uOttawa

Faculté de génie
Faculty of Engineering

GNG2101 Deliverables

2023 Fall

Group: 1.5

Team Members	Student No.
Ben Rundle	300240619
Kaiyuan Ye	300028711
Christopher King	300226522
Haoyu Pu	300250640
Dominic Roy	300232400
Ez Aziz	300251451

Project Preferences:

1st choice: Hearing Aid Reminder
2nd choice: Wheelchair Backpack transfer device
3rd choice: Scheduling Good Habits App

GNG2101
Team Contract

Group1.5

Team Procedures

1. Day, time, and place for regular team meetings:

Our regular meetings will be scheduled on Saturdays from 9am to 12pm. They will be either in person, virtual, or hybrid. Team meeting is open to be moved to another day if agreed upon at least 24 hours in advance

2. Preferred method of communication (e.g., e-mail, cell phone, Facebook, Blackboard Discussion Board, face-to-face, in a certain class) to discuss the project and to inform each other of team meetings, announcement, updates, reminders, problems:

   The team has set up a Discord chat with all members that will serve as the primary form of communication. Moreover, for virtual meetings, Discord will be the default platform.

3. Decision-making policy (by consensus? by majority vote?):

   Major group decisions will be made by majority vote, with extra effort given to ensure agreement between members. Absence during the vote will be deemed as abstention.

4. Method for setting and following meeting agendas (Who will set each agenda? When? How will team members be notified/reminded? Who will be responsible for the team following the agenda during a team meeting? What will be done to keep the team on track during a meeting?):

   Every team member can add tasks to the team agenda in Wrike. The team leader will assume the responsibility of maintaining focus during the meeting, ensuring that each agenda item is addressed.

5. Method of record keeping (Who will be responsible for recording & disseminating minutes? How & when will the minutes be disseminated? Where will all agendas & minutes be kept?):

   A OneDrive folder containing a Word document for each meeting will be accessible to all team members. Within these Word documents, the meeting's discussion content will be documented, including updates on tasks, issues, task assignments, and plans for upcoming meetings.

Team Expectations

Work Quality

1. **Project standards** (What is a realistic level of quality for team presentations, collaborative writing, individual research, preparation of drafts, peer reviews, etc.?):

   Presentations must be concise, on-point, and effectively structured. Research should be comprehensive, pertinent, and sourced from academically credible references. Tasks should be completed efficiently and within established deadlines. Drafts should offer a clear delineation of the intended objectives, and peer reviews should entail members comprehending their assigned tasks and offering constructive feedback, all while respecting each member's contributions.

2. **Strategies** to fulfill these standards:

   In team meetings, team members will share updates regarding their ongoing work with the entire team. This will create an opportunity to address any potential challenges or acknowledge achievements, while also allowing for further discussions in smaller groups among team members after the meeting concludes.

Team Participation

1. Strategies to ensure cooperation and equal distribution of tasks:

   Task assignments will take place during team meetings, each allocated to individual team members through Wrike.

2. Strategies for encouraging/including ideas from all team members (team maintenance):

   All team members will uphold a respectful and inclusive atmosphere, ensuring that every member has an equal chance to voice their thoughts. One method to facilitate this will involve breaking into pairs, followed by regrouping as a whole to foster creative idea generation and allow for the expression of concerns.

3. Strategies for keeping on task (task maintenance):

   During each meeting, the team will assess the progress made by its members on their respective tasks. If a member is experiencing difficulties in keeping up, they are encouraged to proactively seek assistance from their peers beforehand to collaboratively find a solution. If, during a team meeting, it becomes apparent that a member is falling behind, they will be encouraged to provide reasons for the delay,

enabling the team to work together to prevent such issues in the future. Also, peer reviews will motivate team members to stay on course.

4. Preferences for leadership (informal, formal, individual, shared):

Leadership will be shared between team members and is dependent on the current task. (For example: meeting leadership rotates weekly, so the role is shared between the team and decisions are made based on a vote rather than just following one person's lead)

Personal Accountability

1. Expected individual attendance, punctuality, and participation at all team meetings:

Members are expected to maintain a 100% attendance record and arrive promptly for meetings. If a member is unable to attend, it is crucial for them to communicate their unavailability in advance and explore alternative ways to participate, such as sending a written version of their weekly updates or trying to join the meeting even if they will be arriving late.

2. Expected level of responsibility for fulfilling team assignments, timelines, and deadlines:

Every member bears the responsibility of successfully completing their assigned tasks. It is expected that members proactively seek assistance from their peers when necessary and promptly communicate with the team if any issues or challenges arise. All work should adhere to the highest standards to meet the client's specified requirements, and all established deadlines must be honored.

3. Expected level of communication with other team members:

Members will be required to regularly check their Discord and email accounts at least 2-3 times daily and respond, as necessary. Additionally, during meetings, active engagement is expected, and members should feel comfortable expressing any concerns they may have regarding decisions or tasks.

4. Expected level of commitment to team decisions and tasks:

All team members must honor the decisions made by most of the team and fulfill their assigned tasks. While concerns and issues can be openly discussed, once a plan is established, it must be respected and adhered to.

Consequences for Failing to Follow Procedures and Fulfill Expectations

1. Describe, as a group, how you would handle **infractions** of any of the obligations of this team contract:

   For the initial two violations, team members will be addressed collectively by the team. They will receive a verbal warning and engage in a discussion to plan and implement strategies for avoiding similar issues in the future. These strategies may involve task distribution adjustments, clear notifications to team members about task availability, or other appropriate measures.

2. Describe what your team will do **if the infractions continue**:

   Upon the occurrence of a third infraction, the Teaching Assistant (TA) or the Project Manager will be informed, and the appropriate disciplinary actions will be applied in accordance with the course policy.

****

a) *I participated in formulating the standards, roles, and procedures as stated in this contract.*
b) *I understand that I am obligated to abide by these terms and conditions.*
c) *I understand that if I do not abide by these terms and conditions, I will suffer the consequences as stated in this contract.*

1) Ben Rundle Date: 9/13/2023
2) Dominic Roy Date: 9/13/2023
3) Ez Aziz Date: 9/13/2023
4) Christopher King Date: 9/13/2023
5) Haoyu Pu Date: 9/13/2023
6) Kaiyuan Ye Date: 9/13/2023

GNG2101
Client Interview Plan

Group1.5

Interview Organization

- We need at least 2 persons to jot down answers.
- Interview will be conducted virtually.
- Ask permission for voice or video recording.
- If anyone has follow-up or clarifying questions they should be asked right away

Interview Questions

Kaiyuan Ye: Could you please describe your daily usage with the wheelchair? What do you usually carry with you daily?

3. Do you need to be able to move while the backpack is on the side?

4. (Hao) Is there anything other than a backpack that you would like to carry?

5. (Chris) What struggles do you face currently with your method of carrying a backpack?

6. (Ez) How does added weight affect the effort to push the wheelchair or the way it can manoeuvre? 400lb, client weight about 120lb

8. Do you have any preference for how the device looks? (color, size, etc)

11. What is your method carrying your bag or carry-on while sitting down? What do you like and dislike about it?

12. (Dominic) Are there any products you have tried specifically for this issue? Have you found any problems or things that can be improved?

14. Are there any items needed for your daily life that you think needs priority in the design of the product? Any specific spots or cubbies that need to be made priority for the design?

16. Would you be willing to open a line of communication with us outside of our scheduled meeting times for additional updates and feedback?

Client Answers – Meeting 1

Client is his son, PERMOBUIL M5

Every day, power wheelchair with a joystick. Uses it for university every day.

2 hooks at the back of the wheelchair where he hands a backpack.

Can not raise his arms, only hand mobility. Has 2 wheelchairs, but only uses one, the other for emergencies.

Right-handed joystick, so make the arm come on the left side.

Primary concern is backpack, needs external help to get things out of the backpack. No way for him to reach around and get things out.
Tray table is needed

Wheelchair is motorized and quite powerful, so added weight it less of an issue.

Always stored inside but occasionally used in all weather

Ideal to be removable from the chair so servicing is made easier (need be basis).

Cannot be too large for elevators etc.

Cannot splice into wheelchair battery source. Warranty Void

Built in bag, REALLY LIKES bag built onto arm. Water bottle storage as well

Bag must be brought to the front of him, in front, less preferable on the side.

Laptop, lunch, books

Weather affects his hands and mobility, only after an extended period outside

Can be put on right side, same side as controller

Cannot exceed width of wheelchair.

Side swing arm and overhead arm acceptable design criteria

GNG2101
Gantt Chart

Group1.5

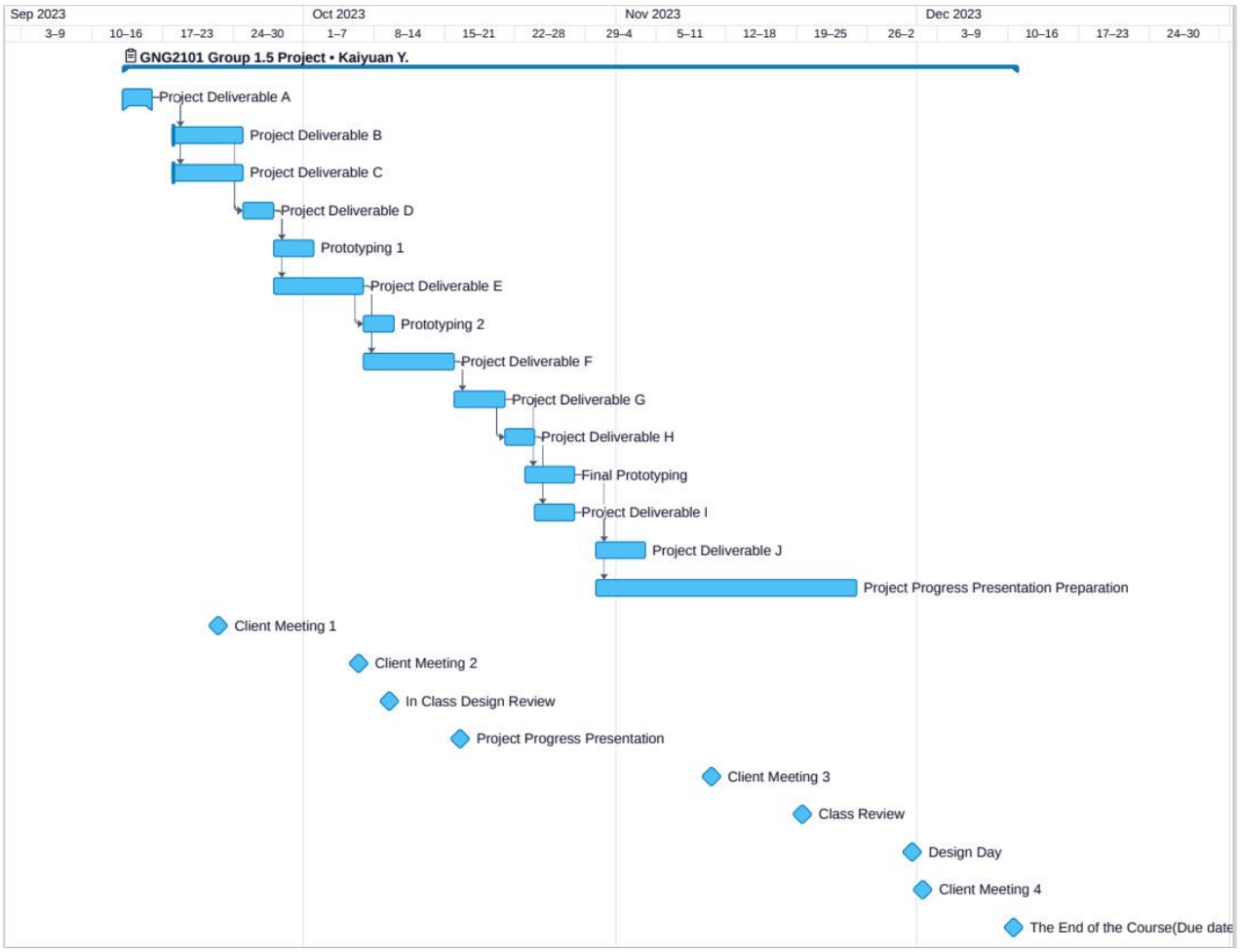


Figure 1: Wrike Gantt Chart as of Sept 16th, 2023

GNG2101 Deliverable B

B.1 Business model and sustainability report:

1. Identify and describe your value proposition that would be well suited to commercializing your team's product. Discuss the reasons for your choice.

- **"Creating Independance and mobility for wheelchair users."**
    - Addressing a Genuine Need: Our product solves a genuine need in the wheelchair community. It is very common to see people in wheelchairs with their backpacks on their laps or to imagine the cumbersome task of reaching around to access your things. Our product proposes a solution to these problems.
    - Accessibility: This product provides accessible and convenient access to personal belongings, making everyday tasks more manageable. This not only simplifies daily life but also boosts the overall quality of life for users.
    - Safety and Reliability: The project will be designed with a strong focus on safety and reliability. We plan to ensure the backpack attachment mechanisms and safety precautions that give users peace of mind.

- *2. Fill in a triple bottom line business model canvas by answering the how, what, who and how much of your chosen business model.*

Triple Bottom Line Business Canvas

Key Partners • Wheelchair manufacturers for integration. • Healthcare providers and therapists for referrals. • Non-profit organizations for distribution to underserved communities. • Long-term care centers and retirement homes.	**Key Activities** • Research and development for continuous product improvement. • Production and quality control. • Marketing and outreach to wheelchair user communities. • Sustainability monitoring and reporting.	**Value Proposition** Creating Independance and mobility for wheelchair users.
Key Resources • Product development teams. • Manufacturing Facilites. • User feedback and testing.	**Customer Relationships** • Direct sales and customer support.	**Customer Segments** • Wheelchair users of all ages and abilities.

• Sustainable Material suppliers.	• Online communities and forums for user engagement. • Collaboration with healthcare professionals for recommendations.	• Healthcare institutions and assistive device suppliers. • Non-profit organizations and foundations focused on disability support.
Cost Structure • Research and development costs. • Manufacturing and materials expenses. • Marketing and promotion. • Customer support and service. • Sustainability initiatives.	**Revenue Streams** • Product sales (physical/online) • Accessories and add-ons Customization Services (branding/color customizations) • Government/Corporate contracts	**Channels** • E-commerce platform for direct sales. • Partnerships with wheelchair manufacturers and healthcare providers. • Participation in assistive technology expos and events.
Social & Environmental Costs • Compliance: Compliance with environmental regulations, safety standards, and accessibility requirements can be a significant constraint, leading to potential legal issues • Resource Availability: The availability of sustainable materials, such as recycled plastics or eco-friendly textiles, can be limited. • Cost Considerations: Sustainable practices often come with additional costs, whether it's using recycled materials or implementing energy-efficient manufacturing processes. • Market Acceptance: The market's willingness to pay a premium for sustainable products can be a constraint. Customers may not be willing	**Social & Environmental Benefits** • Use of sustainable materials and energy efficient manufacturing. • Reduction in waste through long-term durable design • Increased independence and quality of life for wheelchair users. • Collaboration with disability advocacy groups.	

to pay more for eco-friendly features.		

- *3. Describe the core assumptions that you have made in developing your business model canvas and comment on its feasibility. Important: These core assumptions should be based on the business model you have chosen and not on your prototype (e.g. what type of clients do you assume your product will attract?).*

Some assumptions made of our target audience are as follows:

Environmental Consideration: We are assuming that our users are whiling to pay the additional costs that come with developing an eco-friendly product and that they see the benefit of prioritizing renewable production methods in our work. It isn't realistic to think everyone will share this opinion, but it is observed by many.

Individual Market Acceptance: We are making the assumption that the user/customers will see the value in our product and its advantages. It is possible that a portion of the market does not see our product as an upgrade, but rather a hassle or liability, but it is reasonable to assume that a large portion of the market will see its value.

Universal Compatibility: Lastly, we are assuming that the device can be constructed with sufficient compatibility to be adaptable to a wide range of models, enough to be able to facilitate an online market and bulk orders. It isn't feasible to assume that one product could do this, but if a small range of options were developed, then this could be doable.

- *4. Provide a sustainability report that reflects on at least two of your product's major social, environmental, and economic impacts, both positive and negative. Perform a simple analysis of these impacts and use this analysis to help you fill in the triple bottom line of your business model canvas. B.2*

Our commitment to sustainability and accessibility is at the core of our mission. We will develop a wheelchair backpack transfer device to enhance the quality of life for individuals facing accessibility challenges, particularly those who rely on wheelchairs. This innovative device addresses a gap in the accessibility market and aligns with global sustainability and accessibility standards and goals.

Social Impact:

This device will offer substantial social impacts for individuals who face accessibility issues. This includes:

- Enhanced quality of life
    - This device will allow wheelchair users to live more independently with fewer hurdles to overcome in their daily life.

- Inclusivity
    - This device will allow wheelchair users to actively participate in daily tasks.

Environmental Impact:

- Sustainable resources
    - Our device will make use of sustainable materials to minimize the environmental impact and resource depletion.
- Efficient manufacturing
    - This device will be made by energy efficient and minimal waste manufacturing processes.
- Longevity
    - The durability of our product will stand the test of time, leading to less waste from the consumers
- Limited resource availability
    - Although we are committed to using sustainable materials, resources will be more limited, and we will continue to monitor resources in order to ensure that we arent depleting any materials.

Economic Impact:

- Consumer savings
    - Although the use of sustainable practices will lead to raised production and product costs, ensuring that the customers will receive a reliable and high-quality product will lead to long-term savings.
- Market growth
    - By introducing an innovative and sustainable product to the market, we anticipate a growth in the accessibility market as more people recognize this product and invest in this new industry.

Socially, this will allow people to live their lives with fewer hurdles to overcome. Environmentally, this product will be made of sustainable materials and efficient manufacturing processes. However, sustainable resources are limited in numbers and a shortage in the market can possibly cause environmental problems. Furthermore, a well-built and future-proof design will eliminate waste coming from this product. Economically, this product will require extra expenses to accommodate for the sustainable materials and manufacturing processes, though buying a one-time purchase device will save consumers money in the long run.

Design Criteria

1. Ease of use
    a. The number one consideration of the client it that the device can be operated by his son, who has very little mobility. The device must bring the bag close enough to his lap to be useable for him throughout the day.

2. Compact Design
    a. The client expressed concern regarding the width of the design. Since the wheelchair already is quite wide, making it any wider would make it quite difficult to navigate doorways and elevators.
3. Independent Operation
    a. It is also crucial that the design does not modify the wheelchair in any way that would void its warranty. The chair is relatively new and very expensive so the design must run on its own and not use the power source of the wheelchair.
4. Storage Accommodation
    a. The client likes the idea of a standalone storage device that could accommodate his son's things. It must be able to safely hold its school supplies, lunch, water, etc. while still being easily accessible.
5. Durability
    a. The design must be built strong enough to hold his things (~10kg) and operate ~10 times a day. The device will be shaken and could withstand impacts from daily use, and therefore must be constructed with strong materials and fittings.

GNG2101 Deliverable C

C.1 Problem Definition

1. Introduction

2. Client Statement and Interpreted Needs

Client Statements	Interpreted Needs	Priority
"He uses wheelchair all the time. The wheelchair is electric powered. His wheelchair has a control stick on the right-hand side"	The wheelchair backpack organizing device is compatible with the electric-powered wheelchair.	5
"He cannot rise his hands."	The wheelchair backpack organizing device allows for easy access to the backpack without requiring the user to raise their hands.	5
"He is right-handed person"	The wheelchair backpack organizing device has the most control module mounted on the right-hand side.	3
"He has to ask for assistance every time because he has no mobility."	The wheelchair backpack organizing device delivers the backpack to somewhere accessible for the client.	5
The wheelchair is very powerful….it can withstand up to 400 lbs.	The wheelchair backpack organizing device weights less than 100lb (Considering there would be the backpack and the customer weighs about 150lb).	1
The wheelchair is kept in house all the time, but it also could stand with the rain"	The device operates under any weather condition.	4
It is preferable if the device is removable without the need to send the wheelchair to somewhere."	The device created is easily removable with no permanent mounting points.	3
The device should have its own power source. That way, it is independent for the wheelchair."	The device is motorized and has its own power source.	5
I like that … that is a much better approach to the design because if the bag sits on the arm itself there would not be any pressure on his knees…	The device has a compartment to store items.	4
"So far we don't have much concern….I am not sure what kind of locking mechanism you can put it there because his hand strength is not too much….for physical locks, he won't be able to lock and unlock."	The device has a locking mechanism that does not require much physical effort to open or close.	3

"He used to sit on a normal chair to eat, but he cannot do that anymore. What we did was to put a riser on the table …that way he can put his hands on the table and eat. However, at a restaurant, we cannot do that."	The device has a flat tray that can be used as a table for eating.	4
"He normally carries his laptop, lunch box, …."	The device has enough storage space for his daily school essentials.	3
"If his hands get cold, then it would be difficult for him to move the joystick. However, that kind of situation would not happen unless he is outside for hours."	The device can be operated with gloves on.	3
"Some cases we find that are not wide enough for him to go through."	The device is between the maximum width of the chair.	5
"We don't have any requirement for that, but if you can make this device fully automated…that would be our preference. If you want to add additional features, I won't mind."	The device could have additional features.	2

3. Problem Statement

Wheelchair users need an organizing device that allows them to easily and safely retrieve or store items on themself without assistance.

"Design a durable, lightweight, and automatic/electronic backpack transferring device that is easy to use for a wheelchair bounded person. The device is made to carry belongings of the person in an efficient, safe and cost-effective way."

4. Benchmarking Metrics

	Design Criteria	Metrics	Assessing Process

Functional	Reduction of arm movement	m	Measure the longest distance that the user needs to reach to retrieve or store items.
	Status Signaling	Yes/No	Determine if the device would signal its power level.
	Operate in all weather conditions	Yes/No	Determine if the device could operate in rain, in cold temperature, or in hot temperature.
Non-Functional	Level of Automation	%	Determine the maximum number of steps the user needs to take to retrieve any item. Then take the inverse of this number.
	Storage Capacity	cm^3	Measure the storage volume of the device.
	Simple to Maintain	%	Measure the hours of maintenance required for 100hrs usage.
	Simple to Use	count	Determine the maximum number of steps the user needs to take to retrieve any item.
	User safety	count	Determine the number of potential hazards related to the device.
	Reliability	count	Determine the average usage time before the battery runs out.
Constrains	Cost	$	Determine the total manufacturing cost.
	Size	cm^3	Measure the total volume of the device.
	Weight	kg	Measure the weight of the device.
	Compatibility	Kg/cm^3	Take of the coefficient of the device's overall weight divided by the overall volume.

5. Similar Product Benchmarking

5.1 Similar Product #1: Wheelchair Side Organizer Storage Bag

The organizer bag is designed to attach securely to the client's wheelchair, allowing them to access their belongings. The bag's location on the side of the wheelchair makes it easily reachable for the client, even with limited mobility. They can access their essentials, such as a backpack or personal items, without the need to raise their hands or ask for help. It is simple to use and maintain; it is cheap to manufacture; also, it is lightweight. One the other hand, this product does not provide large storage capacity, and it is not waterproof nor weather-proof.

5.2 Similar Product #2: EZ-Shopper Electric Grocery Cart

The Electro Kinetic Technologies, EZ-Shopper 8000 Electric Shopping Cart, provides a large storage compartment, which is in the front. Also, it has a very high-capacity rating of 250lb. However, this device may not be fit for everyone; this device requires the user to have a certain mobility. Also, this product is quite expensive to manufacture, and it is not weatherproof.

5.3 Similar Product #3: Wheelchair Backpack Bag

The wheelchair backpack bag is designed to attach securely to the client's wheelchair, allowing them to access their belongings. The bag's location on the back of the wheelchair might make it

- difficult for the clients with limited mobility. It is weatherproof and simple to maintain; it is cheap to manufacture; also, it is lightweight.

5.4 Similar Product #4: Wheelchair Tray

The Wheelchair Tray is a small table that can attach to the front of a wheelchair to allow a user to place and use their belongings on top. This tray measures 20.5 x 11.8 inches and can hold up to 14.97kg. This solution cannot be easily removed and does not securely hold the users' belongings. Furthermore, the user cannot exit the wheelchair while the device is installed.

6. Target Specification

ID number	Subject	Unit of measurement	Target spec range	Ideal spec range
1	Time from down position to up	Time	10-20s	>15s
2	Time from up position to down	Time	10-20s	>15s
3	Number of cycles needed to complete	N/A	5-8 cycles (1 cycle is up and down)	>=6 cycles

	before battery dies			
4	Total weight of the package	lbs or kg	20-40lbs or 9-18kg	<30 lbs
5	Gross carry weight of the product	lbs or kg	10-20lbs or 5-9kg	>15 lbs
6	Time to charge the battery	Time	2-8 hours	<3 hours
7	Size of storage bin	L	6-12 L of volume	>8L of volume
8	Safety factor	Count	<1 safety concern from wear and normal use	0 safety hazards
9	Maintenance	Time	Every 50-100hrs	>60hrs

Potential Solutions and Theoretical Specification

The solution we are visualizing for the project is a storage bin that moves from the front, side, or back of the wheelchair. The advantage of the wheelchair used by our client is the availability of mounting point all along the side of the wheelchair, which gives more freedom to mounting solutions for the device, we must also make sure that the solutions created do not directly increase the maximum width of the wheelchair as the customer stated the wheelchair is already too wide to fit in elevators, doorways etc. We also need a storage bin as that will act as the secure location for his backpack and belongings. On this matter, the customer stated that it would be ideal if the bin could act as a flat tray to facilitate eating as the customer has limited movement in his arms to reach the dinner table. For the automation of the device, the solutions conceptualized by the team must use a DC (Direct Current) motor with a way to bring the storage bin to the lap area of the customer where it is the easiest reachable area. The ideas being using a DC motor with a gear train, a DC stepper motor with a cable and spool, a linear actuator and rod, and a pivoting robotic arm. For the bin, we also thought of many ways of making sure the backpack and belongings are secured. Making a removable box on the tray, a removable cargo net or simply using backpack hooks.

Automation:

Geartrain DC motor: A simple DC motor with a reduction gear system would provide a simple and compact solution to powering the arm. DC motors can be had for cheap (15-40$), however the drawbacks are finding a motor with enough torque to carry the weight multiplied by the length of the arm is difficult. And finding gears to sustain that weight as well will increase the cost and manufacturing time of the device

Stepper motor with cable and spool: A DC stepper motor has all the gears needed to provide the torque required for our weight application but will add more weight and cost (around 40-60$). The savings come from the cable and spool setup which would increase the simplicity of the automated system.

Linear actuator: A linear actuator is a type of DC motor that translates rotational motion into linear motion. These actuators can range for about the same price as a stepper motor but are much more compact than a stepper motor. The drawback we can see is the potentially unconventional method of mounting a linear actuator to a device that rotates around towards the front of the chair. We cannot put too much strain on the actuator for reliability and efficiency.

Robotic arm: A robotic arm would be a good concept but difficult to pull off. The programming, cost and weight would make this almost unfeasible with the budget and time.

Mounting configuration:

Front mount: Mounting the storage bin in the front would allow for less material and a lower center of gravity as the backpack would be at the feet, rotating up to the lap area. The problem may come from leg room as the bin will be directly in front of the feet. This design also allows for the backpack to be in the user's view, increasing security.

Rear mount: Mounting the storage bin in the back, behind the back rest of the chair would provide lots of free space in front of the user, however the security problems become apparent when the backpack is never in view by the user. The way the backpack would have to travel over the headrest or around the armrest can cause a center of gravity issue for improper handling or tipping over.

Side mount: Side mounting the bin for the backpack has some advantages and disadvantages of both front and rear mounted systems. It is in the users' view most of the time and it would not affect the center of gravity as much as rear mounting. However, it may be more difficult to make a system compact enough to not affect the width of the chair.

Storage solution:

Storage bin: An enclosed storage bin would be the most secure way of storing belongings as no one would be able to see what is in the box. The drawbacks come from construction time and

finding a solution to make the box removable to uncover the eating tray. It would also be bulkier than the rest of the options.

Cargo net: Using a cargo net would provide a good amount of security and can adapt to any shape put into the netting area, retrieving items would be just as easy as the storage bin but would not provide as much protection to the elements.

Backpack hooks: A simple solution that would not provide any security and any protection against the elements if the user goes outside. The bag's security would be at risk due to the uncertainty of the bag's ability to stay hooked on.

Solution Selection Matrix

Potential solution	cost	simplicity	safety	speed	reliability	Total score
Geartrain DC motor	4	4	3	1	2	96
Stepper motor w/cable and spool	3	4	2	3	4	288
Linear actuator	2	4	4	4	3	384
Robotic arm	1	1	4	3	2	24

Potential solution	simplicity	cost	compactness	security	Weather protec.	Total score
Cargo net	4	4	3	4	2	384
Storage bin	3	3	2	5	5	450
Backpack hooks	5	5	5	1	1	125

Potential solution	simplicity	bulkiness	Cost of materials	security	ergonomics	Total score
Front mount	5	4	5	5	2	1000
Rear mount	2	3	3	2	5	180

Side mount	3	3	3	3	4	324

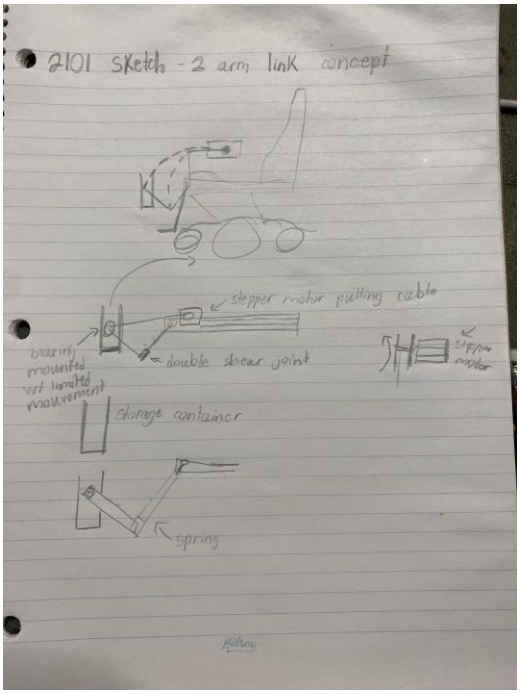
Conclusion

The conclusion we can draw from the potential solutions for each subsystem is that the stepper motor or linear actuator would theoretically work better for automation, the cargo net or storage bin for the storage and front mounting for the mounting solution.

C.2 Concept Development

Potential Concept 1 (Dominic):

Front mounted 2-link arm concept



The concept of this sketch is to have two squared-off arms off the outside of the chair, using the rails on the seat as the mounting point for the arms. This would use a stepper motor and a cable to pull the storage bin from the front of the chair to the lap area for the user, having the storage bin mounted on bearings with hard stops to prevent over-rotation and items falling out. The 2-bar concept shares similar sub-systems with the 4-link arm concept such as the storage box and the cable-drive system.

Potential concept 2: Front mounted 4-link arm concept

This design features a custom-made storage box that is mounted in front of the users' legs. With the push of a button, a motor behind the chair will real in the box, hinging on a 4-bar linkage until it rests on the stoppers – horizontally on the user's lap.

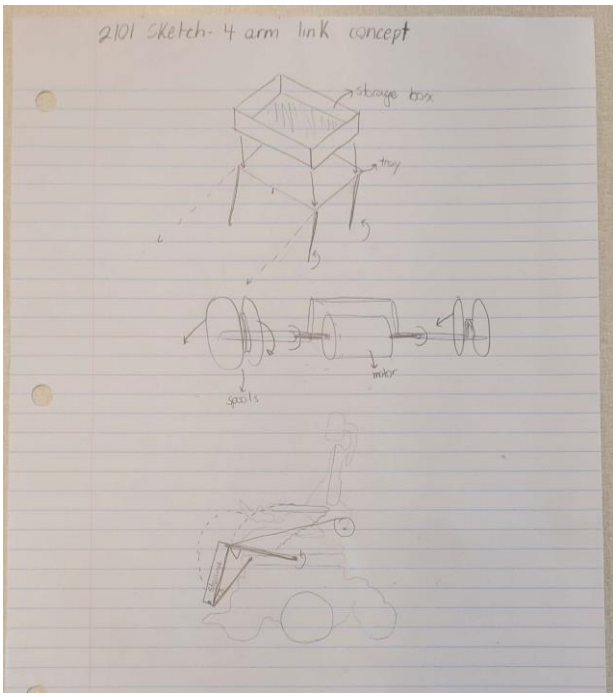
Sub-Systems:

- 4 Bar Linkage
  - The linkage system connects at 2 points on either side of the chair, just below the seat of the wheelchair, and at the 4 corners of the storage box. The links are also fitted with bump stops that will allow the box to securely rest in the upper and lower positions. The links are the appropriate lengths to rotate the box to rest in an upright position and each connection in pinned to only rotate about 1 axis.

- Cable-Drive System
    - Using one DC stepper motor mounted at the rear of the wheelchair, a solid axle will rotate 2 pulleys that will wind up a cord that is connected to each side of the box. This system will be stowed out of the way and is relatively force balanced for reliable operation.
- Storage box
    - The client expressed interest in a custom storage box for the design that will hold the users school supplies and other essentials. The storage box in this design will be a rectangular hard box that will open like a laptop once in position. It will securely hold the users' items and allow for easy access to the internals.

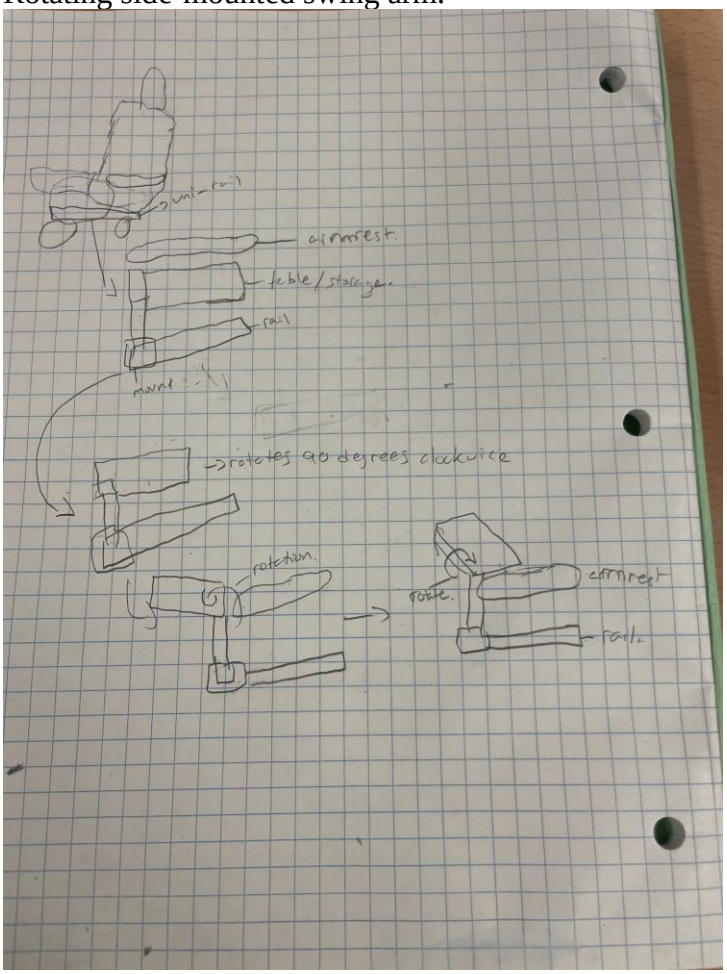
ary of design features

- Won’t extend the chairs width
- Pulleys allow for easy speed/torque adjustment of the cable system
- Motor torque is applied effectively over the extension of the box
- The hinging system is very simple to favor reliability and ease of use



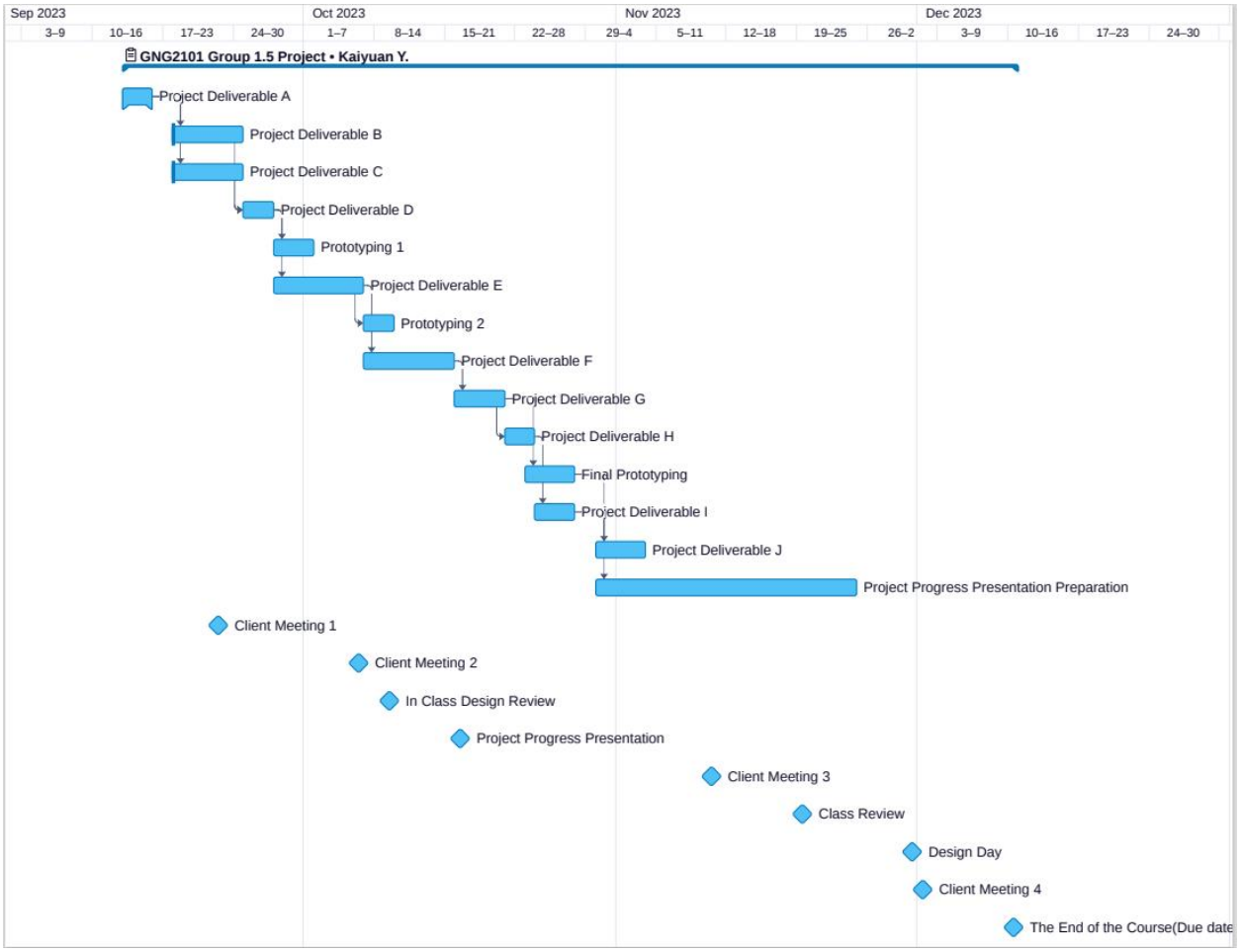
Potential Concept 3:

Rotating side-mounted swing arm.



In this design, there is a storage compartment that doubles as a desk which is attached to the wheelchair with an arm via the universal UniTrack rail available. When not in use, this device will be hidden under the left side arm rest, which then will undergo three different rotations to be situated directly in the reach of the user.

C.3 Project Plan



(Wrike is not working for our team, we do not have access, we cannot edit or make a Gantt chart)

Project Deliverable D

Detailed Design and BOM

Group: 1.5

Team Members	**Student No.**
Ben Rundle	300240619
Kaiyuan Ye	300028711
Christopher King	300226522
Haoyu Pu	300250640
Dominic Roy	300232400
Ez Aziz	300251451

Introduction

In this project deliverable, the best conceptual design from the last deliverable is further developed based on the feedback from the last client meeting. SolidWorks has been used to design the device, where a 3D model has been developed for better visualization. Moreover, based on the detailed concept drawings, the bill of material and list of equipment are created to reveal some possible material or equipment to be used during the prototyping phase. The bill of material lists the materials to build the full-scale prototype. The list of equipment contains the material or equipment that might be used to build small scale prototypes for future project development. Furthermore, a detailed prototyping plan has been developed, where the objective and methodology are defined for the three prototyping phases. Lastly, several risks associated with the project are identified, and contingency plans are made accordingly.

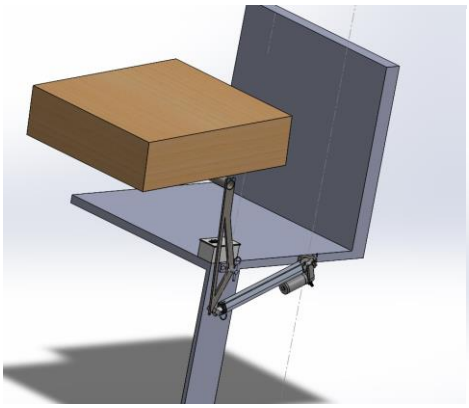
Detailed Design

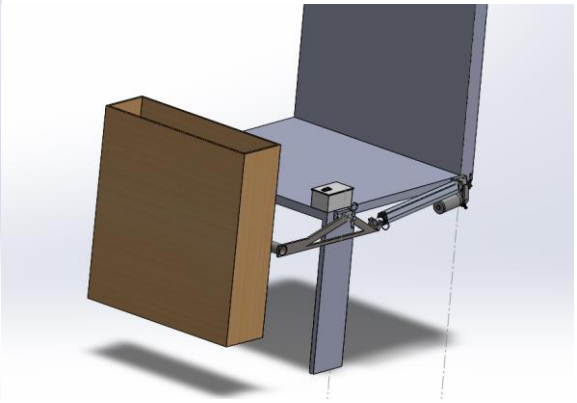
Client Feedback

During the previous client meeting, the client seemed to like our design idea of having the tray table functionality. However, the client was also concerned with the wheelchair's accessibility once installed. Specifically, with our earlier design, the tray table has two arms that control the motion, which greatly complicated the process for the client to get out and get in the wheelchair. Moreover, the client was concerned with the rigidity of the tray table since our previous design were all power by step motors, which are known to have a low holding torque.

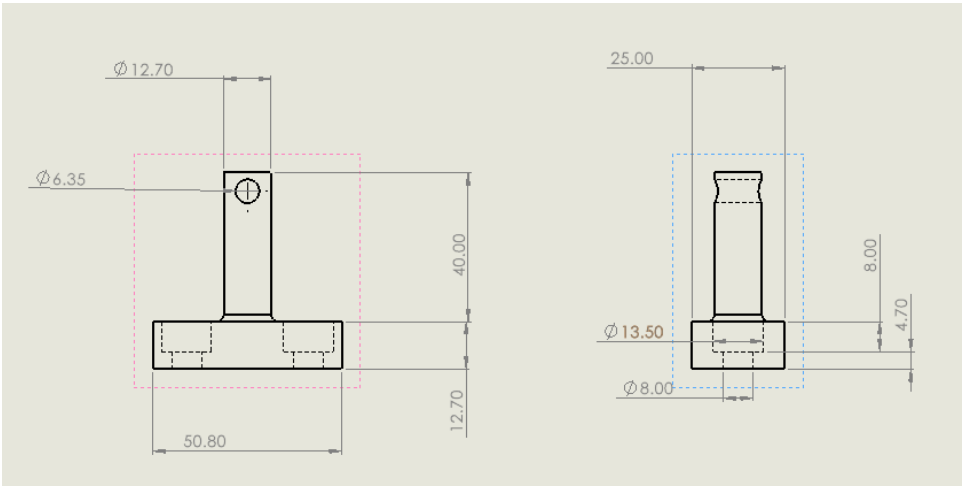
The Latest Design

Based on the latest client feedback, we have revised the design extensively. We changed the cable pulling system to a linear actuator, which will push the lower part of the triangular arm to pivot the tray table assembly to upright position. Additionally, the tray table assembly will be fixed onto one triangular arm, which would give the client better accessibility to get in and get out of the chair. For the detailed design drawings please see the figures below.

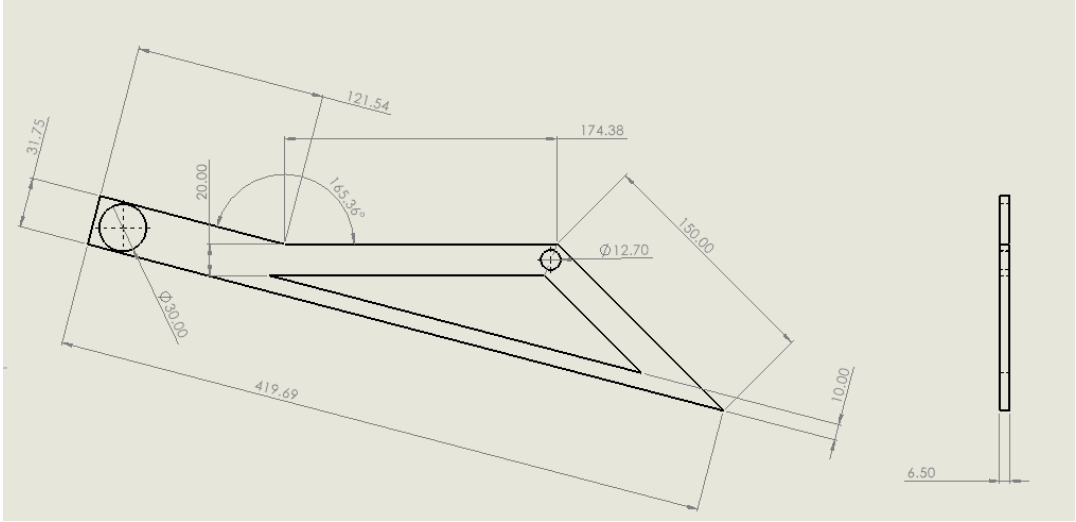




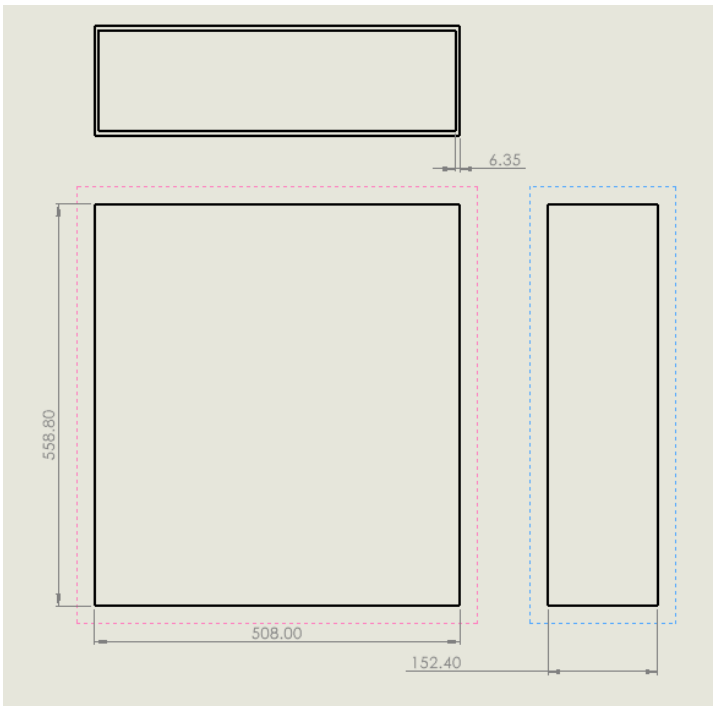
Custom part breakdown:



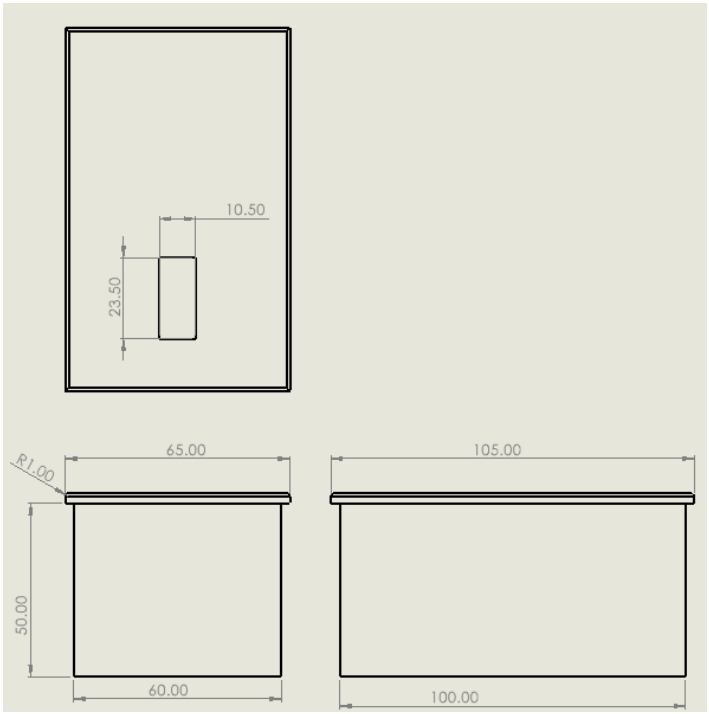
Bell crank mount dimensions, *the linear actuator mount has the exact same dimensions apart from the rod being 6.35mm and a hole of 5mm.



Bell crank dimensions



Storage box dimensions



Electrical controller box dimensions

Available Resources

Welding:
There is a high chance that the members used in our system will need to be welded to connect them to the various attachments. We will use the welders in the Brunsfield Center and use a MIG welder as it is the easier to operate.

3D Printers:
Parts such as latching components and electronics supports will be 3D printed as it is the fastest and cheapest way to produce small parts. The 3D printers in Makerspace will allow us to make prints at any time when needed.

Pre-Manufactures Components:
We will take advantage of components such as electrical components, pin-joints, and other supplies that we don't need to manufacture ourselves. While operating within our budget, this will decrease our manufacturing time and reduce the number of components that we need to produce in-house.

Laser Cutting
Depending on the storage box's design, we will need to use the laser cutter to shape the sides of the box to fit together. The laser cutter and MDF supply in the Makerspace will allow us to complete these tasks at a very low cost and high convenience on campus.

Arduino and Circuitry
If electronic devices such as linear actuators are used, they need to be controlled with a microcontroller to meet with the user. We will need to use a soldering iron and solder to create strong connections between these components. The microcontroller will be programmed using Arduino software with motor controller libraries.

Implementation Schedule

The following is a 7-week plan of how we will implement our fully functioning system by Nov 30th (Design Day). We plan to take advantage of lab times and weekend meetings to keep to our schedule and ensure constant progress.

Time Period	Tasks	Details
Week 1 (Oct 16-20)	First Physical Prototype	Order Parts Construct prototype from cheap materials to visualize feasibility
Week 2 (Oct 23-27)	Reading Week	Collect Components and make 3D models for all parts to be manufactured
Week 3 (Oct 30-Nov 3)	Prototype with useable components	Manufacture all components into first real prototype

Week 4 (Nov 6-10)	Integrate design	Use a normal wheelchair to affix our design to thoroughly test
Week 5 (Nov 13-17)	Last prototyping phase and changes	Make any necessary changes to the design and assemble the electronic components
Week 6 (Nov 20-28)	Testing and Improvements	Final testing a change.
Week 7 (Nov 27 - 30)	Final Testing and Presentation	Design day presentation on Nov 30th

Bill of Materials

Material	unit	How to get it	Cost	Link
3/16 x 3-inch Flat Head Square Drive Stove Bolt with Nut - Zinc Plated- 6 pcs	1	buy	4.48$	Paulin 3/16 x 3-inch Flat Head Square Drive Stove Bolt with Nut - Zinc Plated- 6 pcs | The Home Depot Canada
12” linear actuator	1	buy	79.95$	Homend DC 12V 12 Inch Stroke Linear Actuator with Mounting Bracket 300MM 6000N/1320LB Maximum Load for Recliner TV Table Lift Massage Bed Electric Sofa Linear Actuator : Amazon.ca: Industrial & Scientific
1.25” ¼-20 U-bolts	4	buy	4.43$	Everbilt 5/16 x 5 x 2-1/2-in U Bolt in Zinc - 1pc | The Home Depot Canada
Electrical Switch	1	buy	11.29$	weideer Jack Momentary Switch Reverse Polarity Toggle Rocker Switch DC Motor Control RV Power DPDT 4 Pin(ON)-Off-(ON) 20A 12V DC with Wires for 5th Wheel Tongue Trailer KCD2-7-223-4P-X, Toggle - Amazon Canada
Electrical controller box (3D printed abs)	1	custom	N/A	
Linear actuator mount (1/4" steel)	1	custom	N/A	
Bell crank mount (½" steel)	1	custom	N/A	
Bell crank (1” steel tubing)	1	custom	N/A	
Storage box (laser-cut)	1	custom	N/A	
M8x1x20 bolts	4	available	N/A	
Bell crank (¼" steel sheet)	1	custom	N/A	
Linear actuator joint (milled)	1	custom	N/A	
		Total	100.15$	

Project Risks and Mitigations

Listed below are potential project risks our group may run into while creating our prototypes and doing testing, how likely they are to occur, the severity they might impact our project, and how we may be able to overcome these challenges.

Risk	Severity	Likelihood	Mitigation/Contingency
Parts not available in store/locally	Medium	Medium	Find alternative parts online with fast shipping (such as amazon prime) or ask around to other groups or others if they have alternative parts.
Critical team member is absent	High	Medium	Divide responsibilities so that no single member is required to proceed.
Another Covid lockdown	High	Very Low	Arrange online meetings in Teams and communicate through Instagram.
Program crashes causing data loss	Medium	High	Regularly save the file and upload file to cloud if possible.
Unexpected prototype cost increase	Medium	Low	Conserve budget for emergencies.
Team dispute causes schism	Low	Low	Team takes a break to calm down before returning to work.
LRT breaks down	Low	High	Ensure that every team member knows an alternate bus route.

Deliverable E

Project Progress presentation, Prototype 1, peer feedback and Team dynamics

Group: 1.5

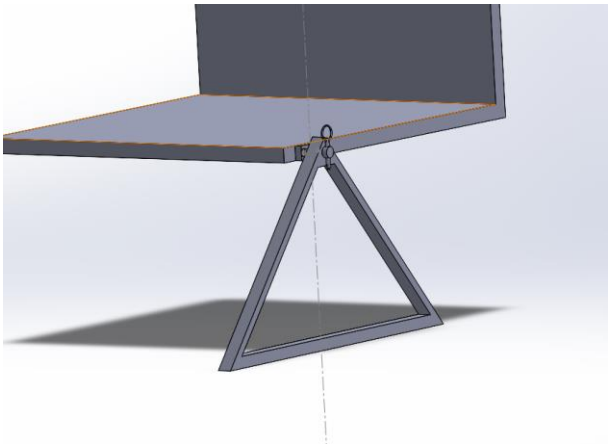
Team Members	Student No.
Ben Rundle	300240619
Kaiyuan Ye	300028711
Christopher King	300226522
Haoyu Pu	300250640
Dominic Roy	300232400
Ez Aziz	300251451

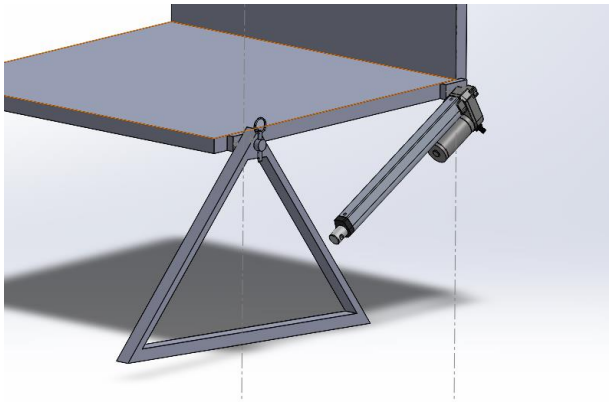
E.1: Prototype

Purpose:

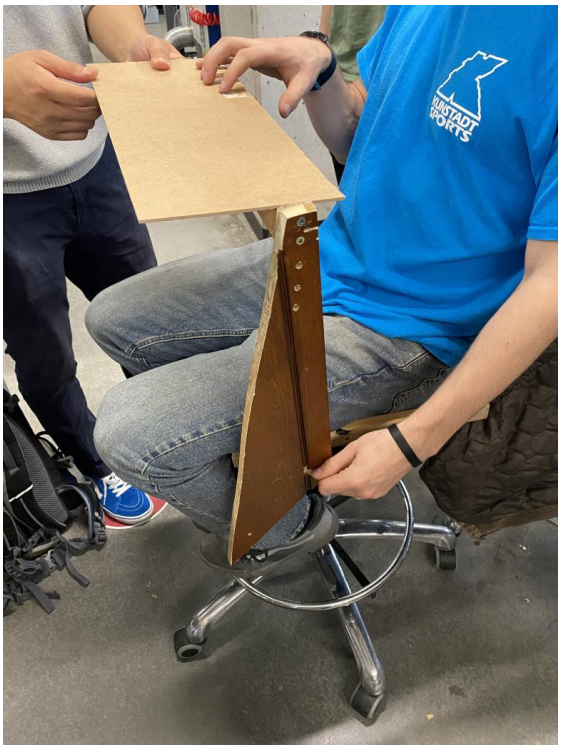
1. The physical prototype allowed us to check the clearances for the dimensions of our design. We wanted to make sure that the tabletop would leave sufficient room at the knees and sit at a workable height.
2. We also wanted to get an idea of motion ratios so that we could determine what size of linear actuator would be sufficient for the project.
3. Finally, the prototype gave us an idea of the forces that would be acting on the device, and where it would need to be strengthened. This is help us plan our material choices and manufacturing methods

After constructing the physical prototype, we made a couple of alterations to some dimensions and can now proceed with our design construction.





Pre-prototype design



These pictures come from our preliminary prototype testing. The criteria we were looking for in our testing are presented in the table below.

Prototype Testing

Test	Desired Spec	Achieved Spec	Changes to be made
Knee room when lowered	>5cm knee room	~10cm knee room	No changes needed
Lap Height when raised	~20cm above lap	~30cm.	Will lower tabletop when designing storage box or create an adjustable mechanism
Weight of Prototype	The prototype weighs 2kg without storage box and using wood.	Must be under 10kg when complete	Still within spec for final design.
Feasibility of single-arm design	Minimal wobble when extended	Significant strengthening needed	Will design metal pivot to support structure and create support triangle from metal.

Prototype fidelity

Our first design is a low fidelity prototype aimed at making a very simplified version of our final product. By omitting the fine details, and functionalities, we were able to figure out correct dimensions, so the client has the correct amount of leg room needed while not having a design that is too big and bulky. This prototype is the closest to the full scale model and is being used to rule out any possible issues with the shape and design of our final model.

E.2: Presentation

Group 1.5 Project Progress Presentation

E.3: Peer Evaluation

Completed individually through ITP Metrics

Deliverable F

Design Constraints and Prototype 2

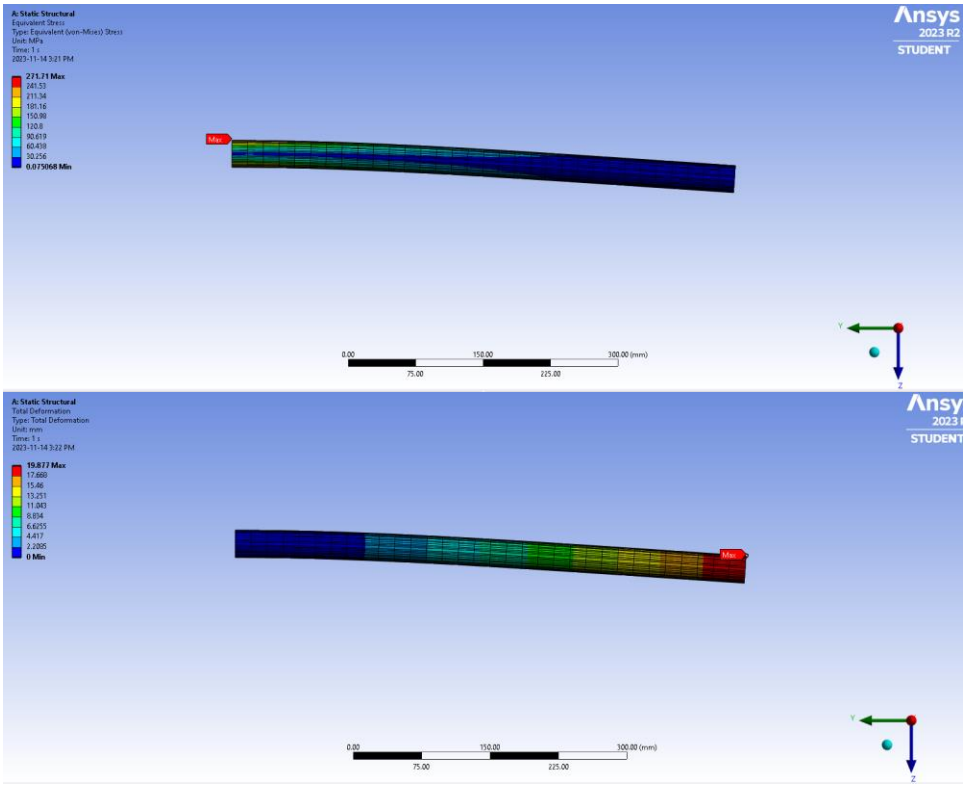
Group: 1.5

Team Members	Student No.
Ben Rundle	300240619
Kaiyuan Ye	300028711
Christopher King	300226522
Haoyu Pu	300250640
Dominic Roy	300232400
Ez Aziz	300251451

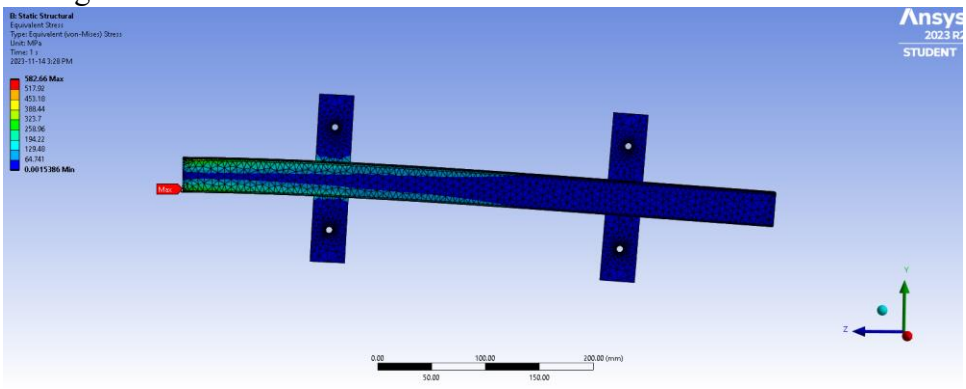
F.1: Design Constraints

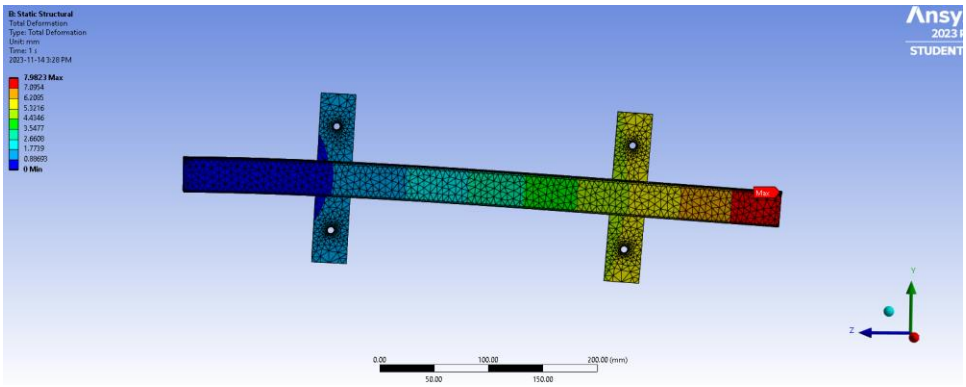
Non-Functional Design Constraints:

- Current storage box mounting solution.
    - We concluded that the metal pipe mounting design with U-bolts would not be strong enough to hold the weight of items in the storage box. Also, mounting circular hardware to the flat panels would be difficult and may pose slipping issues. We switched to a piece of box steel with sheet metal mounting tabs to further space out the distribution of load and to have a flat mounting surface.



Total stress and deformation of pipe, 10kg load spaced evenly along length at 2 points (440N), assumed to be aluminum alloy. Average stress of 57.85MPa, average deformation of 8.02mm. Young's modulus of 7.1x10^4 MPa.



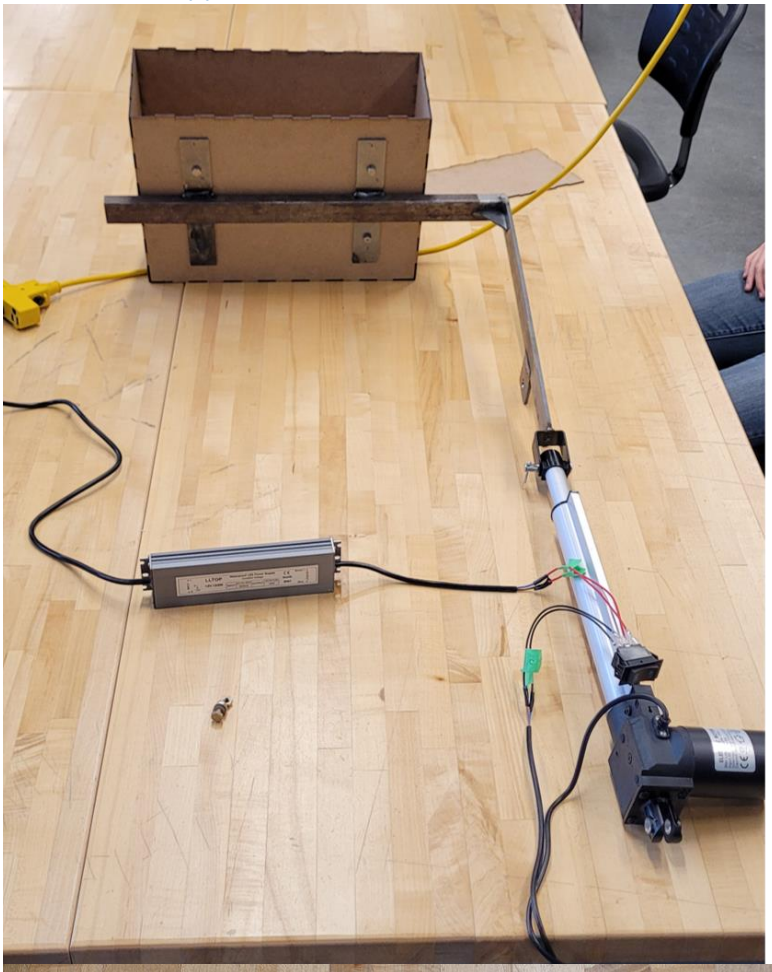


Total stress and deformation of pipe, 10kg load spaced evenly along length at the 4 bolt holes(245N), 1020 carbon steel. Average stress of 78.89 MPa. Average deformation of 3.29mm. Young's modulus of 2.12x10^5 MPa.

With our new solution, it was much easier to fix the mounting beam to the rotating assembly due to the rod being made of aluminum. This gave us a stronger, more reliable piece that is easier to incorporate into the rest of our design.

- Amperage supply to linear actuator.
    - Since we cannot use the original power supply in the final prototype, we have come up with an independent, battery-powered solution to make the device usable anywhere.
    - With a max current draw of 5A from our linear actuator and a worst-case scenario of 2 minutes per cycle (full extend and full retract) needing to be used a minimum of 6 times per day as per our client's request,
    - $Ah = \frac{It}{V} = \frac{5A \cdot \frac{2}{60} hours}{12V} = \frac{1}{12} Ah$
    - From this basic calculation, the 8Ah battery we're planning to use should be more than enough to keep the device powered reliably and for a long duration of time.

F.2: Prototype 2



Prototype Testing

Test	Desired Spec	Achieved Spec	Changes to be made
Time to extend/retract	10-20s	~1 min	Increase voltage to linear actuator
Weight	20-40 lbs	20lbs	No changes needed
Gross carry weight	10kg	>10kg	No changes needed

New Client Feedback

- No concerns on prototype 2 design
- Wants to see a very high-fidelity prototype for design day to then deliver to the client to be used in the real world.
- Wants us to plan our design for use after design day; add more features.

Critical Product Assumptions

The second prototype enabled the group to test the strength of individual components and verify the functionality of the electronics. The entire system has not been tested while mounted to a real wheelchair. The client has indicated they will send their wheelchair to allow the group to install on the chair to continue testing the system.

Client Meet 3 Presentation

Presentation Power Point

Project Task Distribution

Name	Task
Kai & Chris	All electrical component connection soldering, testing
Ez	Linear Actuator Bracket Mounts
Hao	Storage Box & 3D printing
Dom & Ben	Bell crank & storage box support

Deliverable G

Other Considerations

Group: 1.5

Team Members	Student No.
Ben Rundle	300240619
Kaiyuan Ye	300028711
Christopher King	300226522
Haoyu Pu	300250640
Dominic Roy	300232400
Ez Aziz	300251451

Economics Report

Variables

Cost	Type	Fixed/Variable	Direct/Indirect
Salaries	Labour	Fixed	Indirect
Materials	Material	Variable	Direct
Equipment	Expense	Fixed	Indirect
Rent	Expense	Fixed	Indirect
Electricity	Expense	Fixed	Indirect
Overhead	Expense	Fixed	Indirect
Marketing	Expense	Fixed	Indirect

Assumptions:

- The unit cost is $250.
- The selling price is $800.
- Salaries: $50,000 per year
- Overhead: $20,000 per year
- Rent: $15,000 per year
- Material Cost: $10,000 per year
- Equipment: $5,000 per year
- Depreciation: $8,000 per year

Mock 3-Year Income Statement:

	Year 1	Year 2	Year 3
Units Sold	500	1,000	1,500
Revenue	$400,000	$800,000	$1,200,000
Cost of Goods Sold (COGS)	$125,000	$250,000	$375,000
Gross Profit	$275,000	$550,000	$825,000
Salaries	-$50,000	-$50,000	-$50,000
Overhead	-$20,000	-$20,000	-$20,000
Rent	-$15,000	-$15,000	-$15,000
Material Cost	-$10,000	-$10,000	-$10,000
Equipment	-$5,000	-$5,000	-$5,000
Depreciation	-$8,000	-$8,000	-$8,000
Operating Income	$177,000	$432,000	$717,000

NPV Analysis

NPV Income

$$(400{,}000/(1+0.10)^1) + (800{,}000/(1+0.10)^2) + (1{,}200{,}000/(1+0.10)^3) \approx 1{,}144{,}628$$

NPV Expenses

= (-50,000 / (1 + 0.10)^1) + (-20,000 / (1 + 0.10)^1) + (-15,000 / (1 + 0.10)^1)
+ (-10,000 / (1 + 0.10)^1) + (-5,000 / (1 + 0.10)^1) + (-8,000 / (1 + 0.10)^1)
+ (-50,000 / (1 + 0.10)^2) + (-20,000 / (1 + 0.10)^2) + (-15,000 / (1 + 0.10)^2)
+ (-10,000 / (1 + 0.10)^2) + (-5,000 / (1 + 0.10)^2) + (-8,000 / (1 + 0.10)^2)
+ (-50,000 / (1 + 0.10)^3) + (-20,000 / (1 + 0.10)^3) + (-15,000 / (1 + 0.10)^3)
+ (-10,000 / (1 + 0.10)^3) + (-5,000 / (1 + 0.10)^3) + (-8,000 / (1 + 0.10)^3)
≈ **-$181,818**

Net NPV = NPV (Income) + NPV (Expenses)

= $1,144,628 - $181,818

≈ **$962,810**

Calculation of Operating Expenses:

The total operating expenses for each year are the sum of salaries, overhead, rent, material cost, equipment, and depreciation:

Yr	Salaries	Overhead	Rent	Materials	Equipment	Depreciation	Total Operating Expenses
1	-$50,000	-$20,000	-$15,000	-$10,000	-$5,000	-$8,000	-$108,000
2	-$50,000	-$20,000	-$15,000	-$10,000	-$5,000	-$8,000	-$108,000
3	-$50,000	-$20,000	-$15,000	-$10,000	-$5,000	-$8,000	-$108,000

Calculation of Net NPV:

Year	Revenue	COGS	Operating Expenses	Net NPV
1	$400,000	$125,000	-$108,000	$283,000
2	$800,000	$250,000	-$108,000	$558,000
3	$1,200,000	$375,000	-$108,000	$717,000

Break Even Point Calculation:

Break Even point occurs when net NPV = 0

$$NetNPV = \big(800(X) - 250(X)\big) - Operating\ Expenses$$
$$NetNPV = 500X - Operating\ Expenses$$
$$X = \frac{(Operating\ Expenses)}{550}$$

So, for a yearly operating expense of $108,000:

$$X = \frac{108000}{550} = 197\ Units$$

Intellectual Property Report

- 2 Intellectual properties
    - Patents
        - A patent would provide us with the exclusive right to use our products and design, which would allow us to gain a market advantage as the only company to use our designs or would allow us to receive royalties from companies that use our designs. The only drawback to a patent is that our designs will be shared on a public database, though it would not be an issue for our company as we will have the exclusive rights to our designs as mentioned above. A patent not only grants exclusive usage rights but also boosts our credibility. This enhances trust, attracting support from investors, collaborators, and customers, showcasing our team's innovation in accessibility technology.
    - Trade secrets
        - Contrary to patents, trade secrets are not shared with the public and will be protected as long as they are kept confidential. Trade secrets will be used to keep our company information and secrets secured, which would provide us with a competitive advantage against the wheelchair accessory market. Furthermore, trade secrets are a much more cost effective and simple method to protect our intellectual property, than to create and enforce our patents.
    - Being used side by side, these two forms of intellectual property will significantly help our company to maintain a market advantage for our unique and innovative designs. They would provide us with the legal enforcement of the use and share of our designs from all aspects.

Deliverable H

Final Design and Design day pitch

Group: 1.5

Team Members	Student No.
Ben Rundle	300240619
Kaiyuan Ye	300028711
Christopher King	300226522
Haoyu Pu	300250640
Dominic Roy	300232400
Ez Aziz	300251451

Area 1: Solution or final product

MotionWorks BTD

The automated storage bin transfer device

Problem

- The problem at hand is that wheelchair bound people and users have a difficult time placing their backpack or belongings in an easily accessible and secure location on their wheelchair.
- People such as our client cannot retrieve their belongings without asking for help due to most electric wheelchairs not having an effective or any storage solution at all.

“Design a durable, lightweight, and automatic/electronic storage bin transferring device that is easy to use for a wheelchair bound person. The device is made to carry belongings of the person in an efficient, safe, and cost-effective way.”

Solution

- The solution is to make an automated device that brings a storage box from a secure location on the chair to an easily reachable location that doesn’t require reaching or getting out of chair.

Product

- Our solution includes an automated rotating assembly actuated by a linear actuator. This connects to the left side of the chair using factory mounting rails.
- The arm comes around to in front of the shins, where the storage box is mounted and rotates up to the lap area for you to retrieve your belongings.

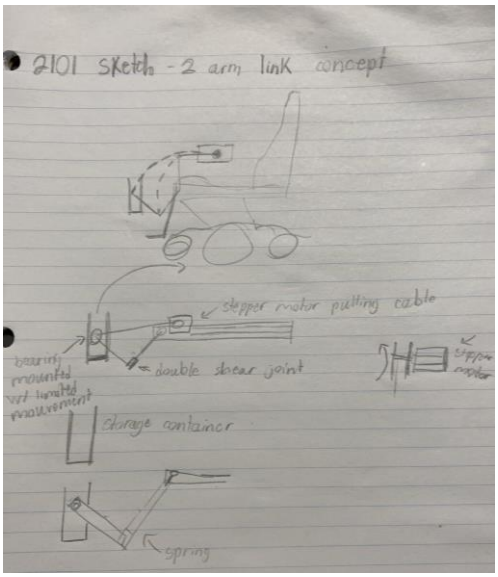
About the client

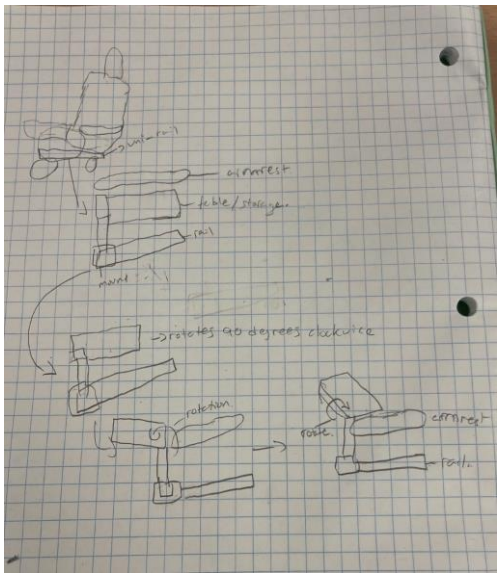
- Our client has a condition that deteriorates muscle tissue, slowly removing motor function from his legs and arms.
- Limited range of motion in upper body

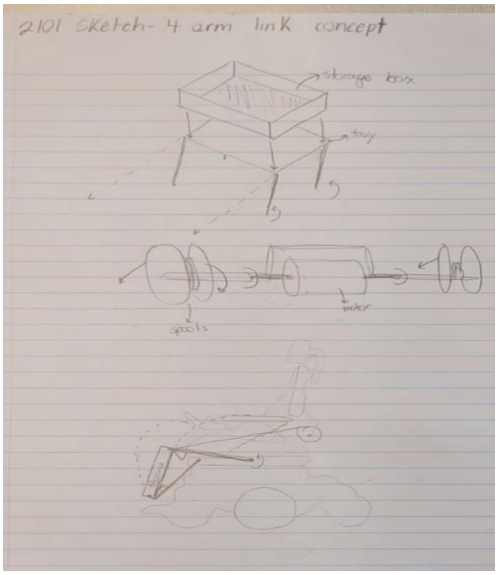
uOttawa

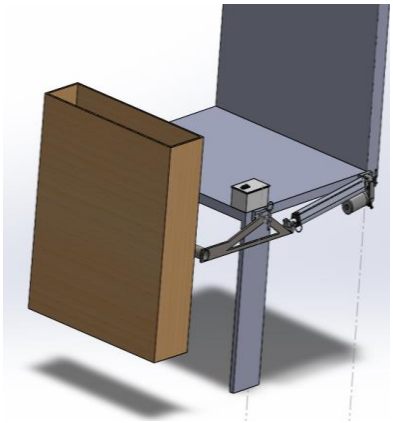
Tetra Society

of North America

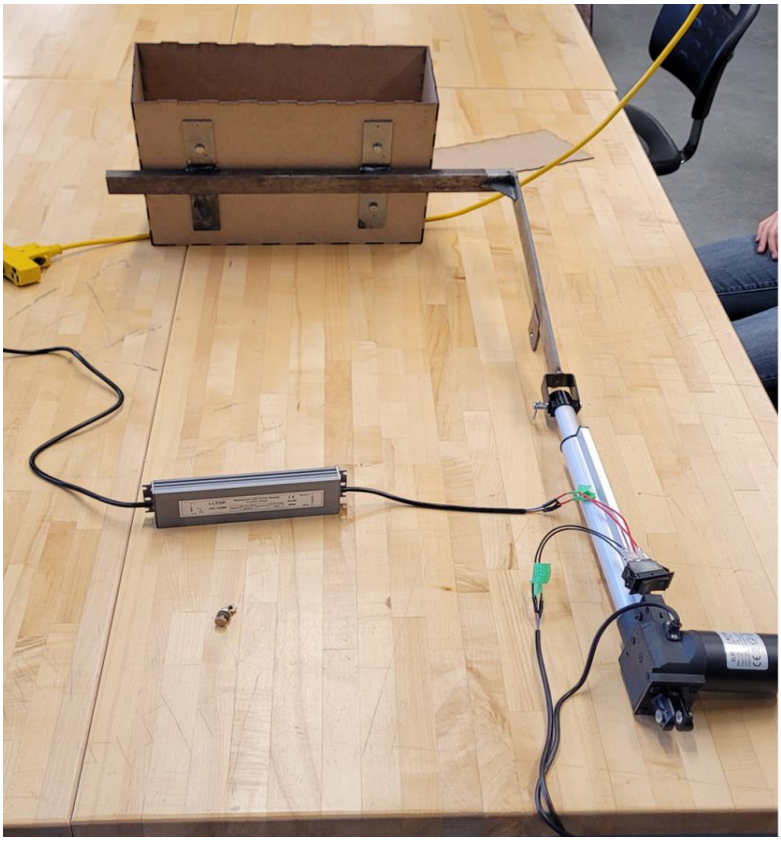

2101 Sketch - 2 arm link concept
stepper motor pulling cable
double shear joint
storage container
spring

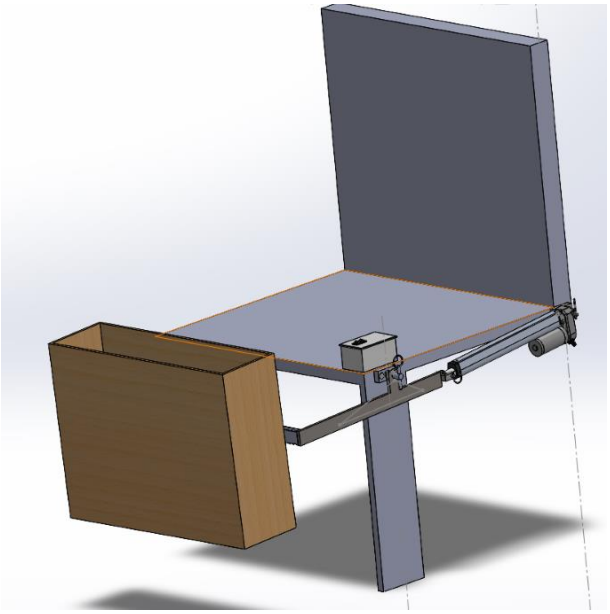

armrest
table / storage
rail
rotates 90 degrees clockwise
rotation
armrest
rail

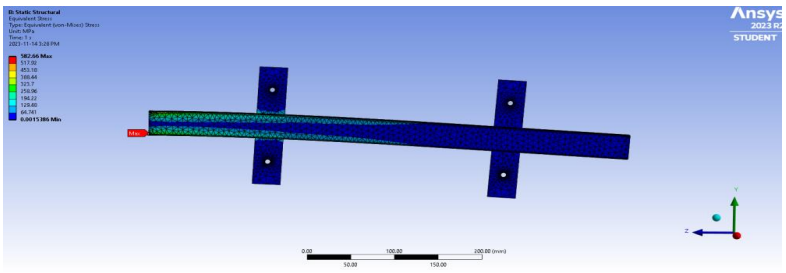

2101 Sketch - 4 arm link concept
storage box
tray
spools
motor




KUNSTADI
SPORTS






B: Static Structural
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: MPa
Time: 1
2021-11-14 3:28 PM
582.66 Max
517.92
453.18
388.44
323.7
258.96
194.22
129.48
64.741
0.0015386 Min
Ansys
2023 R2
STUDENT
0.00
100.00
200.00 (mm)
50.00
150.00

ID number	Subject	Unit of measurement	Target spec range	Ideal spec range
1	Time from down position to up	Time	10-20s	>15s
2	Time from up position to down	Time	10-20s	>15s
3	Number of cycles needed to complete before battery dies	N/A	5-8 cycles (1 cycle is up and down)	>=6 cycles
4	Total weight of the package	lbs or kg	20-40lbs or 9-18kg	<30 lbs
5	Gross carry weight of the product	lbs or kg	10-20lbs or 5-9kg	>15 lbs
6	Time to charge the battery	Time	2-8 hours	<3 hours
7	Size of storage bin	L	6-12 L of volume	>8L of volume
8	Safety factor	Count	<1 safety concern from wear and normal use	0 safety hazards
9	Maintenance	Time	Every 50-100hrs	>60hrs

Prototype 1

Test	**Desired Spec**	**Achieved Spec**	**Changes to be made**
Knee room when lowered	>5cm knee room	~10cm knee room	No changes needed
Lap Height when raised	~20cm above lap	~30cm.	Lower tabletop closer to knees
Weight of Prototype	The prototype weighs 2kg without storage box and using wood.	Must be under 10kg when complete	Still within spec for final design.
Feasibility of single-arm design	Minimal wobble when extended	Significant strengthening needed	Will design metal pivot to support structure and create support triangle from metal.

Prototype 2

Test	**Desired Spec**	**Achieved Spec**	**Changes to be made**
Time to extend/retract	10-20s	~1 min	Increase voltage to linear actuator
Weight	20-40 lbs	20lbs	No changes needed
Gross carry weight	10kg	5kg	Change to box construction required

SWOT ANALYSIS

Strengths:

- No similar product on the market.
- Heavy duty components.

Weaknesses:

- Low development time means some small features were overlooked.
- Slower time to extend and retract.

Opportunities:

- Insurance companies.
- Government financial aid/incentive

Threats:

- Competition entering market space.
- Constant rising in steel prices.

THE 4P’S

Product:

- Our product allows low mobility individuals to easily access their belongings while sitting in a wheelchair.

Pricing:

- $800 sale price is a fair and competitive price in the market where there is existing financial aid and government incentives.

Place:

- There are currently no other products that solve this problem.

Promote:

- Targeted ads for people in wheelchairs
- Partner with existing wheelchair companies to promote the product.
- Partner with medical stores to sell product.

Area 3: Non-technical constraints

Ez: working on business canvas model

Mock-up Income Statement

Assumptions:

- The unit cost is $250.
- The selling price is $800.
- Salaries: $50,000 per year
- Overhead: $20,000 per year
- Rent: $15,000 per year
- Material Cost: $10,000 per year
- Equipment: $5,000 per year
- Depreciation: $8,000 per year

	Year 1	Year 2	Year 3
Units Sold	500	1,000	1,500
Revenue	$400,000	$800,000	$1,200,000
Cost of Goods Sold (COGS)	$125,000	$250,000	$375,000
Gross Profit	$275,000	$550,000	$825,000
Salaries	-$50,000	-$50,000	-$50,000
Overhead	-$20,000	-$20,000	-$20,000
Rent	-$15,000	-$15,000	-$15,000
Material Cost	-$10,000	-$10,000	-$10,000
Equipment	-$5,000	-$5,000	-$5,000
Depreciation	-$8,000	-$8,000	-$8,000
Operating Income	$177,000	$432,000	$717,000

Business Model Canvas

Key Partners

- We will develop partnerships with companies who specialize in making wheelchairs and other accessibility products.
  - This will help us reach more customers
  - This will allow use to make our products in specifications that will be usable for different wheelchair models and sizes
- We will partner with the Council of Canadian with Disabilities (CCD).
  - We would be in direct communication with the users for feedback and concerns.

Key Activities

- Design and manufacture innovative products.
- Provide customer support and after-sales services.
- Develop and implement marketing campaigns.
- R&D for continuous product improvement.

Key Resources

- Solid relations with suppliers
- Patents
- Trade secrets
- Skilled employees

Value Proposition

- Our target audience are students who suffer from mobility issues and have difficulties with living their day to day life.
  - Our clients will be able to live more independently
  - Our clients will not suffer from space constraints as the width and length of the wheelchair will not be affected

Customer Relationships

- We will keep in touch with our customers through email based marketing.
- We will have a customer service team that will be helpful to our customers when they face difficulties.

Channels

- We will sell our product online and at major medical store chains. We will reach our customers through:
  - Targeted advertising
  - Our key partners

Customer Segments

- Our target market will be the accessibility market.
- Our early adopters will be clients who will be able to benefit from our innovation, and that can provide insightful feedback that will help us to make improvements.

Cost Structure

- Fixed costs:
  - Material, manufacturing, shipping, salaries, rent, equipment.
- Variable costs:
  - Hiring/training, advertising, loans, overhead costs

Revenue Streams

- We will generate income through sales of our products, as well as their accessories and replacement parts.
- Our secondary revenue streams will be through selling our patents, royalties, and our key partners.


ROHO


ROHO
M3

Deliverable I:
Video and User Manual

Group1.5

Team Members	**Student No.**
Ben Rundle	300240619
Kaiyuan Ye	300028711
Christopher King	300226522
Haoyu Pu	300250640
Dominic Roy	300232400
Ez Aziz	300251451

Submission Date: Nov 18th, 2023

User manual can be accessed here: GNG_2101_User_Manual_MotionWorks.docx
Video can be accessed here: Motionworks BTD.mp4