FRC 2017 Steamworks – Gear Floor Pick Up Mechanism Design

CS450HO – Robotics Design and Fabrication, Honors

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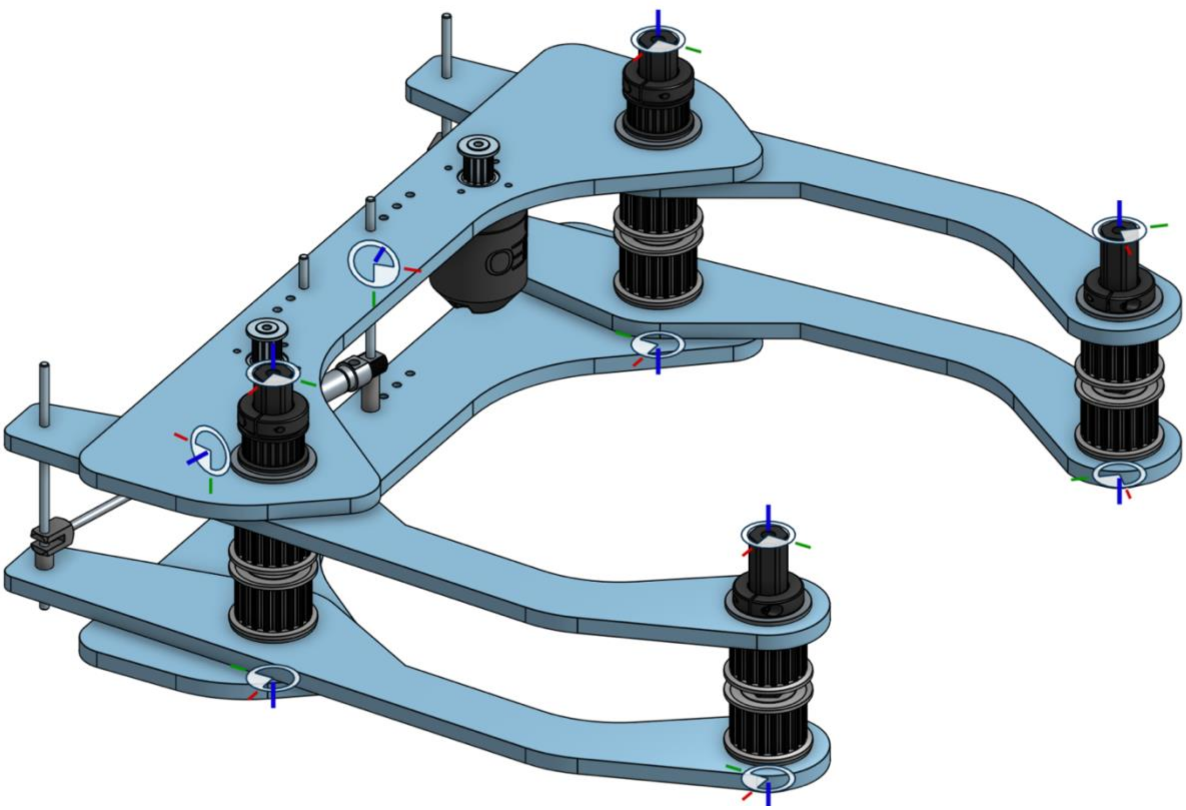

Table of Contents

Introduction **.. 3**

Strategic and Functional Requirements Design Analysis **.. 4**

Computer Aided Design Process **.. 5**

Manufacturing & Assembly **.. 12**

Testing Setup & Results **.. 13**

Conclusion **.. 14**

Works Cited **.. 15**

Figure 1: sketch of arms and restraint plate 6
Figure 2: extrusion of arms and restraint plates with holes cut for motors and pneumatics 7
Figure 3: labelled parts 7
Figure 4: mates used in the CAD 8
Figure 5: closed position, top view 9
Figure 6: open position, top view 10
Figure 7: final CAD with colors 11
Figure 8: final assembly given time and resources 12

Table 1: strategic and functional requirements 4
Table 2: priority ranking 4
Table 3: parts list and breakdown 12

Introduction

For Inspiration and Recognition of Science and Technology (FIRST) is an not-for-profit international youth organization that organizes competitions such as the FIRST Robotics Competition, the FIRST Tech Challenge, and FIRST LEGO League Challenge (FIRST, n.d. b). It was founded by Dean Kamen on March 20, 1989 in Manchester, New Hampshire (FIRST, n.d. a). FIRST emphasizes “friendly sportsmanship, respect for the contributions of others, teamwork, learning, and community involvement” (FIRST, n.d. b). Their core values include discovery, innovation, impact, inclusion, teamwork, and fun (FIRST, n.d. b).

Choate competes in the FIRST Robotics Competition, often called FRC. FRC “pairs high school students with adult mentors to design and build robots that compete against one another in a high energy environment” (FIRST, 2017, p. 7). Each January, a new game is announced. The 2017 FRC game was called FIRST Steamworks. This game “invites two adventurers’ clubs, in an era where steam power reigns, to prepare their airships for a long distance race” (FIRST, 2017, p.13). Each club, called an alliance, is made up of three teams. There are three goals of this game: to build steam pressure, to start rotors, and to prepare for flight (FIRST, 2017, p. 13). Robots can build steam pressure by collecting balls and scoring it in their boilers, which are basically hoops. Robots can also start rotors by delivering gears to the human players on their airship for installation. Once a gear train is complete, the human player can turn the crank to start the rotor. Finally, robots can prepare for flight; they must latch onto their airship before the end of the match to signal they are ready for takeoff.

Our project was to create a mechanism that would pick up a FIRST Steamworks gear from the ground with a partner. This project was designed to teach us how to conduct background research when designing a subsystem for a robot, CAD design in Onshape, manufacturing design and fabrication, and testing our system.

We used one video as inspiration for our design: Team 1684’s 2017 robot reveal video (The Chimeras FRC Team 1684, 2017). Although their intake system might not have been unconventional, their outtake system was, it got our creative juices flowing and inspired us to create an unconventional and unique gear intake system compared to other groups in the class we observed during the brainstorming period.

Strategic and Functional Requirements Design Analysis

We started the project with a basic understanding of the FRC 2017 Challenge "Steamworks." Our goal was as follows for the project: create an intake that can successfully and efficiently obtain an 11-inch diameter gear.

We had very few design constraints other than building around the dimensions and odd shape of the gear. We started with a strategic and functional analysis at the beginning of our mechanical design project. We needed our intake to securely acquire and hold the FRC gear and be adjustable. Our original design included as set of horizontal rollers, but since everyone in the class was doing something similar, we decided to step it up a notch. Over 4 or 5 iterations, our pneumatic claw intake was born.

Table 1: strategic and functional requirements

STRATEGIC REQUIREMENTS	FUNCTIONAL REQUIREMENTS
Acquire and hold the gear	Must be able to hold one gear
Needs to be effective from all angles	Needs adjustabilitiy

Table 2: priority ranking

PRIORITY RANKING
Aquire gear
Consistency from all angles
Hold the gear
Adjustability

Computer Aided Design Process

Computer aided design, often abbreviated to CAD, is a way to digitally create 2D drawings and 3D models of real-world products before they are ever even manufactured (PTC, n.d. a). There are many different companies who make CAD software. Some examples include SolidWorks and Onshape. We used Onshape for this project. Onshape is a "design platform build for the cloud, combining CAD and PDM with advanced collaboration and analytics capabilities" (PTC, n.d. b). One of the biggest highlights of using Onshape in this collaborative project was Onshape's collaborative tools, including the ability to have multiple people work or view the same project at once. This was very helpful during our basic "what should our pieces look like" design phase.

The CAD techniques and features we used during our use of CAD in this project included part sketches, sketch constraints, the mirror tool, sketch extrusions, the use of the MKCad Parts Library and importation of parts and mates. The MKCad Parts Library is has a multitude of parts that are available for one to use in their Onshape CAD assemblies, all for free. Many of these parts are configurable to one's desired specification.

We began our CAD by sketching the arms. We used sketch constraints to ensure proper sizing for our plates and used the mirror tool to ensure our design was symmetrical over the vertical axis. The sketch of our arms and restraint plate can be seen in Figure 1. After we finished sketching our arms, we extruded them into parts. We later went back and added holes for our motors and pneumatics. Our extrusions for our four arms and two restraint plates can be seen in Figure 2. Then we began using the Assembly to bring self-designed and imported pieces together. On our arms, we decided to use the VEX Robotics HTD belts and pulleys and imported these pieces using the MKCad Parts Library. We decided to use REV Robotics' NEO 550 motors to run these belts that would drag the gear into our system and imported them into our project through the MKCad Parts Library. For our pneumatics that would keep the arms either open or closed, we decided to use two pneumatic cylinders we found in the shop, but also imported them using the MKCad Parts Library, under cylinder, configurable. We also used the MKCad Parts Library to import our shafts and shaft collars, which would be used to hold the entire device together, the pinions that would be used to transfer the power and torque from the motors to our shafts, and the bearings that would help the shafts rotate freely. Additionally, we imported the shafts and clevises to retain our pneumatic systems from the McMaster-Carr website through their publication of their STEP files. Finally, we constructed four spacers to prevent our pneumatic cylinders from falling down. Figure 3 has labels for all the parts we imported and our spacers.

After constructing and importing parts into the Onshape assembly, we used mates to keep the parts where we wanted them to be. We generally used revolute mates, but we also used fastened mates, cylindrical mates, and planar mates. Figure 4 depicts where all the mates we used are. The mates completed our CAD model. Within Onshape, we can now adjust the assembly to either be in the opened position or the closed position, and all the parts will move and function properly. The closed position is depicted in Figure 5 and the closed position is depicted in Figure 6.

Finally, our last step was to assign an appearance for our assembly. Although we will not be using these colors, we chose blue and gold for the CAD. This is represented in Figure 8.

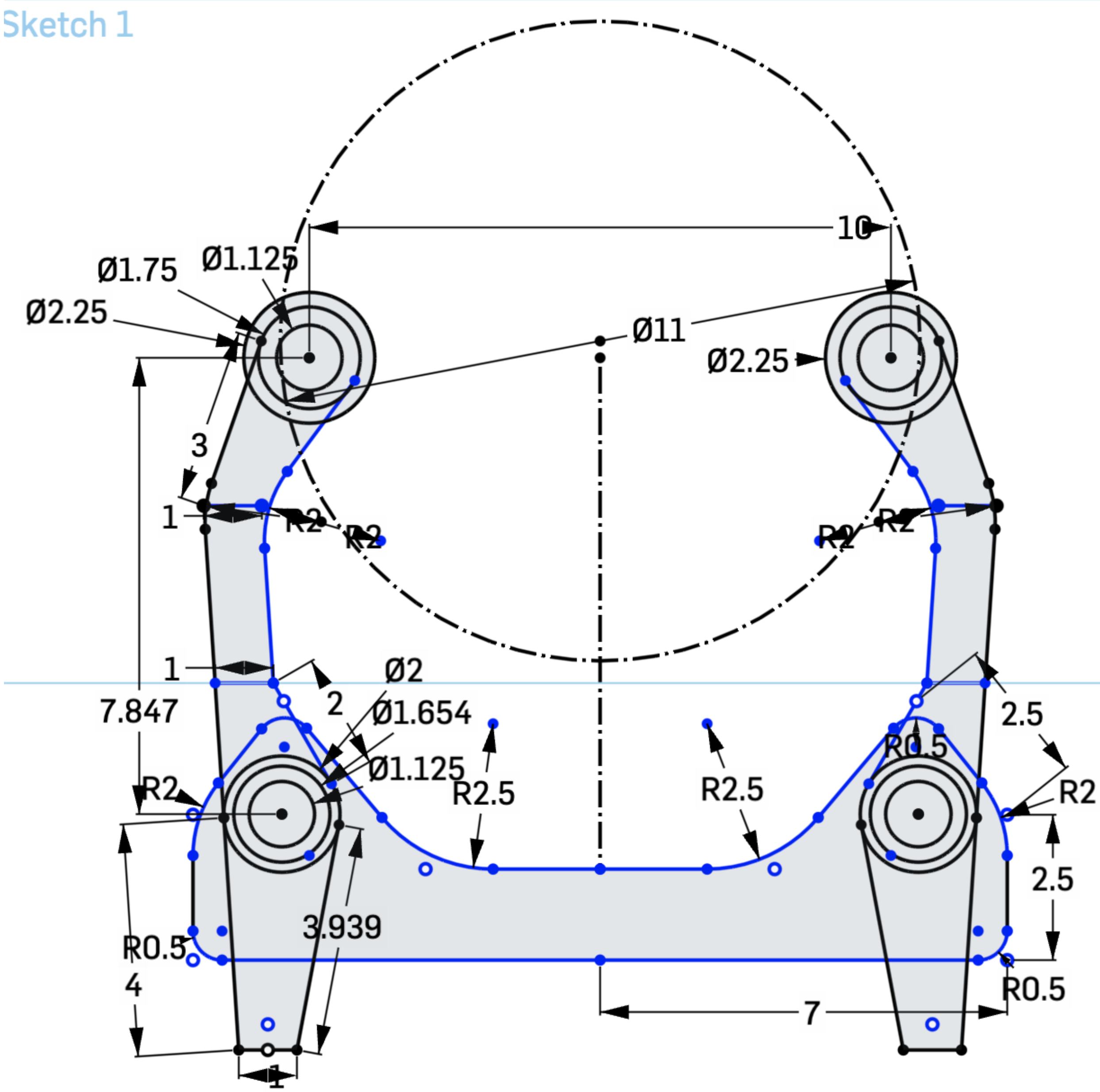

Figure 1: sketch of arms and restraint plate

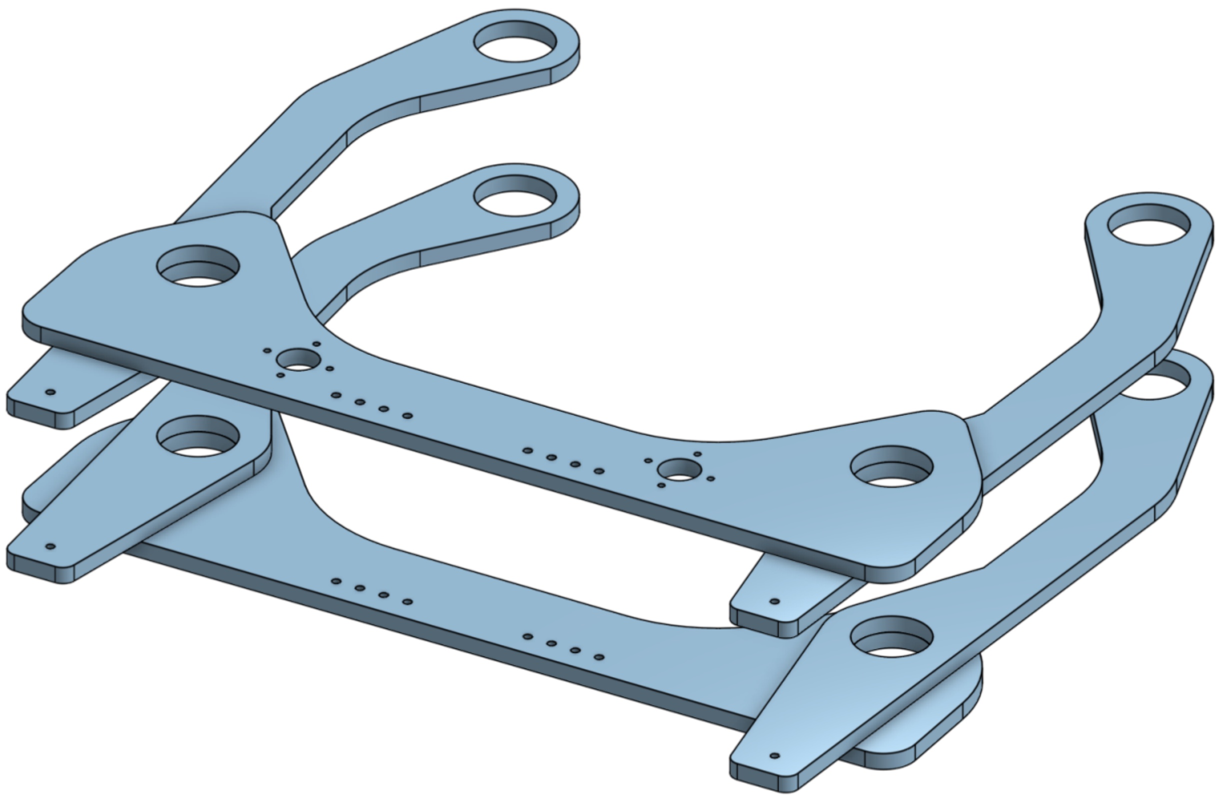

Figure 2: extrusion of arms and restraint plates with holes cut for motors and pneumatics

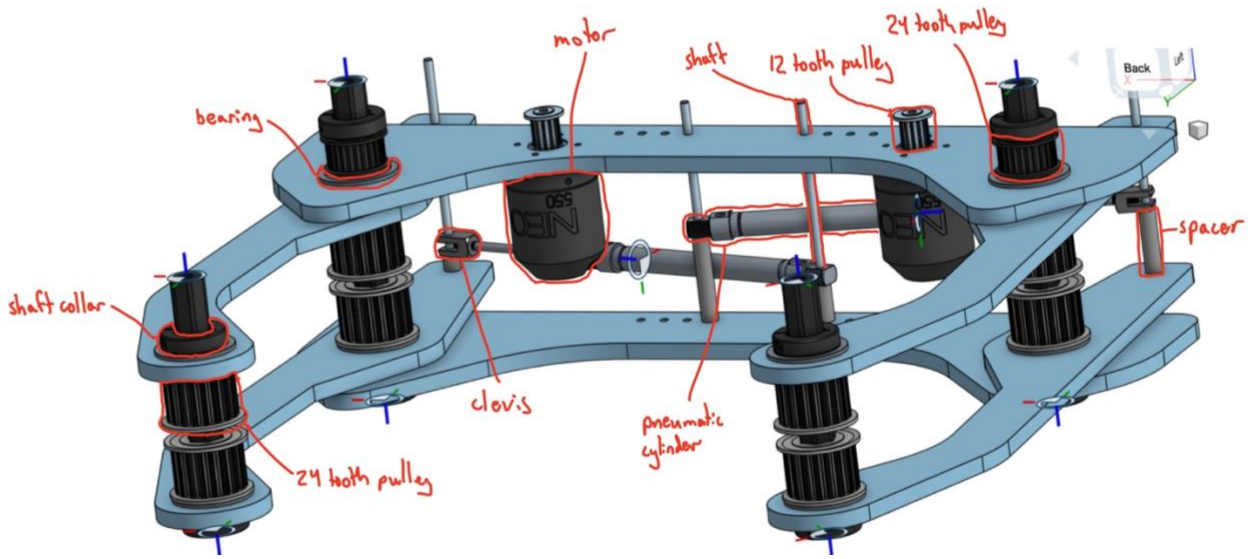

Figure 3: labelled parts

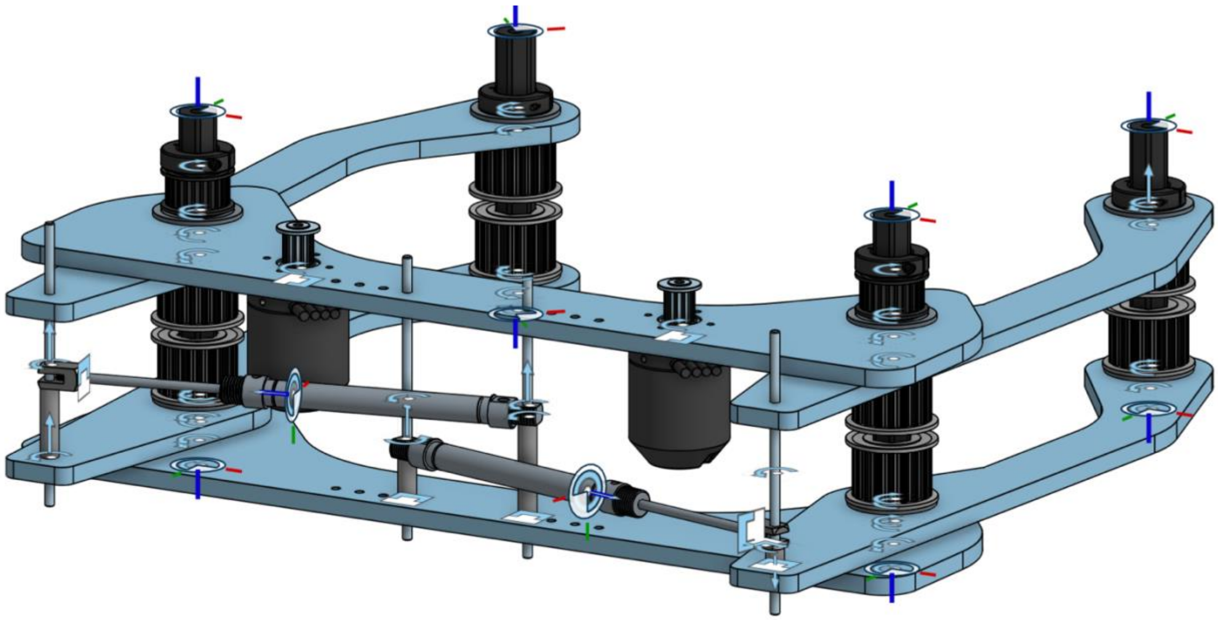

Figure 4: mates used in the CAD

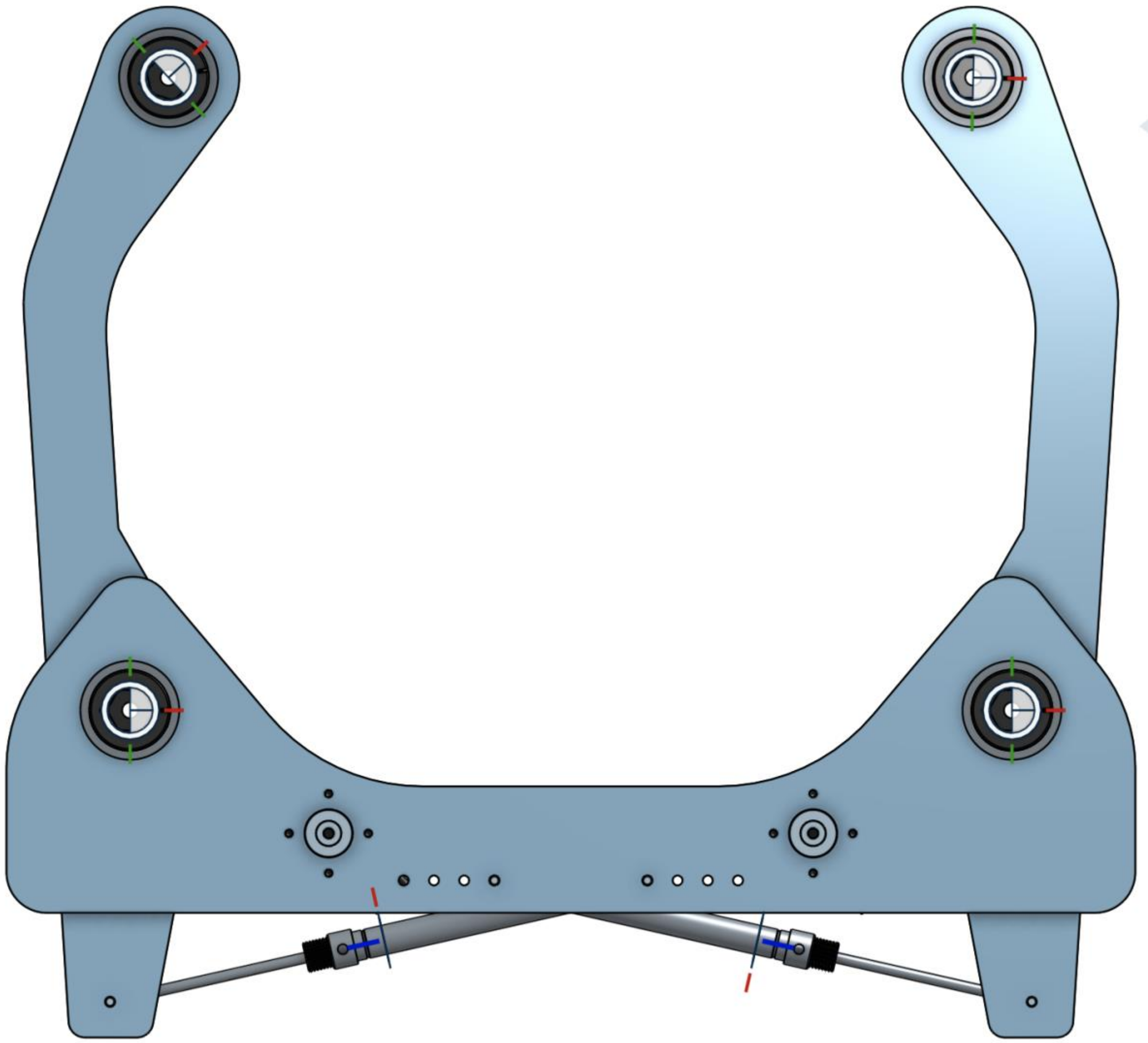

Figure 5: closed position, top view

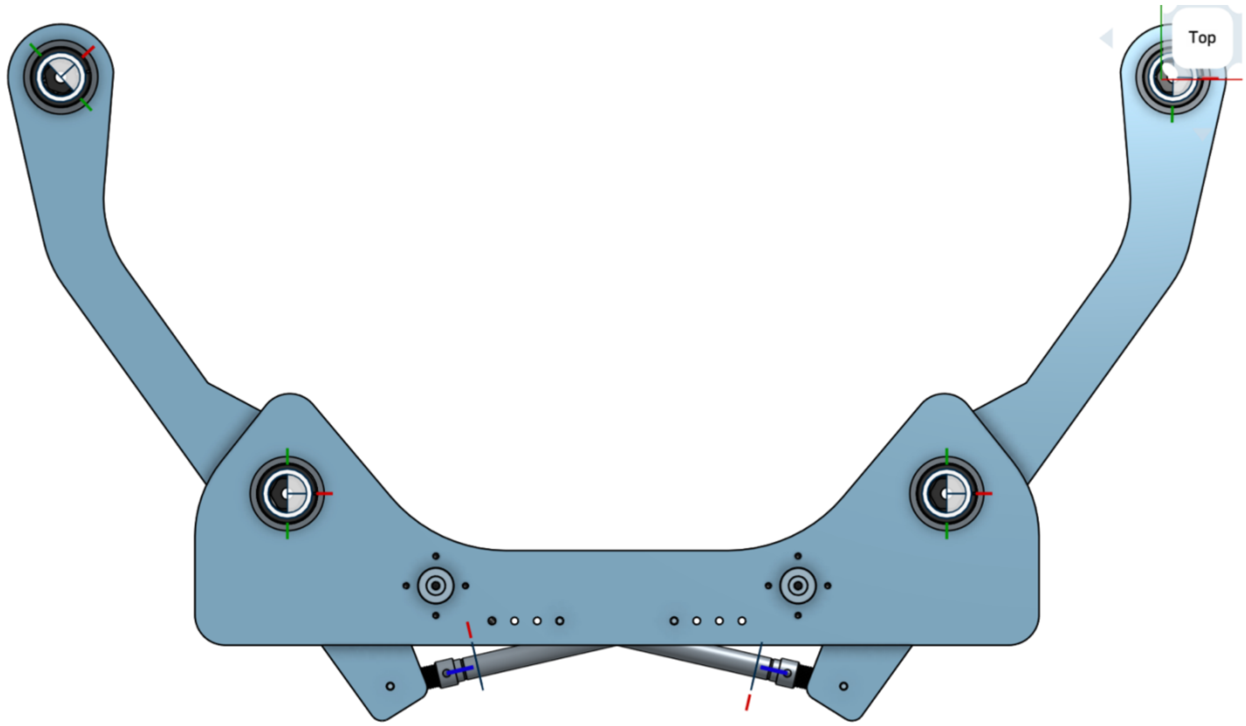

Figure 6: open position, top view

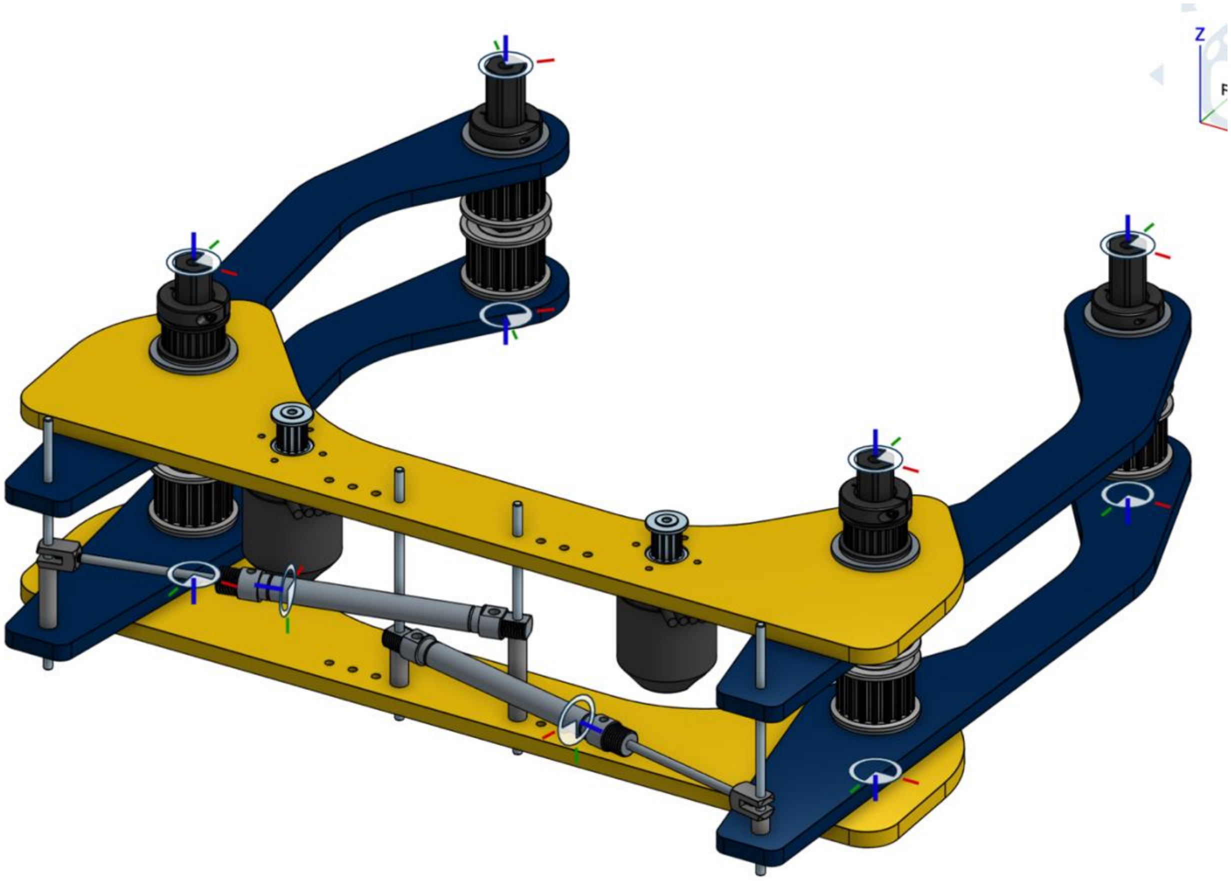

Figure 7: final CAD with colors

Manufacturing & Assembly

After our design process, we began our build. Throughout our manufacturing and assembly process, we have run into just a few issues. We have just started manufacturing our parts including shafts and structural plates. We cut our hex shafts to length with a horizontal bandsaw, and we are beginning to CNC our plates out of polycarbonate. We are doing this now using Fusion 360. We will then use the CNC to cut our pieces and then begin the final assembly.

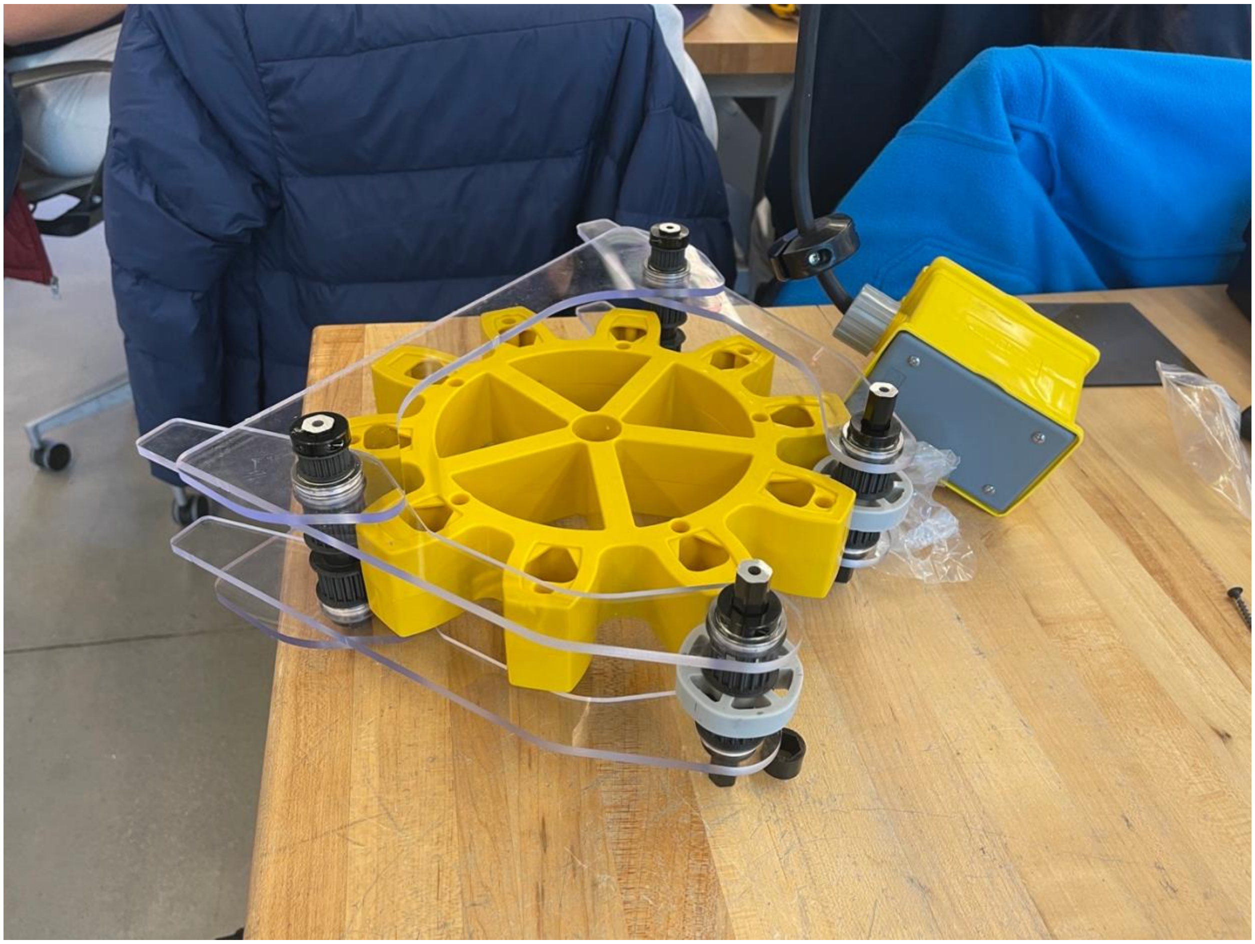

Figure 8: final assembly given time and resources

Table 3: parts list and breakdown

Part Number (SKU)	Name/Description	Price	Quantity	Total Price	Vendor	Link
REV-21-1651	NEO 550 Brushless Motor	$25	2	$ 50.00	REV Robotics	https://www.revrobotics.com/rev-21-1651/
217-4101	HTD Timing Pulley, 24T x 15mm Wide	$12.99	8	$ 103.92	VEX Robotics	https://www.vexrobotics.com/htdpulleys.html
217-3476	HTD Timing Belt, 104T x 15mm Wide	$13.99	4	$ 55.96	VEX Robotics	https://www.vexrobotics.com/htdbelts15.html
217-4017	ThunderHex Stock, 1/2" x 0.201" ID (36")	$15.99	1	$ 15.99	VEX Robotics	https://www.vexrobotics.com/thunderhexstock.html
217-2737	Clamping Shaft Collar, 1/2" Hex ID	$4.99	8	$ 39.92	VEX Robotics	https://www.vexrobotics.com/shaft-collars.html
1257K84	1/8" Dia. 303 Stainless Steel Rotary Shaft (4")	$4.03	4	$ 16.12	McMaster-Carr	https://www.mcmaster.com/shafts/rotary-shafts-5/
6498K551	Rod Clevis with Pin for 5/16" Bore Double-Acting Roudn Body Air Cylinder	$5.06	2	$ 10.12	McMaster-Carr	https://www.mcmaster.com/6498K551/
091	5/16" Inch Bore, 2" Stroke Pneumatic Cylinder	$22.70	2	$ 45.40	found in Robotics Lab - no need to purchase	https://www.bimba.com/en/detail/original_line_cylinder
REV-21-1908	GT2 3mm 550 Motor Pinion Pulley - 12T	$9.00	2	$ 18.00	REV Robotics	https://www.revrobotics.com/550-motor-pinions/
217-5875	GT2 1/2" Hex Bore Timing Pulley - 24T	$14.99	2	$ 29.98	VEX Robotics	https://www.vexrobotics.com/gt2pulleys.html?q=&locale.name=English
217-5885	GT2 Timing Belts, 9mm Width - 70T	$4.99	2	$ 9.98	VEX Robotics	https://www.vexrobotics.com/gt2-timingbelts.html?config=325-1715,326-1730

Testing Setup & Results

Unfortunately, we were not granted to privilege of time required to finish this project. Our belts are too long. The clevises for our pneumatic cylinders are too small. Additionally, getting the CNC'd restraint plates out of their housings was a more difficult process than we had anticipated. As a result of our difficulties, we were unable to complete a working prototype of our design. Had we gotten a working assembly going, it would have been tested by using a screwdriver to turn the shafts or attached to the 2020 robot (with a control system and pneumatics). One of the strengths of our idea, however, was the ease (theoretically) our gear would be intake into our design. One of the weaknesses of our idea was the fact that it is a little unwieldy in shape, and in its current form, does not have a way to turn the intaked gear vertically. We would implement this functionality into a future iteration of our design. Another implementational iteration is adding a compliance wheel to the ends of our arms as to intake the gear easier.

Conclusion

The goal of this project was to create a mechanism that would pick up a FRC Steamworks gear from the ground and "intake" it into a subsystem of a robot. Our goal was to design, prototype, and test this subsystem.

We started our CAD process by drawing various sketches of our idea. The goal here was to get our idea out of our heads onto paper. We then transferred the idea from our heads to Notability to Onshape, starting with Onshape's sketching features. After sketching, we extruded parts, imported other parts, and assembled all our parts into a computerized version of our final assembly.

We began manufacturing by ordering parts and preparing machines for CNCing our arms and restraint plates. We then CAM'd the parts that needed to be CNC'd and send the g-code over to our CNC router.

After CNCing the parts, assembly began. As mentioned above, we had some issues with our assembly, causing the prototype to not work in the end.

If given a week more to finish this project, we hypothesize we would have the time to finish the project and come up with a working prototype.

We learned many things from this project, including patience, resilience, and teamwork. Neither partner had worked on such a large project with another person before. Working in pairs for this project was mind-opening for both of us. Not only did we get different perspectives from each other, but we also got different perspectives and opinions from other individuals and pairs in our class. It was great to work on the same project as everyone else. However, by far the most important lesson we have taken away from this project is persistence. It is rare for something to work right away in robotics, and persistence is needed to evolve a design and manufacture it to work.

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