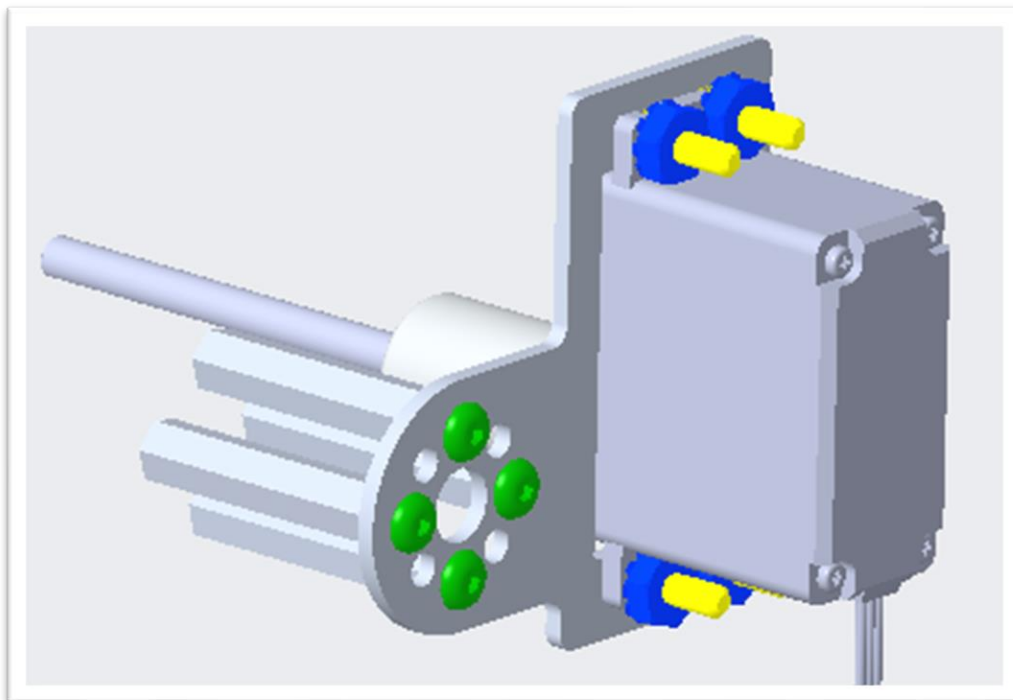
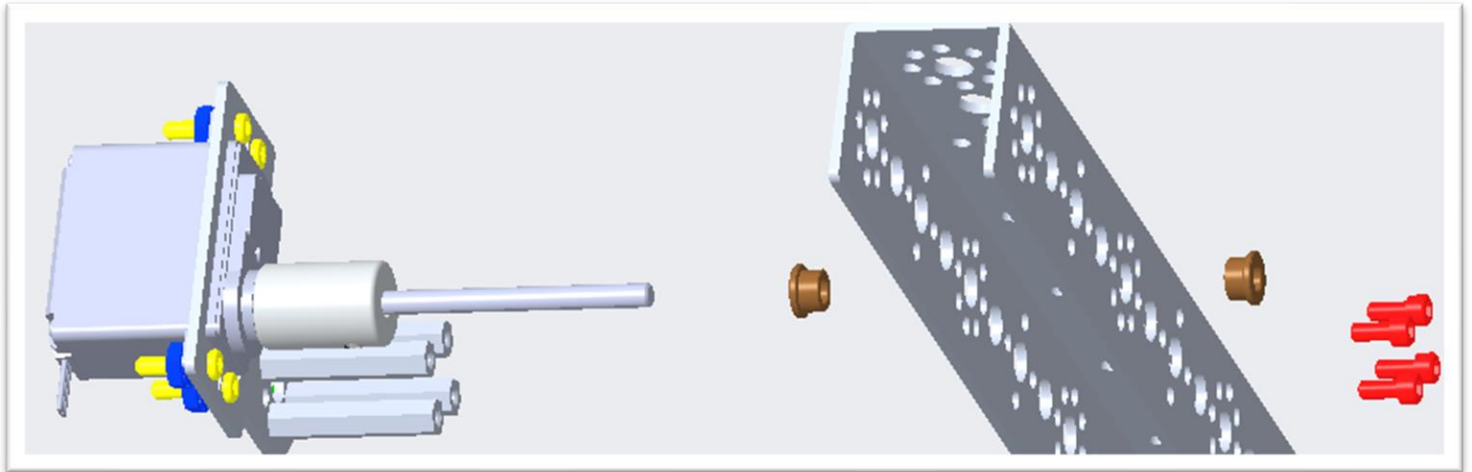
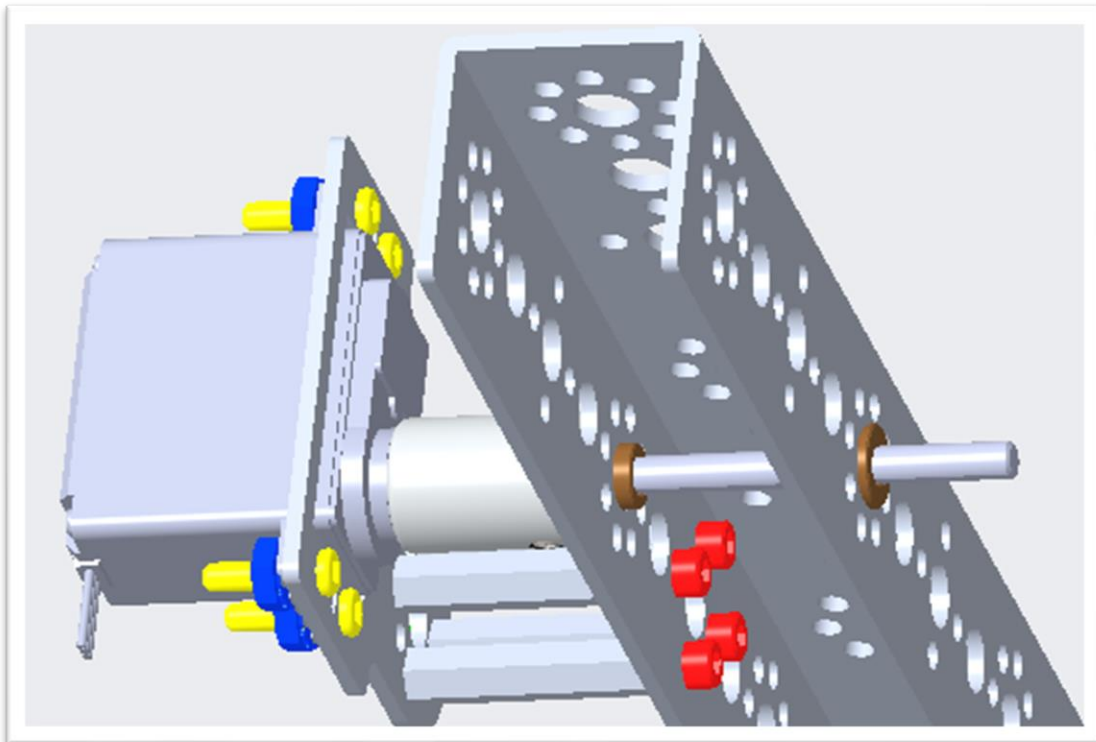


Figure 28- Assembled View of Servo Standoffs

Step 13: Add Servo 1 to Arm**Parts Needed:**

39098 - 5/16" socket head cap screws (4)

41792 - 7mmx4mm Bronze Bushing (2)

*Figure 29- Disassembled View of Servo 1 to Arm**Figure 30- Assembled View of Servo 1 to Arm***Helpful Hint**

The servo should be plugged into port 0 with an extension cable.

Step 14: Add Servo 1 Gear

Parts Needed:

- 39100 - Axle Spacer (1)
- 39111 - 3/8" button head cap screws (4)
- 39028 - 40 Tooth Gear (1)
- 39172 - Axle Hub (1)

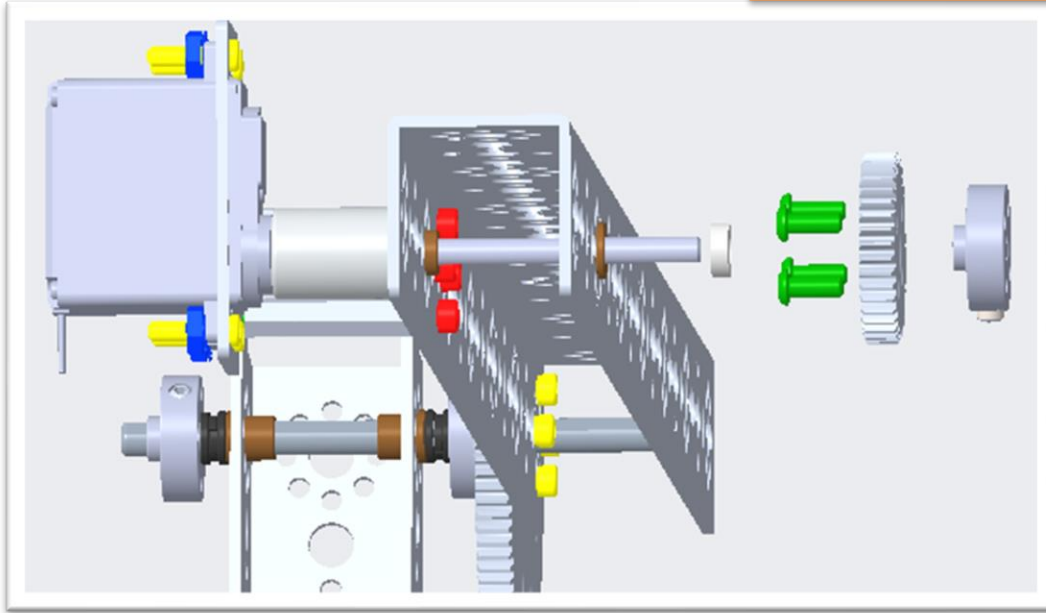


Figure 31- Disassembled View of Servo 1 Gear

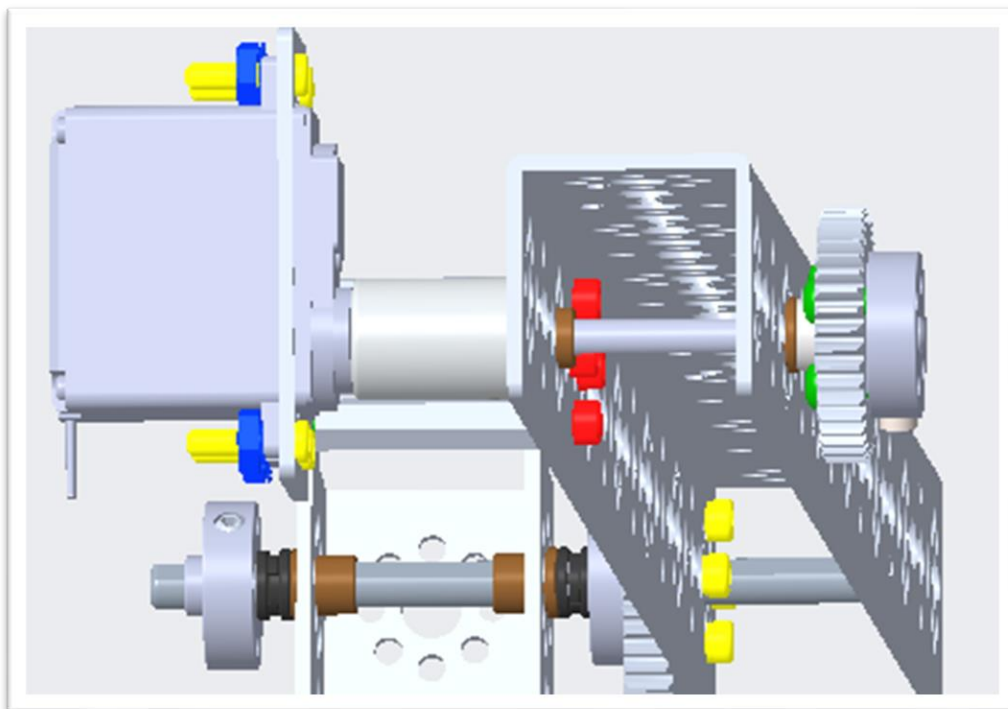


Figure 32- Assembled View of Servo 1 Gear

Forearm

Step 15: Assemble forearm channel

Parts Needed:

- 39066 - 96mm Channel (1)
- 39273 - 96mm Flat (1)
- 39062 - L Bracket (1)
- 39111 - 3/8" button head cap screws (2)
- 39098 - 5/16" socket head cap screws (2)
- 39094 - keps nuts (4)

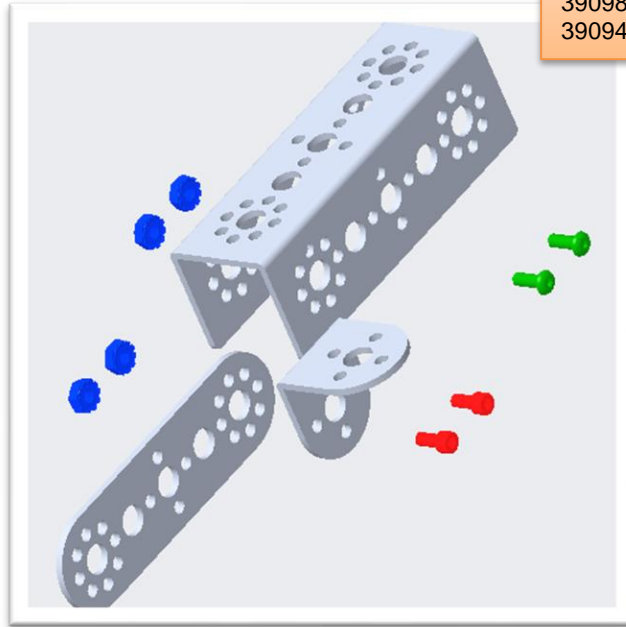


Figure 33- Disassembled View of Forearm Channel

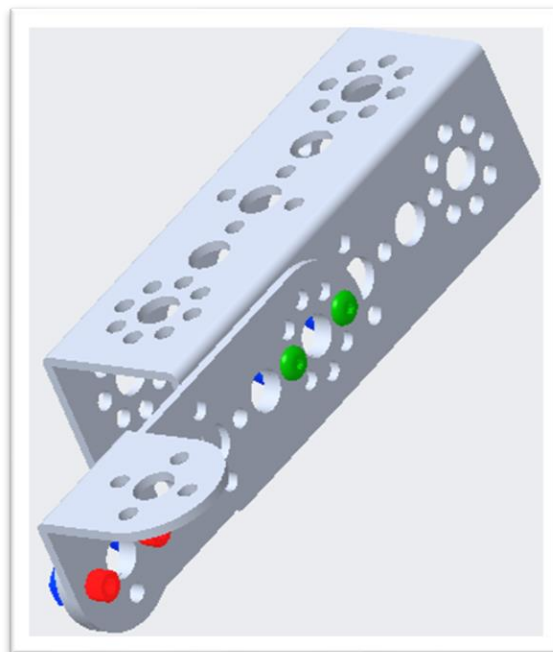


Figure 34- Assembled View of Forearm Channel

Step 16: Assemble Forearm

Parts Needed:

- 39062 - L Bracket (2)
- 39273 - 96mm Flat (1)
- 39111 - 3/8" button head cap screws (6)
- 39094 - keps nuts (6)

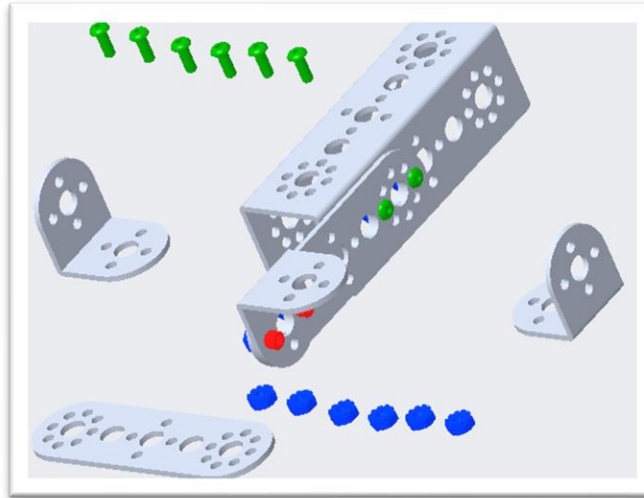


Figure 35- Disassembled View of Forearm

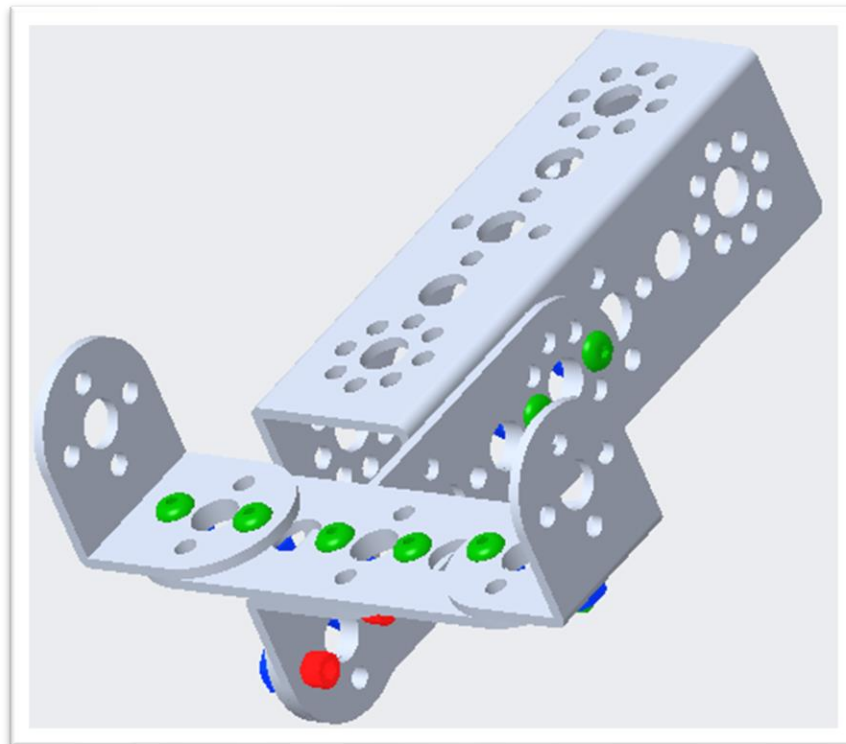


Figure 36- Assembled View of Forearm

Step 17: Add Servo Mount

Parts Needed:

41789 - Servo Mount from Mounting Kit (1)
39098 - 5/16" socket head cap screws (3)
39094 - keps nuts (3)

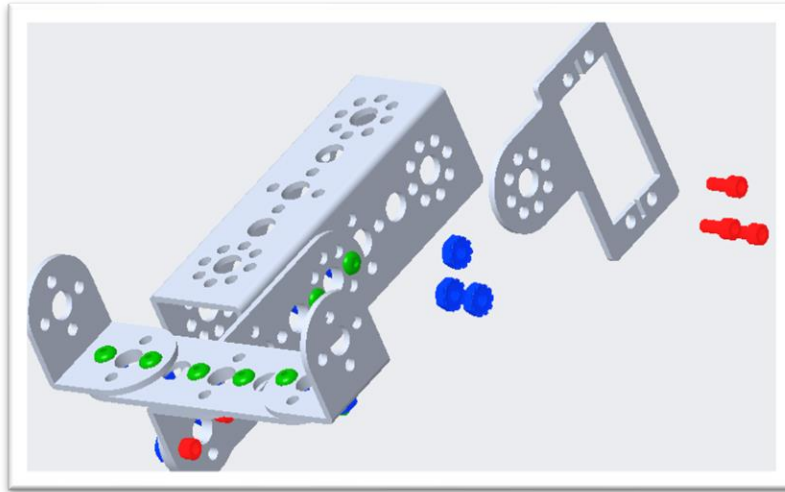


Figure 37- Disassembled View of Servo Mount

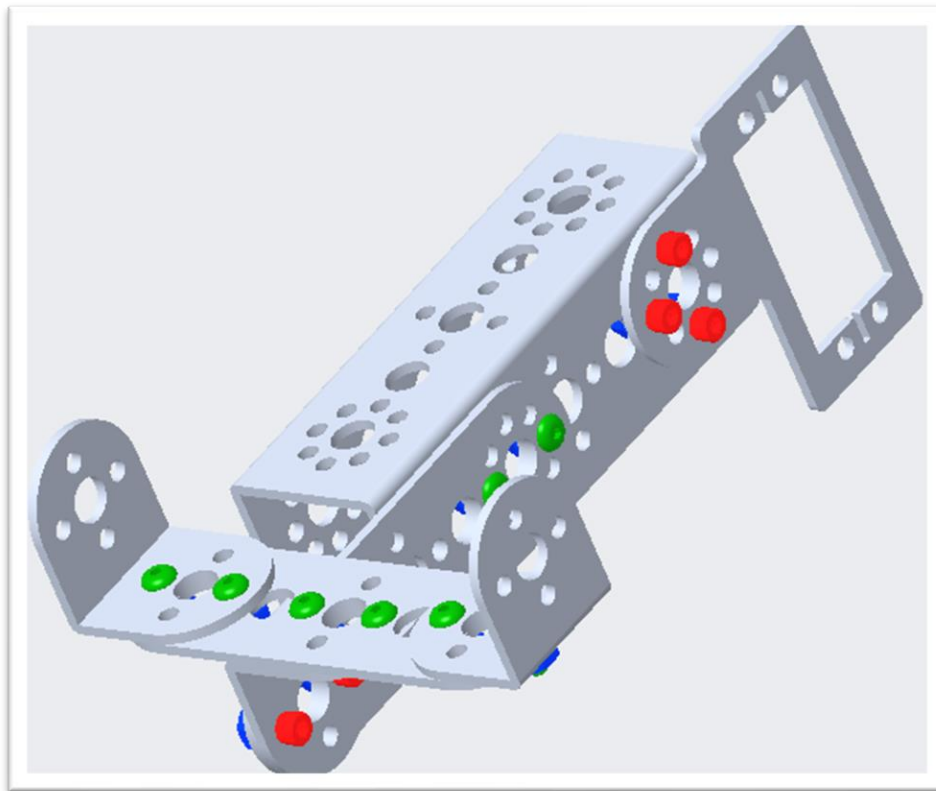


Figure 38- Assembled View of Servo Mount

Step 18: Attach Servo

Parts Needed:

- 39197 - Servo (1)
- 39097 - 1/2" socket head cap screws (4)
- 39094 - keps nuts (4)

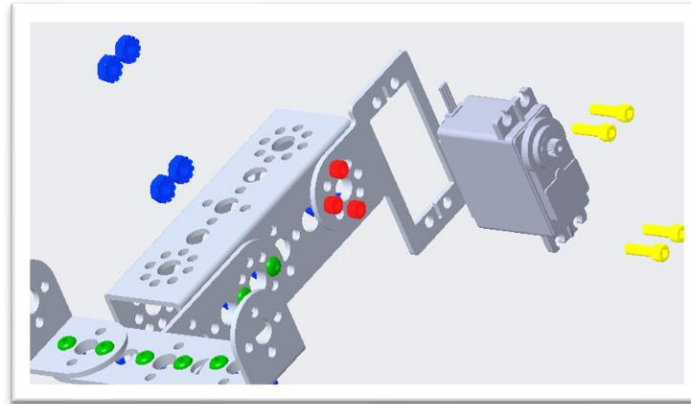


Figure 39- Disassembled View of Servo Attachment

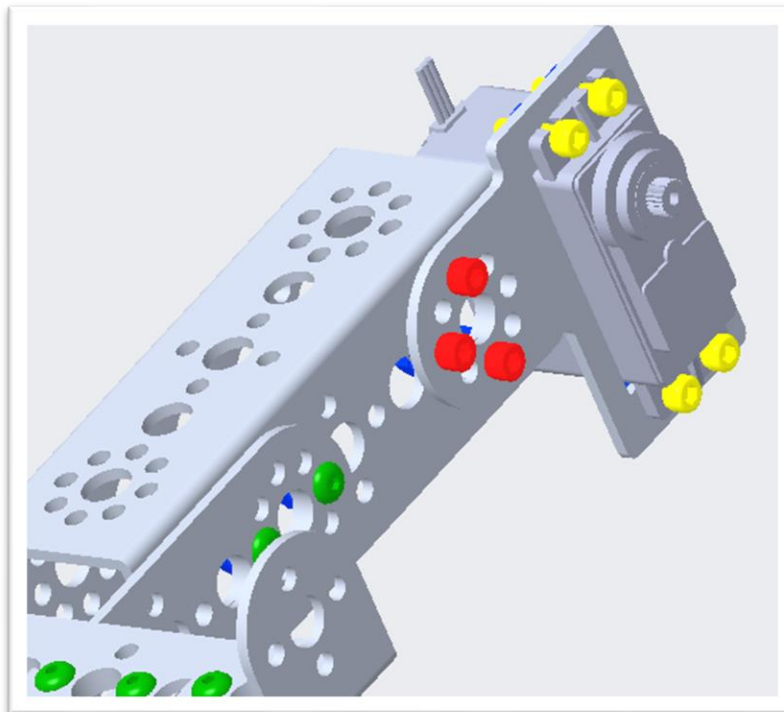


Figure 40- Assembled View of Servo Attachment

Step 19: Attach Gear

Parts Needed:

39085 - 120 Tooth Gear (1)
39097 - 1/2" socket head cap screws (4)
39172 - Axle Hub (1)

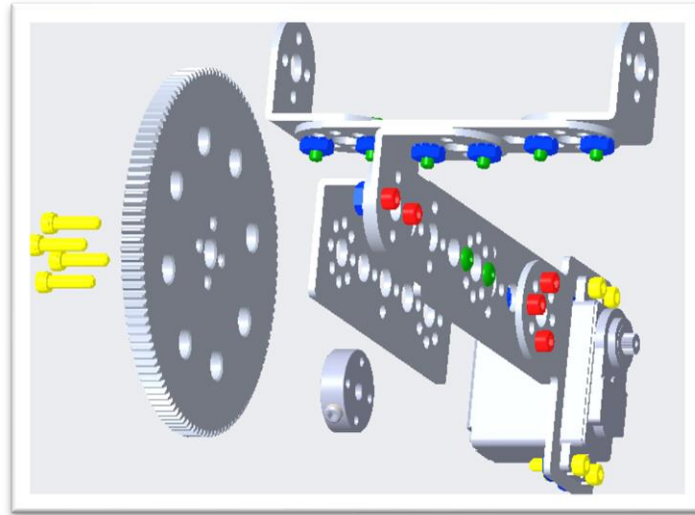


Figure 41- Disassembled View of Gear to Attach

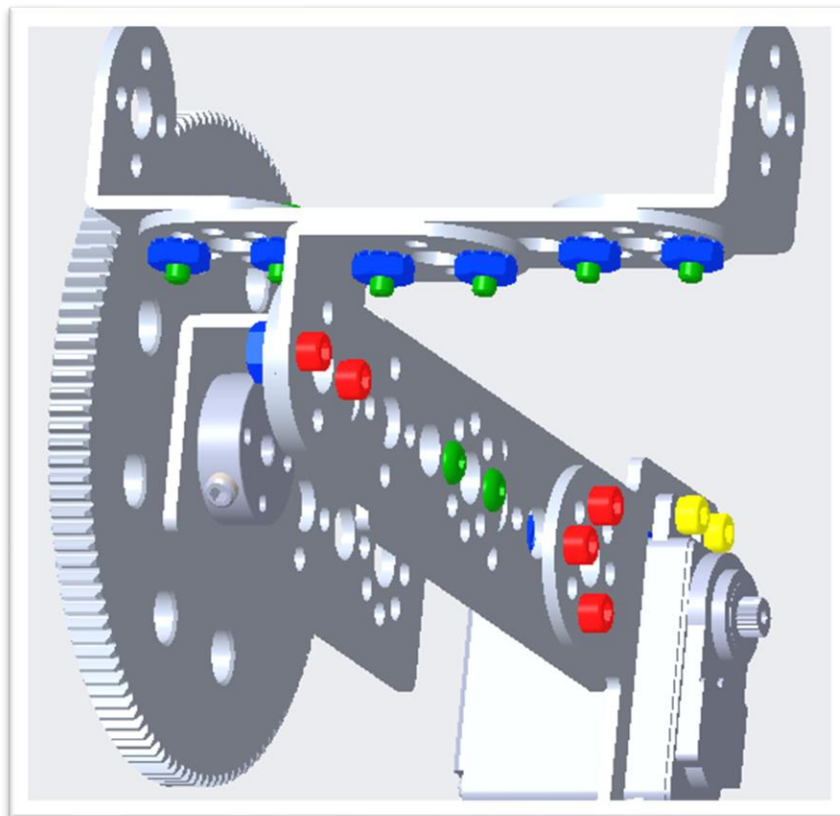


Figure 42- Assembled View of Gear

Step 20: Add the Forearm Assembly to the Robot

Parts Needed:

- 39092 - Axel Set Collar (1)
- 39091 - Bronze Bushing (2)
- 39088 - Steel Axle 100mm (1)
- 39100 - Axle Spacer (1)

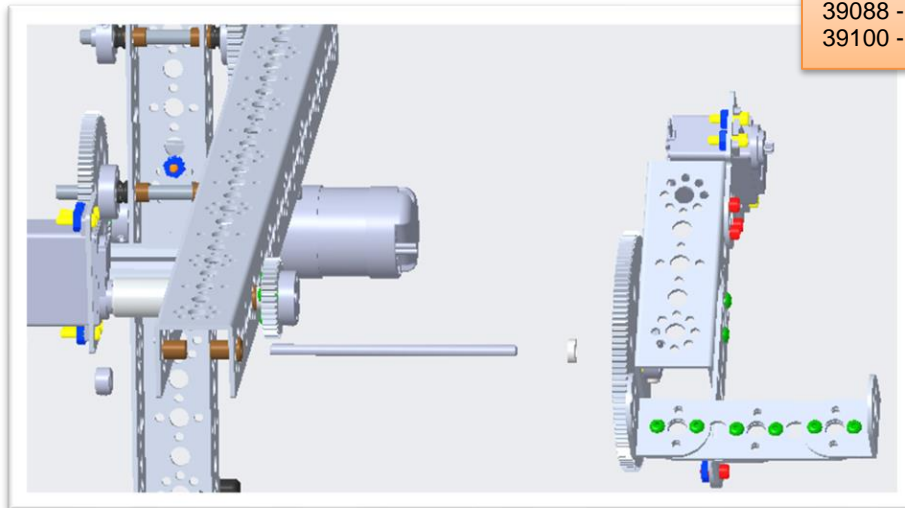


Figure 43- Disassembled View of Forearm Assembly to Robot

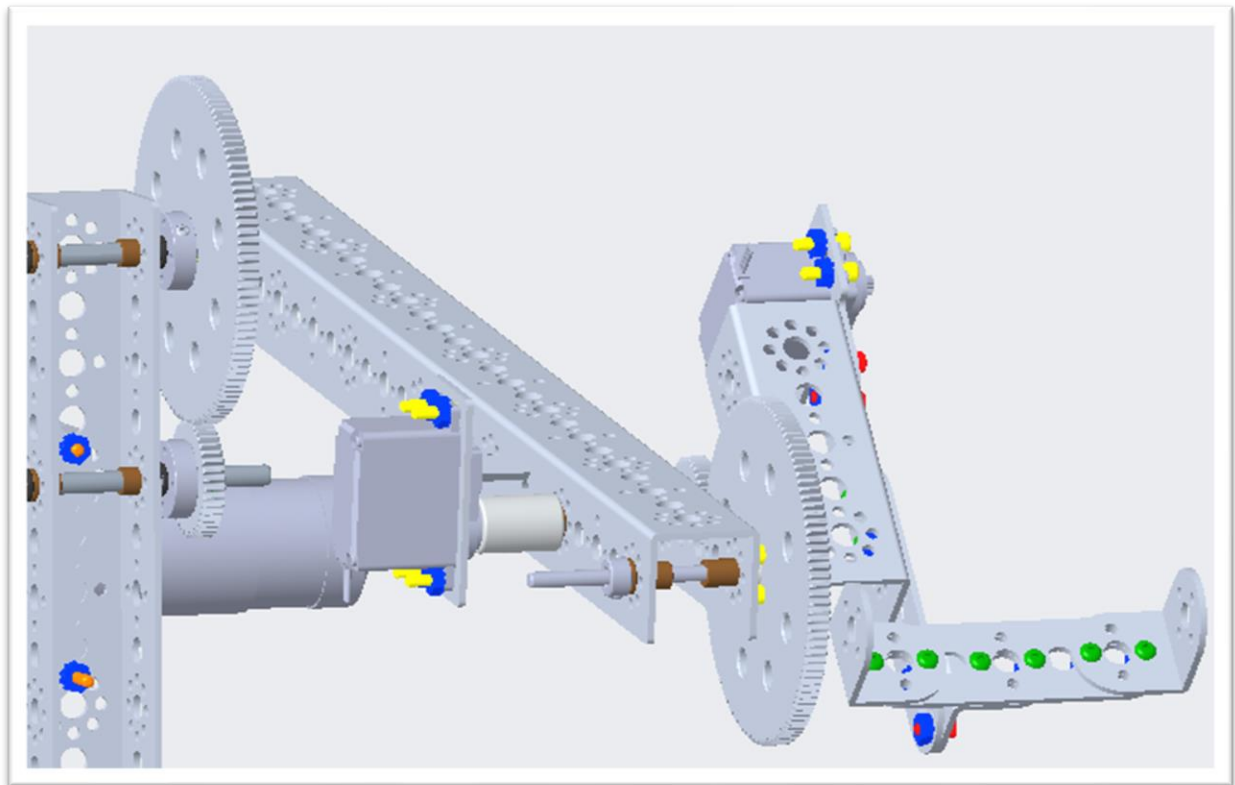


Figure 44- Assembled View of Forearm Assembly to Robot

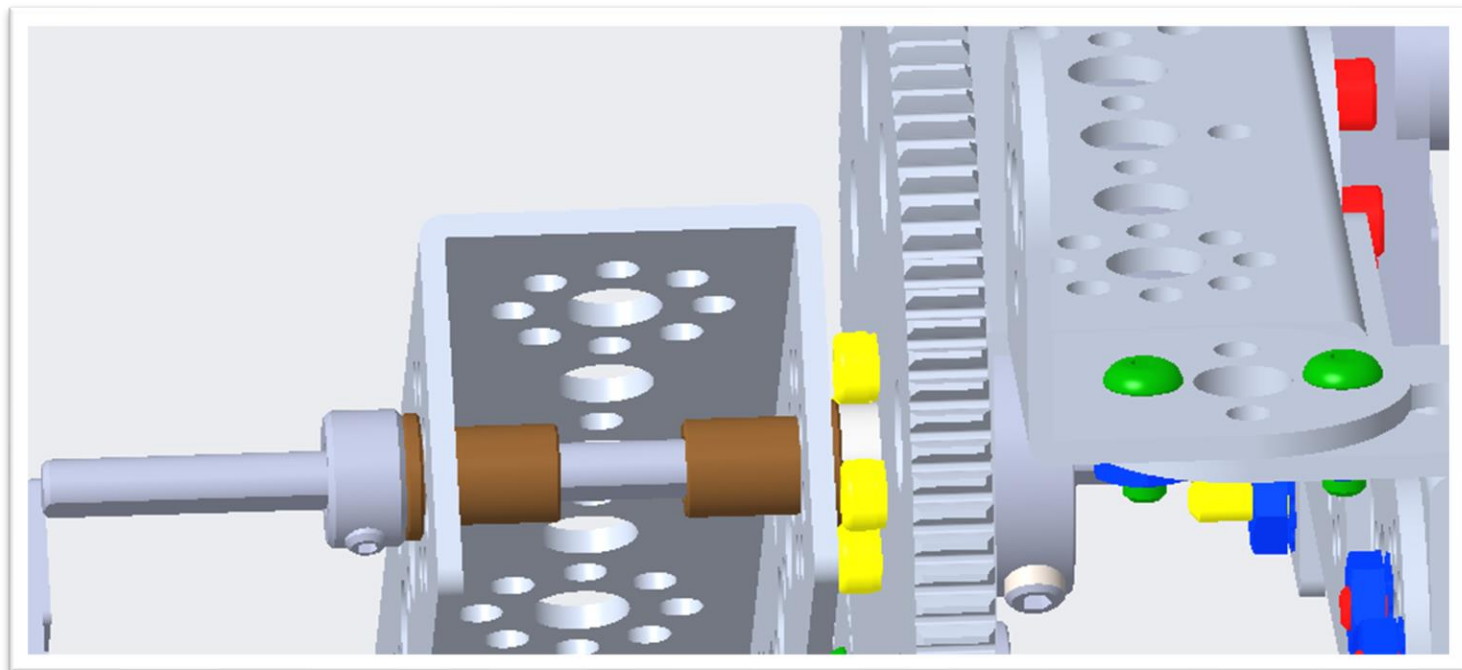


Figure 45- Assembled View of Forearm Assembly to Robot (Detail)

Hand

Step 21: Assemble Hand

Parts Needed:

39272 - 160mm Flat

39273 - 96mm Flat

39111 - 3/8" button head cap screws (2)

39094 - keps nuts (2)

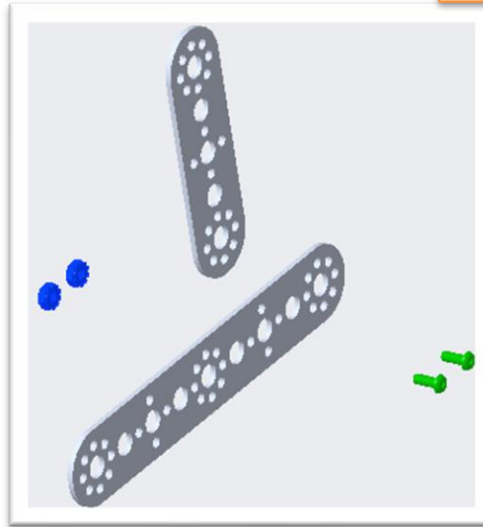


Figure 46- Disassembled View of Hand

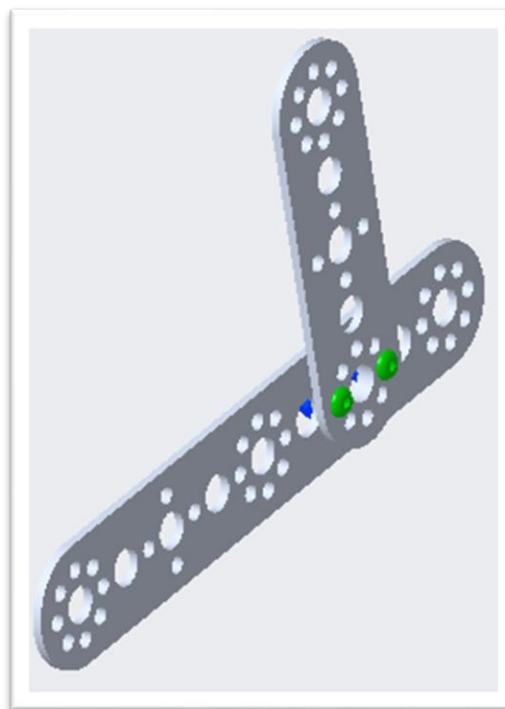


Figure 47- Assembled View of Hand

Step 22: Attach L Bracket

Parts Needed:

39062 - L Bracket (1)

39098 - 5/16" socket head cap screws (2)

39094 - keps nuts (2)

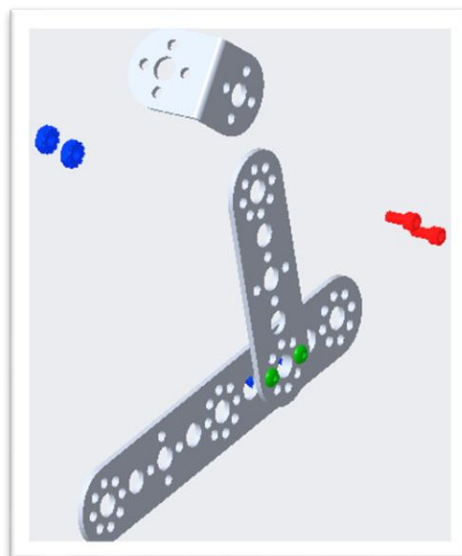


Figure 48- Disassembled View of L Bracket Attachment

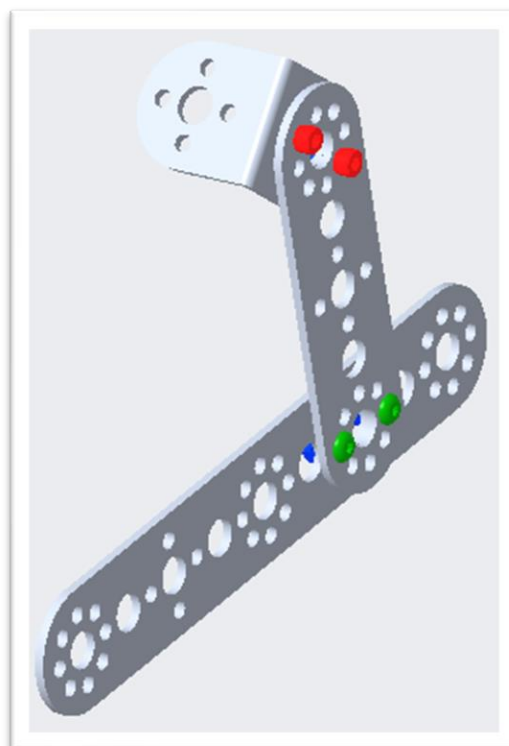


Figure 49- Assembled View of L Bracket Attachment

Step 23: Hand Assembly

Parts Needed:

39273 - 96mm Flat

39098 - 5/16" socket head cap screws (2)

39094 - keps nuts (2)

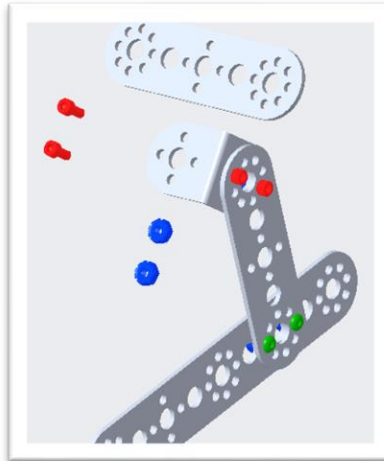


Figure 50-Disassembled View of Hand

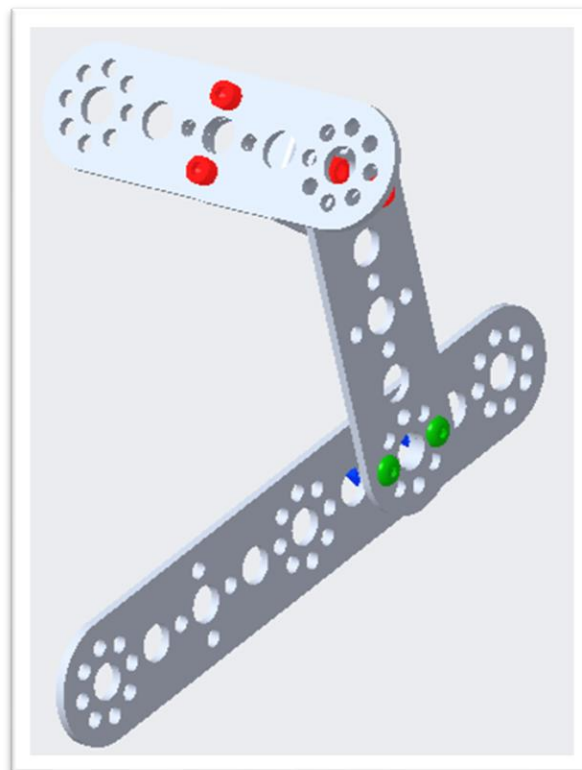


Figure 51- Assembled View of Hand

Step 24: Hand Assembly

Parts Needed:

39062 - L Bracket (2)

39111 - 3/8" button head cap screws (4)

39094 - keps nuts (4)

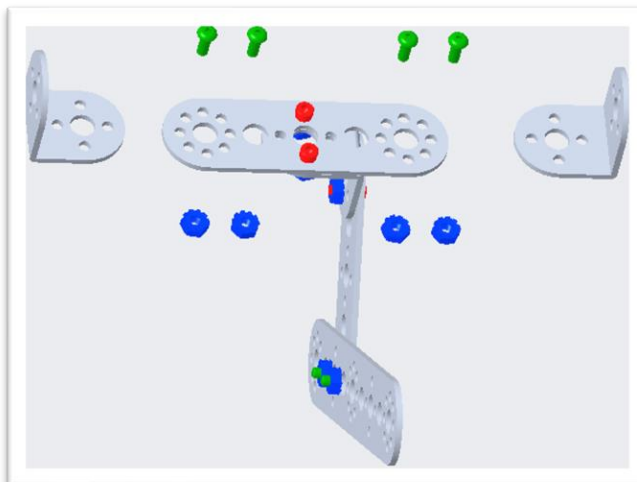


Figure 52- Disassembled View of Hand Assembly

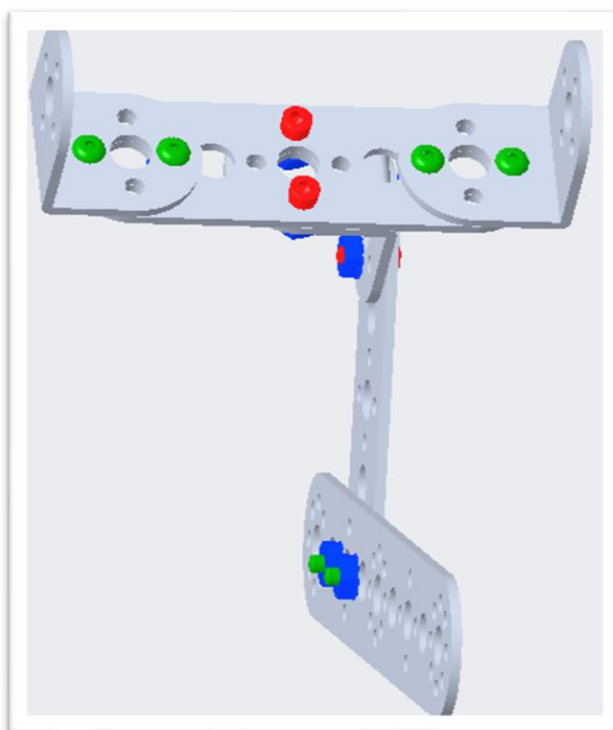


Figure 53- Assembled View of Hand Assembly

Step 25: Add Hand Assembly to the Robot

Parts Needed:

39098 - 5/16" socket head cap screw (2)
39094 - keps nut (2)

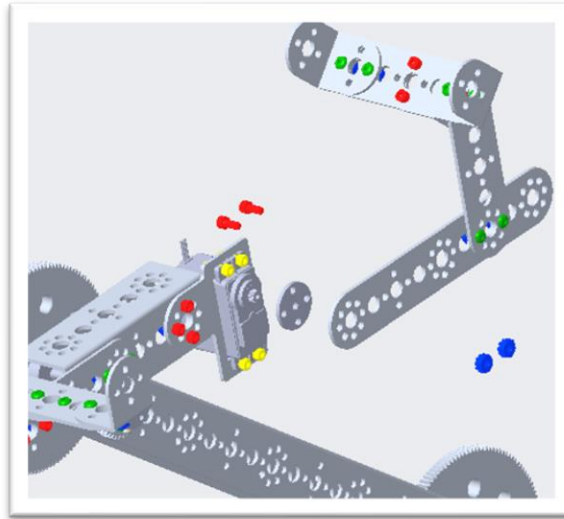


Figure 54- Disassembled View of Hand Assembly to Robot

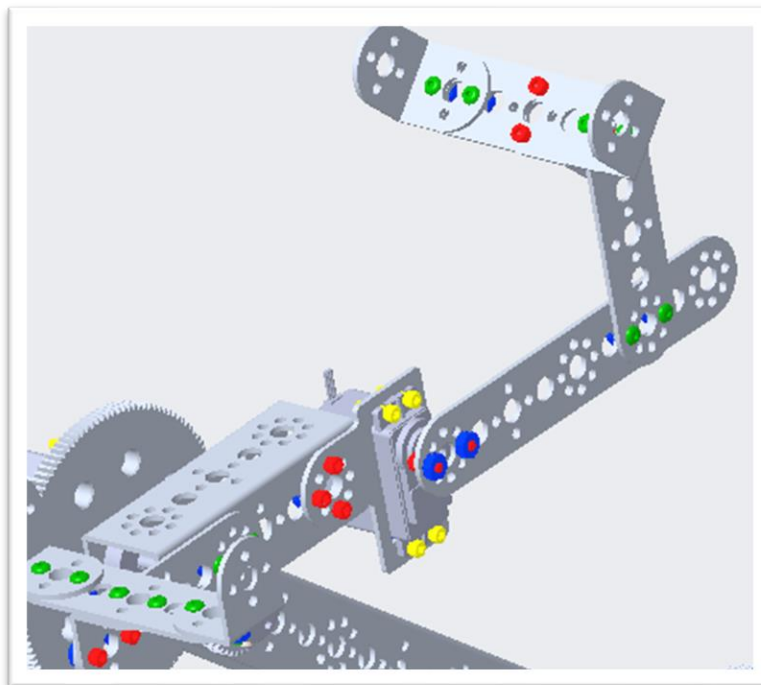


Figure 55- Assembled View of Hand Assembly to Robot

Final Steps

What's Next?

- After the gripper/release mechanism is complete, it needs to be installed on the servo so that it can fully open and close. Once this is done, use the screw that originally held on the plastic servo horn that came on the servo to hold the metal servo horn on.
- The first servo should be set so that the cone is gripped securely when closed and free to come out when open. The servo that rotates the gripper should have the base of the gripper level when it is just above the floor. It should rotate down when the arm is lifted to make it easier to line up with the junctions.
- You have now constructed the frame of your Basic 'Bot, however, programming will be needed to make the robot functional.
- Testing should be done to determine whether anything needs to be changed or optimized for the season's game rules. Testing will also show whether more cables need to be secured or re-routed.
- Numbers and other stickers will be needed to make the robot competition ready. Check the game rules for all the applicable stickers - usually the game rules include a self-inspection check list.
- Use the [Robot Reliability Checklist](#) BEFORE Competition
- Visit the FIRST website for more [Programming Resources](#), [Robot Building Resources](#) and [Game & Season Materials](#)

Appendix A – Resources

Game Forum Q&A

<https://ftc-qa.firstinspires.org/>

Anyone may view questions and answers within the *FIRST*® Tech Challenge game Q&A forum without a password. To submit a new question, you must have a unique Q&A system user name and password for your team.

Volunteer Forum

Volunteers can request access to role specific volunteer forums by emailing FTCTrainingSupport@firstinspires.org. You will receive access to the forum thread specific to your role.

FIRST Tech Challenge Game Manuals

Part 1 and 2 - <https://www.firstinspires.org/resource-library/ftc/game-and-season-info>

FIRST Headquarters Pre-Event Support

Phone: 603-666-3906

Mon – Fri

8:30am – 5:00pm

Email: Firsttechchallenge@firstinspires.org

FIRST Websites

FIRST homepage – www.firstinspires.org

[FIRST Tech Challenge Page](#) – For everything *FIRST* Tech Challenge.

[FIRST Tech Challenge Volunteer Resources](#) – To access public volunteer manuals.

[FIRST Tech Challenge Event Schedule](#) – Find *FIRST* Tech Challenge events in your area.

FIRST Tech Challenge Social Media

[FIRST Tech Challenge Twitter Feed](#) - If you are on Twitter, follow the *FIRST* Tech Challenge Twitter feed for news updates.

[FIRST Tech Challenge Facebook page](#) - If you are on Facebook, follow the *FIRST* Tech Challenge page for news updates.

[FIRST Tech Challenge YouTube Channel](#) – Contains training videos, game animations, news clips, and more.

[FIRST Tech Challenge Blog](#) – Weekly articles for the *FIRST* Tech Challenge community, including outstanding volunteer recognition!

[FIRST Tech Challenge Team Email Blasts](#) – contain the most recent *FIRST* Tech Challenge news for teams.

Feedback

We strive to create support materials that are the best they can be. If you have feedback about this manual, please email firsttechchallenge@firstinspires.org. Thank you!

Appendix B: Examples of Proper and Improper Gear Meshing

The following pictures show examples of meshing the gears from a previous year's robot. The first is too loose; the second is too tight; the third is a good mesh. To test, rotate the mechanism by hand. If the gear teeth slip, then it is too loose, if the mechanism binds, then it is too tight.



Figure 56- Gears are too loose



Figure 57- Gears are too tight

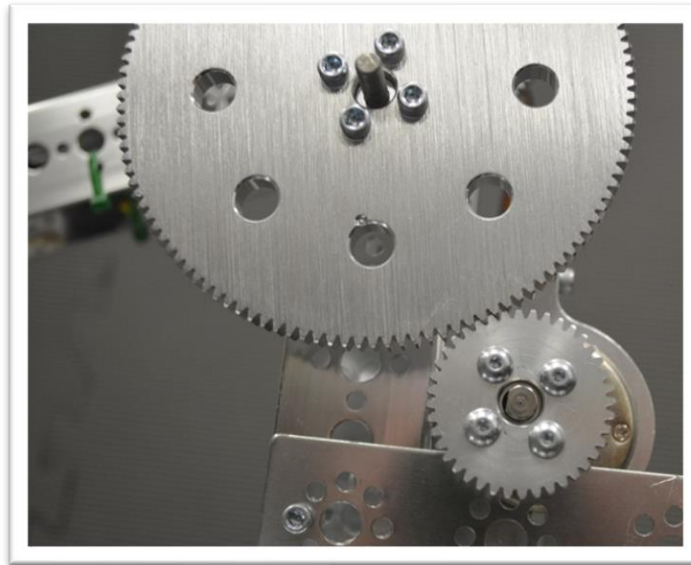


Figure 58- Gears are just right