Engineering Design Portfolio

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Sustainably Powered Snow and Ice Melting System

Capstone Project

Project Scope

1. Design a snow and ice melting system for campus walkways in Ontario, Canada which is powered through a sustainable energy source.

2. Build a scaled prototype of the design to prove the system works.

Major Challenges

1. Designing ideal pipe layout

2. FEA on tubing

3. Developing control system

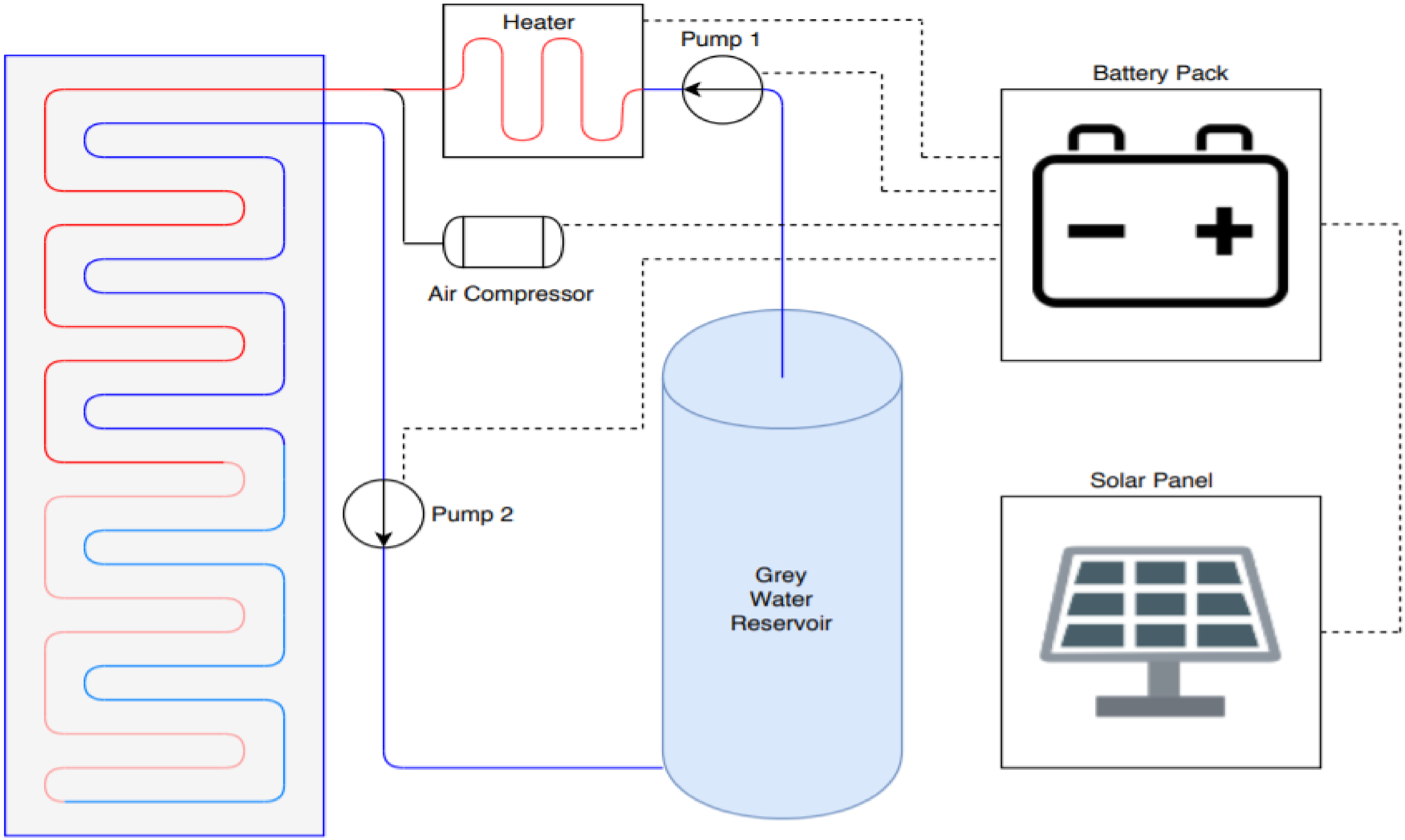

Figure 1: Component Diagram of Hydronic Snow and Ice Melting System

Programs and Skills: **NX** (CAD, FEA, Drafting), **Arduino** (Algorithm Development)

Sustainably Powered Snow and Ice Melting System

Capstone Project

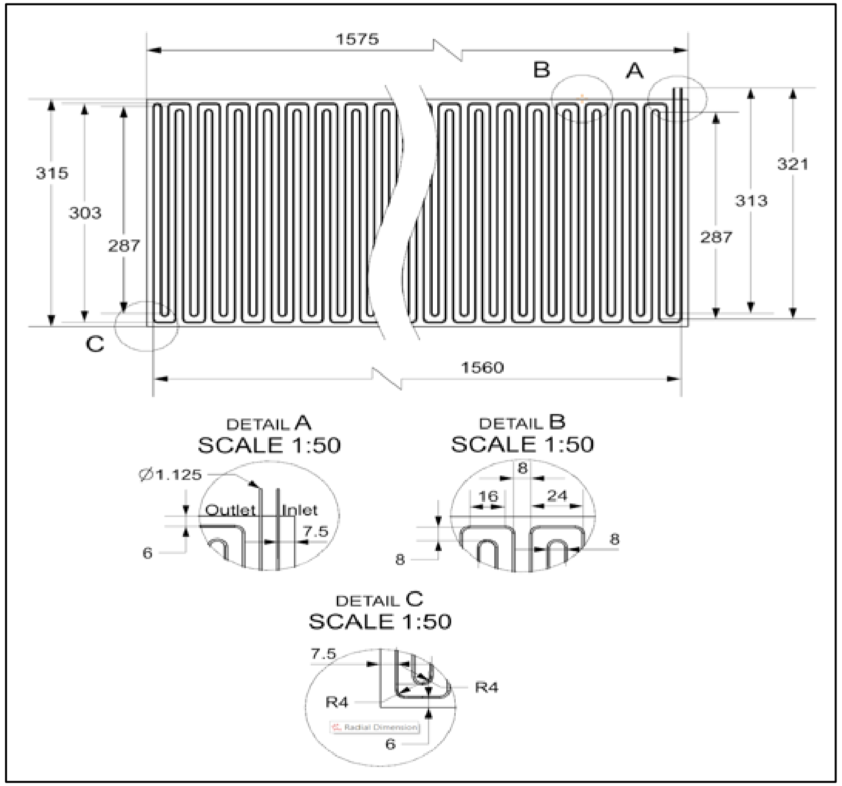

Figure 2: Piping Layout

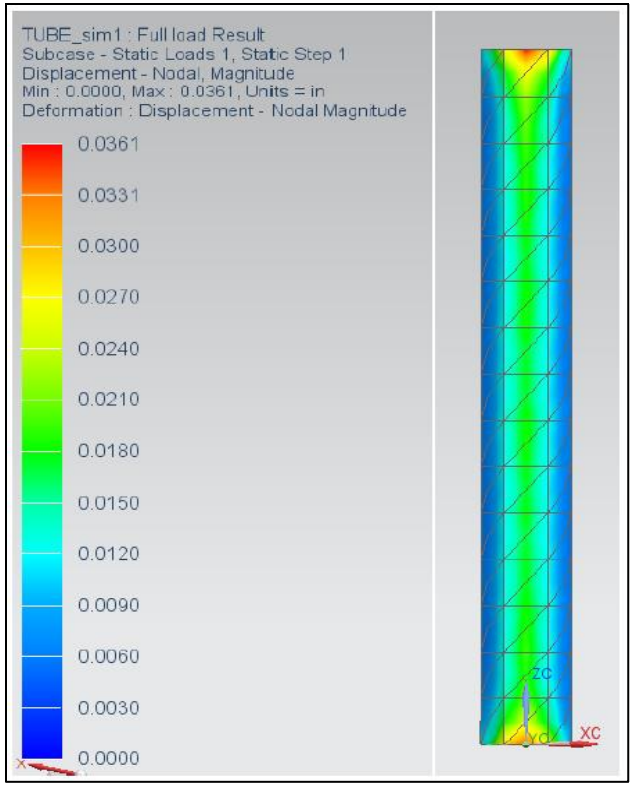

Figure 3: Finite Element Analysis on a Portion of the PEX Tubing

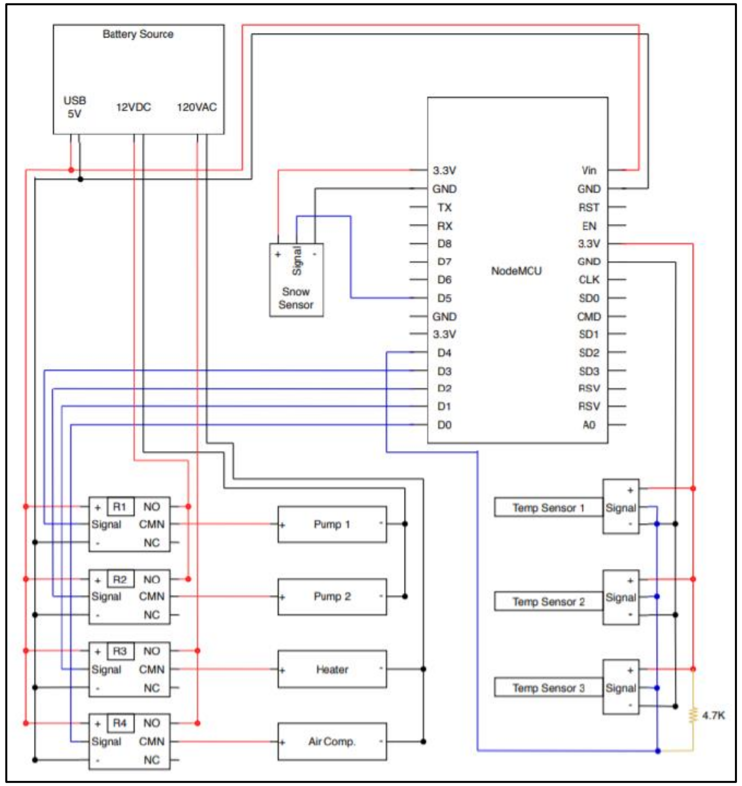

Figure 4: Circuit Diagram of Control System

1. A double reverse piping layout was used instead of a regular serpentine pattern for better heat distribution. The spacing between the pipes was determined based on the manufacture's recommendation of a minimum bending radius.
2. A Finite Element Analysis was done on the piping to ensure it can withstand the weight of the concrete and people walking on top. The tubing faces a maximum deflection of 0.0361in under maximum load.
3. To control the mechanical components, temperature sensors and snow sensors were used to provide feedback to the controller. A phone app was also created to monitor the system or control the system manually.

Lessons Learned: 1. Piping layout using NX 2. Finite Element Analysis

Autonomous Maze Solving Robot

4th Year Course Project

Project Scope

Design and build a robot that can navigate a two-level maze autonomously, maneuver around obstacles, and identify a Lego miner placed in the maze. The robot must navigate the maze wirelessly.

Major Challenges

1. Rapid Prototyping
2. Navigating ramps
3. Picking up obstacles
4. Turning without hitting walls

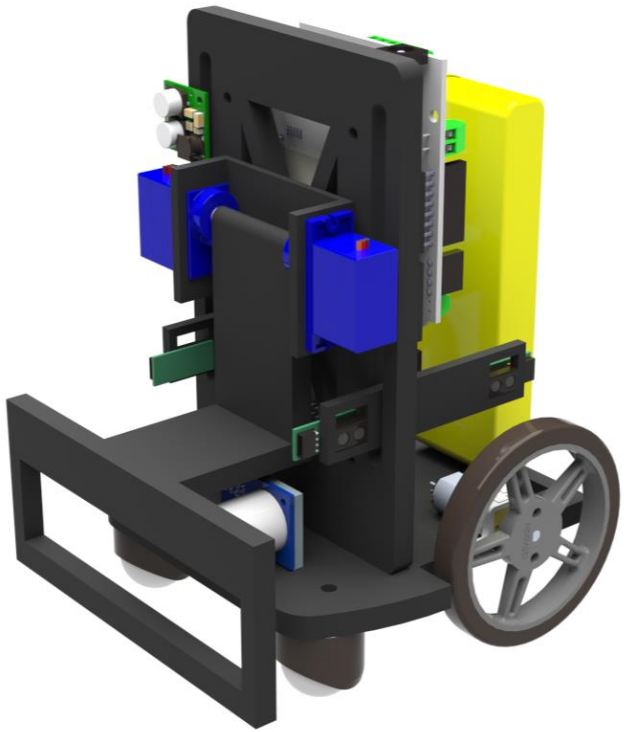

Figure 5: CAD Model of the Autonomous Maze Solving Robot

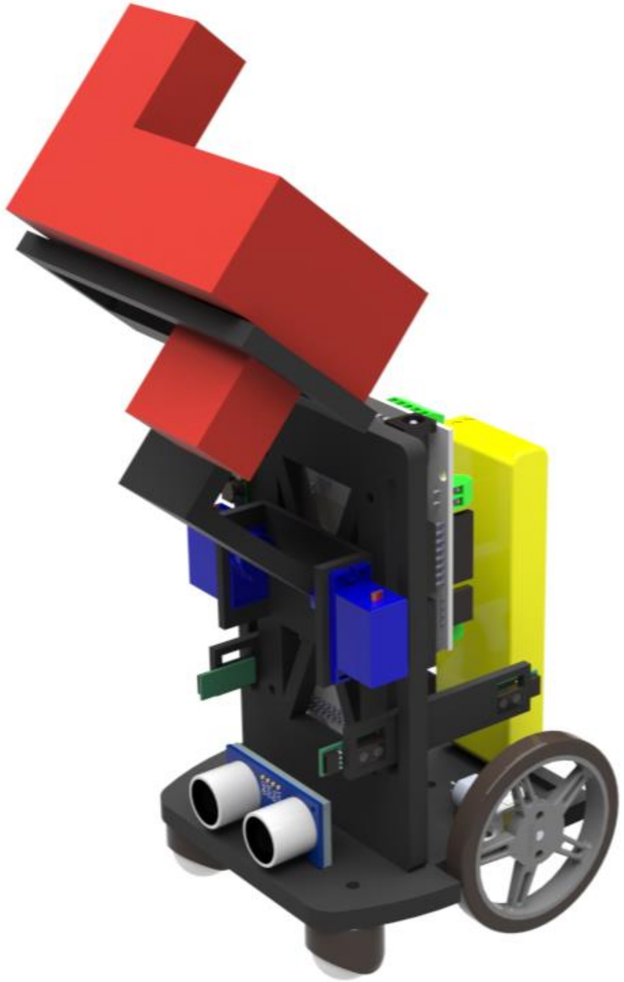

Figure 6: CAD Model of the Autonomous Maze Solving Robot Holding an Object

Programs and Skills: **NX** (CAD, Simulations), **Arduino** (Algorithm Development), **Cura** (3D Printing)

Autonomous Maze Solving Robot

4th Year Course Project

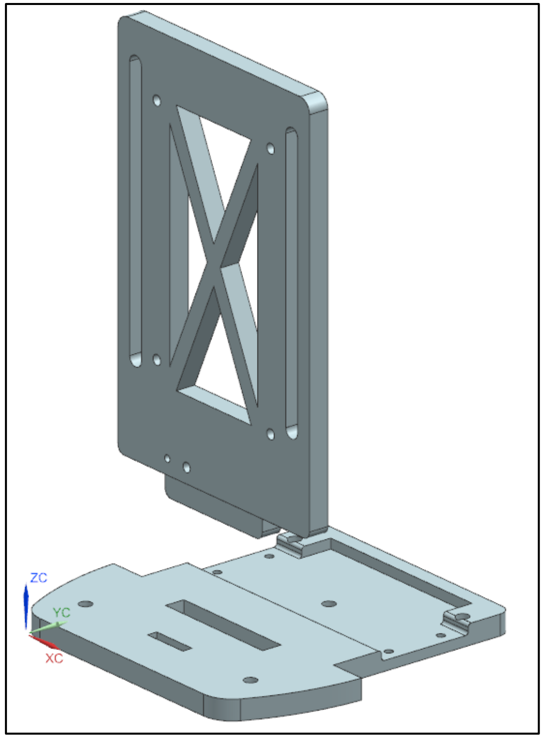

Figure 7: CAD Model of Robot Structure

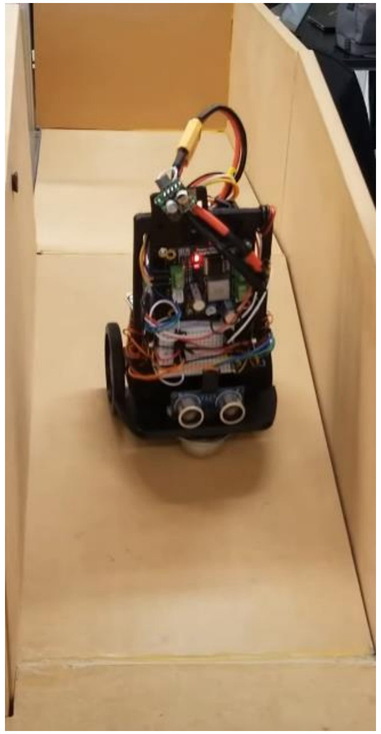

Figure 8: Ramp Analysis

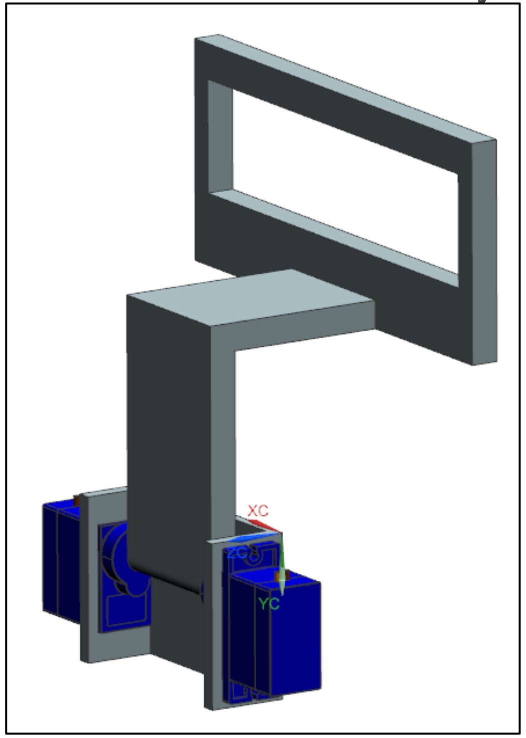

Figure 9: CAD Model of Claw

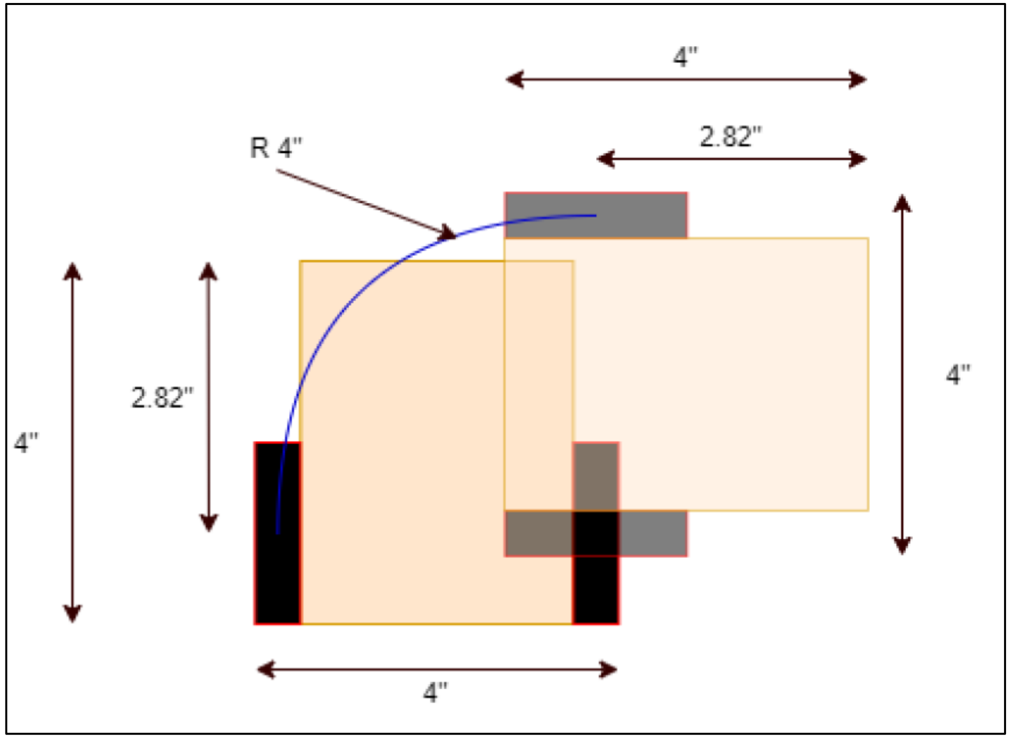

Figure 10: Theoretical Calculations of Turning Radius

1. The main structure is split into two main parts so it can easily be 3D printed. The parts were designed to be press-fit together to make prototyping easier. Either of the two parts could be modified and 3D printed again without impacting the other.
2. Tipping was a major concern for the robot which is why the robot was assembled so it could handle slopes two times steeper than the one in the maze.
3. Since the robot did not have to carry around obstacles, only move around them, a simple passive claw was designed to pick and reposition the obstacles.
4. There were many tight spaces in the maze, so the robot needed to be able to turn easily. Theoretical calculations were done to verify the robot can turn by pivoting on one wheel or turn on the spot by moving both wheels in opposite directions without hitting any of the walls or pillar.

Lessons Learned: 1. Designing for rapid prototyping 2. Calculating tolerances for press fit assemblies

PLC Based Box Manipulator

4th Year Course Project

Project Scope

1. Design a box flipping mechanism that can flip every other box coming in at a steady pace (30 boxes per minute).

2. Develop the ladder logic for a PLC to automate the system.

Major Challenges

1. Designing a box flipping mechanism to flip every other box.

2. Spacing out boxes

3. Mounting the flipping mechanism and stopping mechanism onto an existing conveyor

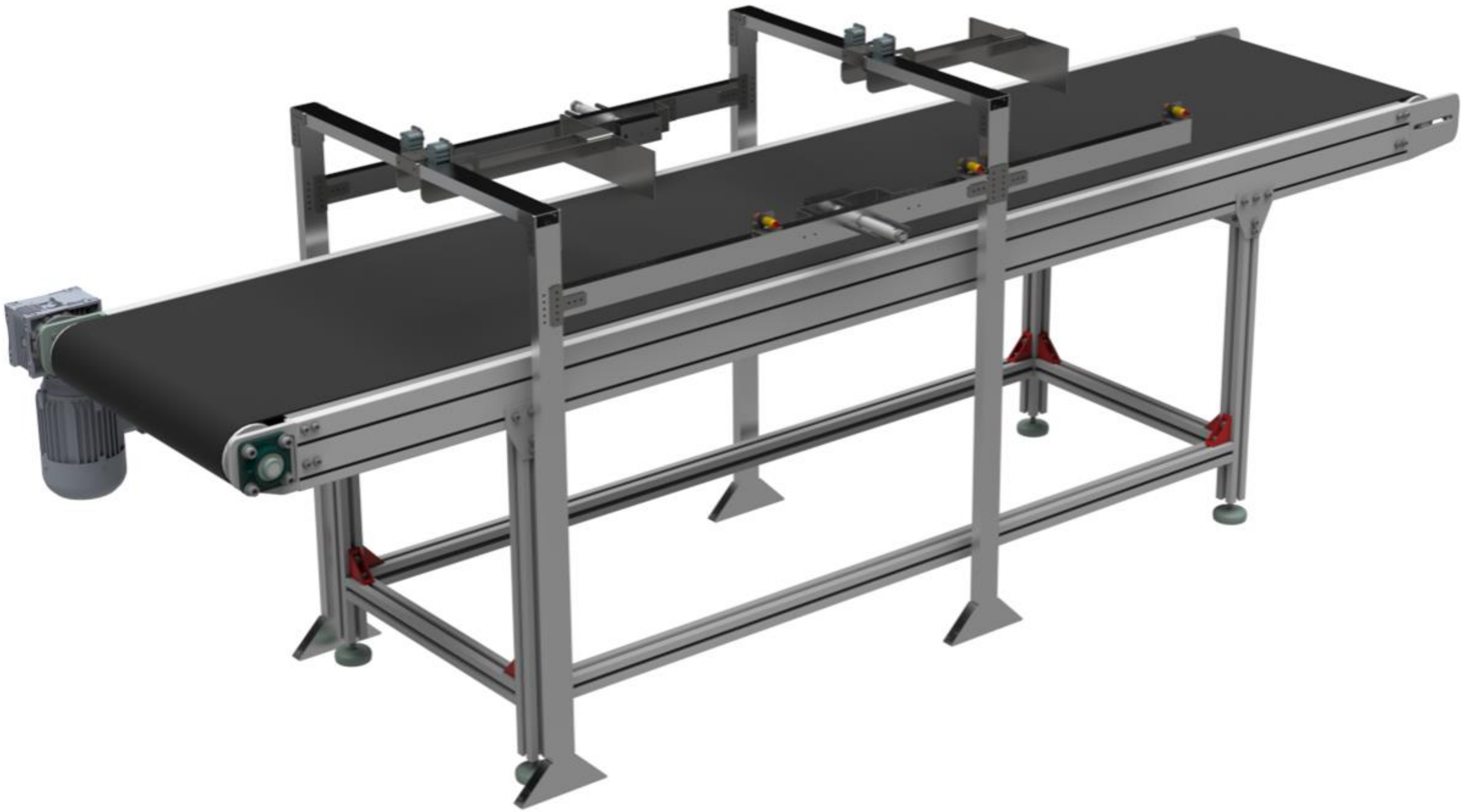

Figure 11: CAD Model of the Box Manipulator

Programs and Skills: **NX** (CAD, Simulations), **FactoryIO** (PLC Automation Simulation)

PLC Based Box Manipulator

4th Year Course Project

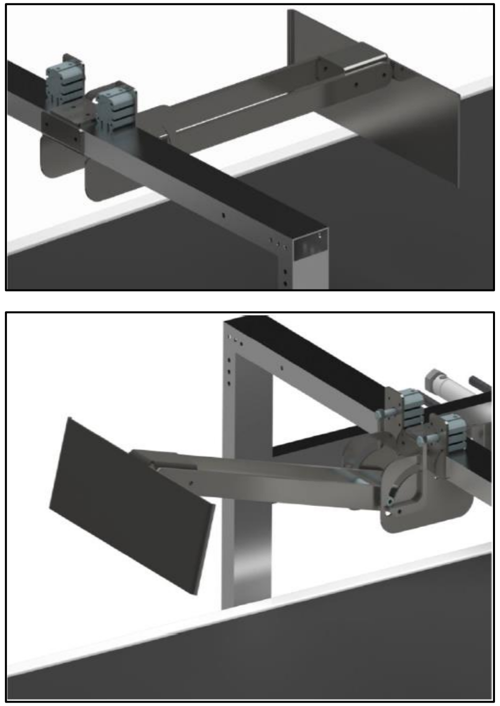

Figure 12: Box Flipping Mechanism

1. This design flipped every box passively and pneumatic actuated locks helped skip every other box.

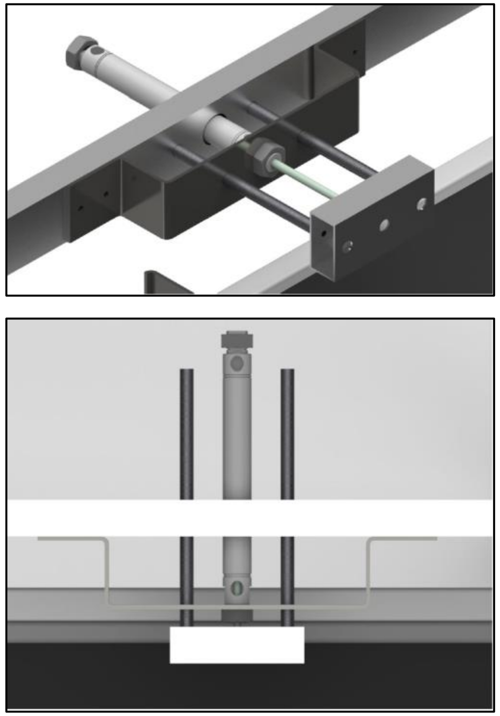

Figure 13: Box Stopping Mechanism

2. To space out the boxes on the conveyor two pneumatic actuators clamped onto the box and held it in place for a predetermined time.

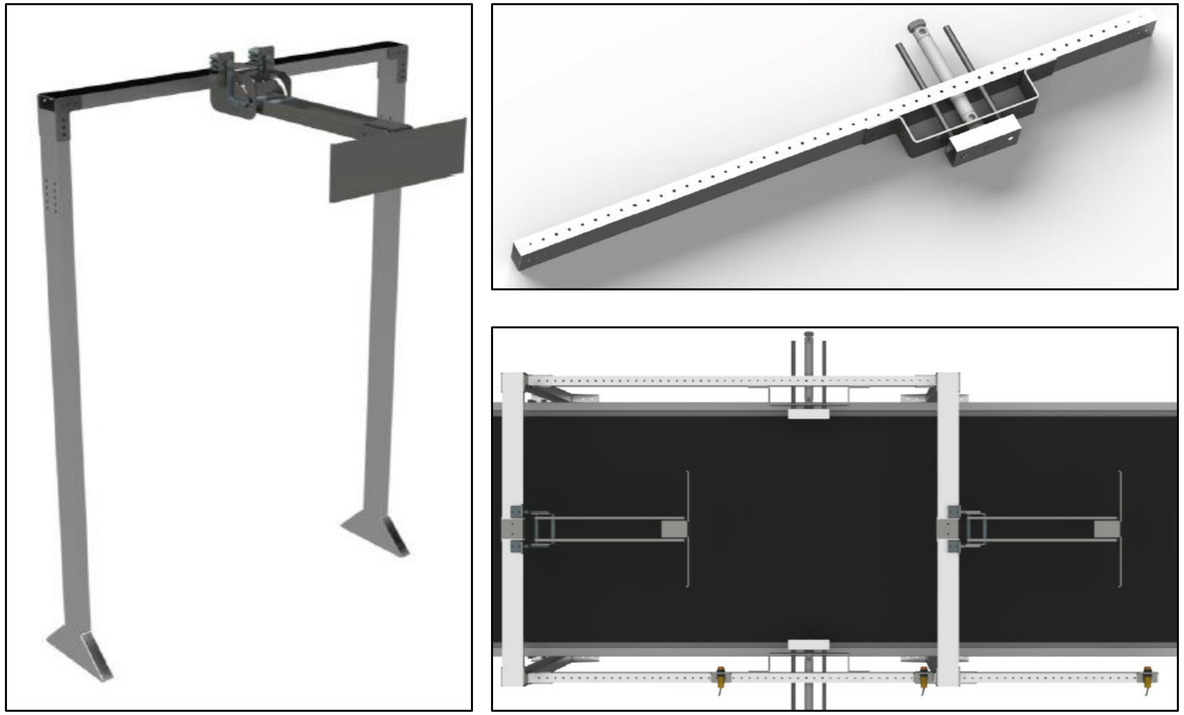

Figure 14: Subassembly of Flipping Mechanism (Left), Subassembly of Stopping Mechanism (Top Right), Full Assembly of Box Manipulator (Bottom Right)

3. Subassemblies were created for individual mechanisms and then put together in the final assembly.

Lessons Learned: 1. Sheet metal design and assembly 2. Rendering

Cupholder with Integrated Wireless Charger

Designation – National Design League

Project Scope

Add wireless charging capabilities to the cupholders located in rear seat armrests.

Major Challenges

1. Adding a wireless charger that can work with existing rear armrests
2. Cable management
3. Locking the lid in the open or closed position

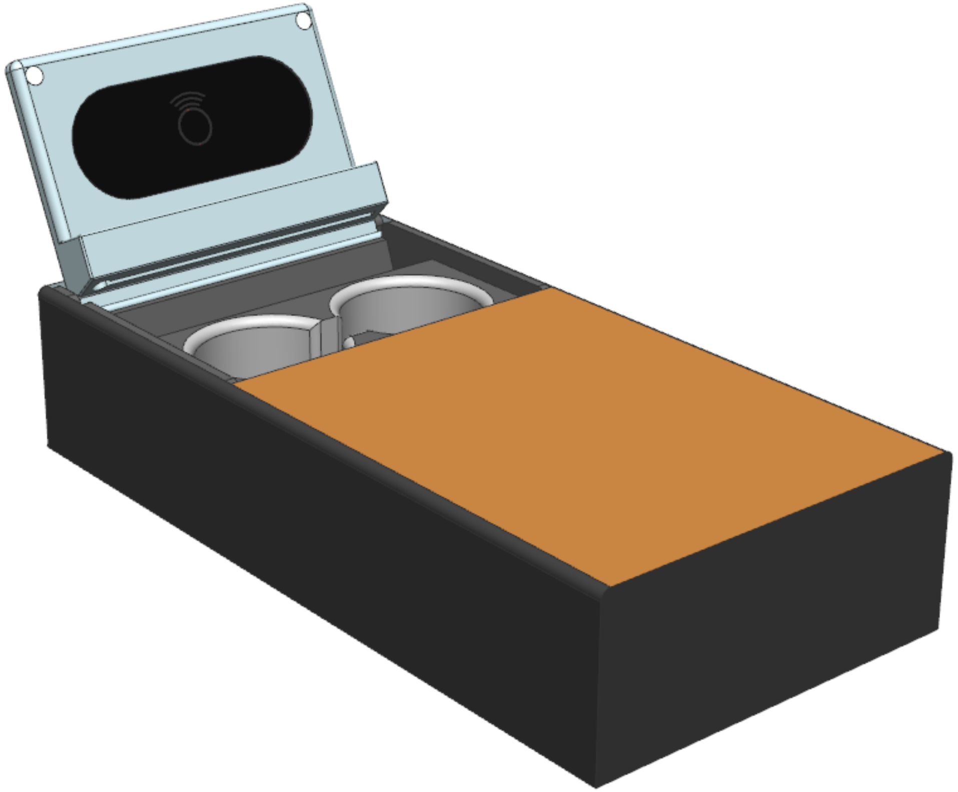

Figure 15: Full Assembly of Wireless Charger Design

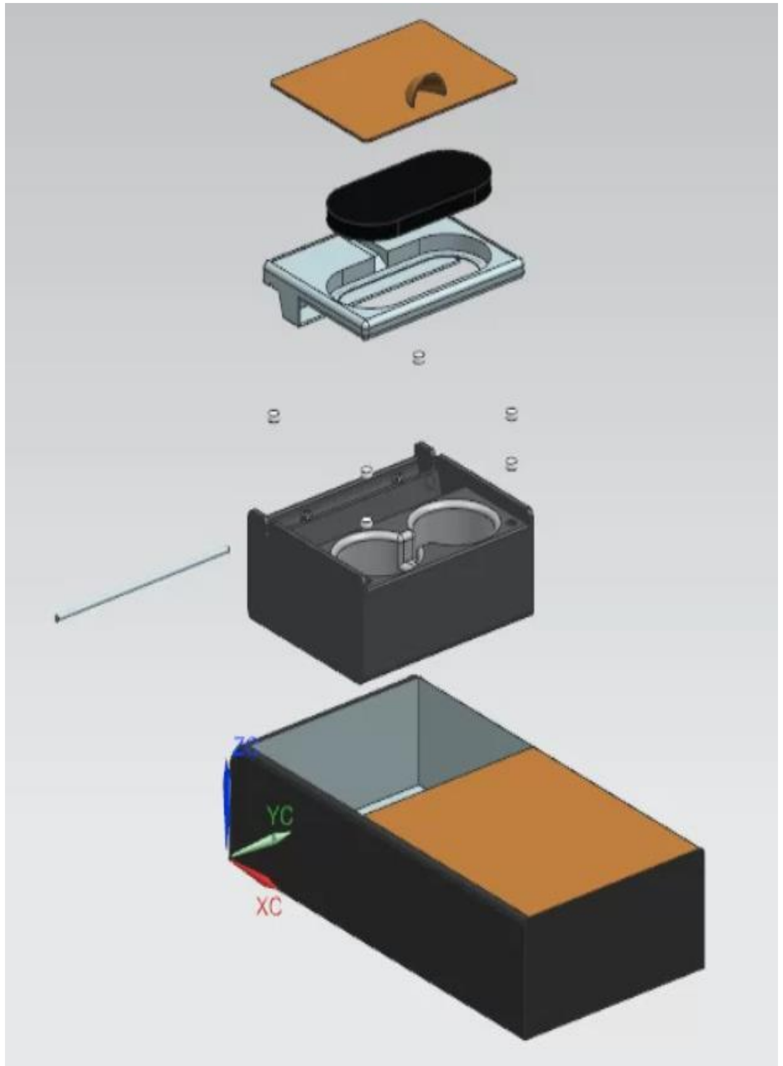

Figure 16: Exploded View of Design

Programs and Skills: **NX** (CAD, Simulations)

Cupholder with Integrated Wireless Charger

Designation – National Design League

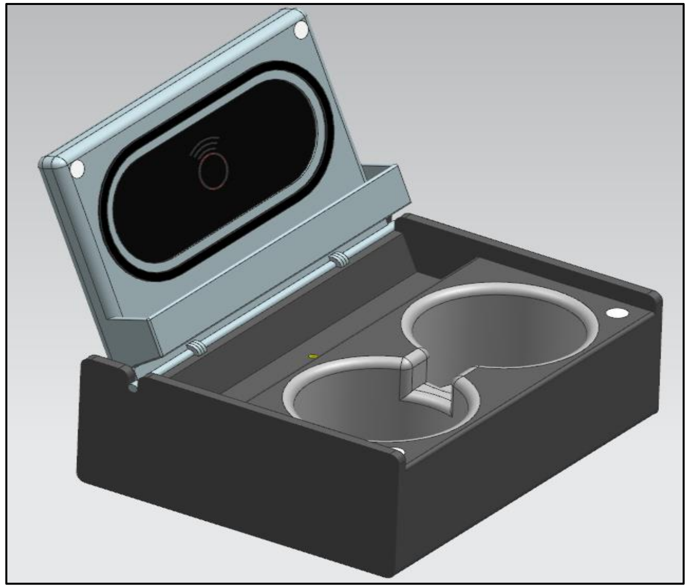

Figure 17: Sub Assembly of Wireless Charger Design

1. The wireless charger was integrated into a lid that covers the cupholders when not in use. This design made it easier to implement into existing armrests and still allowed full use of the cupholders while also using the wireless charger.

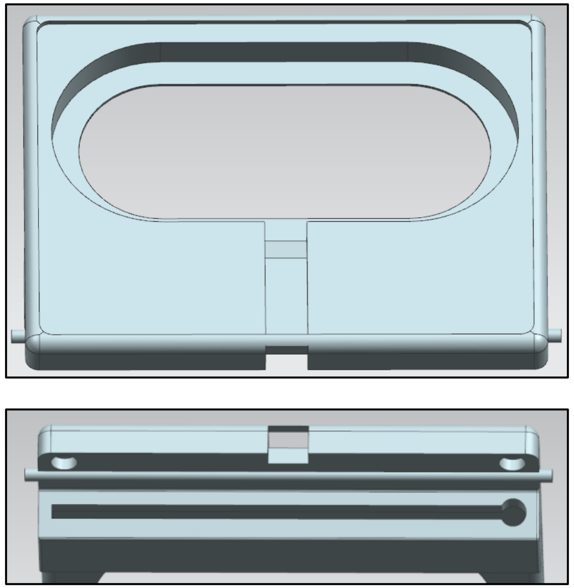

Figure 18: Cable Routing

2. The design accounted for the spaced required to hold the power cable securely and without any pinch points when opening or closing the lid.

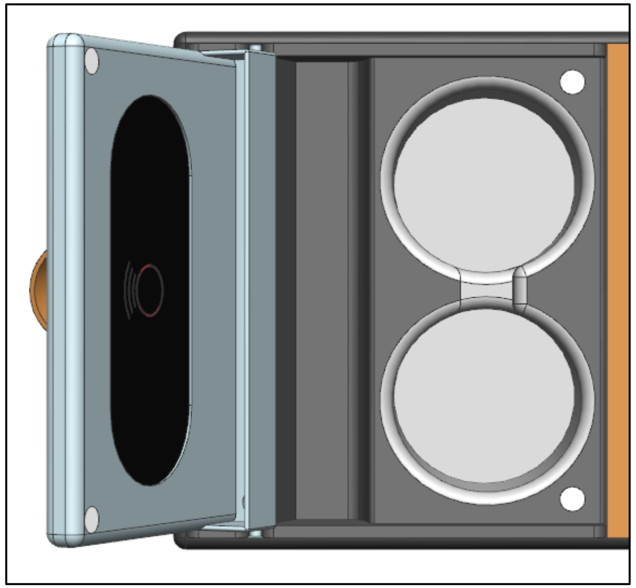

Figure 19: Top View of Charger Design

3. It was important for the lid to remain in either the open or closed position, which is why magnets (shown in white in figure 19) were used to securely hold the lid in either of the two positions.

This design was chosen as the best design in the competition by 3 judges and earned an average score of 26.6/30.

Lessons Learned: 1. Integrating electronics into mechanical designs 2. Defining project requirements for open ended projects

PCA Pump

Work (3D Printer Design Assistant)

Project Scope

Design a 3D model of a PCA pump that can be 3D printed and used in labs for Durham College's Nursing program. The pump should have the same physical features as the real pump and let the instructor showcase different messages where the screen would be.

Major Challenges

1. Designing for minimal cleaning once printed
2. Adding a slot to show different messages on screen
3. Designing a clamp to hold the pump on an IV pole

Figure 20: Real PCA Pump

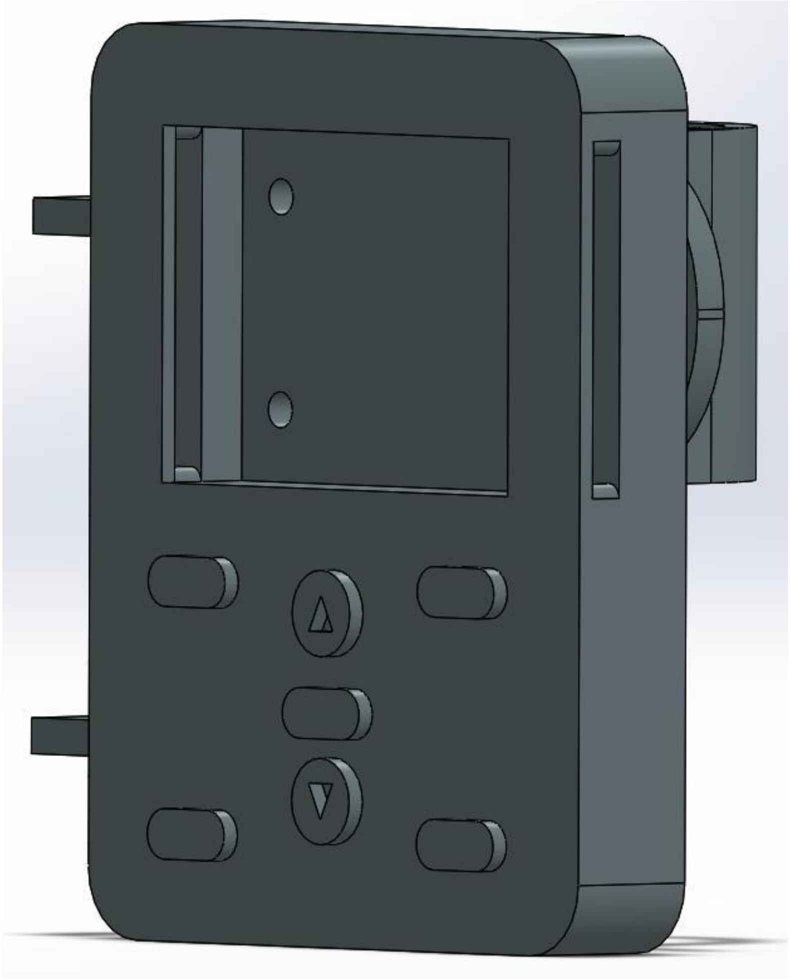

Figure 21: CAD of Model PCA Pump

Programs and Skills: **NX** (CAD), **Cura** (3D Printing)

PCA Pump

Work (3D Printer Design Assistant)

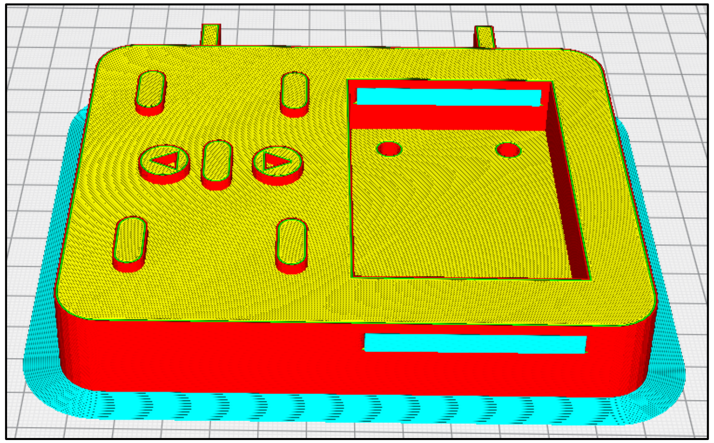

Figure 22: 3D Printing Layer view

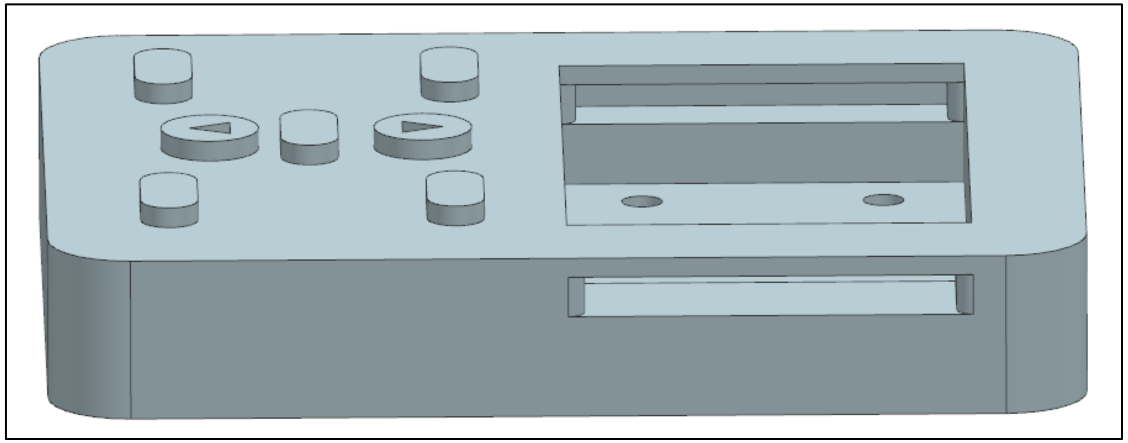

Figure 23: Opening Slot for Manual Screen Inserts

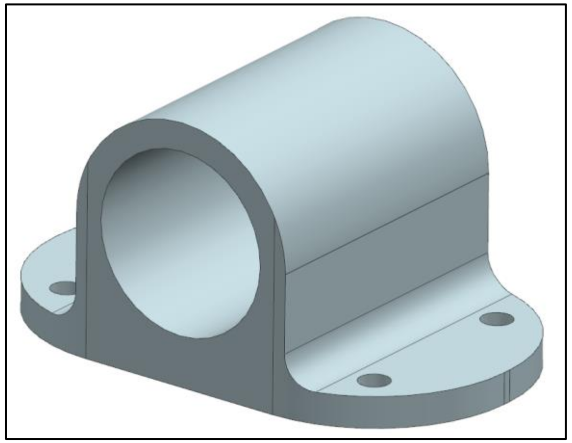

Figure 24: Mounting Bracket

1. The PCA pump was designed so there was minimal cleaning required after printing. There were only a few spots were supports (shown in light blue in figure 22) were needed which could easily be removed and did not impact the overall aesthetics.
2. The customer wanted an opening on the model to display different messages where the screen would be. I created a slot on the side of the model with curved edges to make it easier to slide in different messages quickly.
3. I also designed a custom mount which would allow the customer to mount the 3D printed PCA pump onto IV poles in the lab. The mount attached to the PCA pump using off the shelf fasteners.

The model I designed was used my Durham College's Nursing program to provide students with more hands-on learning without spending thousands of dollars on real PCA pumps which were not being utilized for anything other than display purposes.

Lessons Learned: 1. 3D printing 2. Understanding customer requirements

FIRST Robotics

Extracurricular

Project Scope

Design, prototype, manufacture, assemble, and program a robot within six weeks to compete in the annual FIRST Robotics Competition.

Major Challenges

1. Designing Drive Systems
2. Designing object manipulators
3. Prototyping
4. Design for Manufacturing (DFM) and Design for Assembly (DFA)

Figure 25: 2018 Final Robot

Figure 26: 2016 Final Robot

Figure 27: 2017 Final Robot

Programs and Skills: **SolidWorks** (CAD, CAM), **Cura** (3D Printing)

FIRST Robotics

Extracurricular

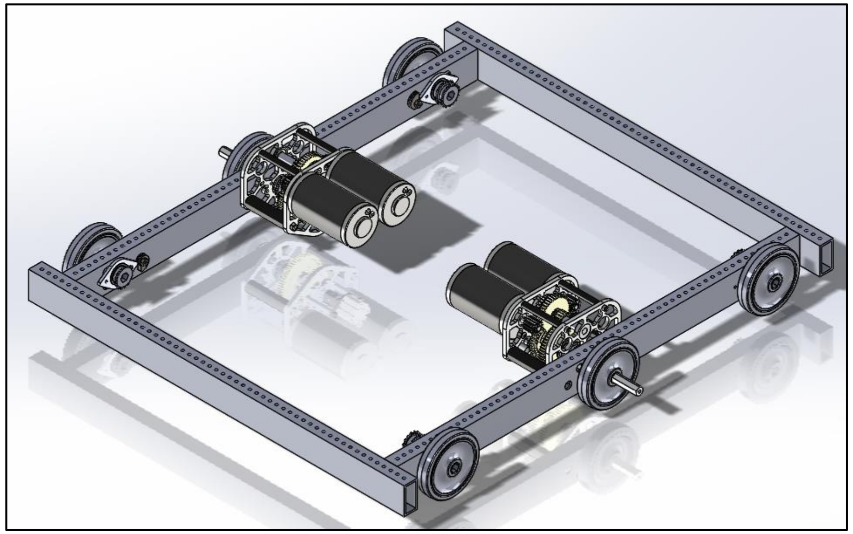

Figure 30: 2018 Base Assembly

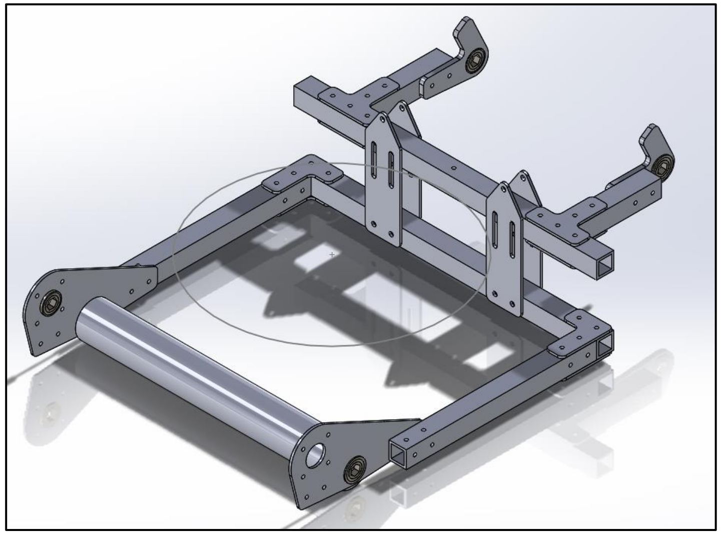

Figure 28: 2019 Object Manipulator Assembly

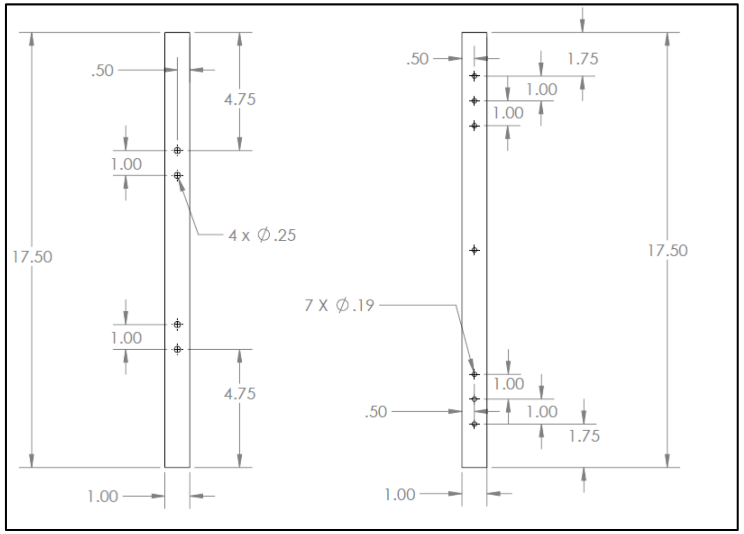

Figure 29: Object Manipulator Part Draft

1. Designed various drive systems to compete in annual FIRST robotics competitions. Each year the challenge was different so the drive system would need to change each year. The drive systems were designed to be easily manufactured, assembled, and maintained.
2. Like the drive system, each year different object manipulators would need to be designed. I sketched concepts and created CAD models of possible prototypes while focusing on design for manufacturing, design for assembly, and repairability. I also considered possible sensor placements within the design for future automation.

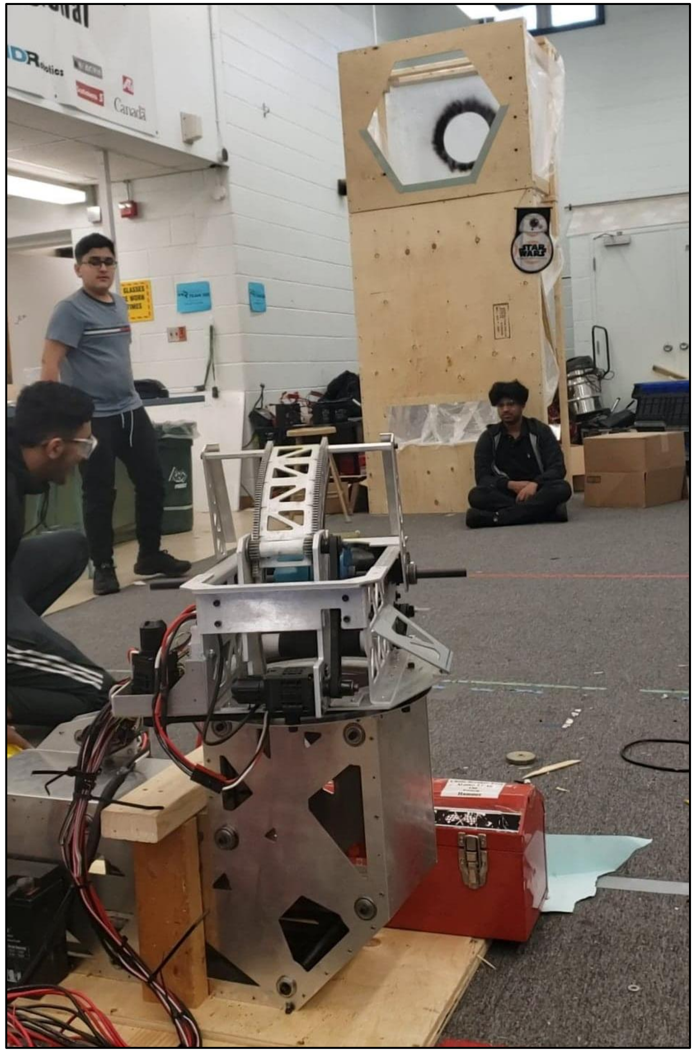

Figure 31: 2020 Shooter Prototype

Figure 32: 2020 Intake Prototype

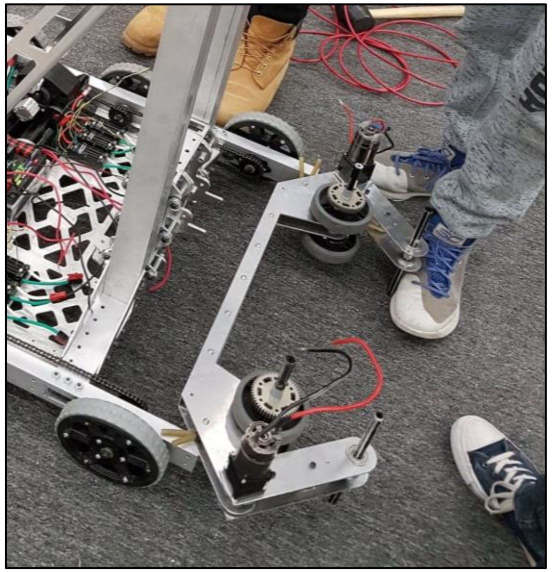

Figure 33: 2018 Intake Prototype

3. Prototypes were created using wood and metal to evaluate designs. The wooden parts and some box tubing parts were manufactured in-house while other box tubing and sheet metal parts were sent out to be laser cut. Tests were designed to check the accuracy, versatility, and reliability of the prototypes.

4. Manufacturing capabilities were taken into consideration early in the design stage. Therefore, all parts were designed so they could easily be manufactured with a 3-axis CNC machine or laser cut and bent as required. Additionally, appropriate tolerances made it easier to assemble parts and clearance holes in the parts made it easier to assemble and maintain the system throughout the season.

Lessons Learned: 1. Design for Manufacturing/Assembly 2. Prototyping (wood and metal) 3. Manufacturing (CNC Machining)

Other CAD Projects

Course and Lab Projects

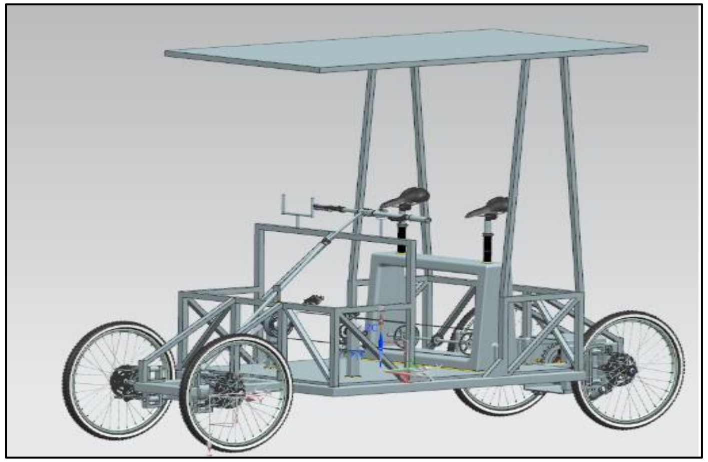

Figure 34: Quadracycle Design (3rd Year)

The Quadracycles was designed as part of a 3rd year class design competition. The quadracycle was designed by reusing parts from a regular bicycle.

This design was chosen as the best design by the class and earned extra credit from the professor for its complexity.

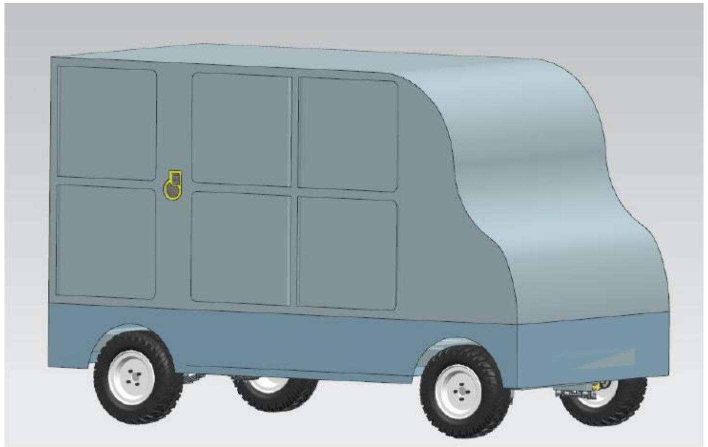

Figure 35: Autonomous Delivery Vehicle Design (3rd Year)

The autonomous delivery vehicle was designed for a 3rd year design project. The main goal of the project was to produce a concept vehicle and conduct a Finite Element Analysis on the structure of the vehicle.

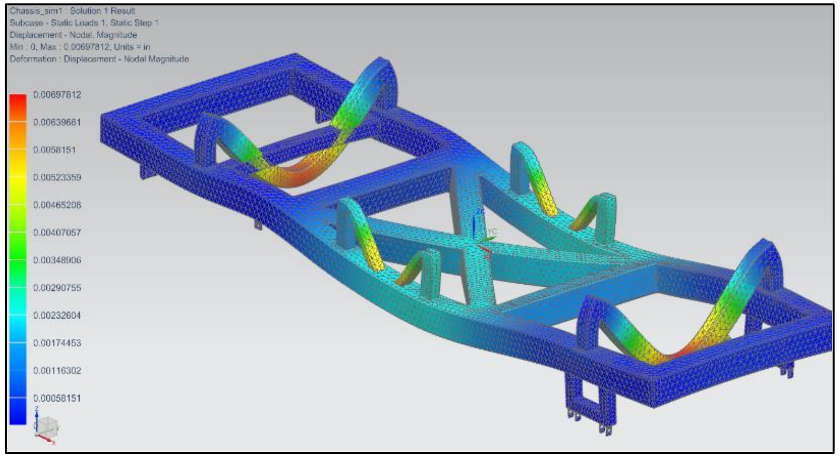

Figure 36: Finite Element Analysis on Vehicle Frame

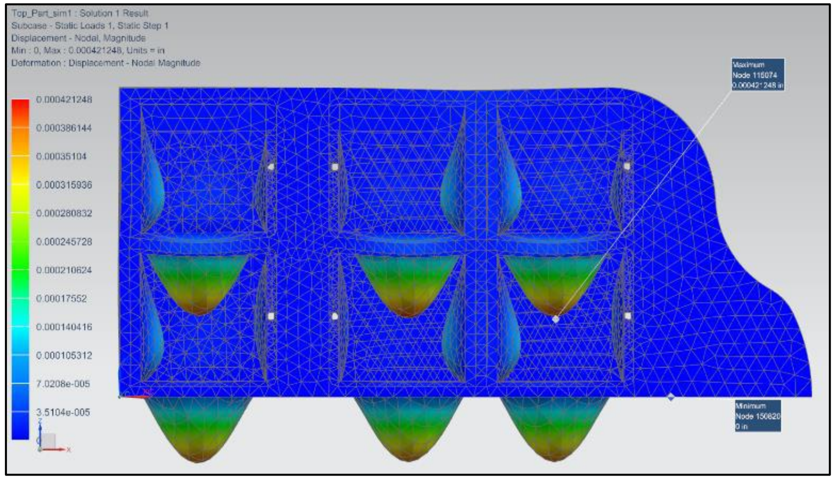

Figure 37: Finite Element Analysis on Vehicle Body

Other CAD Projects

Course and Lab Projects

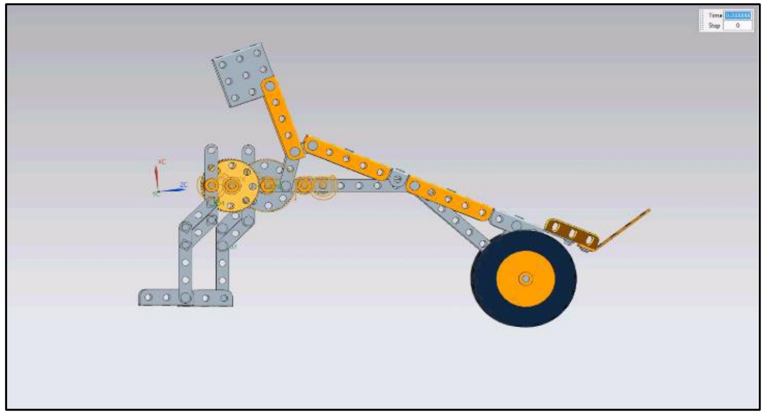

Figure 38: Rickshaw Design (2^{nd} Year)

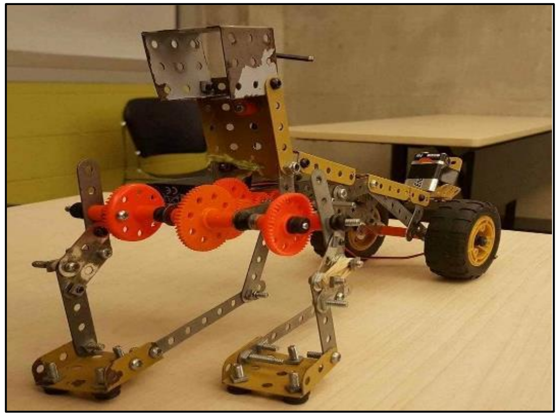

Figure 39: Rickshaw Prototype (2^{nd} Year)

The rickshaw was created for a 2^{nd} year design project. The main goal of this project was to design a rickshaw and create a motion simulation to show the movement of the gears and how they would move the legs.

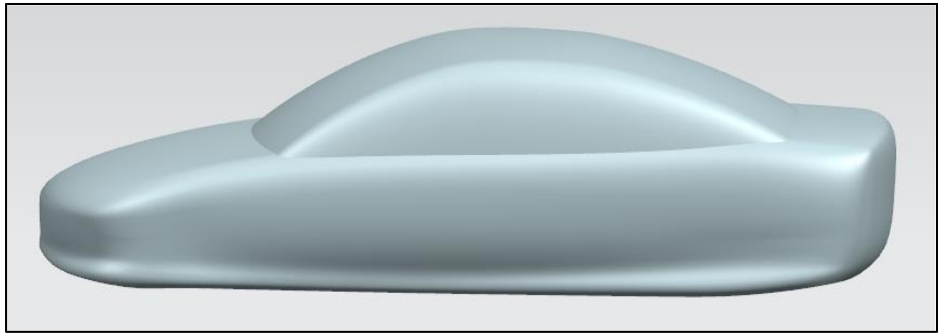

Figure 40: Car Body (3^{rd} Year Lab Assignment)

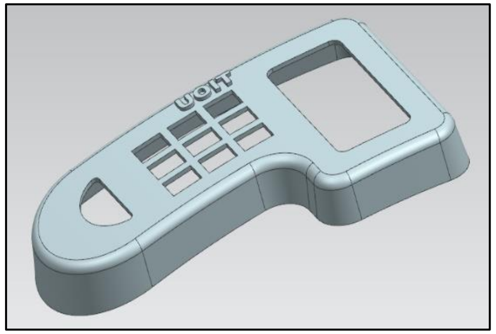

Figure 41: Enclosure (3^{rd} Year Lab Assignment)

Through my undergrad courses, I have gained the required skills for advanced part modeling, creating complex assemblies, making drafts, and creating a bill of materials.

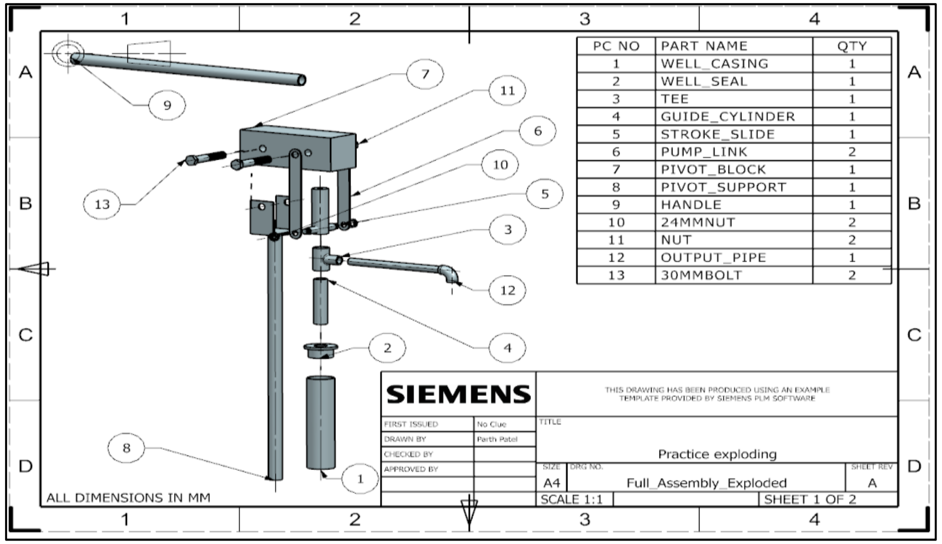

Figure 42: Hand Pump Exploded View (2^{nd} Year Lab Assignment)

Thank You