ENGINEERING

McMaster University

Project Four – Power in Community:

ENGINEER 1P13 – Integrated Cornerstone Design Projects

Tutorial 7

Thurs 05

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Submitted: April 15, 2021

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Academic Integrity Statement

The student is responsible for performing the required work in an honest manner, without plagiarism and cheating. Submitting this work with my name and student number is a statement and understanding that this work is my own and adheres to the Academic Integrity Policy of McMaster University.

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Recoverable Signature

X Dariusz Wolosz

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Yuvraj Sandhu 400319134

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Executive Summary:

For project 4, a device was required to be designed and created to make Alanna's, our client, daily life better. Alanna is impaired by lymphedema (causes swelling), fibromyalgia, and spondylitis arthritis. These autoimmune conditions make certain motor functions difficult and painful while also affecting her cognitive performance negatively. This can make certain daily tasks not so easy to do. During the client interview, Alanna mentioned that she was having difficulty cleaning after her kid's toys since it required her to constantly bend down and pick up small objects off the ground. To solve this problem and allow Alanna to focus on other aspects of her day, like her hobbies, rather than worrying about cleaning, the automated toy-picking vacuum was designed known as Auxilium.

Photo of prototype:

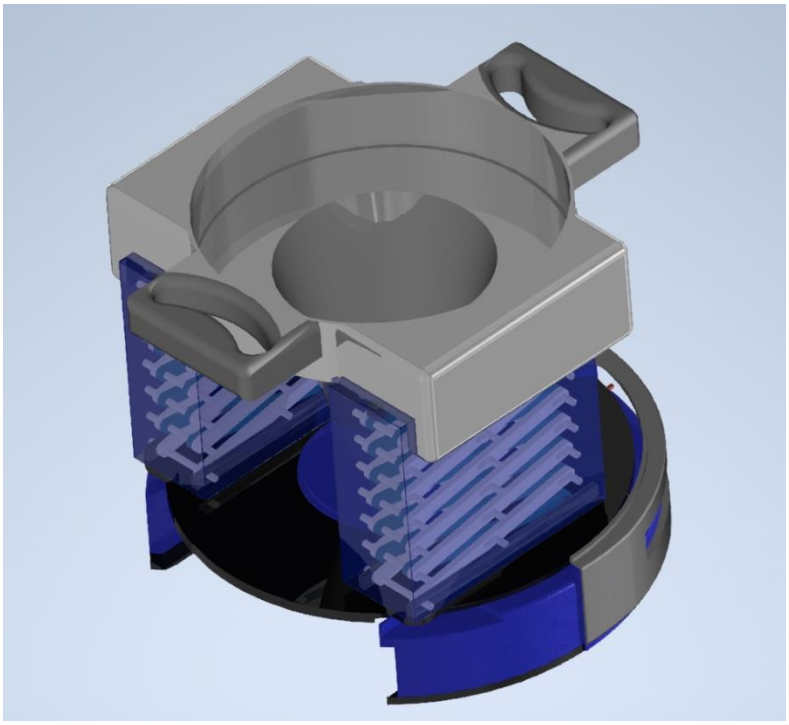


Figure 1: Auxilium Final Prototype

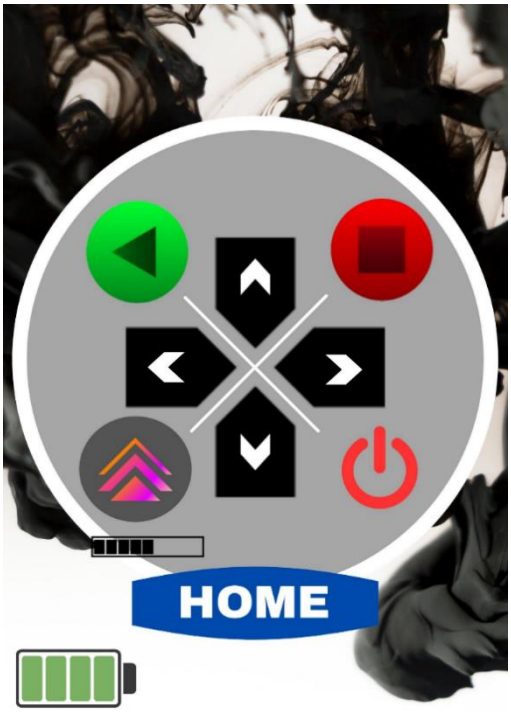


Figure 2: Concept App Interface

Description*:*

Auxilium is a semi-automated vacuum controlled through a phone/tablet app (whose interface can be adapted into a physical remote if needed). Auxilium has an advanced vacuum system that will suck in smaller toys into an attachable basket. The basket then will be lifted with a scissor lift system for the clients to easily access the contents of the basket without having to bend down. Auxilium has 4 different proximity sensors which will help prevent the device from ingesting items bigger than what it is capable of and will allow Auxilium to move autonomously. *Fun Fact, Auxilium was taken from the Latin word for "helper".*

The UI for Auxilium is specifically designed for the device by making use of the entirety of its functionality. Mobility, lift operation, home navigation, and basic controls for powering the device are all incorporated in an aesthetically pleasing display. The UI also includes a bar to display the incline of the scissor lift and a battery bar in the bottom left for the client's knowledge. All these features are simple enough to pick up and use while allowing Auxilium to have a versatile toolkit in effectively picking up toys. *The coding flowchart that was used to develop this UI can be found in Section 2.*

Benefits*:*

The scissor lift system implemented into the device is what makes Auxilium unique. There are numerous autonomous vacuums that clean items from the ground, but most of them do not accommodate for disabilities. Alternatives such as grabber tools are usually made for bigger objects and require a certain amount of motor capability to use. Auxilium on the other hand is a fully automated device that requires no physical strength to operate, while also allows her to avoid any cuts or bruises from manually cleaning up toys while being very safe. All edges on the device are rounded and all contact surfaces are made up of medically inert and sanitary material, allowing Alanna to use the device without any worries.

Next Steps*:*

Given more time and resources, the device could have been improved through upgrading the app interface. Possibilities include modifying the app interface specifically for Alanna, making it easier for her to control Auxilium the way she wants to. Also, optimal results could have been observed with building a physical model and testing the vacuum system to further investigate how well a vacuum design would work to collect toys. The production cost, considering the materials and electronics, for Auxilium is currently around $299-$359. Given more time and money; the group would also try to further decrease the production cost of the device to make it more accessible and refine the design based on feedback received from physical testing.

Introduction:

Client Background

The objective of Project 4 can be derived from the client, Alanna. Alanna is a Breast Cancer survivor and has been in a car accident that had severely impaired her health. As a result of undergoing rigorous amounts of chemotherapy and incidents of abnormal physical stress, Alanna has developed multiple illnesses and chronic impairments. She has developed Fibromyalgia, caused by emotional or physical stress. Fibromyalgia is a chronic rheumatic condition that causes musculoskeletal pain throughout the body, memory issues, mood swings, and problems when sleeping. Common triggers of fibromyalgia include stress, injury, or illness which makes flares somewhat unpredictable. The client has developed lymphedema because of cancer treatment. Lymphedema is a chronic condition that arises when the lymph nodes are damaged during certain cancer treatments, specifically breast cancer treatment in Alanna's case. It activates swelling from lymph fluid building up in the tissue and causes an increased chance of infection when she receives a cut. Therefore, it is critical that she prevents injury to her skin because of the sensitivity lymphedema causes. Alanna is also diagnosed with spondylitis arthritis, an autoimmune disease that causes overgrowth of bone on the spine creating back pain and restricting spinal movement. Consequently, Alanna has mobility issues and can develop brittle bones in the spinal region. With the combination of these prior conditions and Alanna's health she has other problematic symptoms such as difficulty with stamina, difficulty bending, poor posture, unpredictable body patterns, sleeping irregularities, and other common muscle implications. The nature of these conditions is random and triggered for the Client which limits her ability to complete simple tasks and her lifestyle.

Implementing a device that gives Alanna more time to spend on her hobbies will be beneficial to her physical and mental wellbeing.

All client meeting notes can be found in the appendix, Section 1.

Refined problem statement

Design a safe, durable, and easy-to-use device to help Alanna pick up small objects off the floor without requiring her to bend down. Her children often leave objects on the ground and picking them up is difficult for her due to limited motor function resulting from 3 autoimmune conditions.

Design objectives and constraints

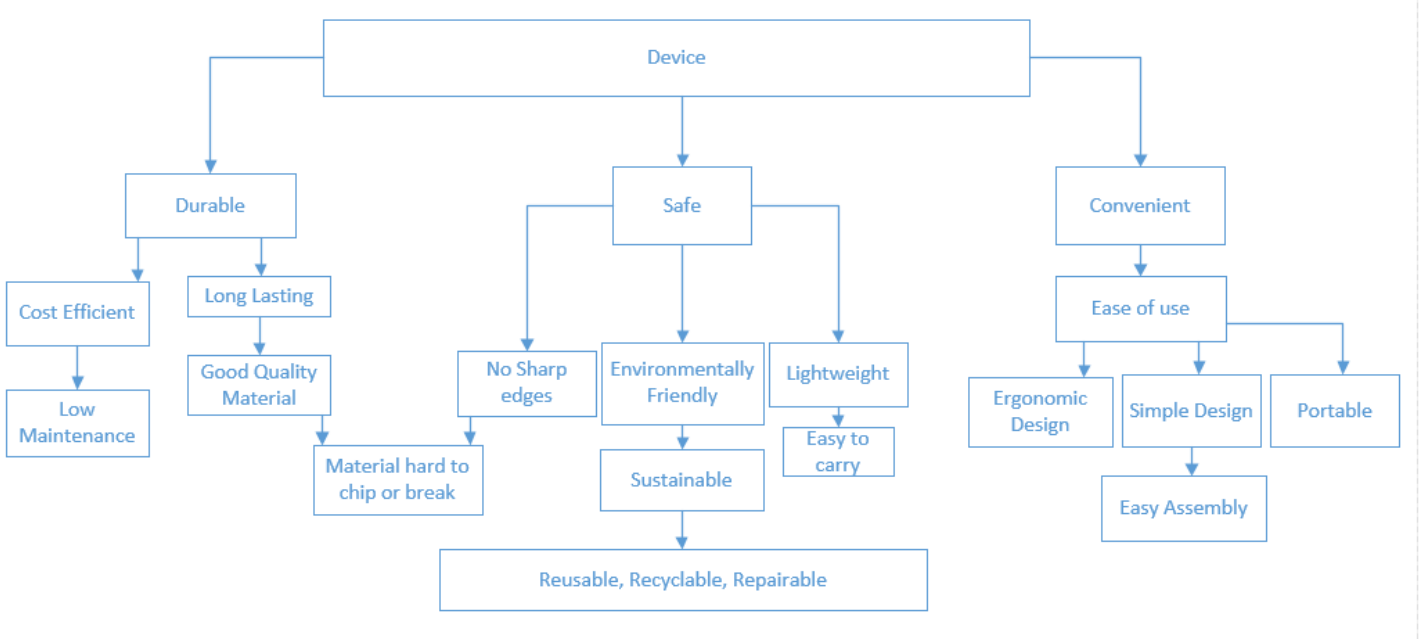


Figure 3: Objective Tree

The three main objectives were making the device safe, durable, and convenient. Constraints are focused on the ability of Alanna to use the device. Therefore, eliminating any sharp edges (0 sharp edges) present in the design, minimizing the weight of any components that would require to be picked up to less than 5 lbs and minimizing production cost (cheaper than 500 dollars) were the constraints we had for our design.

Safety was a major concern, as the client has severe reactions to infections, cuts, and physical injuries. Due to these issues, the device should reduce injury risk by not provoking any health conditions. As a result, the design itself must keep to certain constraints such as being easy to carry and structurally stable. Also, the client must handle and use the device without any pain caused by lymphedema, fibromyalgia, and back pain. The safety of the client is one of the most important objectives as the client's health is sensitive and needs to be approached in a safe manner. The device also cannot chip or flake off because of the possible health risks that could arise because of how it could be absorbed into the skin and cause other problems.

A durable design was also an important objective since Alanna, during one of the client meetings, mentioned that her kids play and break most of the stuff at home. Thus, having strong and durable materials in our design was a key objective.

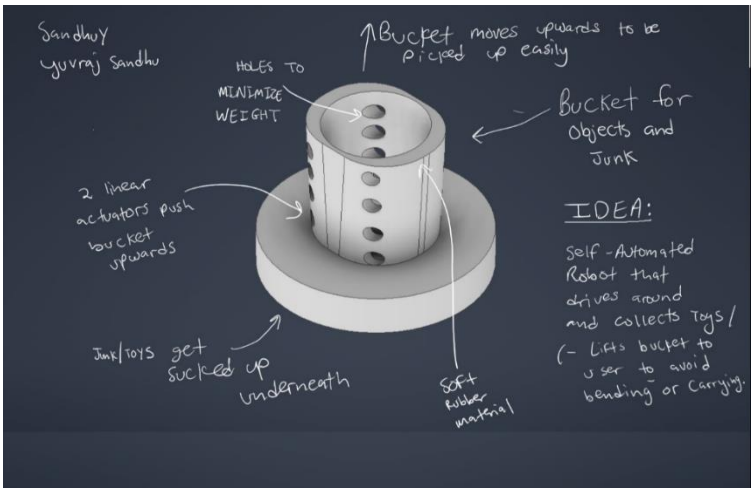
Existing Ideas / Solutions

Figure 4: Grabber Tool. Tools such as this are often used by people with disabilities to extend their reach.

There are a couple of existing ideas and solutions in the market today. Certain devices, such as grabber tools, can help Alanna pick up objects off the ground by extending her reach, preventing her from needing to bend down and pick items up [1]. These are handheld mechanical tools, designed to a varying length, many of which are customizable depending on the task needed [2]. For people with fibromyalgia, a grabber tool such as this is recommended to alleviate the mobility issues accompanied by the condition [3]. However, these tools are usually made for larger objects and not normally equipped to pick up smaller objects. Materials used vary, but generally grabbers are made of a body consisting of aluminum or steel alloys, with rubberized grippers. The materials are designed to minimize weight while maximizing strength and durability. As a safety feature, many grabbers have retention clips or buttons that hold the grippers in place, so that as little force as possible is needed to use them [4]. While these solutions are great for what they are designed to do, they do not account for any disabilities that affect the motor capabilities of the user. For example, if Alanna has a flare of one of her autoimmune conditions, there is the potentiality that she could injure herself by dropping a grabber tool on herself. With her lymphedema- a condition that causes increased swelling and infections from wounds- a grabber tool is not the optimal tool to use due to the increased risk of injury.

Conceptual Design:

Initial Sketches and Design Alternatives



Two possible design solutions and sketches were thought of by all team members. Auxilium was already recognizable but lacked functionality and safety features. Like all other concepts, Auxilium was designed to pick up objects off the ground but was the only solution that could be partially or fully automated. *All other initial sketches can be found in the Appendix, Section 2.*

Figure 5: Initial Auxilium Sketch

Morph Chart- Functional Analysis

To refine initial design concepts into something more specific for the client's needs, a morph chart was used to find potential alternative design solutions for the device through functional analysis. As a method of functional analysis, morph charts are a great way to determine sub-functions of the main function, while conceptualizing and brainstorming potential means as design solutions. In other words, they can help the team generate a complete range of alternative design solutions for a product through functional analysis.

Device Functions	Mean 1	Mean 2	Mean 3	Mean 4
Pick up objects off the ground	Magnets (metal)	Claws/jaws	Tray/Basket	Suction Cup
Avoid Injury to the User	All edges rounded	Soft touch materials	Plastic Resin (doesn't shatter)	Anti-bacterial material (copper synthetics)
Increase user's reach	Stick/Pole	Drones	Lever/spring system	Catapult
Allow for convenient and accessible storage	Hangar/Hook	Feet (so it stands up straight on its own)	Clips	Velcro

Table 1: Morph Chart

Refined Design Alternatives & Decision Matrix

Using the morph chart, four refined concepts were created using Autodesk Inventor. All these designs are unique and try to solve the problem statement using a variety of methods. Auxilium had been created in a CAD environment for the first time. *All other designs- the Pick-Up Stick, Grabber Trolley and Bowl stick can be found in the Appendix, Section 2.*

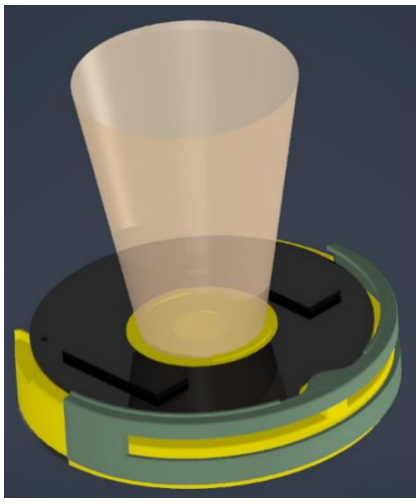


Figure 6: Auxilium Initial CAD model

To decide on one of the refined concepts, a decision matrix was used. Feasibility was the most important aspect of the design, as it would determine how "realistic" and practical the device could be in real life. Auxilium and the Pick-Up Stick were both designs that had good potential, with many similar solutions already used in the market today. Simplicity and weight are also important criteria, with simplicity being how easy the device would be for the client to use, and weight being minimized so that the client will not become fatigued using it. The Pick-Up stick has the advantage of simplicity, as it has fewer moving parts, but the Auxilium has the advantage of weight, as it has a detachable pod that will weigh very little. Lastly with ease of modelling and repairability, it was determined that since the pick-up stick had fewer moving parts and less mechanization, it would be both easier to create a model of and fix. As a result, the Pick Up Stick and Auxilium were the top 2 designs and chosen for the first design review with the Science Students.

		Pick up Stick		*Auxilium*		*Grabber Trolley*		*Bowl Stick*	
Criteria	Weight	Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating
Feasibility	5	4	20	5	25	3	15	3	15
Simplicity	4	4	16	3	12	2	8	1	4
Weight	3	3	9	4	12	1	3	2	6
Ease of modeling	2	3	6	1	2	2	4	3	6
Repairability	1	3	3	1	1	2	2	3	3
TOTAL			**54**		**52**		**32**		**34**

Table 2: Decision Matrix

Design Review 1

After the first design review, it was decided that Auxilium would be the way to go- despite getting a lower score on the decision matrix- as it was the more unique design of the two and received more positive feedback. Auxilium had received two major areas of feedback. The bucket had to be fitted to a retractable system so any items retrieved would be easy to pick up. Furthermore, contact surfaces would need to be washable and medically inert so that Alanna's lymphedema would not flare while also being completely sanitary.

Design Revision 1

As a result, the new concept had a pneumatic lift system put in place, and potential contact surfaces were being researched. Firstly, with the pneumatic lift system, Alanna would now be able to pick up items by controlling the lift mechanism (either through a phone app, or remote). Secondly, potential materials that could be used for any contact surfaces needed to be medically inert. For this reason, it was decided to use silicone rubber or gripped rubber, as it is a material that does not react with body tissues.

Figure 7: Auxilium Design Revision 1

Design Review 2

During the second design review, feedback received from the IAI and Science students focused on 3 things- adding motion sensors to prevent objects too big from being sucked it, determining the materials for the final design, and adding a third wheel to increase stability of the design. In addition to this, it was decided to change the pneumatic lift system, to a scissor lift system, as it would make the design more compact and aesthetically pleasing. All this feedback was implemented and incorporated into the final proposed design solution.

All Design review notes can be found in the appendix, Section 2.

Final Proposed Design:

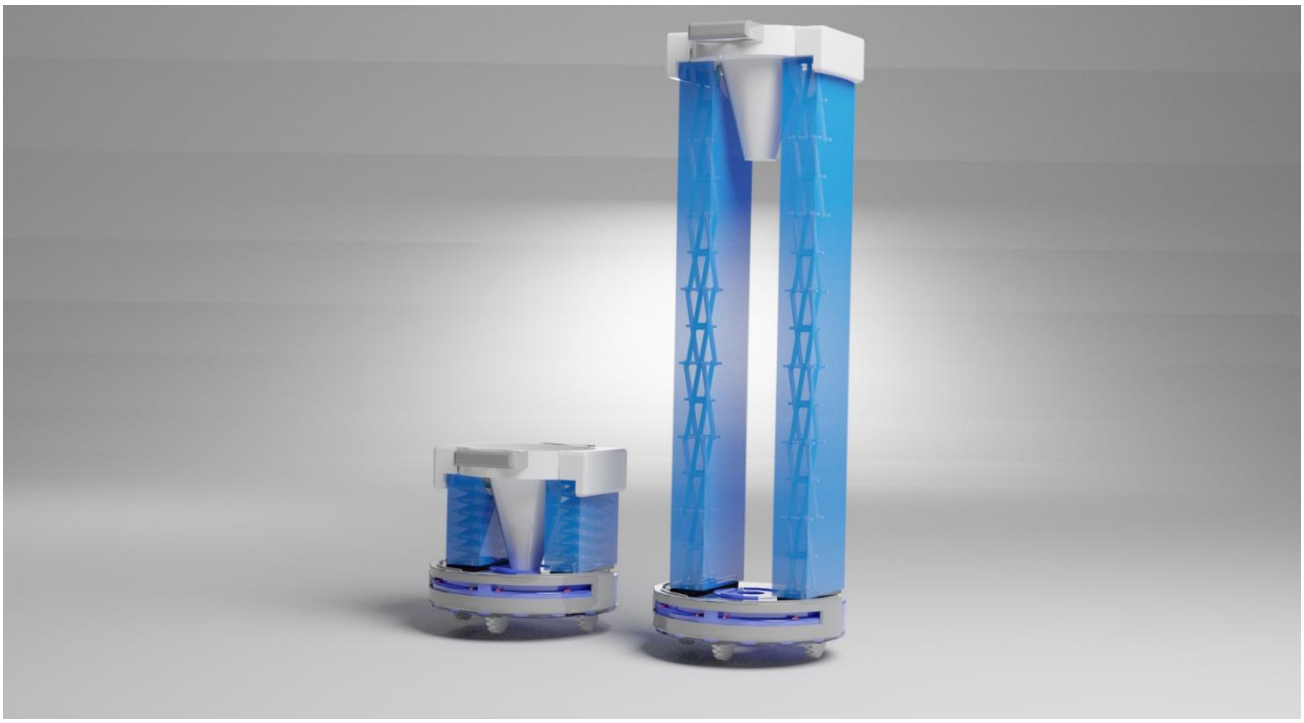


Figure 8: Auxilium with Bellow Covers, Left- Lowered, Right- Maximum extension

Design Overview:

Auxilium final design is composed of 3 main components, the body where the vacuum system is implemented, the bin which collects items sucked into it, and of course, and the scissor lift system which lifts the bin to allow Alanna to retrieve items from it.

Firstly, the body is composed of 3 parts and planted on 3 wheels. The choice of 3 wheels makes the design more stable and lowers center of gravity of the device. Additionally, 4 proximity sensors are placed on the front of the body, preventing Auxilium from attempting to ingest items that are too large. The suction hole is fitted to suck in any small items- such as Legos and toy cars. All items are then deposited into the bin. Lastly, the scissor lift was implemented to lift the bin up to make any deposited items in the bin easy to retrieve. The maximum height to which it can be extended is 3.5ft (~1.07m) and can be adjusted to any height lower as wanted. Bellow covers- which can be made from a variety of materials such as plastic and fabric- will be used to cover the scissor lift, preventing any potential injury while touching them.

All technical drawings for each component used in Auxilium can be found in the Appendix, Section 3.

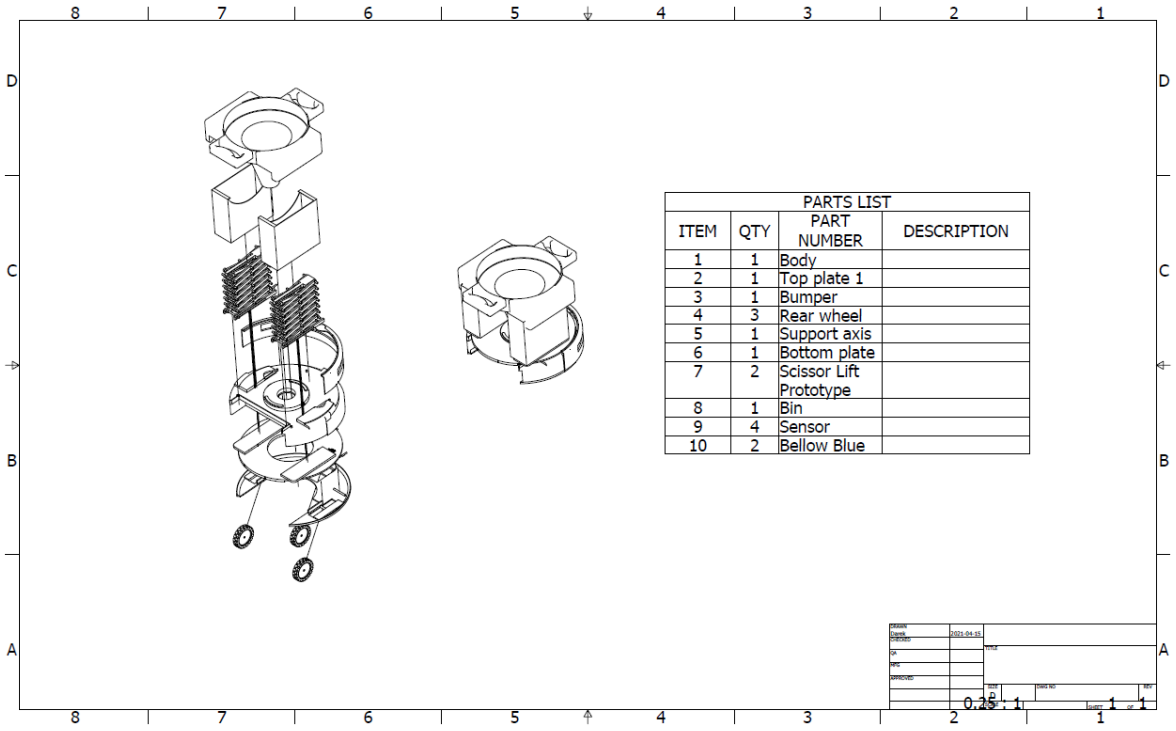


Figure 9: Auxilium Blown Up View & Parts List

Objectives:

Objective	Metric	Total in Design	Explanation
Lightweight	lb	1.15	• The only part of the device that will be picked up by the client is the bin. • Bin is composed of ABS plastic, with gripped rubber handles. • Since the total bin weight(1.15 lbs) is less than the constraint of 5 lbs,
Durable	Lifespan of materials in years	Aluminum-30 y ABS plastic- 50 y	• The materials chosen are durable and long lasting. • Aluminum and ABS plastic have a long lifespan. • Aluminum is naturally corrosion resistant. • Mechanical wear at a minimum with good and easy maintenance
Safe	Number of sharp edges	0	• All edges are rounded. • Scissor lifts are covered with bellow covers- can't injure finger by mistake
Cost Efficient	$	~$356	• Satisfies the constraint of being less than 500$ • Cost efficient

Table 3: Objective Breakdown

Materials:

Parts	Quantity	Price of Each Part($)	Cost for Parts($)
Scissor Lift	2	$37.95	$75.90
Body	1	$25.40	$25.40
Wheels	3	$21.54	$64.62
Bin	1	$12.75	$12.75
Bellow Covers	2	$18.25	$36.50
Proximity Sensors	4	$22.71	$90.84
Raspberry Pi + Bluetooth Adapter	1	$50.49	$50.49
		Total Cost	**$356.50**

Table 4: Bill of Materials

The materials chosen for Auxilium were ABS Plastic, Gripped Rubber, and Aluminum. ABS plastic is a cheap, durable, and accessible material that can be used in 3D printing which is why it is used for the main body parts and bin. Gripped rubber is used for any contact surfaces- such as the bumper on the front of the device and handles on the bin. It is a material that is easy to clean, making the overall design very sanitary. Additionally, the wheels are also made of rubber, allowing Auxilium to operate on any household surface, including ones that may be slippery. Lastly, the chosen material for the Scissor-Lift Mechanism was aluminum, as it is a material that is long lasting, durable, and lightweight, which will increase the devices longevity. These materials are easy to acquire, manufacture and are all medically inert, making them optimal to use in the design of Auxilium.

Lastly, while not exactly a material, a computer is needed to control the automated aspects of auxilium. For this reason, a Raspberry Pi with a Bluetooth adapter was chosen. It will allow for connectivity for any modern smartphone or tablet as a controlling device and can easily be adapted to take inputs from a remote controller if needed. The Raspberry Pi will also monitor the inputs received from the 4 proximity sensors, and control Auxilium to return it to its docking/charging station if the home button is pressed. On top of this the Raspberry Pi can connect to motherboards and batteries and can run seamlessly with other technologies that will be present on Auxilium.

Conclusions:

Looking Ahead

Had there been more time and resources, Auxilium would have been made into a physical prototype. This would require access to a 3D Printer, CNC Machine, and a rubber press. With more time and a physical model, the device could have been tested for safety with physical methods. This would give us more information on how to improve the device's safety measures and not just rely on tests done by software. The code that would allow Auxilium to be controlled remotely and autonomously would have been designed, to make the application more accessible and easier to use for Alanna. Additionally, the vacuum system would have been tested with a variety of toys and objects with different sizes to measure the effectiveness of the design to collect toys.

Looking Back

After going through our design process, the group had the chance to reflect on what made the design unique and effective. After many shared ideas through team collaboration, the group was able to identify a design with the most significant number of strengths in favour of the client's need. Everyone had then identified the best utilities to use for completing our design process in the early stages. It was imperative to take time to work on each step as the feedback received was kept to a minimum and enhanced the minor aspects of Auxilium such as the prototype layout. The team benefited from the nature of our initial approach as the group quickly was able to focus on certain aspects of our device and optimize the final design alongside the pitch video. Similarly, the team dynamic had a balanced workflow, and everyone was able to learn about the best approach to the objective. The group learned to prioritize communication and compile resources into a shared environment to support one another. Additionally, having regular meetings and sharing thoughts led to a positive trend of consistency for the thought process of the design. Alternatively, the thought process was not perfect and could have been structured differently. Rather than spontaneously deciding to have meetings the group could have made a routine that was easily accessible for everyone. This would help us avoid conflicts with time zones and conflicting schedules, thereby facilitating, and accommodating everyone equally.

Regarding our design process, the group exchanged the design ideas during the research step of the design process which could have limited the possible design solutions. Everyone could have delayed sharing ideas and making solution-specific decisions before the research and brainstorming steps, to increase the range of the design space alternatives. Another step that could have been done differently was the step including feedback received from the science students. The group was able to test our designs after meeting with the science

students, which limited the information gathered from them. İf the design was tested before, there could have been more time for deciding on relevant questions to ask the science students.

Final Thoughts

The abstract engineering design process that this project introduces is interesting, as finding the perfect design solution for the problems the client has is quite difficult. Having access to more information would make the design process easier, and more efficient for the engineering side of the process. However, in everyday scenarios, having all the information wanted is unlikely and design solutions will have to adapt to information given. For this reason, this project has been quite insightful and fun, especially seeing how many different designs and solutions have been made for the client, despite all groups being given the same information.

Appendices

Section 1 – Patents, Commercial Products, Objective Trees, Client Meeting Notes:

Patents:

Wilkinson Samuel Cliffo Walter, "Method of forming a flexible bellows connection between axialy spaced members," US3372076A, 05-Mar-1968.

This patent is a cross sectional design for a bellow cover. The bellow covers used in Auxilium CAD model are just solid rectangular prisms, but any future refinement would require making custom bellow covers similar to this one in order for a simulation to be created.

Stefanos Konandreas, Andrew Ziegler, Christopher John Morse, "Autonomous surface cleaning robot for wet cleaning," US20150289741A1, 15-October-2015

An Autonomous surface cleaning robot similar to a Roomba which is designed to "wet clean"(that is, avoiding the use of any chemical cleaning solvents) to clean surface such as carpets.

Objective Tree:

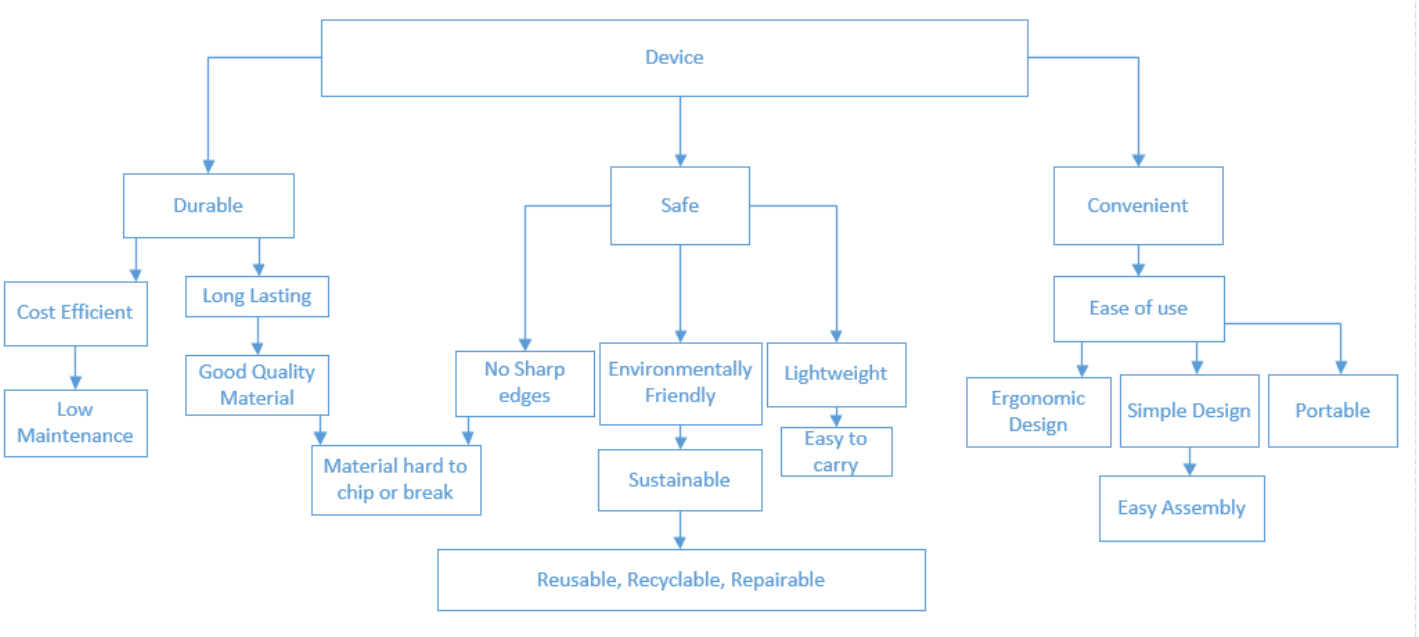


Figure A10: Objective Tree

Client Meeting Notes, Week 1:

Name: Yuvraj Sandhu	MacID: Sandhuy

Background:

- *In 2016, contracted illness from an auto-immune disease*
- *Does sculpture work sometimes*
- *To increase mobility and flexibility, trained in Brazilian jujitsu*
- *Got into a car accident*
- *Had breast cancer*
- *Wants to showcase activism through her paintings*
- *Does painting for healing*
- *Wants to bring positive changes to the world*
- *Intensely into meditation practice and yoga*
- *Was a mid-wife from early 2000 - 2016*

Actions:

- *Sculpting*
- *Painting*
- *Molding*

Works with wires

- *Quilting and Sewing with needles*

Problems we can focus on:

- Molding:

Wires cause finger bleeding due to Lymphoedema
Wires hurt her hands

- Painting

Issues with precise motor movements
Flares leave her in her bed

Preferences:

- *Painting in bed is comfortable to her*
- *Does not like to work digitally*
- *Prefers physically painting and drawing instead of working*

Previous Solutions:

- *Utilizes medical grade compression vest for lymphoedema for when she is sculpting, molding, and painting.*
- *Arthritis gloves*

CAN NOT WEAR BOTH COMPRESSION VEST AND ARTHRITIS GLOVES AT THE SAME TIME

Name: Armon Bal	MacID: bala

About the Client:

- *In her Early 40's*
- *Studied Midwifery in post secondary and was a midwife roughly from 2001 - 2017*
- *Paints professionally and for personal use such as a method of healing and coping*
- *Painted from 2001 and prior, stopped for a couple years and picked it back up since 2017*
- *Sculpts as well, predominantly using wire*
- *Meditates a lot either through are or yoga*
- *Practiced Jujitsu pre Covid*
- *Owns a website called inapowerfailure.com where she has posted her art*

Condition/Health of Client:

- *Was caught in a Car accident that impaired her health*
- *Was diagnosed with breast Cancer and survived after undergoing rigorous chemo and has had her breast removed*
- *Has unpredictable body patterns*
- *Has common muscle trouble*
- *Diagnosed with Fibromyalgia: Disorder that causes musculoskeletal pain throughout the body*
- *Diagnosed with Lymphedema: Condition where excess fluid collects in tissues that is known to cause swelling*
    - *Wears compression parts such as a vest to help with this*
- *Diagnosed with Spondylarthritis: Autoimmune disease that attacks the spine and has lower back pain as a common symptom*
- *Suffers from spinal pain and has a hard time maintaining her posture*
- *Has a Gluten Allergy*
- *Difficulty with stamina and bending*
- *Usually only works with soft materials as rough/sharp materials can irritate/damage her skin and body*
- *Has sleeping issues and is often bed ridden some days due to one or more of her conditions influencing her mobility*

Areas we can Address/Help:

- *Relieving tension/issues when painting as it influences a large part of her life in regard to personal and professional life*
- *Cannot work with rigid materials as her health is significantly compromised when working if she receives a cut (Possibly make it so she can)*
- *Cannot wear her gloves at the same time as her compression gear*
- *Cannot lift heavy objects*
- *Some of the equipment she has worn have proven not as effective such as her joint brace (except for walking)*

Devices we can design to help the Client:

- *A device that can allow her to lift heavy objects off the floor and move it around freely*
- *A device allows can help relieve pain when working on her art in bed*
- *A device that is able to allow her to continue sculpting with wire as she once did as she prefers sculpting that way*

Name: Dariusz	MacID: wolosd1

Client Notes

Artistic Themes:

- Avid sculptor and painter
- Visions for art come from where she is in the healing process.
- Not inspired by commercial gains, more about activism
- A lot of art is inspired by trying to make her body do what she wants it to do.
- Due to mobility issues and problems using fine tools, the art will sometimes be re-visioned using large tools which are easier to use.

Activities & hobbies:

- Painting -avid painter and finds ways to paint even if it is difficult.
- Sculpting- can do it but using find tools difficult due to increased infection risk (must be careful and tools cannot harm her hands). Must wear specific devices to even be able to do this. (Compression vest, gloves)
- Knitting- used to do often but cannot anymore- using precision tools difficult.
- Gardening- cannot do anymore but would like to. Used to be an avid gardener and it is one of the hobbies missed most.
- Brazilian Jiu Jitsu- but impacted by COVID. Not the same through a screen, lacking community feeling.
- Started yoga but not the same, many online instructors do not provide adaptations for her mobility issues.
- Meditates daily – helps her manage symptoms, and create inspiration for art.
- Uses a variety of coping mechanisms and tools to try and manage pain – tens machine, vibrating heat belt on SI joint, self-acupressure, cupping, traditional Chinese medicine, exercise, and movement.
- Finds that the best tools are ones she can use to find her own power.

Health Issues:

- Often unpredictable, some days are worse than others. Makes planning (art, work, hobbies) very difficult.
- **Fibromyalgia –** a disorder causing pain all around the body. Can cause sleeping problems, as well as memory and mood swings, and general lower cognitive ability.
- **Lymphedema -** swelling in limbs that causes mobility problems and increased risk of infection, can be caused by cancer treatment by damage to the lymph nodes

- **Spondylitis arthritis –** autoimmune disease, causes overgrowth of bone on the spine making any back movement very difficult and painful. Can also lead to brittle bones in the spinal area.
- **Cancer Survivor –** had undergone treatment for breast cancer including removal of both breasts, and presumably radiation/chemotherapy. Cancer survival and journey a key inspiration/theme for many of her art projects.
- When one issue/symptom "flares", can cause other issues to flare and be stuck in bed for days. Pattern like a menstrual cycle, particularly with back issues and fibromyalgia

Mobility Issues:

- Easier to crouch and squat, because any movement or bending of the back is painful due to Spondylitis Arthritis.
- Weight bearing with arms is difficult- picking up heavier items is not easy.
- Up/down movement can be done but can cause dizziness and vertigo.
- Lymphedema flares are probably her biggest challenge – makes holding arm up difficult and holding small brushes almost impossible.
- Client tends to be clumsy – working with fine tools needs caution to avoid causing injury.
- Finds ways to adapt- ex. when joints in back locked during a flareup of spondylitis arthritis, painted kneeling and even lying down. Every day, the mobility issues can be different and coping strategies need to be adapted to.
- Impacts/Flares can be made worse by exceeding limitations.

Potential Devices:

- Something that can help pick up small objects from the ground without much effort. Children often leave things on the ground.
- A smart shopping cart- can help move heavy items around the house. Could make chores and hobbies easier.
- App that controls devices around her house (doors, kitchen utensils etc.) to make daily life easier and allow more energy to be spent on hobbies

Name: Kaan Ozkan	MacID: Ozkank

- One of the biggest issues she is having is the unpredictability of her symptoms, she doesn't know which symptoms she will experience. Due to this nature of her symptoms, she continually needs to switch positions while painting.
- Her sleep is also affected by her conditions.
- Fine motor difficulty due to pain, muscles being impacted (burning sensation) caused by fibromyalgia, the pain occurs in random body parts and she needs to rest those parts of her body.
- She cannot drive because of her condition.
- Stress increases her pain.
- She cannot bend, so it is difficult for her to pick up small objects from the ground (Legos)
- She has lymphedema, this condition makes it harder for her to use certain materials, it's a hard for her to bend wires.
- She wears a compression west and gauntlets for lymphedema, she also tried medical arthritis gloves, but because she also wears lymphedema gauntlet, she can't wear them both.

- She has spinal pain because she forgets posture.
- SI joint brace is helpful if she needs to walk but not helpful with other things, it causes compression in part of her spine which is uncomfortable. **She mentions that a softer design could be helpful!**
- She has difficulty with lifting cooking utensils.

Problems we can focus on:

A device which will allow her to easily bend wires in different shapes.

A device which will allow her to pick up small objects from the floor without bending down.

A device which will allow her to pick up heavy cooking utensils and use them.

Client Meeting Notes, Week 2:

1. The client used a similar device before, the device she used was intended pick up bigger objects off the ground. İt was made out of plastic.
2. Her kids eventually break the old device, so she says it is particularly important for her that the new device is very durable and hard to break.
3. She is 5 foot and a half tall; we should consider her height when designing the device.
4. She wishes she could paint on much bigger canvases (4–5-foot square)
5. She is right-handed, she has small hands, and her hand ring size is around 5-6.
6. Large sized brushes are easier to hold, (Thicker handle is better). So, if our design will have handles, it is better to go with a thicker handle, so it is easier for her to hold it.
7. Her upper extremity is a strength for her
8. Painting is her occupation
9. She has Ankylosing Spondylitis is a medical condition that is episodic and chronic
10. Exercises would help her according to physical therapists
11. She hasn't tried holding the paintbrush in a different way, and she can adapt very easily to abstract work, but she does not invasion adapting to detailed paintings
12. Ankylosing Spondylitis primarily impacts the base of her spine, her hands are not currently impacted by this
13. Pain in her hands are from other difficulties
14. All her daily activities are more difficult compared to when she did not have any pain

15. Bending at her waist is much more painful, doing squats would be better for her, but she can only do so much a day
16. The largest painting she has done is about 10 feet x 10 feet
17. The maximum load she can lift is about 5 to 10 pounds
18. Alanna enjoys only painting in her studio
19. She grows her plants from already planted ones from the store
20. Built raised beds in a garden facility in Philadelphia
21. Indoor plants and she had outdoor space that she has not planted
22. She has grown vegetables, but does not have patience for it now
23. She struggles more using smaller paint brushes
24. She has limited range in motion, her hands start to freeze up when having muscle spasms, and she sometimes drops the paint brush. She can only grip the brush for short amount of times
25. Prefers to paint on the floor, sits on meditation cushions as a seat, and she uses a stool to place her canvas on. If she places the canvas on the floor, she uses the floor to hold her own body up and paint, it feels easier for her to do this and she is able to paint longer. The closer she is to the ground, the less nausea she has (side-effects to her cancer treatment) because she feels like her body is stabilized. Holding the weight of her own body is exhausting.
26. While working with the Arthritis community, she finds repetitive movements painful rather than non-repetitive
27. She cannot work with paper mache as she cannot work with gluten, she cannot work with some canvas' due to her allergies. She is cautious with chemical components
28. Small wrists, right wrist (dominant) is 5 ¾ inches at the base and the left wrist (non-dominant) is the same. The width from the tip of her middle finger to her wrist is 6 ½ inches and the crook of the thumb to the outer inch of the hand is 4 inches
29. Works with a variety of brushes (sizes) on one piece
30. Finger painting was tried (making fine adjustments with her paintings)
31. When holding her paint brush, sometimes it affects her arms before the small joints on her fingers and vice versa, it is unpredictable of what will happen first
32. Bearing the weight of her own arm is sometimes a lot of work also, she does just have lymphedema in her arms, it's in her torso, along the side, and in her back (specifically in her pectoralis muscle)
33. The swelling is minimal as she catches it quickly

34. She does not struggle to extend her fingers rather than it is to grasp things with her fingers. It is also easier for her to pull her arms downwards rather than lifting it up.
35. A favourite activity that she likes and wants to do less effortlessly is painting as she has a need to leave the world a better place and the way she wants to do that is through painting
36. Her wrist motions is similar to writing with a pen
37. 7 feet from chalkboard wall to sink
38. She does not enjoy fabric with sharp edges, velcro, and other things that are not comfortable with the skin
39. Any material that feels too strong on her will feel more comfortable
40. It is more comfortable to hold something with a lighter grip for longer periods of time

Section 2 – Morph Charts, Decision Matrices, Sketches, Design Review notes, Initial Prototype / Prototype Iteration pictures, etc :

Morph Chart:

Device Functions	Mean 1	Mean 2	Mean 3	Mean 4
Pick up objects off the ground	Magnets (metal)	Claws/jaws	Tray/Basket	Suction Cup
Avoid Injury to the User	All edges rounded	Soft touch materials	Plastic Resin (doesn't shatter)	Anti-bacterial material (copper synthetics)
Increase user's reach	Stick/Pole	Drones	Lever/spring system	Catapult
Allow for convenient and accessible storage	Hangar/Hook	Feet (so it stands up straight on its own)	Clips	Velcro

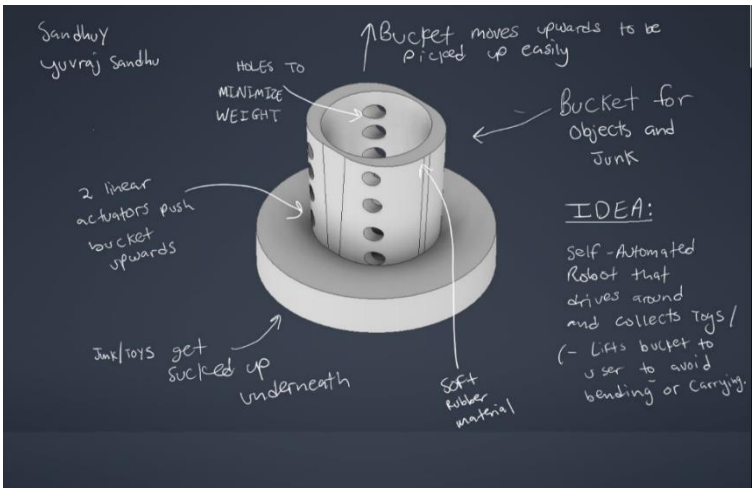
Table A1: Morph Chart

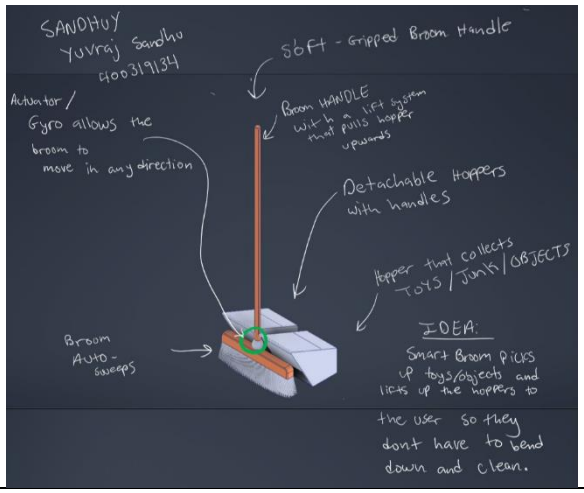
Decision Matrix:

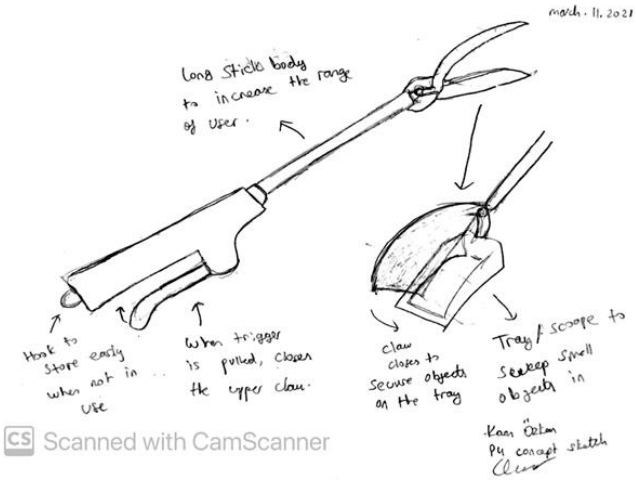
	Weight	*Pick up Stick*		*Auxilium*		*Grabber Trolley*		*Bowl Stick*	
Criteria		Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating
Feasibility	5	4	20	5	25	3	15	3	15
Simplicity	4	4	16	3	12	2	8	1	4
Weight	3	3	9	4	12	1	3	2	6
Ease of modeling	2	3	6	1	2	2	4	3	6
Repairability	1	3	3	1	1	2	2	3	3
TOTAL			**54**		**52**		**32**		**34**

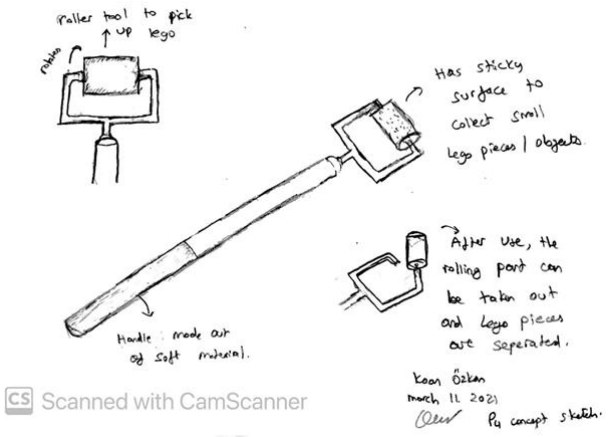
Table A2: Decision Matrix

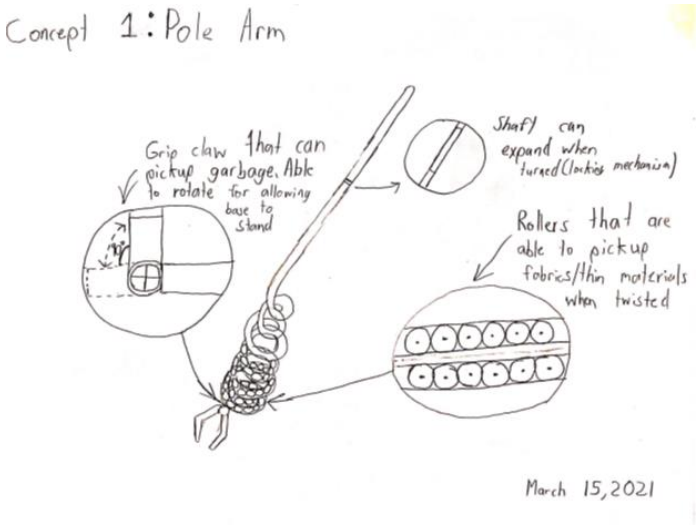
Initial Concept Sketches/Designs:

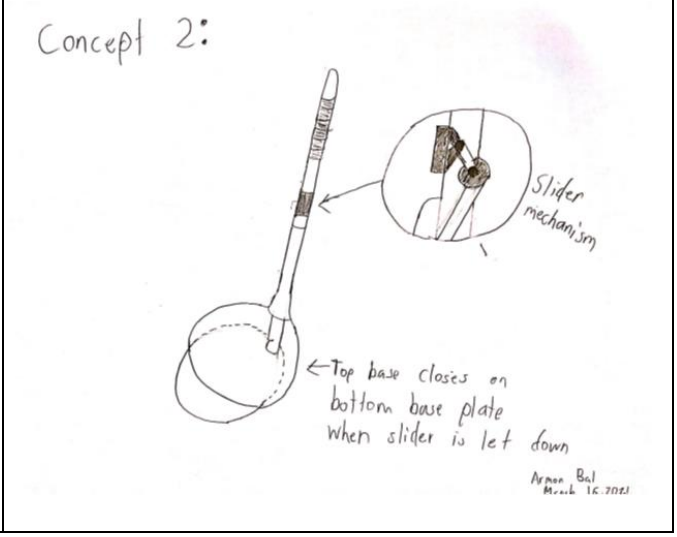


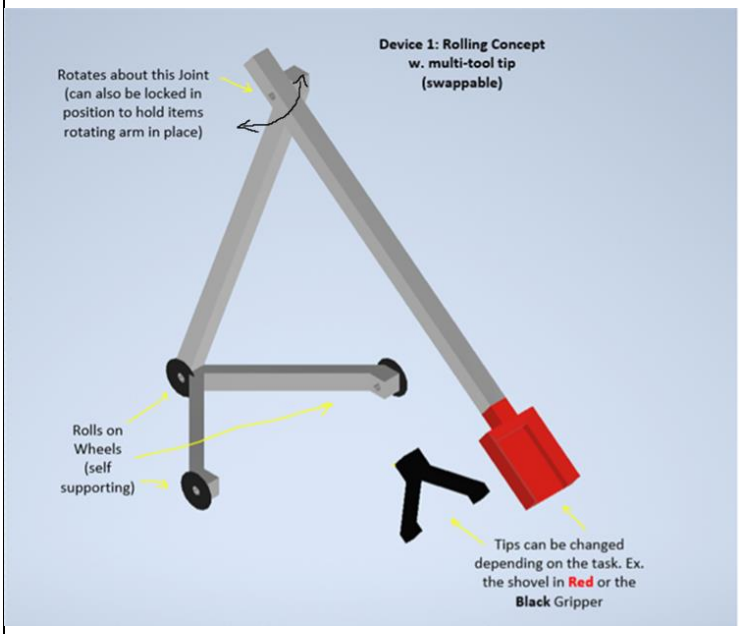


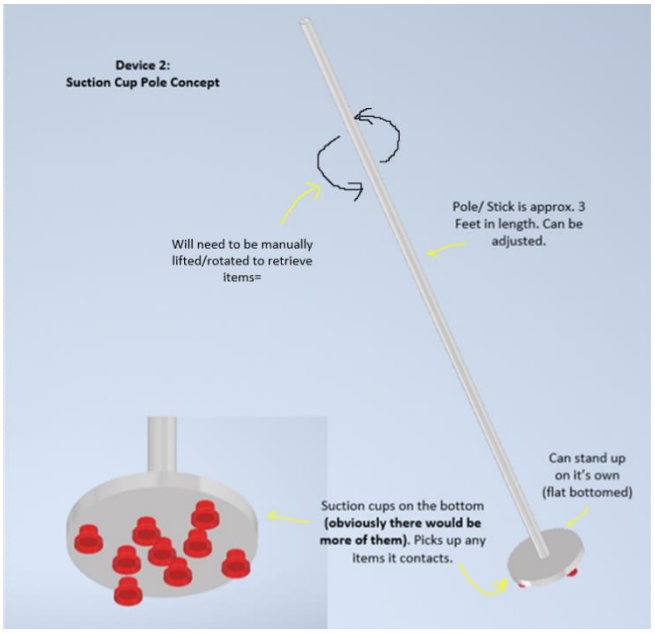












Figures A11-A19 : Initial Concept Sketches of our designs

First design review

General Feedback (From John S. & Kenzie L.)
• *Model device in Auto Inventor to make technical drawings easier* • *OK to simulate demonstration of device in blender if we find that easier* • *No need to model how functionality works completely. Ex. vacuum cleaners or clamp mechanisms don't need to be modeled to "make sense" but more about showing where they would be used function wise* • *Dynamic simulations can be done through basic spatial constraints*
Auxilium
• *Can be made retractable (pushing up any picked-up items higher)* • *Easier Gripping function – handle maybe, rope- client needs to be able to pick up the box containing the item easily* • *Gripper material- needs to be medically inert and reduce sweating as lymphedema could flare if not designed properly*

- *Generally, a Great Design and unique*

Pick up Stick

- *Perhaps adding a suction device or rubberized grabber at the end might be a good idea*
- *Functional size (what kind of toys can it hold at a maximum)*
- *How does it close and will it get jammed by larger toys?*
- *How do you turn the gripper on and off (battery powered potentially)*
- *Material that is touched(handle) should be easy to clean and maybe detachable so that you can replace it easily.*
- *Cost /Price?*
- *Possibly requires additional parts to implement well (supports, padding etc.)*
- *Possibly, make the device holdable by two hands to reduce burden on one hand. Ex- making the trigger usable by the second hand somehow.*
- *Generally a good design*

Second Design Review

Generally, feedback received revolved around 2 things- safety to the user and accessibility.

Firstly, with safety in mind, we decided to implement proximity sensors and changed the some of the materials of the design, while reducing as many sharp edges as possible. The proximity sensors will prevent the Auxilium from ingesting items bigger than it can safely do so and will stop operation of the device in the event an obstacle approaches it. Material changes – including the use of rubber and lightweight plastics were considered optimal for the nature of the device. Sharp edges were eliminated, with all contact surfaces changed to rounded edges. Stability was a concern, as only 2 wheels could unbalance in certain situations, so we decided to add a third wheel on the base, to spread the load more evenly. We then decided to work on our first draft of the lifting mechanism that will serve as a possible way for the bin (containing the toys) to lift into Alannah's reach. The current solution involves a pneumatic lifting system, but a scissor lift or stand system is being considered as well.

Feedback from peers in this row.

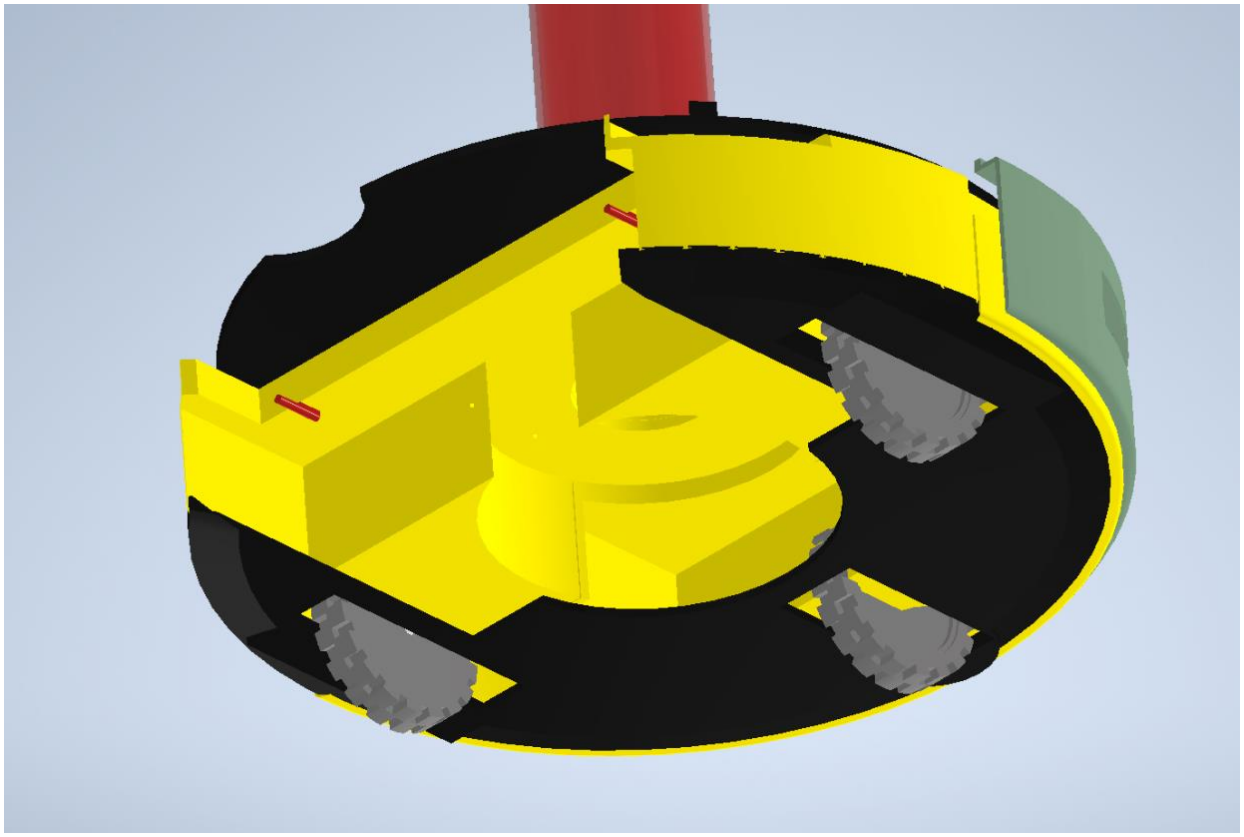
- *Toy could get stuck,*
- *Reverse into the charging block, to avoid being stuck*

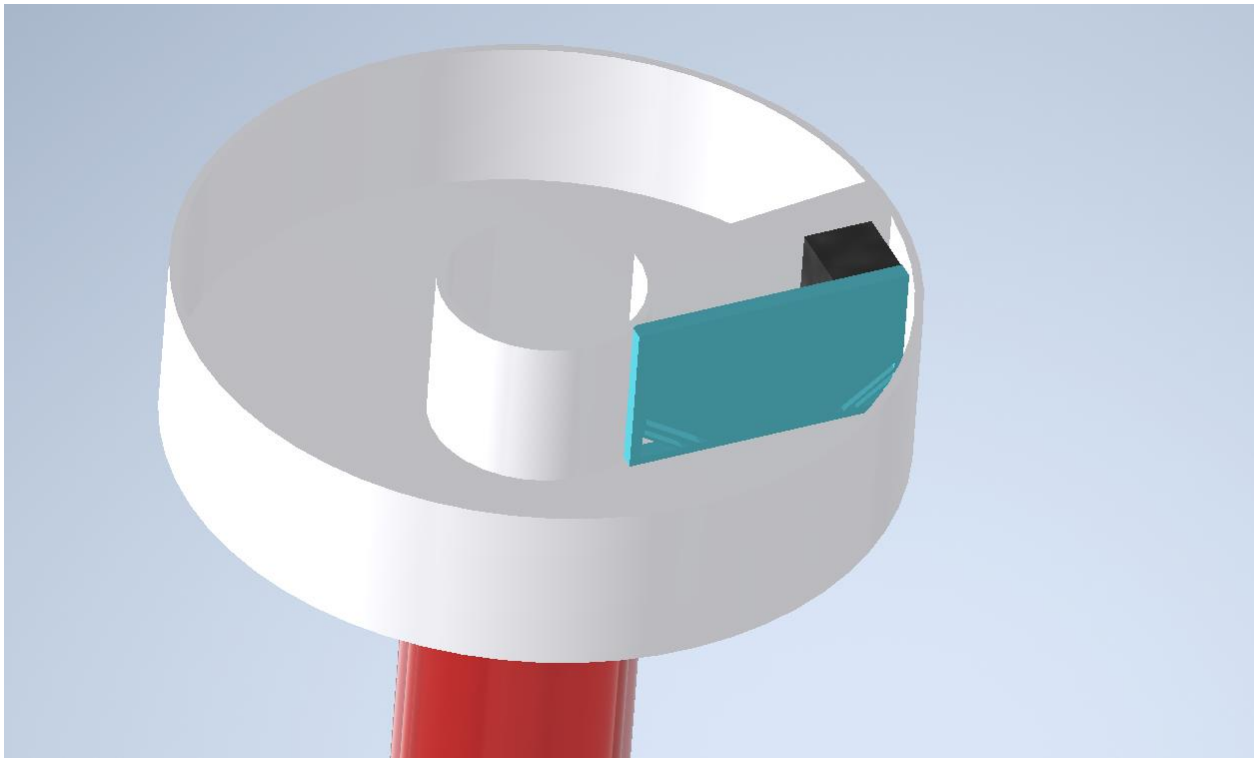
• *What material for the bucket?* • *The hole that sucks in toys could be centered so it is not too close to the charging hole.* • *A third wheel could be added in front of the Roomba to increase the range of motion of the Roomba*
Feedback from science students in this row. • *Does it pick up items that are too small, potentially?* • *Will it be leaning forward potentially (balance a bit weird – only 2 wheels), add a stump or something to ensure weight distribution is good? Maybe a third wheel?* • *Motion sensor to check if items are being sucked or in front of the Roomba*
If applicable, include feedback from the client in this row. *N/A*

Initial CAD Designs:

Figure A20 -A23: Initial CAD Designs of alternative designs and Auxilium

Auxilium First Design Revision:





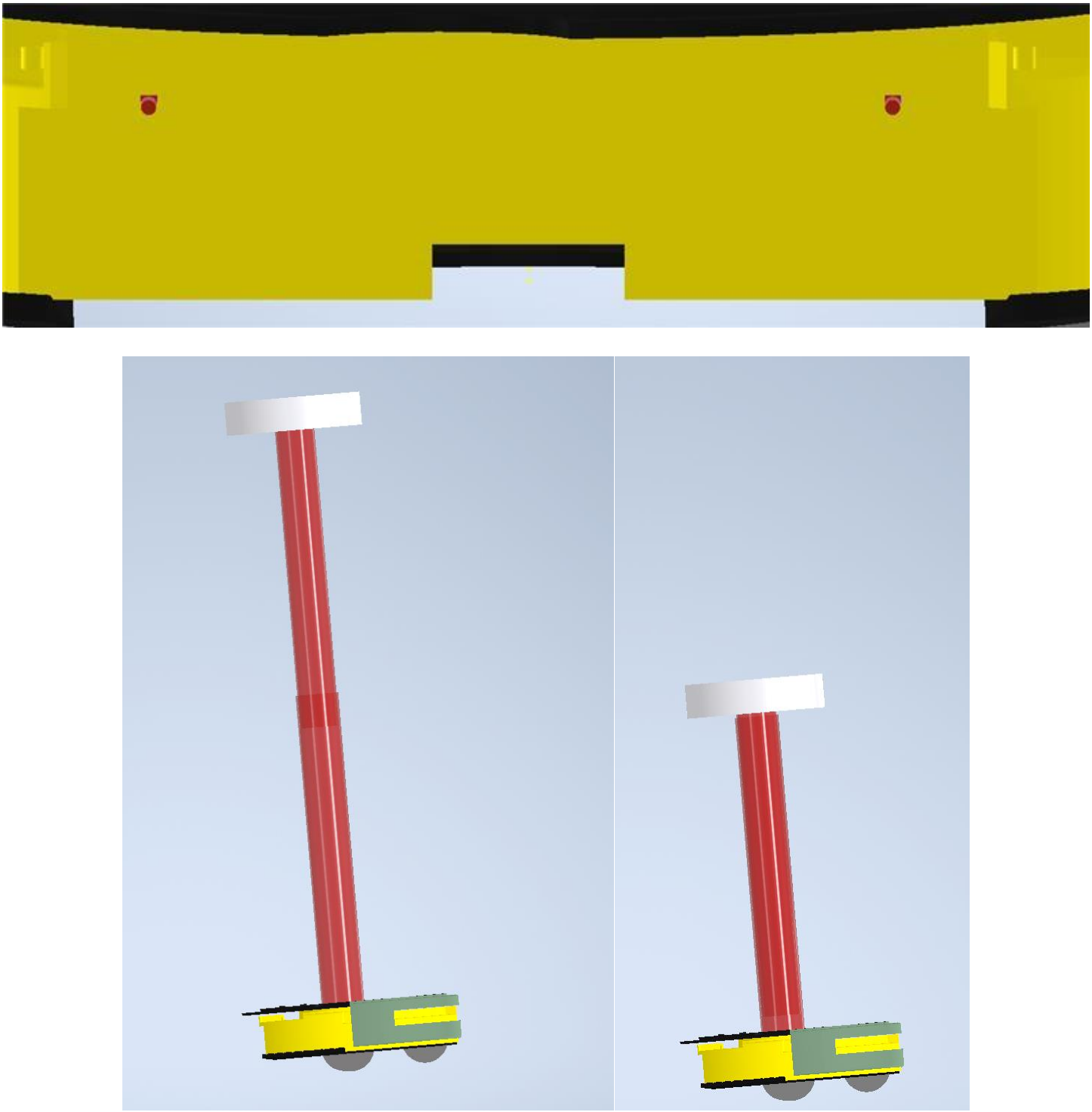


Figure A24-A28: Auxilium first design revision

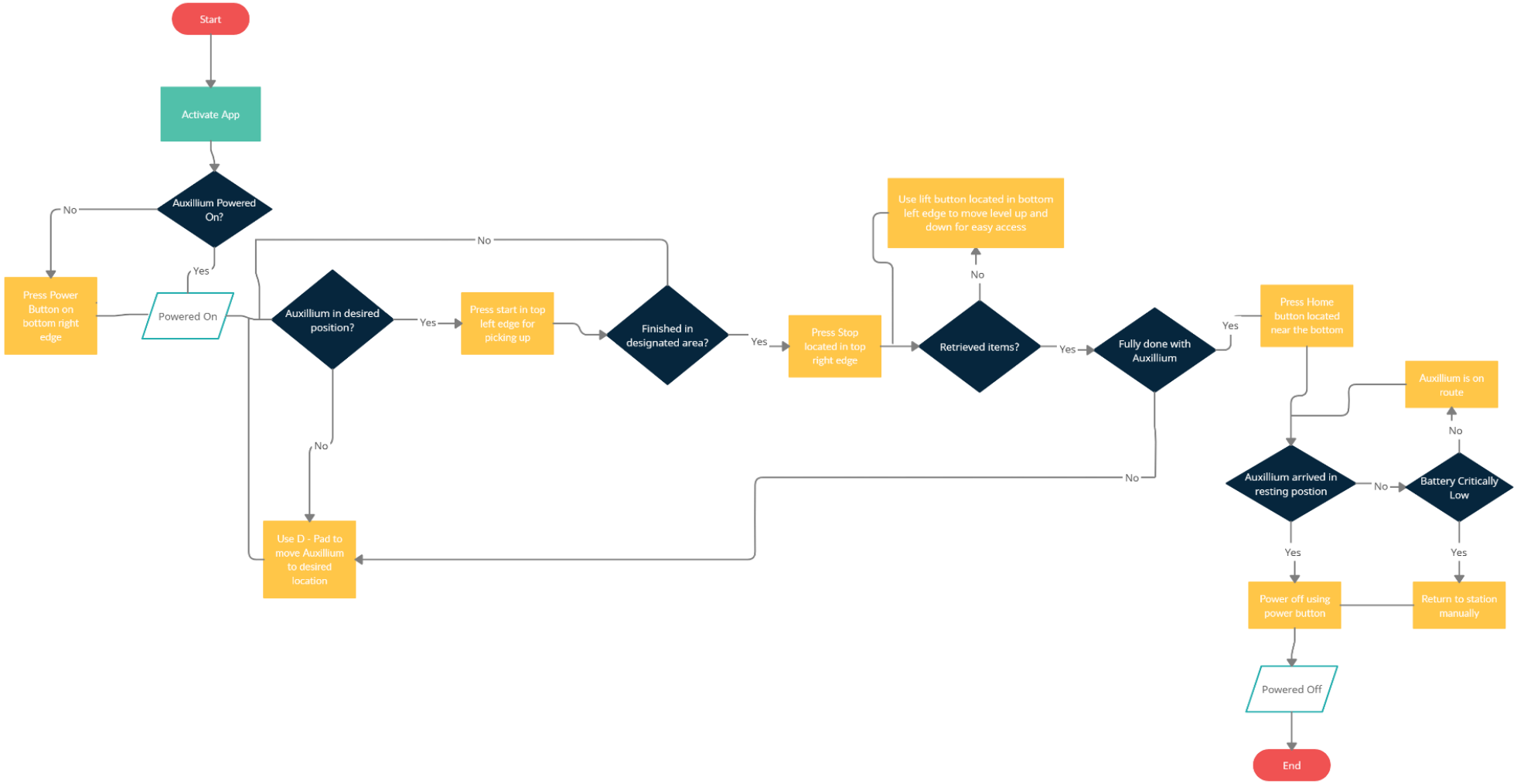
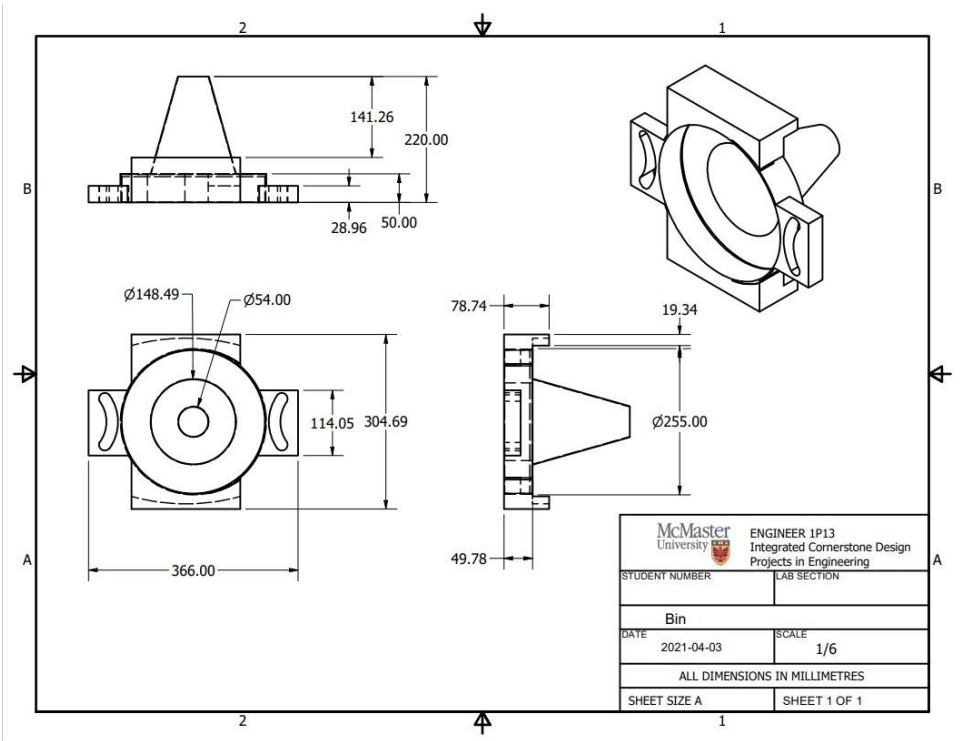
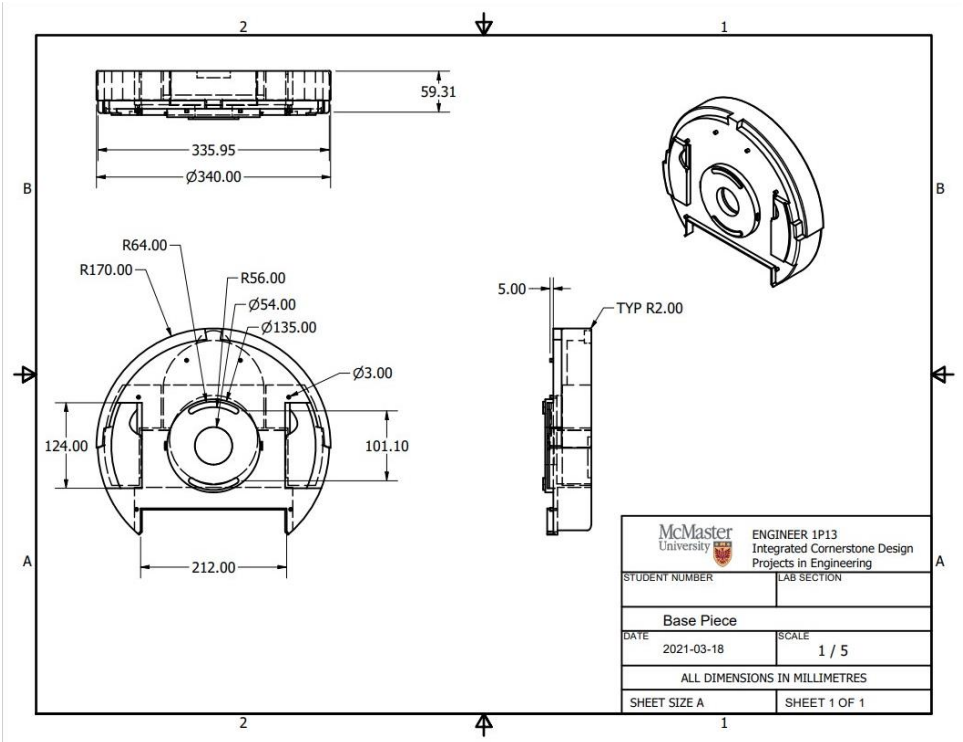


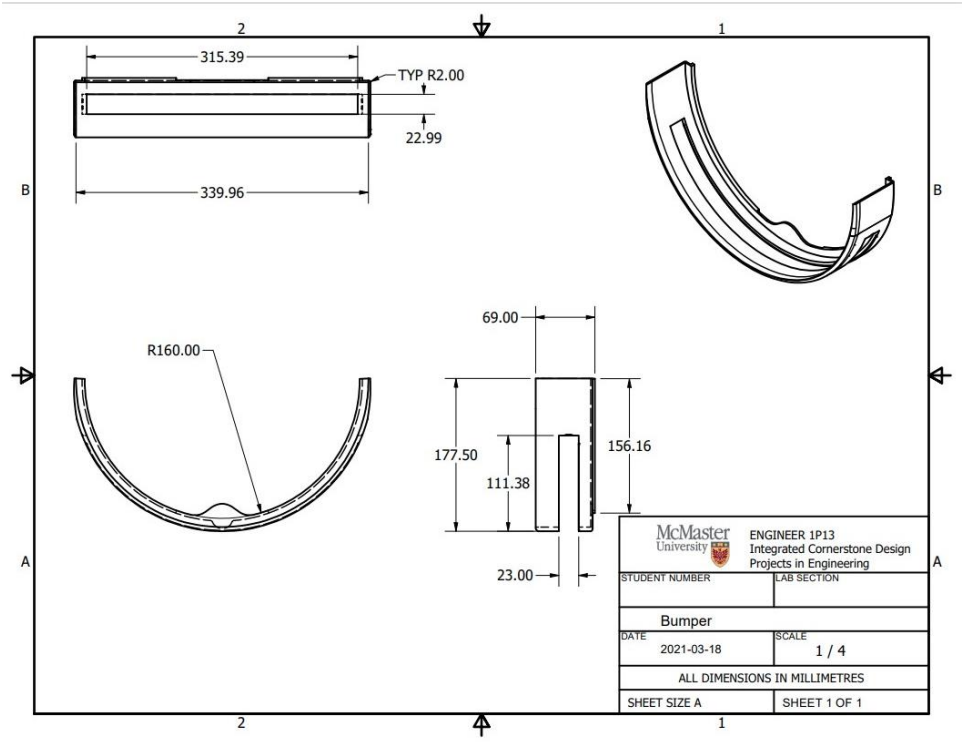
Figure A29: App Coding Flow Chart

Section 3 –Final Drawings, Final Prototype pictures, Bill of Materials (for final design):

Body & Bin Technical Drawings



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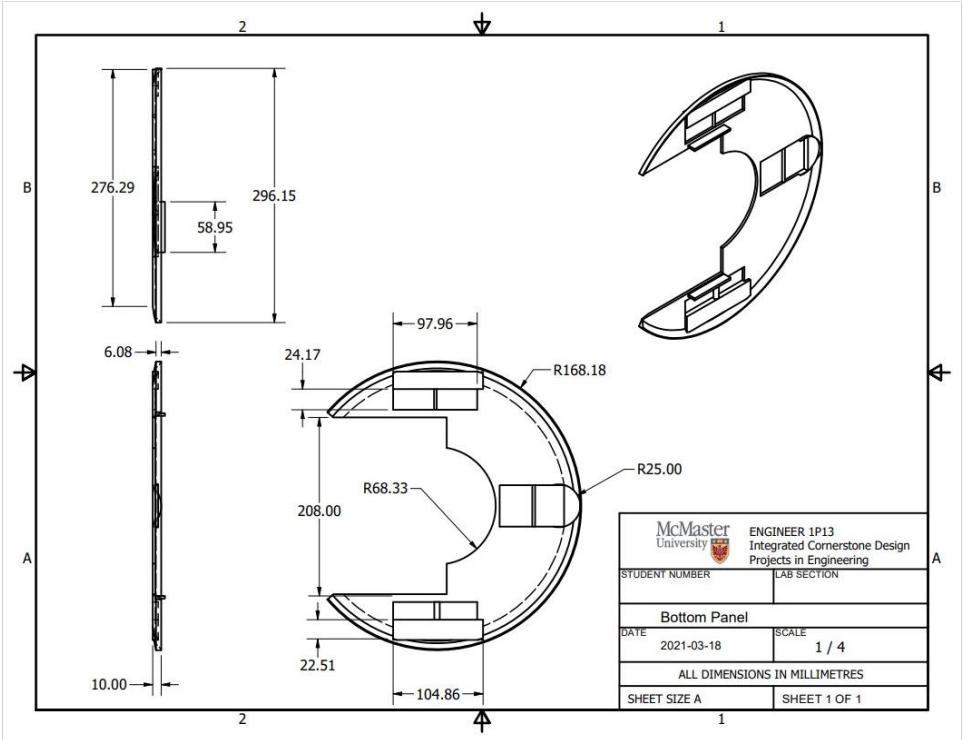
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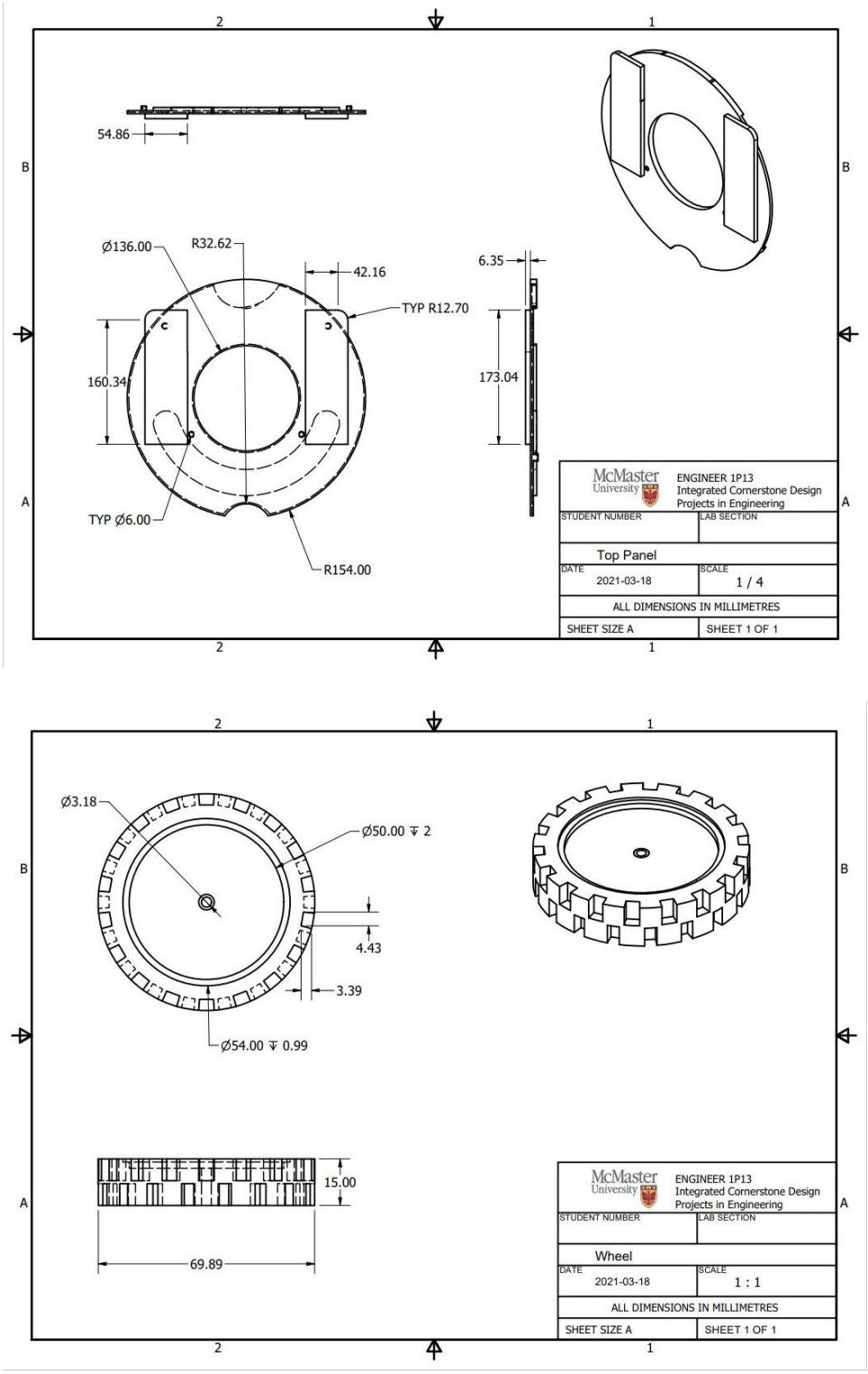
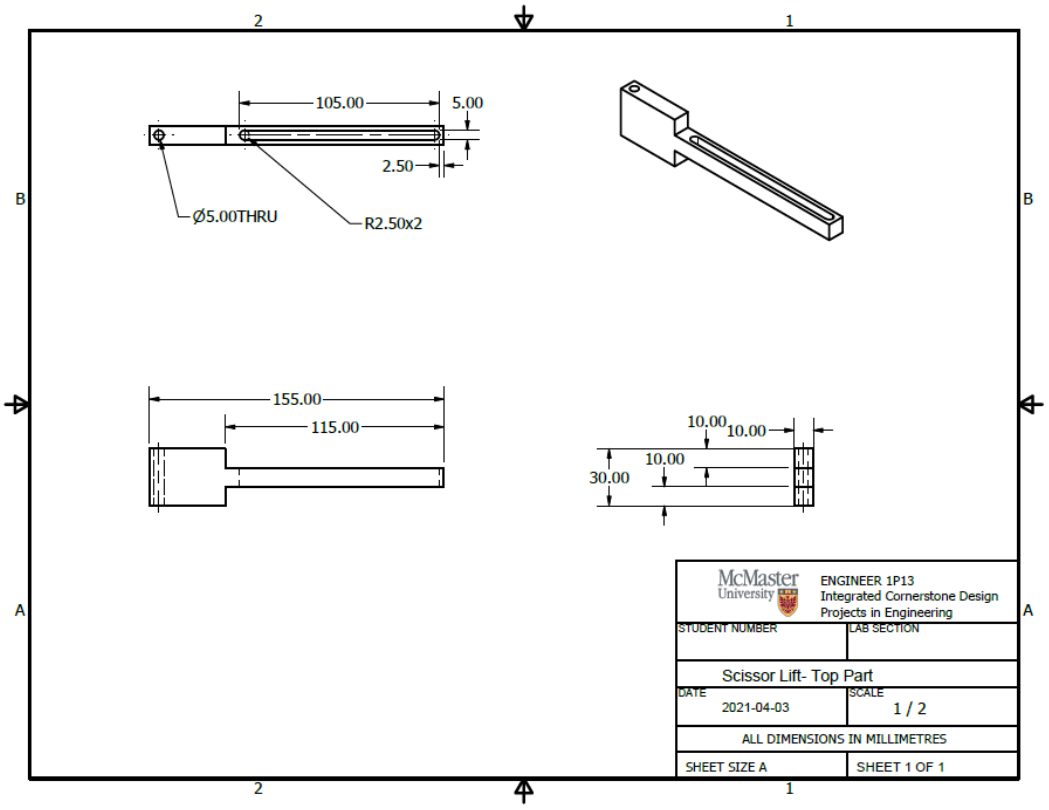
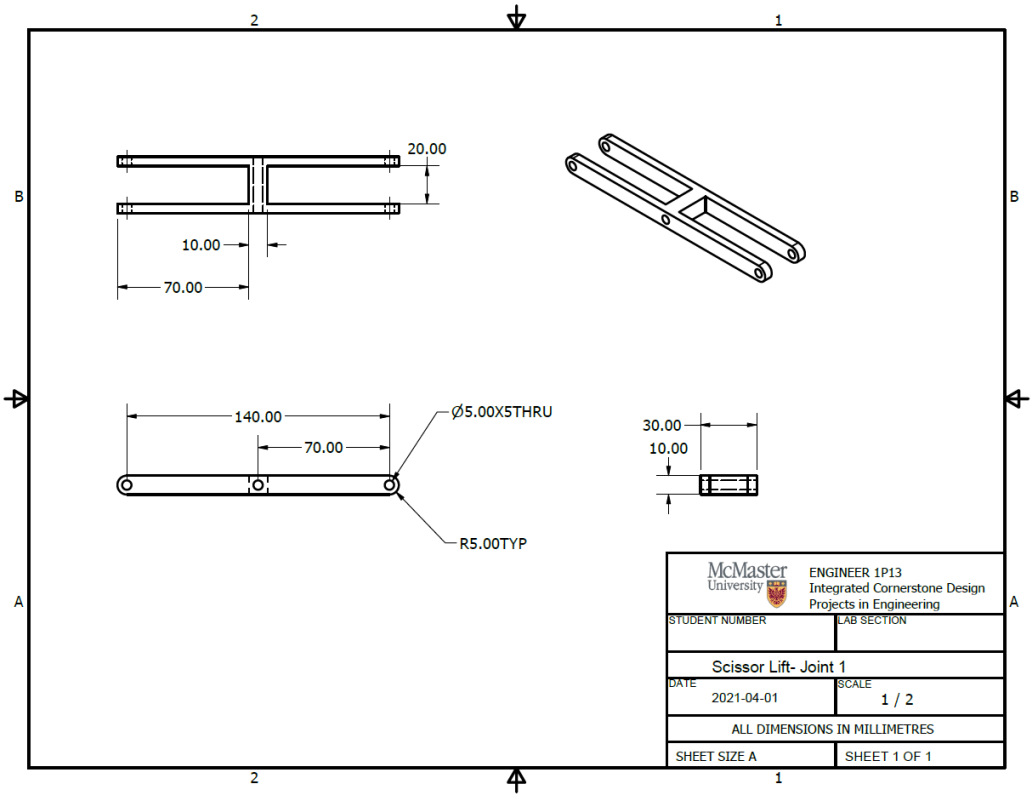
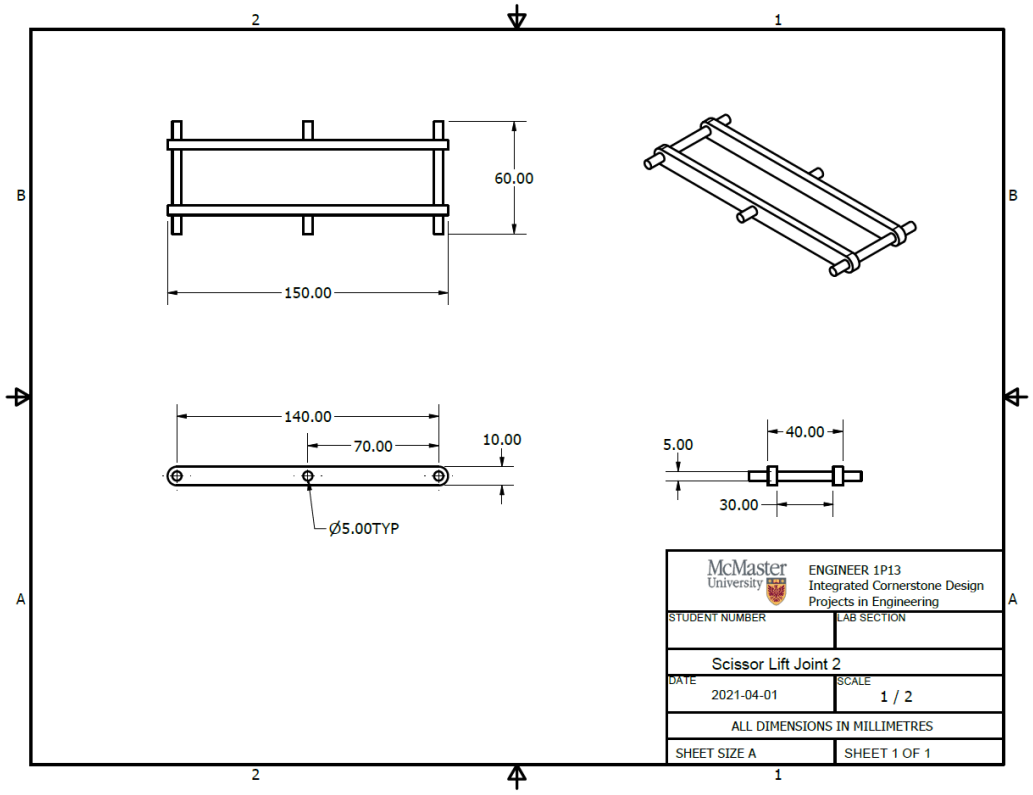


Figure A30 – A35: Body and Bin Engineering Drawings

Scissor Lift Components- Technical Drawings



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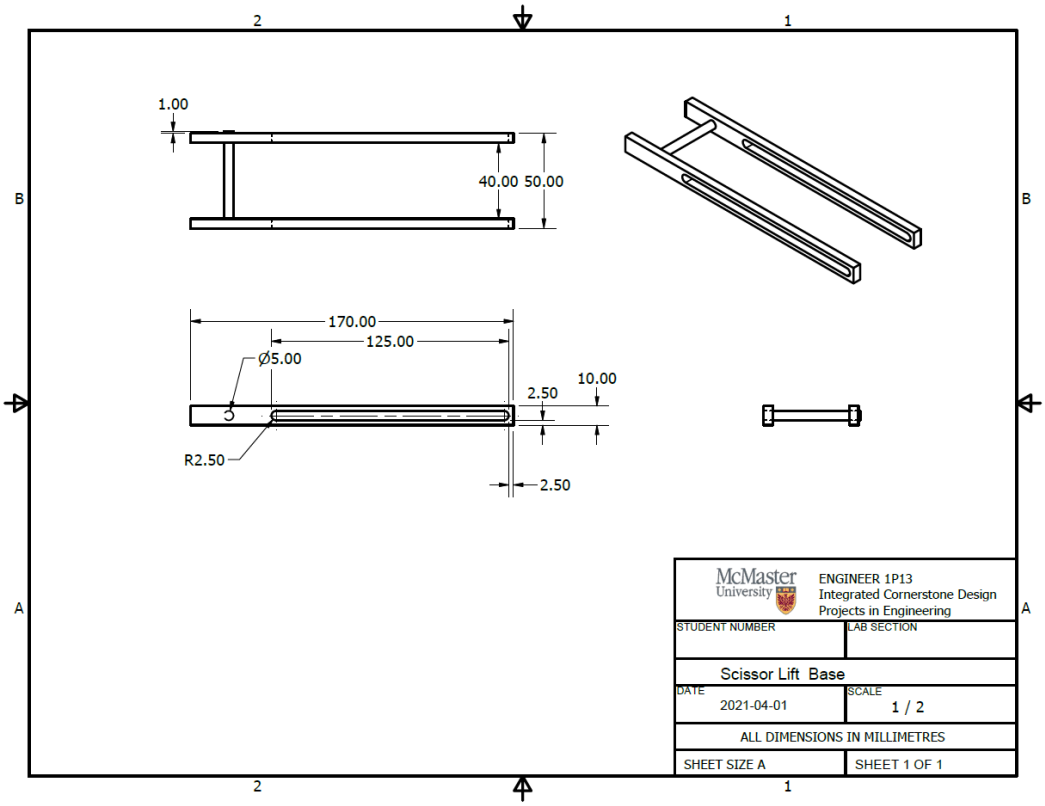
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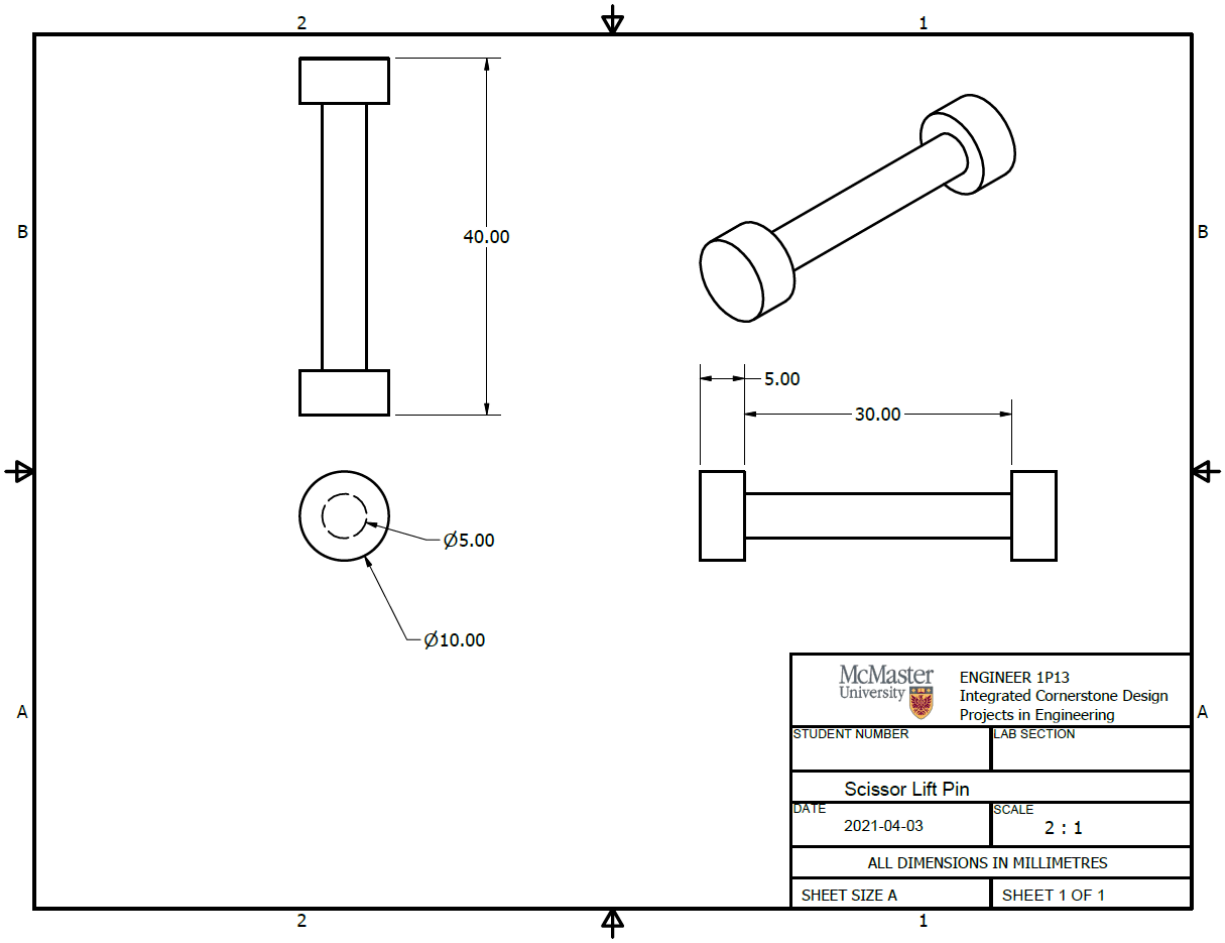


Figure A36 – A40: Scissor Lift Engineering Drawings

Final Prototype Picture:

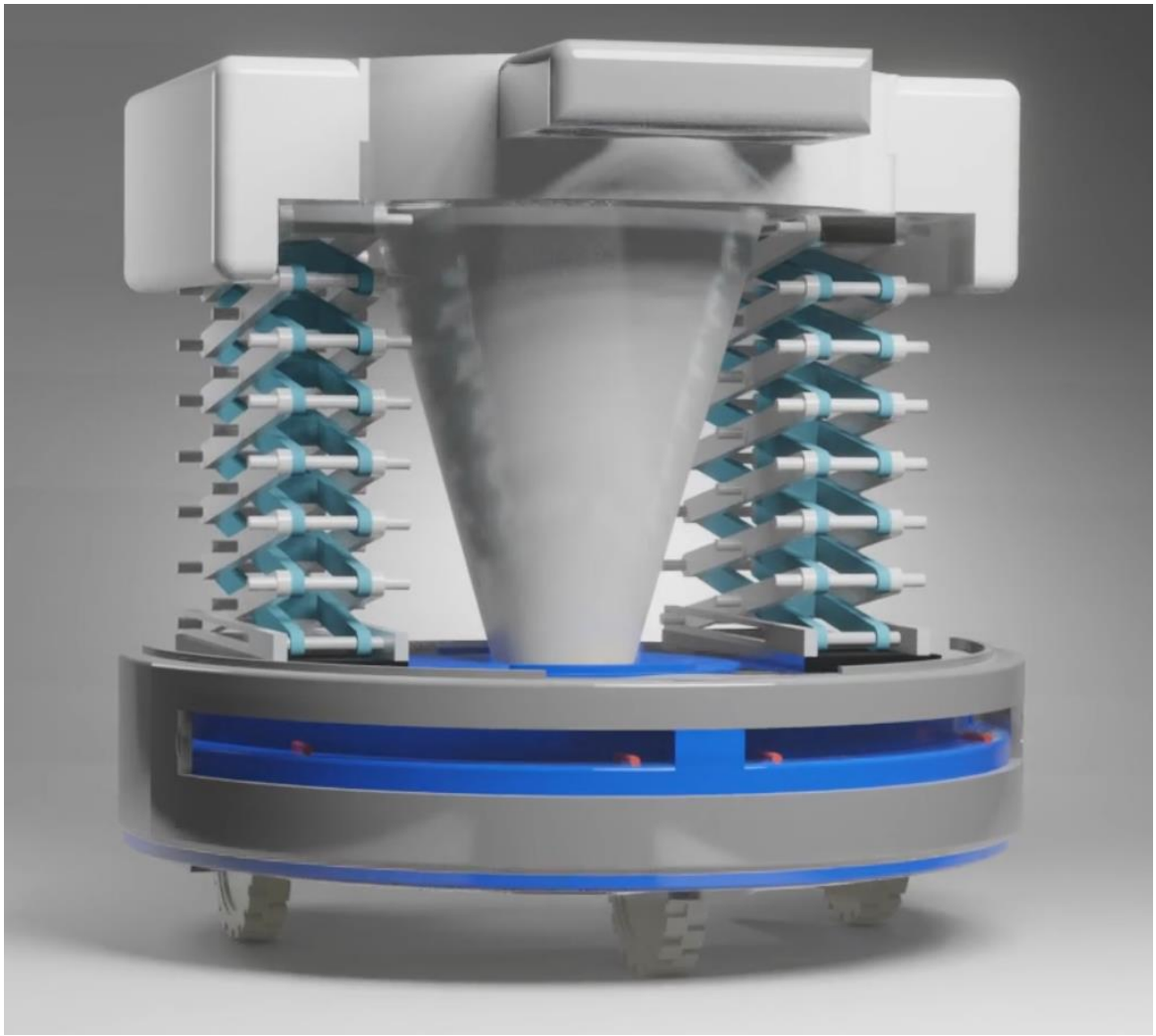


Figure A41: Blender render of Auxilium

Parts	Quantity	Price of Each Part($)	Cost for Parts($)
Scissor Lift	2	$37.95	$75.90
Body	1	$25.40	$25.40
Wheels	3	$21.54	$64.62
Bin	1	$12.75	$12.75
Bellow Covers	2	$18.25	$36.50
Proximity Sensors	4	$22.71	$90.84
Raspberry Pi + Bluetooth Adapter	1	$50.49	$50.49
		Total Cost	**$356.50**

Table A3: Bill of materials

Section 4 – Preliminary Gantt Chart (Manager), Final Gantt Chart (Administrator), Additional Meetings and Discussions (Coordinator):

Preliminary Gantt Chart*:*

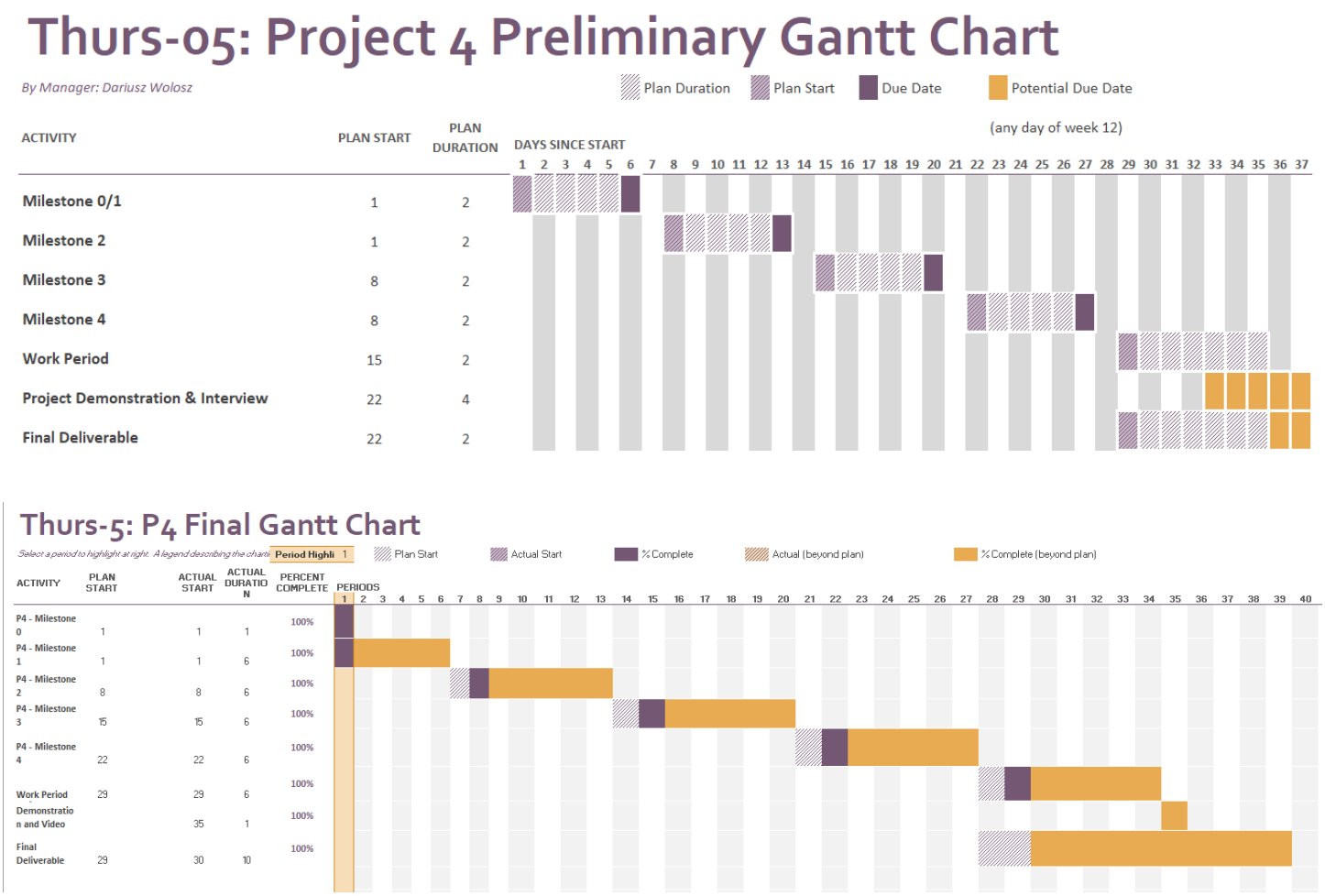
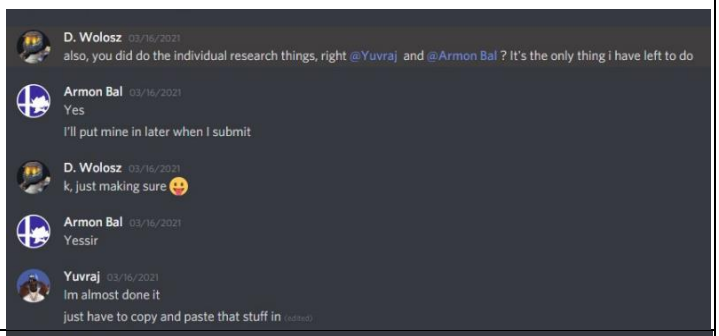
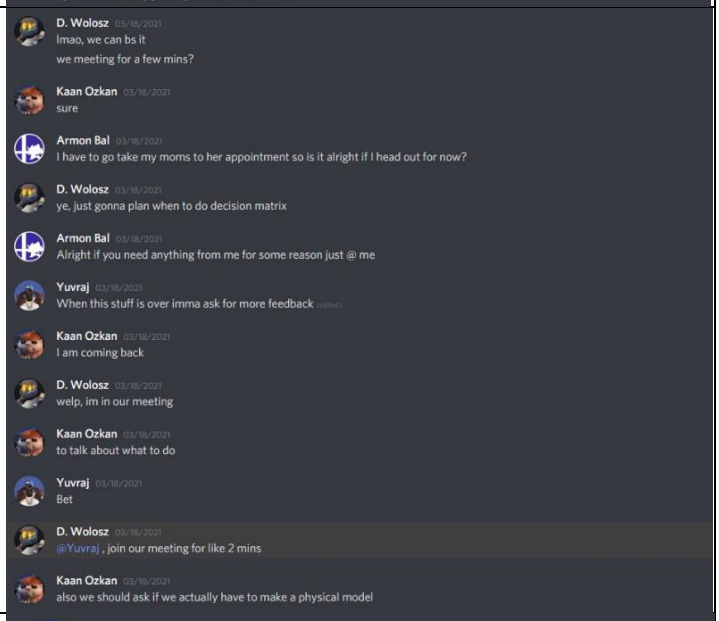
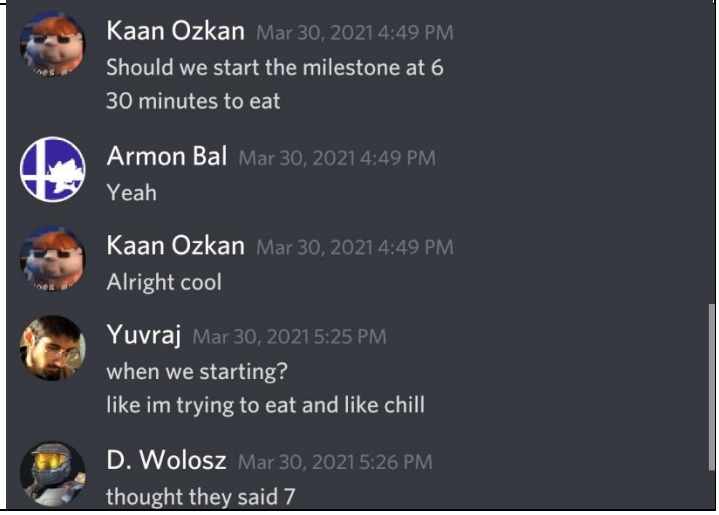
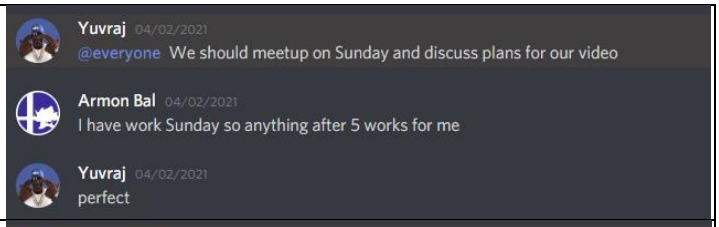


Figure A42 – A43: Preliminary and Final Gantt Charts

Logbook of Additional Meetings and Discussions:

Date	People Included	Summary	Proof
March 16th, 2020	Everyone	Meeting up for Milestone 2 and discussing our plans on finishing	
March 18th, 2020	Everyone	Meeting up for Milestone 3 and finishing it up	
March 30th, 2020	Everyone	Meeting up to finish Milestone 4	

April 2nd, 2020	Everyone	Meeting up to record our video and finalize our script	
April 4th, 2020	Everyone	Finishing our video and started working on the design report	
April 10th, 2020	Everyone	Our group met up to finish up the final design report	

Section 5 – Source List and Source Materials Database (Subject Matter Expert) :

Source List:

[1] "Indoor or Outdoor use for Reaching Grabber Tool For Handicap | Upload Article." (accessed Mar. 15, 2021).

[2] J. T. Miller, "How to Find the Best Reacher Grabber Tool," *HuffPost*, 07-Dec-2017. [Online]. Available: https://www.huffpost.com/entry/how-to-find-the-best-reac_b_5663705. [Accessed: 16-Mar-2021].

[3] "A Grabbing Tool for Disabled to Help Them Reach Things." https://www.grapplersinc.com/a-grabbing-tool-for-disabled-to-help-them-reach-things/ (accessed Mar. 15, 2021).

[4] "Best Crutches For Fibromyalgia | Self Health Care." https://www.selfhealthcare.net/best-crutches-for-fibromyalgia/ (accessed Mar. 15, 2021).

Source Materials Database:

[5] "Reach extender," *Wikipedia*, 22-Jan-2021. [Online].

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