ENGINEERING

McMaster University

Project Four: Power in Community

ENGINEER 1P13 – Integrated Cornerstone Design Projects

Tutorial T02

Team Mon-32

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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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Saarah Ahmed 400304444

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Kavi Gurunathan 400310850

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Executive Summary

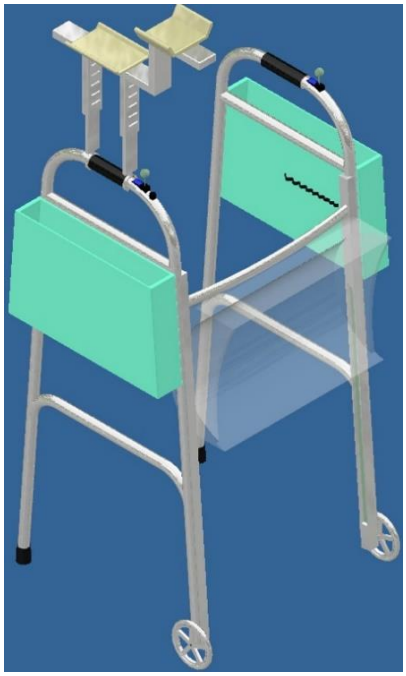


Figure 1: CAD model of final design

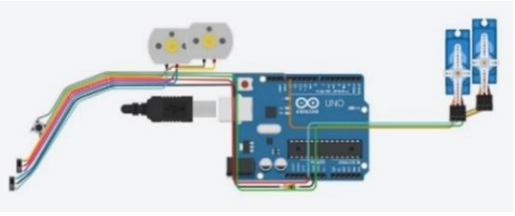


Figure 2: Circuit element of final design

The goal of this project was to design a product for the client that would help them perform their daily tasks. Due to their autoimmune diseases, the client has difficulty with many aspects of their life, including making art and spending time with their children. The client experiences pain in their joints, mostly the spine, right shoulder, wrists, and hands, causing them to have trouble bending down and supporting their body. The final product must address these problems, as well as allow the client to use it independently.

With all this in mind, our team created the Stroll N' Shovel. This walker-like device will allow the client to pick up items without having to bend down, as well as provide support for them while they perform their daily tasks. As seen in Figure 1, the product includes a shovel that can be used to pick things up. This shovel is controlled by the circuit element (see Figure 2). The client can use the switches and the pushbutton located on the handlebars to control the shovel. The Stroll N' Shovel also includes a detachable arm and wrist rest that the client can use while making their sculptures or painting. The design includes cotton pouches on the sides that the client can use to store things as well as elastic paintbrush/pen holders on the left pouch (see Figure 1). The handlebars of the walker and the arm rest would be lined with memory foam and 100% cotton to provide the client with extra comfort.

To test our design, the dynamic simulator in Inventor Autodesk [1] can be used to perform a stress test. Also, online simulations can be used to test the rpm of the circuit and general functionality.

When creating the Stroll N' Shovel, our team made sure that the product could be used independently. The product is reliable and durable, and the client will be comfortable while using it. The use of this product is not just limited to the client's art studio, so they can take this device with them wherever they go.

If given more time and resources, our team would create this product in real life. This way, it will be easier for us to find errors and make more design refinements. We would buy the products outlined in the Bill of Materials (Appendix C). If possible, we would present this prototype to the client and ask them to give us feedback on the design. We could also create ways for the Stroll N' Shovel to be more portable.

Introduction

Our client has medical conditions such as lymphedema and fibromyalgia that cause her pain and make it hard for her to bend down at her waist [2]. She also sometimes has trouble holding up the weight of her body, and leans on other objects for support [3]. However, sometimes these other objects can be uncomfortable or harsh on her skin. Our team's goal was to try and solve all these problems in the best way we could. We decided we wanted to design a product, specifically for the client, to assist her with picking up items without having to bend down. This product should allow her to move in comfort and not rely on others. While keeping the client's needs and concerns in mind, our team came up with three main objectives that we focused on when creating our design. Firstly, the product should be durable and reliable, as she needs to be able to trust that it will be able to safely support her. Secondly, our client would need to feel comfortable while using the product, so materials that agree with her skin must be used. Last, but not least, the client should be able to use this product independently, since she does not want to have to rely on others to do her day-to-day tasks.

We decided to design our product to pick up objects from the ground, provide support for the client, and hold/store items all at the same time. Currently, there are a number of solutions that can help the client perform the mentioned functions. The three most common solutions are: shovels (to help pick up objects), walkers (to provide support to the user while they are moving around or standing for longer periods of time) and pouches/baskets (to hold items) [4] (see patents and Figure A1). While all these things are useful, they only solve one problem at a time. We decided to incorporate all of these solutions into one great solution, the Stroll N' Shovel.

Conceptual Design

The morph chart shown in Appendix B was used to brainstorm potential functions and means for the final design. During the design process, our team used many tools to frame and understand the problem, and to come up with solutions (refer to Figure A2 for objective tree, Table B1 for the morph chart, Table B2 for the decision matrix). The team's initial concepts are shown in Figure B1 and Figures B3-B7. Based on these initial sketches, each team member created a low-fidelity prototype based on one of their designs. These prototypes allowed us to visualize the final product, as well as come up with design refinements (see Figure B1-B3).

During the first design review, we presented these prototypes to the science students. They, as well as other peers, suggested that the prototypes provide more support to the clients (for her back, wrists, and arms). They also suggested that the final product should be made of durable material with softer grips. Additionally, they said we should make the arm rest more adjustable. With this feedback in mind, we were able to choose our final design (Figure C1). The decision matrix in Appendix B was also used to help us narrow down our ideas. To this design, we added an armrest, and also came up with a list of potential materials to use on our design (a walker and shovels made of aluminum, the handles and armrest made of 100% cotton).

During the second design review, our peers suggested that we make the shovel out of plastic rather than aluminum, as it would be safer for the client. They also suggested that we add memory foam under all the cotton parts to provide extra comfort for the client. This feedback allowed us to come up with the final design.

Final Proposed Design

The Stroll n' Shovel is a revolutionary design that will improve the way the client does her day-to-day tasks. We used a traditional style walker but added many additional features. In the front of the walker, we have a shovel which is used to scoop up objects in the client's path. With the use of the pushbutton located on the right handlebar, the client can make the shovel rotate forward and backward for an easy pickup. The switches located on each handlebar are used to lift the shovel so that it reaches an assessable height. This will make it easier for the client to grab what the shovel has collected without having to bend. When both of the switches are pushed forward, the DC motors are able to turn clockwise, and when they are both pulled back the DC motors rotate counterclockwise. This will allow the shovel to move up and down. Additionally, the servo motors can be rotated using the pushbutton. By clicking this button, the user can make the shovel rotate inwards and outwards. The motors are connected to a conveyer belt, which is connected to the rod on the shovel. This means, when the DC motors are activated, they turn the conveyer belt, which in turn operates the shovel. Due to the fact that the servo motors can make the shovel rotate inwards and outwards, the client can make the shovel rotate halfway inwards when it is not being used, so that it takes up less space when she is moving around. This is done using the servo motors. The pouches on both sides of the walker are for the client to store anything she may need while on the go, so that she does not have to carry them herself. There are also elastic holders located on the left pouch of the walker to hold things like paint brushes or pencils. This would come in handy if she were to be using the walker as support while she was painting. We have included a detachable arm and wrist rest for the client when she is using the walker for support. It attaches onto one of the handlebars and is perfect support for when she is painting while standing. The parts that meet the arm are made of memory foam and are lined with cotton (Figures C1-C7).

We were able to meet all our objectives. In terms of comfort, we chose to measure it by seeing how comfortable it will be on the client's skin and how long she can use it before she feels any discomfort. We are using materials that she said work well with her so we know that it should agree with her skin, however we are unfortunately unable to test how long she can use it for. We decided to measure independence by considering the number of steps it takes to operate. All the controls are done with the flick of a couple switches. Therefore, it only takes a couple steps to fully operate, which means she can easily use it herself. Finally, we chose to measure reliability by seeing how long the product will last. While we unfortunately cannot say for sure how long it will last, we did choose to use very reliable and long lasting materials, such as aluminum and acrylonitrile butadiene styrene, which should be promising.

The production of Stroll n' Shovel took place online. However, if we were able to produce this product in person, we would include all the materials and parts that were mentioned above. The circuit would be connected internally in the walker, and still controlled using the switches. The total cost of Stroll n' Shovel would be about $152. (Table C1).

Conclusions

In the future, the Stroll N' Shovel could have a lot of potential design upgrades. For starters, if our group had more time to complete this design, we would have replaced the switches with joysticks, as it would have a lower probability of causing any injuries and would be much easier for the client to use, in general and on days her fingers are swelled up. Along with this, the number of switches/joysticks/pushbuttons could also be decreased, and function fully based on the code with minimal manual input. To further improve the design, it would be in best interest to simplify the movements and attachability of the arm rest. This will allow the client to easily attach/detach the arm rest without using excessive force. In the future, we could possibly change the design of the shovel in order to maximize the total volume of objects it is capable of holding, which may highly benefit the client in many of her daily day-to-day tasks. Additionally, we could ask the client for some of her favourite colours and other materials that she prefers to customize the Stroll N' Shovel to her preferences.

Although our team had been missing one person, our team dynamic worked well, as we all contributed extensively to group discussions and milestones. In fact, sometimes we were able to get ahead in some of our milestones due to the fact that we all contributed and attempted to fill in the gaps. If our team were to work together again in the future, we would separate the work more effectively, as to accomplish more in a limited time period.

Looking back, this project was very valuable, as it was able to provide us with a lot of experience on the design process. It forced us to take the situation and look at it step-by-step and get every person in the group involved, instead of one person making a half-decent solution right away. Due to the fact that one of our teammates was missing, to improve the design process in the future, as a group of three, we could brainstorm more ideas and try to look things from different points of view to overcome the lack of another's point of view.

List of Sources

[1] Autodesk Inventor Professional, CA, USA, 2021 (https://www.autodesk.ca/en/products/inventor/overview).

[2] "Ankylosing spondylitis | Symptoms, causes, treatments." https://www.versusarthritis.org/about-arthritis/conditions/ankylosing-spondylitis/ (accessed Mar. 08, 2021).

[3] Drugs.com, "Lymphedema," *Drugs.com*, 2020. https://www.drugs.com/health-guide/lymphedema.html (Accessed Mar. 12, 2021).

[4] "Helpful Devices for People With Ankylosing Spondylitis | Everyday Health." https://www.everydayhealth.com/hs/ankylosing-spondylitis-treatment-management/assistive-devices/ (accessed Mar. 10, 2021).

Appendix A

Medical Documents

[1] "Ankylosing spondylitis | Symptoms, causes, treatments." https://www.versusarthritis.org/about-arthritis/conditions/ankylosing-spondylitis/ (accessed Mar. 08, 2021).

[2] Drugs.com, "Lymphedema," *Drugs.com*, 2020. https://www.drugs.com/health-guide/lymphedema.html (Accessed Mar. 12, 2021).

Patents

Walker: https://patents.google.com/patent/US3945389A/en?q=(walker)&inventor=Alfred+A.+Smith

Shovel: https://patents.google.com/patent/KR200443333Y1/en?q=plastic+shovel&oq=plastic+shovel

Basket: https://patents.google.com/patent/US8322583B2/en?q=bike+basket&oq=bike+basket

Commercial Products

Figure A1: The shovel, walker, and basket which were referenced for our design

Objective Tree

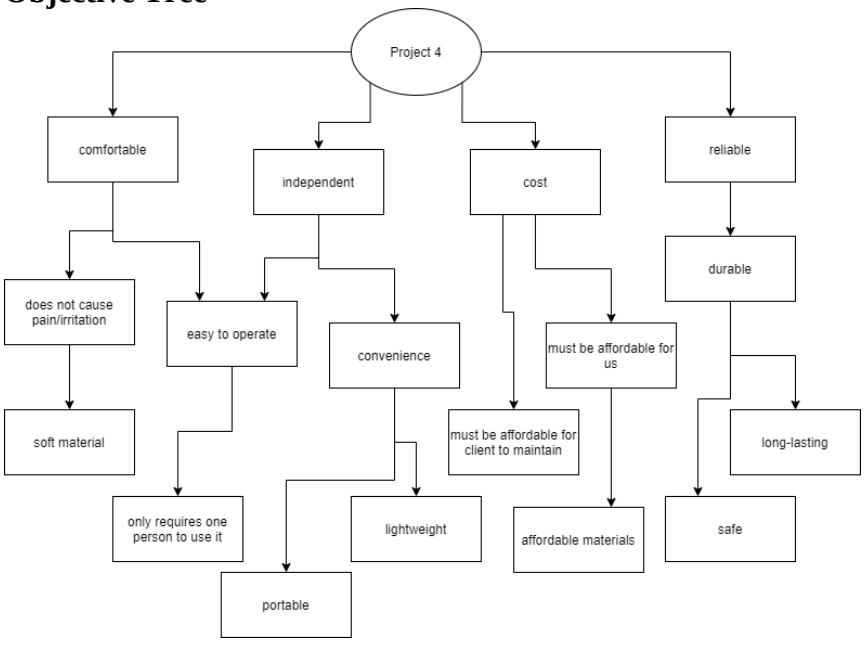


Figure A2: Objective Tree

Client Meeting Notes
https://docs.google.com/document/d/1Ww0lrmZyb_R6aS4ZIE3xPPtM3MVG4y46A_Wk0jCRdZ8/edit?usp=sharing

Appendix B

Morph Chart

Table B1: Morph Chart

Functions	**Mean 1**	**Mean 2**	**Mean 3**	**Mean 4**	**Mean 5**	**Mean 6**
Picking up objects	strong magnet	velcro	suction cups	vertical conveyer belt	gripper/claw	Qbot w/ shovel and mini elevator
Provides support	crutch/cane	waist support belt with wheels 	walker			
Holding items	pockets	basket	pouch	elastic outlining brushes 		

Decision Matrices

Table B2: Decision Matrix

Criteria	**Weight**	**Conveyor belt**		**Walker**		**Supporting Jacket**	
		Rating	**Weighted Rating**	**Rating**	**Weighted Rating**	**Rating**	**Weighted Rating**
Convenience	4	3	12	4	16	3	12
Comfort	5	4	20	4	20	4	20
Easy to Operate	5	3	15	5	25	4	20
Durability	4	5	20	5	20	5	20
Easy to Implement	3	3	9	2	6	3	9
Total			76		87		81

Design Review Notes

Table B3: Design Review Notes and Feedback

	Design Review 1	**Design Review 2**
Peers	- Prototype 2 - should have some more back support - Prototype 2 - Wrist rest + arm rest (moveable) - Prototype 1 – add support for arm - Prototype 1 – make out of durable material with soft grip - Prototype 1 – make box like a shovel - Prototype 1 – able to pick up small objects?	- Think about strength of shovel, weight of walker and what's the max load that can be picked up by the shovel?
Science Students	- Prototype 2 - Adjustable arm rest, should bear weight of arm - Prototype 2 - Wheels/legs should be stable so that it doesn't bend (thicker, made of one piece) - Prototype 2 – can it be used when client is sitting down (adjust/remove legs) - Prototype 2 - Make sure arm straps are lightweight	- Move wheels to the outside of walker - Make shovel out of plastic rather than aluminum - Make arm rest out of memory foam and line with cotton rather than making it fully out of cotton - Try to make design more colourful and artistic in any way

Initial Sketch and Prototype

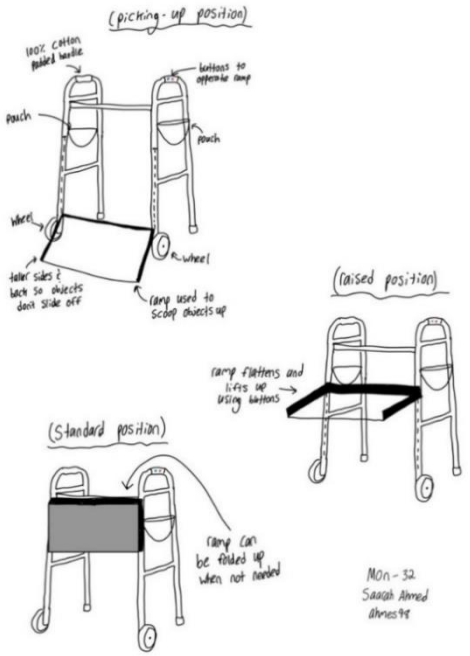


Figure B1: Initial Sketch (Concept 1)

Figure B2: Initial prototype of the Stroll N' Shovel

Sketches of Design Alternatives

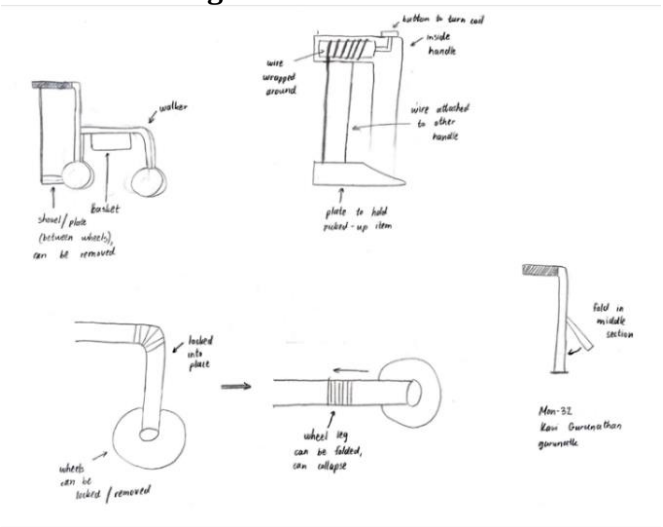


Figure B3: Initial Sketch (Concept 2)

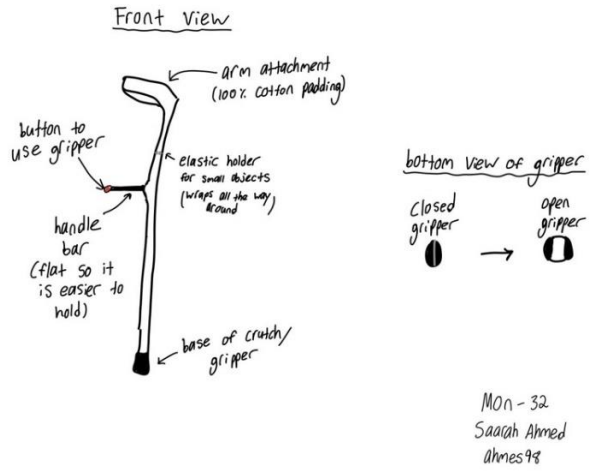


Figure B4: Initial Sketch (Concept 3)

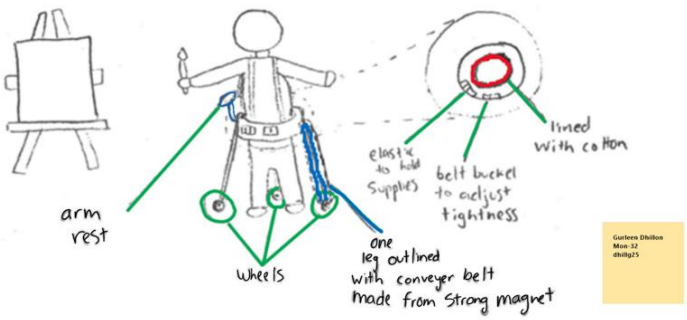


Figure B5: Initial Sketch (Concept 4)

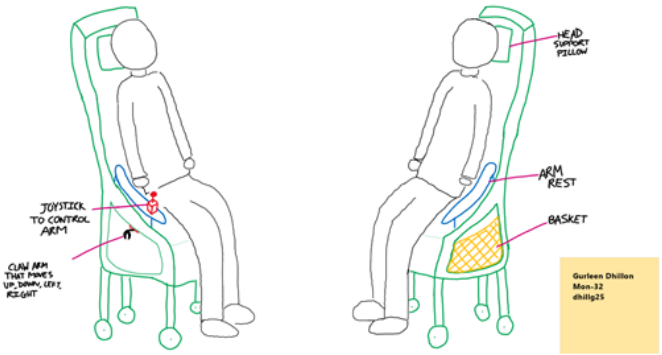


Figure B6: Initial Sketch (Concept 5)

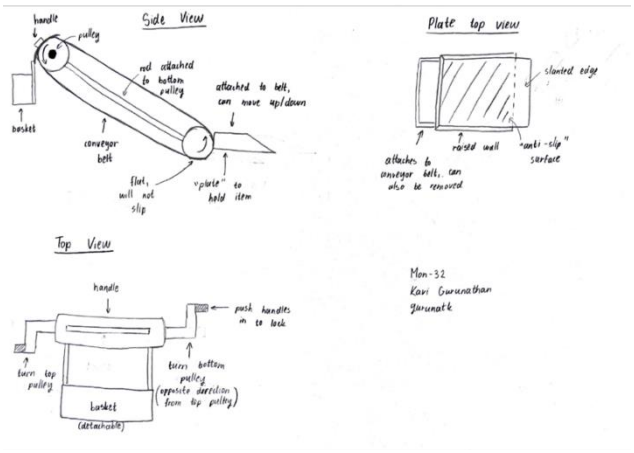


Figure B7: Initial Sketch (Concept 6)

Prototypes of Other Concepts

Figure B8: Prototype of Supporting Jacket

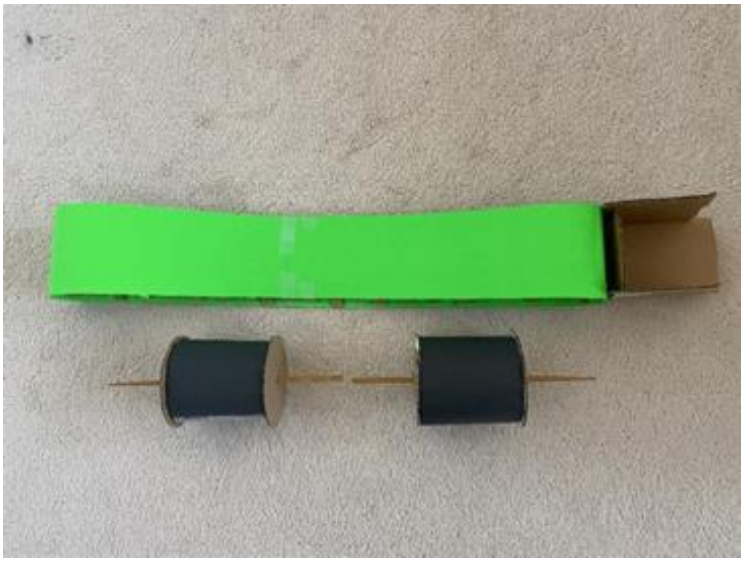


Figure B9: Prototype of Conveyor Belt

Appendix C

Final Drawings

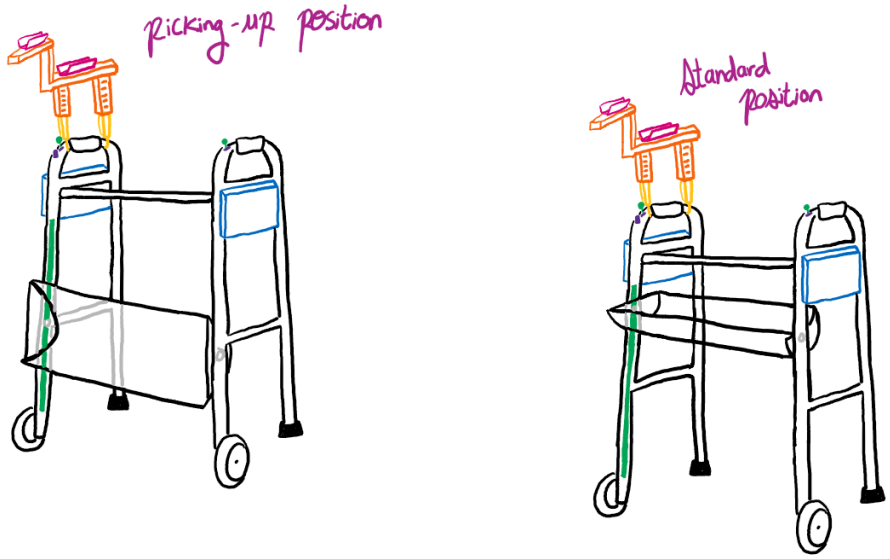


Figure C1: Final sketch of Stroll N' Shovel

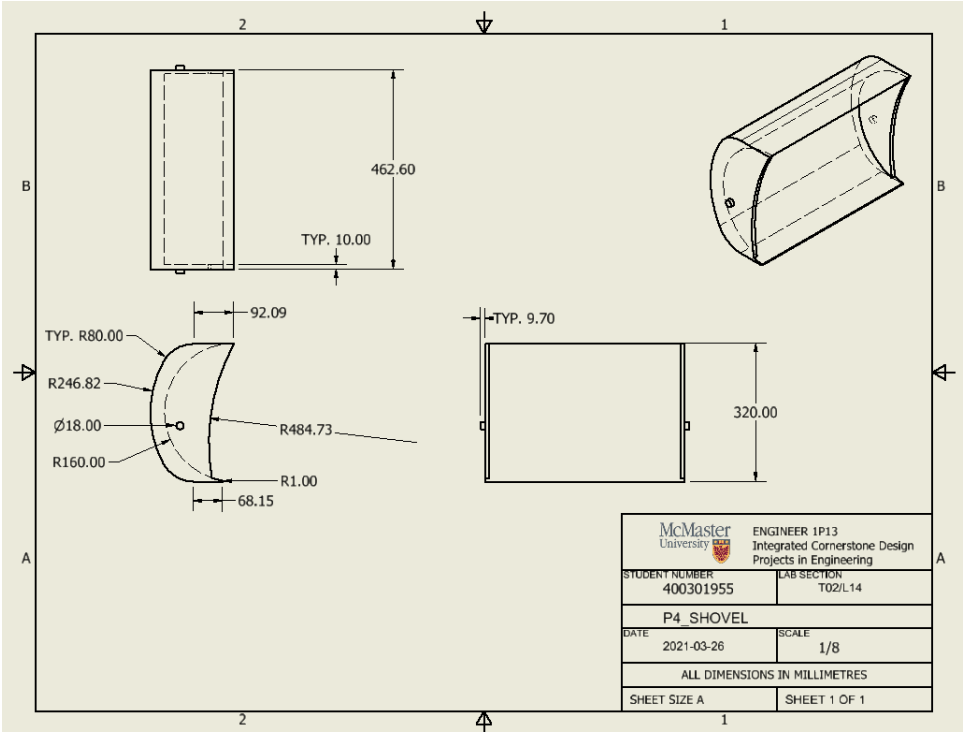


Figure C2: Engineering drawing of shovel

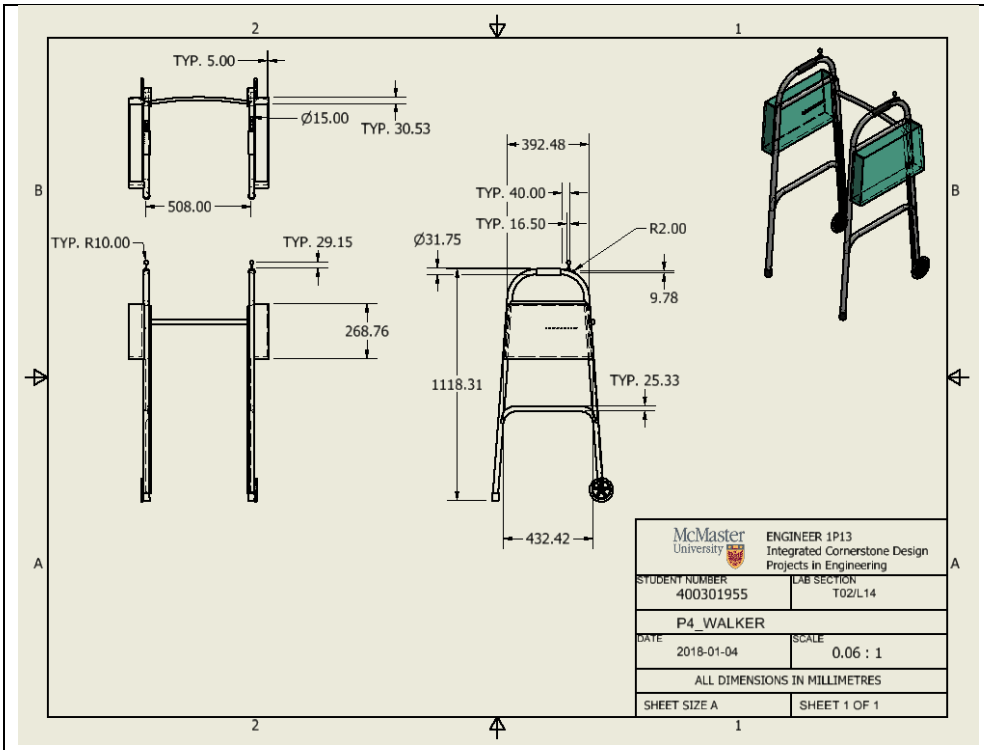


Figure C3: Engineering drawing of walker

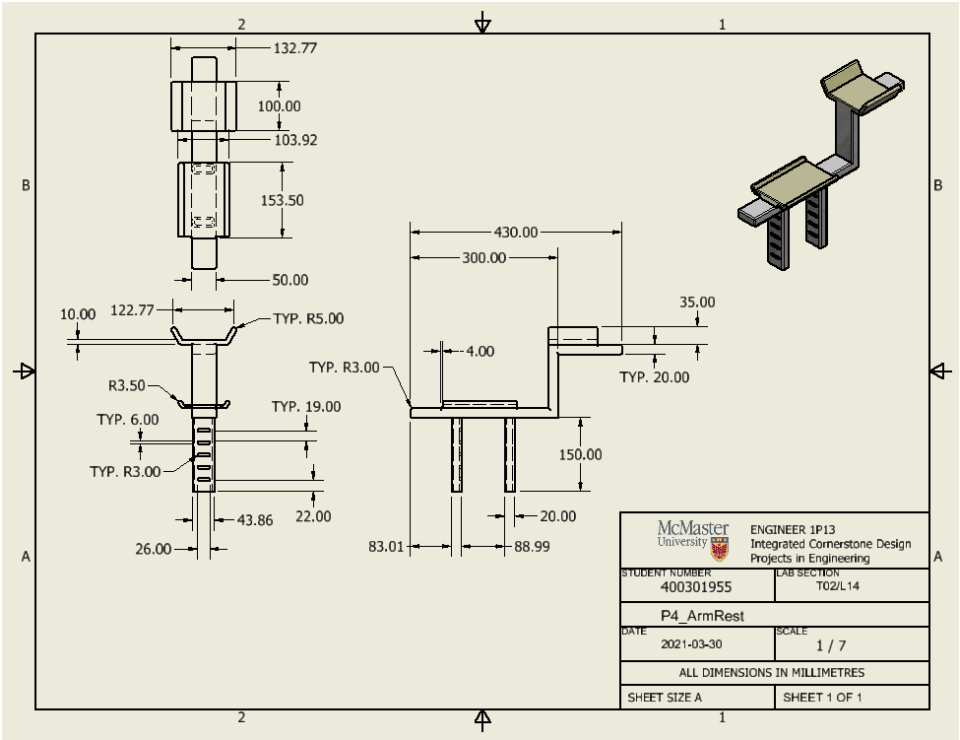


Figure C4: Engineering drawing of arm rest

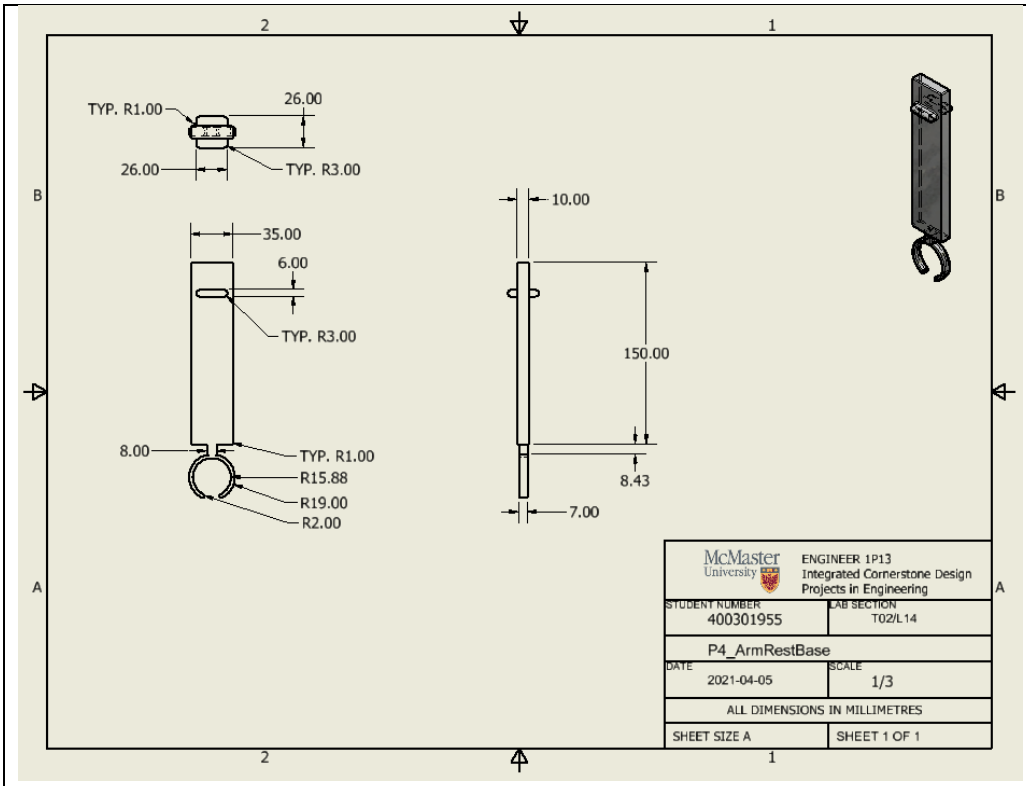
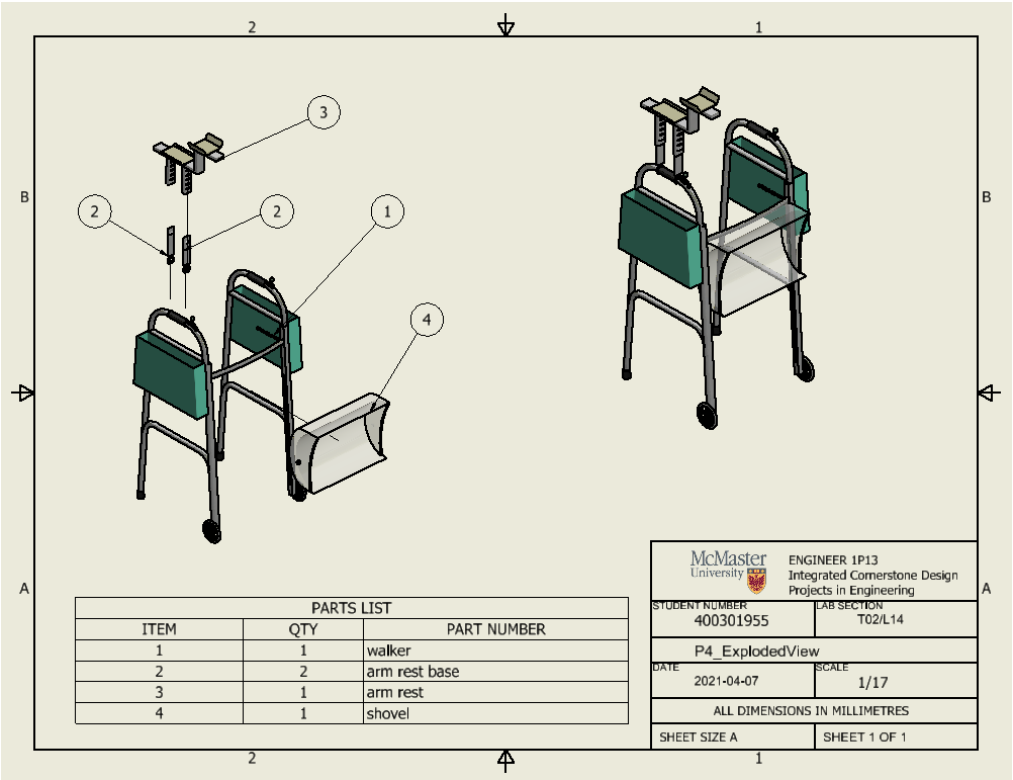


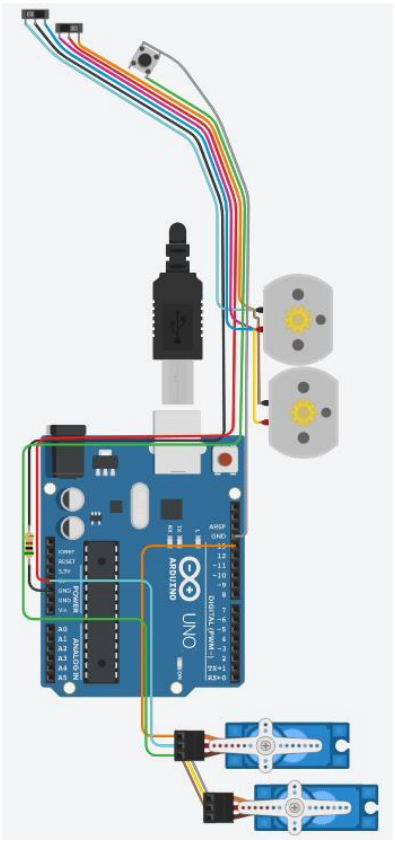
Figure C5: Engineering drawing of arm rest base

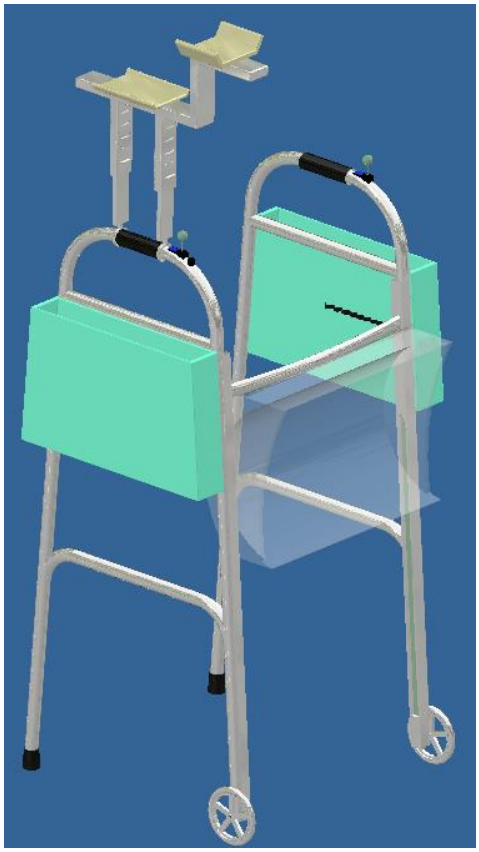


PARTS LIST		
ITEM	QTY	PART NUMBER
1	1	walker
2	2	arm rest base
3	1	arm rest
4	1	shovel

Figure C6: Exploded view

Final Prototype





```
#include <Servo.h>
Servo myServo;

void setup()
{
  myServo.attach(13);
}

void loop()
{
  myServo.write(135);
  delay(1000);
  myServo.write(-135);
  delay(1000);
}
```

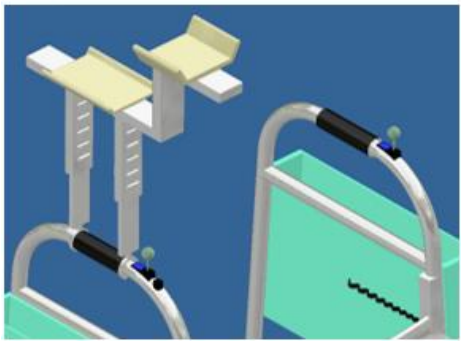


Figure C7: Final layout of circuit on the walker, final CAD prototype of walker, and final code for servo motor

Bill of Materials

Table C1: Bill of Materials

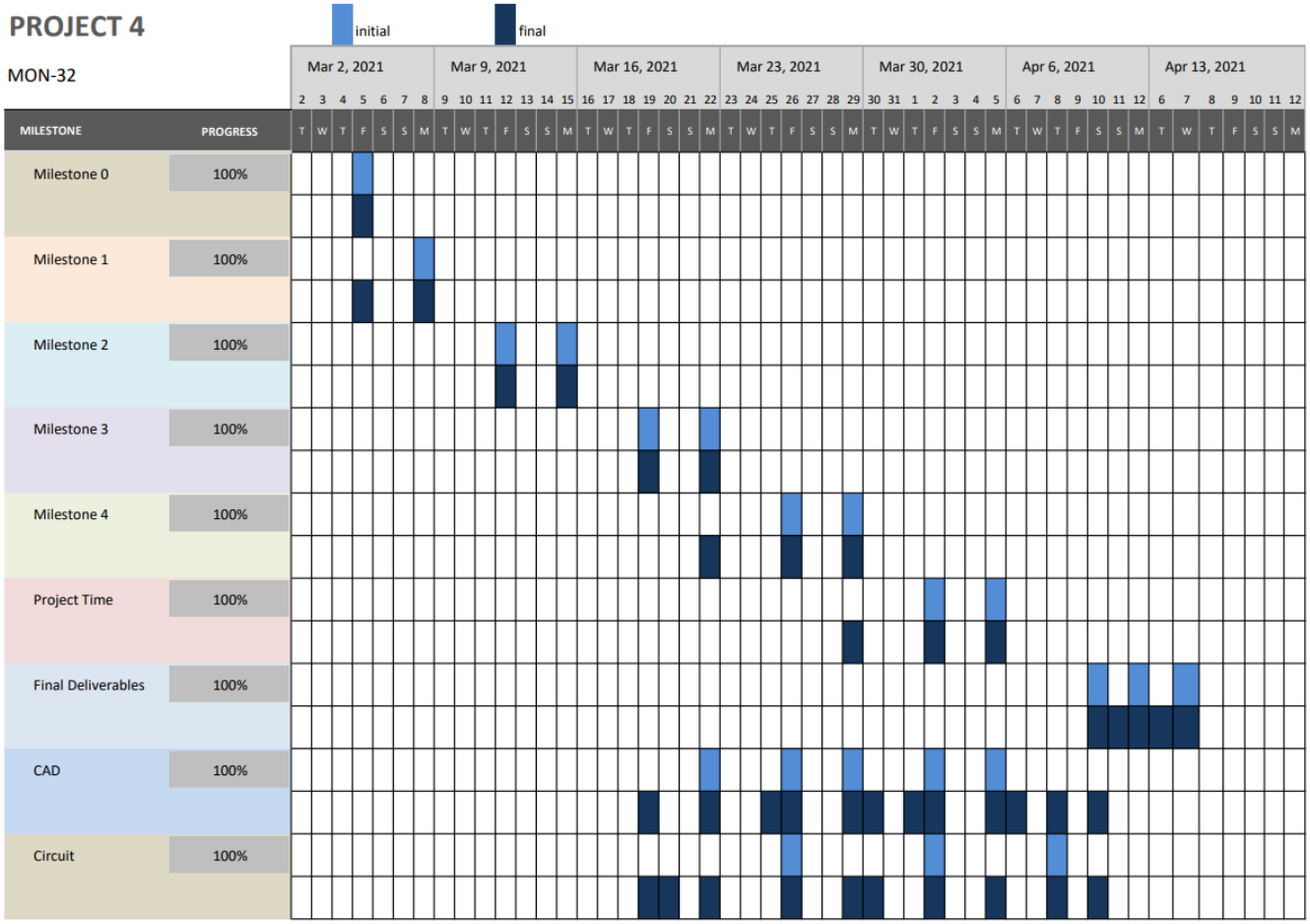
Part	Number	Cost for Each Part ($)	Total Cost Before Tax ($)	Source
Aluminum walker	1	$50.00	$50.00	Hudson's Bay
Servo motors	2	$5.00	$10.00	RobotShop
Cotton lining	1	$14.00	$14.00	Walmart
Memory foam	1	$25.00 (75x40x5cm)	$25.00	Walmart
Plastic shovel	1	$40.00	$40.00	Walmart
Cotton pouches	2	$2.00	$4.00	Michaels
Elastic	1	$1.00 (50 cm)	$1.00	Michaels
Switches	2	$0.77	$1.54	ABRA electronics
Pushbutton	1	$0.69	$0.69	ABRA electronics
DC motor	2	$3.00	$6.00	ABRA electronics
TOTAL COST			**$152.23**	

Appendix D

Preliminary Gantt Chart
No Manager

Final Gantt Chart

Table D1: Final Gantt Chart



Logbook of Additional Meetings and Discussions

Table D2: Logbook

Date	
March 30th, 2021	• Worked on assembly • Adjusted parts to better fit the overall design • Started presentation
April 8th, 2021	• Finished assembly and constraints • Finished presentation slides • Wrote presentation script
April 10th, 2021	• Made any final changes to assembly, presentation and script • Recorded presentation • Divided up final deliverable work

Appendix E

Source Materials Database

Patents in Appendix A

[1] "Foldable walker," May 1973. Accessed: Apr. 11, 2021. [Online].

[2] "Improved Structure of Blade Reinforcement of Plastic Shovel," April 2008. Accessed: Apr. 11, 2021. [Online].

[3] "Detachable collapsible bicycle basket," September 2011. Accessed: Apr. 11, 2021. [Online].

Materials listed in Appendix C, Bill of Materials

[4] "Hudson's Bay: Canada's Iconic Department Store." https://www.thebay.com/ (accessed Apr. 9, 2021).

[5] "RobotShop | Robot Store | Robots | Robot Parts | Robot Kits | Robot Toys." https://www.robotshop.com/ca/ (accessed Apr. 9, 2021).

[6] "Online Shopping Canada: Everyday Low Prices at Walmart.ca!" https://www.walmart.ca/en (accessed Apr. 9, 2021).

[7] "Michaels Stores – Art Supplies, Crafts & Framing." https://canada.michaels.com/en/Home (accessed Apr. 9, 2021).

[8] "ABRA Electronics, at your service since 1990." https://abra-electronics.com/ (accessed Apr. 9, 2021).

Sources from Research Summary (Milestone 2)

[9] "Simple Walker | 3D CAD Model Library | GrabCAD." https://grabcad.com/library/simple-walker-1 (accessed March , 2021).

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