Design Project 4 – Power in Community

Designing a Custom Phone Holder

ENGINEER 1P13 – Integrated Cornerstone Design Projects in Engineering

Tutorial T07

Team Thurs-17

Imaan Sheikh (sheiki6)

Sameer Khichi (khichis)

Sampurna Saha (sahas31)

Yahya Zaher (zahery)

Submitted: April 10, 2024

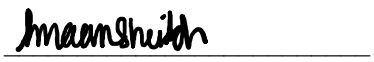
Course Instructors: Dr. McDonald, Dr. Doyle, Dr. Ebrahimi, Dr. Fleisig, Dr. Hassan, Dr. Zurob

Table of Contents

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.

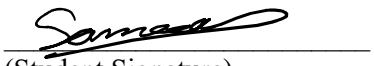
Imaan Sheikh 400524820



(Student Signature)

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.

Sameer Khichi 400518172



(Student Signature)

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.

Sampurna Saha 400529860

(Student Signature)

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.

Yahya Zaher 400501746

(Student Signature)

Executive Summary

"Power in Community" works as part of the Interdisciplinary, Mentorship, Practice, Applied, Community, Transformative (IMPACT) initiative to design a unique and innovative solution for the improvement of a client's daily living [1]. The client in question is a 33-year-old woman with spina bifida; she has limited mobility and uses a power wheelchair to move [1]. Some of the client's main goals include increasing independence with her daily life and tasks, and ensuring her safety whenever she is using her wheelchair. During preliminary client meetings, the client described some of her issues with having limited storage in her wheelchair. She also shared a past situation where a cupholder attachment for her wheelchair was prone to breakage. Keeping these experiences and objectives in mind, a prototype for a custom phone holder suitable for installation on a wheelchair was developed.

The final prototype for this project, as seen in Figure 1, is made of various components. The main structure of the design was modelled in Autodesk Inventor and 3D printed using PLA filament. The design also includes sponge padding along the interior walls to protect the phone and prevent it from being jostled by the movement of the wheelchair. Additionally, the 3D printed structure of the design has cutouts to accommodate the Velcro straps, which can be connected along the bottom or attached directly to the wheelchair with the adhesive backing.

Figure 1. Photo of final prototype.

This phone holder design provides an extra storage option on the client's wheelchair and is adjustable specifically to suit it. Rather than involving an adjustable clamp that can be difficult to maneuver, as many existing phone holders do, this prototype is designed to maximize ease and convenience for the client; it allows the client's phone to be easily put down and picked up without any difficulty. The adjustable Velcro straps also make it easy to install regardless of the wheelchair type or armrest design, in the case that the client gets a different wheelchair in the future.

There were a few notable limitations in the design process, including time, money, and resources. Without these constraints, there are a few improvements that could be made to further refine the design. One of the main issues with earlier prototypes was the time required for production; an earlier CAD model had an expected print time of around 60 hours, which was not feasible given the time and resource constraints of the project. If time was less limited, it would be interesting to explore a more complex CAD model as the base structure for the prototype; for example, one designed with an alternate feature to hold a cup as well as a phone. Furthermore, different attachment mechanisms would be useful to consider to ensure stability and security on the wheelchair. Lastly, it would also be worth incorporating a size adjustment mechanism to accommodate for any changes in the client's phone; the current model is suitable for some of the largest phones currently on the market as well as older models with smaller sizes, but this is an option to explore for future use.

Main Body

Background Information

When designing a prototype to aid the client in her daily life, it was important to understand the medical condition involved. Spina bifida is a kind of neural tube defect that can cause disabilities ranging from mild to severe and has different treatments accordingly [2]. When spina bifida is higher on the spine, it can cause paralysis in the legs, necessitating the use of wheelchairs [3]. In the client's case, she has mobility in her torso, arms, hands, and fingers, but none below the waist [1]. She also has metal rods in her back for straightening her spine [1]. Understanding the effects of the client's medical condition are significant in creating a design that will be truly beneficial to her in everyday life.

Problem Framing

Refined problem statement: Design an addition to the client's current wheelchair to improve convenience, provide more storage, and allow for more independence in the client's daily life.

To accomplish the mission statement, a set of objectives and constraints were set such as maximizing durability and convenience while minimizing weight and size. These objectives were taken into great consideration when designing the prototype to maximize performance as the client had mentioned that attachments, such as the cup holder, in the past have broken off or teared down due to movement. To test durability several phones of various weights were set in the phone holder. Masses of the phones were recorded and changes in the phone holder was observed. The phone holder successfully sustained 226 grams without any breakage or tear, ensuring that the product will last longer and support above the average weight

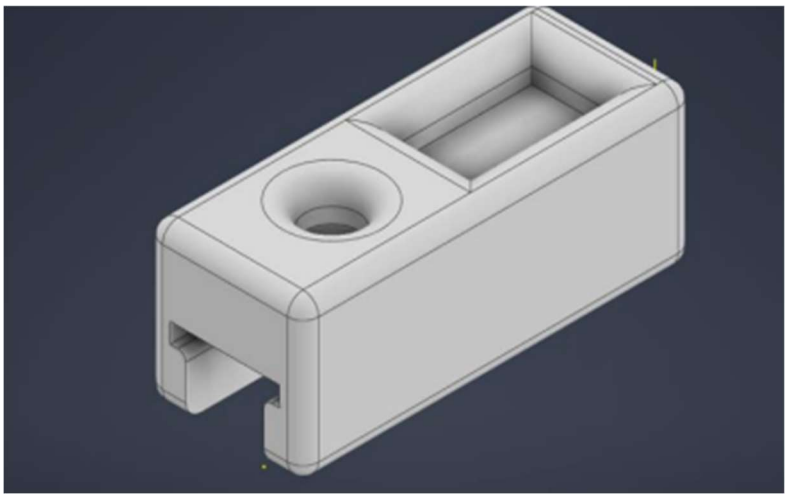
of a phone which is around 179 g [5]. As independence for the client was also a priority, convenience was also tested through user scores. Around 8 random users were selected who used the product and evaluated it in a scale of 1 to 10, with 1 being the lowest and 10 being the highest. The initial prototype received a score of around 7/10. This feedback influenced in the change of the attaching mechanism, where instead of sliding on to the arm rest, a Velcro attachment was used to diversify the use of the product as now it can be easily removed or attached. To ensure that the prototype could be supported with ease by the wheelchair, weight was minimized and tested through comparing the weight of the product to average phone holder weight in the market. The weight of the prototype was 230 grams and tended to be slightly lower than other phone holders sold in Amazon or other sites. Size was also minimized to ensure an appropriate fit on the wheelchair while also fitting various phone sizes. Around 6 phones were tested varying in sizes from the iPhone 15 pro max to the iPhone 8. The prototype was able to support all the phones with enough space for user to take out phone without leaving any excess gap. One of the constraints that was met was cost, as there was a budget of $100. The making of this prototype costed around $30 and it was compared with phone holders of similar design in the market, which also priced to around $25-$30. Overall, thorough testing has evolved the product to ensure it meets objectives and client needs adequately.

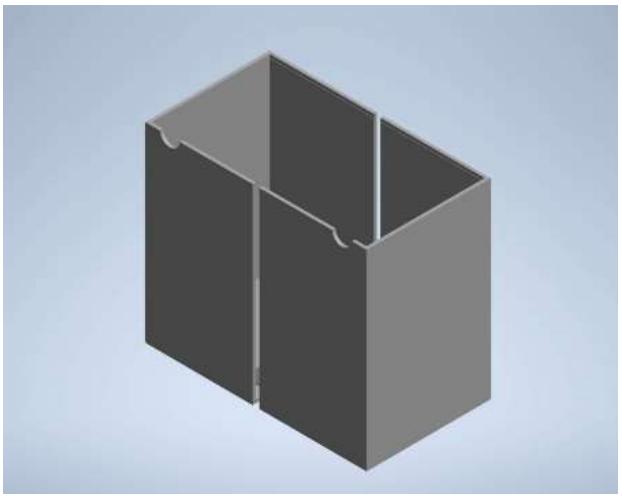
Table 1. Objectives and constraints

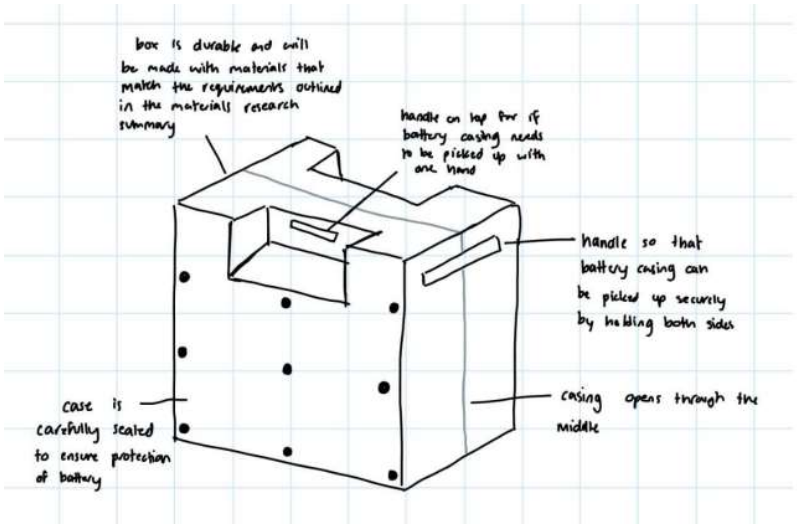
Objectives	**Constraints**
Maximize durability (g) Importance: Ensuring longevity of prototype and protection of phone Testing: Measuring weight that prototype can sustain → tested up to 226 g	Cost ($) Importance: Rough budget of $100 Testing: Comparing to average prices of existing phone holders → price of prototype is ~$30
Maximize convenience (user score) Importance: Ease of use for client with limited mobility Testing: Surveying for user scores → average score of 7/10	
Minimize weight (g) Importance: Weight must be easily sustained by wheelchair Testing: Comparing to average weights of existing phone holders → weight of prototype is 230 g	

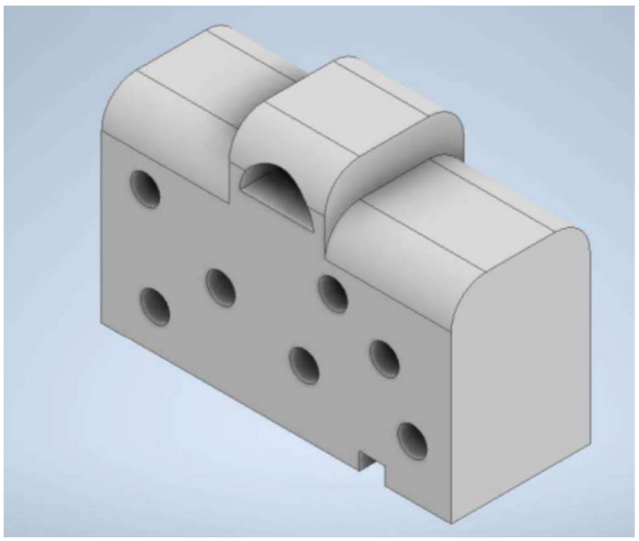
Minimize size (mm^3) Importance: Must be able to accommodate phone while still fitting securely on wheelchair arm Testing: Checking size with various phones of different sizes	

Conceptual Design









Figures 2-5. Initial prototype sketches and designs.

Table 2. Decision matrix

Criteria	Weighting	CAD case with holes		CAD/printed phone holder		Cardboard prototype		CAD design 4 with hinge	
		Score	Total	Score	Total	Score	Total	Score	Total
Durability	5	2.5	12.5	4	20	4	20	3.5	17.5
Lightweight	3	5	15	4	12	3	9	3.5	10.5
Physical design	4	3	12	3	12	3	12	4.5	18
Functionality	5	4.5	22.5	5	25	4.5	22.5	4	20
Creativity	3	3.5	10.5	3	9	2.5	7.5	4	12
Convenience	4	4	16	3	12	4	16	5	20
Total			88.5		90		87		98

Table 3. Functional analysis

Function	Means					
Improves mobility	-Tires with improved traction	- improved seat mechanics and ability to lift and lower the chair.	--Compact Wheelchair	-Better/added suspension system.		
Minimizes need for external mobility aids	-umbrella holder.	-Built in storage	-Customizable attachments			
Maximizes durability	-Protective case for battery	-Snow tires/new tire design with better resistance to snow/slush	-Weather-resistant coating	Incorporate materials with high strength-weight ratio		

From the decision matrix and morph charts above, it is clear to see that the best pick was in-fact the design that blended simplicity with functionality the best, suited to the clients needs. The main decision was between the design of a battery casing and an attachment featuring a phone and cup holder for the wheelchair's armrest. It was decided to create two completely different design concepts and compare them as it gave more of a variety in design process. As it can be seen the highest scored battery case was the 4th prototype which had the best physical design and was the most convenient. The holder on the other hand was the most functional and on average scored higher for other categories as well. Though the battery casing did score higher overall, the holder design was selected for its relevance to the client as well as its functionality. The client expressed her need for a space to keep her phone and cup, and complained about the design of previous remedies as they kept on breaking. All this was kept in mind when designing the mechanism that connects the design to wheelchair. Furthermore, feasibility was investigated and how

realistic each design was when it came to creating and making the proposed design. Battery casings are quite large and would be difficult to implement, and so with the time given the most realistic option was to choose the holder design.

The final proposed design does not include the cup holder in the prototype, as this was to meet the size and weight restrictions that had to be met for 3D printing. From the initial prototype, not much feedback was given apart from the lack of creativity and the idea of being too simple; this led to exploring other ways to add unique functions to the product. Given this information the design suited more towards functionality rather than aesthetic design. After having run into a print time issue, the next solution proposed in feedback was laser cutting, however there a multitude of issues and miscommunications that led to the failure of that idea. Lastly the final design consisted of shaving off excess material and features that were dull and setting it up to be printed. The design features an indent deep enough to fit all phones on the market as well as any other objects the client wishes to store, and a cut out that runs through the entire design to fit a Velcro strap that holds the design in place on the armrest. The design can be used in many contexts and it is very versatile.

Final Proposed Design

The final proposed design is a custom phone holder consisting of a 3D-printed base structure with Velcro attachments and sponge cushioning along the interior walls. The Velcro attachments allow it to be installed on different types of wheelchair armrests; they can be looped to connect at the bottom, or attached directly to the wheelchair using the adhesive backings. It meets the objectives of minimizing size and weight while maximizing durability, as it is designed to closely fit the client's phone while sustaining the weight of various types of phones. The testing plan for convenience was to utilize user scores; upon receiving the average score, the Velcro attachments were incorporated to allow for adjustment and easy installment. The testing plans for weight and durability showed that the prototype weighed 230 grams and could sustain phones up to 226 grams. Additionally, the cost of the prototype was within the proposed budget of $100; see *Table 5. Bill of Materials* for a detailed breakdown of the costs associated. Apart from the PLA filament used in the 3D printing process, sponge and Velcro were used for their respective components, and were attached using hot glue and double sided tape.

The testing plans throughout the project were instrumental in developing a successful final prototype as they highlighted important issues early on. The first testing plans were carried out with a low fidelity prototype made of cardboard and tape; this process emphasized the importance of quality material selection and the objective of durability. See *Figure 12* for a photo of the low-fidelity prototype used in this process. However, those testing plans were useful in assessing convenience and testing how lightweight the

prototype was. In terms of future refinements and testing plans, addressing adjustability for the actual phone holder box would be worth looking into, as well as adding further features targeting convenience.

Conclusions

In case that there was more time, the emphasis would be on enhancing the device further to better respond to user's needs. Also, additional user testing would be done among individuals going through similar mobility challenges to ensure it is usable and accessible by a larger population of users. Moreover, an exploration of integrating features such as an inbuilt cup holder or extra storage compartments would help solve customer concerns about wheelchair storage.

The final test plan has proved very helpful for future improvements. For example, the importance of stability and longevity in wheelchair attachments was evaluated so that decisions could be made regarding the next version of the design. An end-user's input and other participants contribute towards making any necessary changes in order to improve performance and usability of this product.

From this project, a great deal was learned regarding team dynamics and design process. The significance of extensive research coupled with designs based on user requirements that lead to solutions were understood. Ultimately, working as a team resulted into a stronger outcome from diverse perspectives and levels of experience. It also emphasized the importance of open communication as well as assigning responsibilities for effective project development. In view of this experience, there is thought on establishing a formal project management framework that can help better organize schedules and workloads for future.

Suppose collaboration took place again, then an emphasis would be made to define specific responsibilities and roles in advance so as to minimize misunderstandings and expedite decision making processes. Moreover, fostering a candid feedback environment with open communication where people feel free to communicate their opinions will probably enhance the team's spirit of cooperation and efficiency hence leading to more successful project outcomes in coming years.

Reference List

[1] "P4 Project Module", ENGINEER 1P13 class materials, Department of Engineering, McMaster University, Winter 2024.

[2] CDC, "What is Spina Bifida?," *Centers for Disease Control and Prevention*, Oct. 04, 2023. https://www.cdc.gov/ncbddd/spinabifida/facts.html (accessed Apr. 10, 2024).

[3] CDC, "Spina Bifida Health Issues and Treatments," *Centers for Disease Control and Prevention*, Oct. 04, 2023. https://www.cdc.gov/ncbddd/spinabifida/treatment.html (accessed Apr. 10, 2024).

[4] Autodesk Inventor Professional 2024, Autodesk, Inc., San Francisco, California, USA, 2024 (https://www.autodesk.com/ca-en/products/inventor/overview)

[5] Booth, Callum. "Here's How Heavy the Most Popular Phones of 2019 Were — in Chart Form." TNW | Plugged, 20 Aug. 2020, thenextweb.com/news/weight-most-popular-phones-of-2019-chart-apple-samsung-analysis#:~:text=And%2C%20before%20we%20go%2C%20want.

Source Materials Database

[1] "P4 Project Module", ENGINEER 1P13 class materials, Department of Engineering, McMaster University, Winter 2024.

[2] CDC, "What is Spina Bifida?," *Centers for Disease Control and Prevention*, Oct. 04, 2023. https://www.cdc.gov/ncbddd/spinabifida/facts.html (accessed Apr. 10, 2024).

[3] CDC, "Spina Bifida Health Issues and Treatments," *Centers for Disease Control and Prevention*, Oct. 04, 2023. https://www.cdc.gov/ncbddd/spinabifida/treatment.html (accessed Apr. 10, 2024).

[4] Autodesk Inventor Professional 2024, Autodesk, Inc., San Francisco, California, USA, 2024 (https://www.autodesk.com/ca-en/products/inventor/overview)

[5] Booth, Callum. "Here's How Heavy the Most Popular Phones of 2019 Were — in Chart Form." TNW | Plugged, 20 Aug. 2020, thenextweb.com/news/weight-most-popular-phones-of-2019-chart-apple-samsung-analysis#:~:text=And%2C%20before%20we%20go%2C%20want.

[6] "Wheelchair | Mobility, Accessibility & Benefits | Britannica," *Encyclopædia Britannica*. 2024. Accessed: Feb. 27, 2024. [Online]. Available: https://www.britannica.com/topic/wheelchair

[7] "Best Reacher Grabber Tool ~ 6 Best Tools for Grabbing (reviewed)," *Gadget Review*, Nov. 15, 2023. https://www.gadgetreview.com/best-reacher-grabber-tool#-5-fitplus-premium-grabber-reacher-tool (accessed Feb. 27, 2024).

[8] "Vibration & Shock Absorbing Wheelchair Suspension Wheels - Living Spinal," *livingspinal.com*. https://livingspinal.com/suspension-wheels-shock-and-vibration-absorbing/ (accessed Feb. 26, 2024).

[9] P. P. Team, "Rough terrain wheelchairs vs outdoor models – a direct comparison.," *Passionate People by Invacare*, Mar. 28, 2019. https://passionatepeople.invacare.eu.com/rough-terrain-wheelchairs-vs-outdoor-models-a-direct-comparison/ (accessed Feb. 26, 2024).

[10] B. Preston, "What Makes a Car Really Comfortable," Consumer Reports, Apr. 08, 2021. https://www.consumerreports.org/cars/buying-a-car/what-makes-a-car-really-comfortablea1023929368/#:~:text=Driving%20position%3A%20With%20each%20car,around%20you%2C%E2%80%9D%20Shenhar%20says . (accessed Feb. 27, 2024).

[11] "More on Wheelchair Transit Safety Standards | Sunrise Medical," Sunrise Medical, 2016. https://www.sunrisemedical.ca/education-in-motion/clinical-corner/march-2016/more-onwheelchair-transit-safetystandards#:~:text=Both%20the%20RESNA%20WC19%20and,%2C%2020%2Dg%20frontal%20impact. (accessed Feb. 27, 2024).

[12] "Preparing Your Wheelchair for Snow | Gillette Children's," Gillettechildrens.org, 2024. https://www.gillettechildrens.org/stories/preparing-your-wheelchair-forsnow#:~:text=Manual%20Wheelchair%20Snow%20Tips,months%20on%20quick%2Dmount%20wheels (accessed Feb. 27, 2024)

[13] "Self-management and Independence Guideline," Spina Bifida Association, https://www.spinabifidaassociation.org/resource/self-management/ (accessed Mar. 4, 2024).

[14] "Living with spina bifida (young adults)," Centers for Disease Control and Prevention, https://www.cdc.gov/ncbddd/spinabifida/adult.html (accessed Feb. 27, 2024).

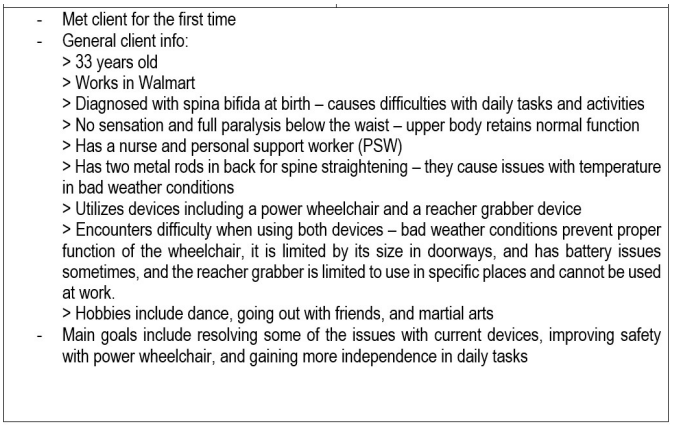
[15] The Children's Hospital of Philadelphia, "Spina bifida causes, symptoms and treatment," Children's Hospital of Philadelphia, https://www.chop.edu/conditions-diseases/spinabifida#:~:text=Spina%20bifida%20is%20a%20birth,central%20nervous%20system%20birth%20defect. (accessed Feb. 27, 2024).

[16] "Spina bifida life expectancy, causes, symptoms & treatment," POBAR, https://www.pobar.org/spina-bifida-causestreatment#:~:text=For%20those%20who%20don't,%2C%20movement%2C%20and%20even%20learning. (accessed Feb. 27, 2024).

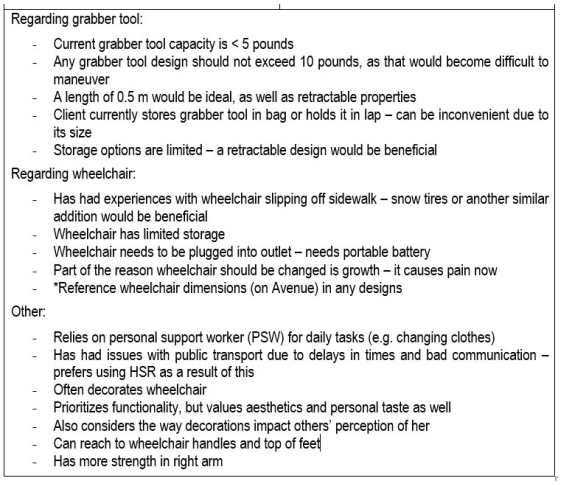
Appendices

Appendix A: Supporting Documents

Client Meeting Notes:



- Met client for the first time
- General client info:
  > 33 years old
  > Works in Walmart
  > Diagnosed with spina bifida at birth – causes difficulties with daily tasks and activities
  > No sensation and full paralysis below the waist – upper body retains normal function
  > Has a nurse and personal support worker (PSW)
  > Has two metal rods in back for spine straightening – they cause issues with temperature in bad weather conditions
  > Utilizes devices including a power wheelchair and a reacher grabber device
  > Encounters difficulty when using both devices – bad weather conditions prevent proper function of the wheelchair, it is limited by its size in doorways, and has battery issues sometimes, and the reacher grabber is limited to use in specific places and cannot be used at work.
  > Hobbies include dance, going out with friends, and martial arts
- Main goals include resolving some of the issues with current devices, improving safety with power wheelchair, and gaining more independence in daily tasks



Regarding grabber tool:

- Current grabber tool capacity is < 5 pounds
- Any grabber tool design should not exceed 10 pounds, as that would become difficult to maneuver
- A length of 0.5 m would be ideal, as well as retractable properties
- Client currently stores grabber tool in bag or holds it in lap – can be inconvenient due to its size
- Storage options are limited – a retractable design would be beneficial

Regarding wheelchair:

- Has had experiences with wheelchair slipping off sidewalk – snow tires or another similar addition would be beneficial
- Wheelchair has limited storage
- Wheelchair needs to be plugged into outlet – needs portable battery
- Part of the reason wheelchair should be changed is growth – it causes pain now
- *Reference wheelchair dimensions (on Avenue) in any designs

Other:

- Relies on personal support worker (PSW) for daily tasks (e.g. changing clothes)
- Has had issues with public transport due to delays in times and bad communication – prefers using HSR as a result of this
- Often decorates wheelchair
- Prioritizes functionality, but values aesthetics and personal taste as well
- Also considers the way decorations impact others' perception of her
- Can reach to wheelchair handles and top of feet
- Has more strength in right arm

Figures 6-7. Client meeting notes.

Decision Matrices:

Table 4. Decision matrix

Criteria	**Weighting**	**CAD case with holes**		**CAD/printed phone holder**		**Cardboard prototype**		**CAD design 4 with hinge**	
		Score	Total	Score	Total	Score	Total	Score	Total
Durability	5	2.5	12.5	4	20	4	20	3.5	17.5
Lightweight	3	5	15	4	12	3	9	3.5	10.5
Physical design	4	3	12	3	12	3	12	4.5	18
Functionality	5	4.5	22.5	5	25	4.5	22.5	4	20
Creativity	3	3.5	10.5	3	9	2.5	7.5	4	12
Convenience	4	4	16	3	12	4	16	5	20
Total			88.5		90		87		98

Design Review Notes:

Include feedback from your faculty mentor, staff, or assigned TA/IAI in this row - Keep in mind that physical prototype must be created in short time frame. - Battery design is more realistic. - Avoid modifying main functionalities of wheelchair - Include unique features to make design stand out from existing solutions - Ensure design is in line with main objective of increasing client's independence
Include feedback from science students in this row. (if applicable) - Ensure design is realistic and can have a prototype modelled after it

Include feedback from science students in this row. - Concerns about height of prototype and if it would negatively impact convenience for client - Consider a mechanism for attachment on the side of the armrest rather than on top -
Include feedback from your faculty mentor, staff, or assigned TA/IAI in this row - Design lacks creativity - Would be considered a level 3 design rather than level 4 because of the low creativity - More unique features needed/better optimization of current features to achieve a level 4 - Consider including extra features – e.g. consider client's personal style and aesthetic preferences - Clamping mechanism for attachment would be harder to manufacture but may be more convenient for client – however, since it has more moving parts it may be less durable

Figures 7-8. Design review notes from TA meetings.

Initial Prototype/Prototype Iteration pictures:

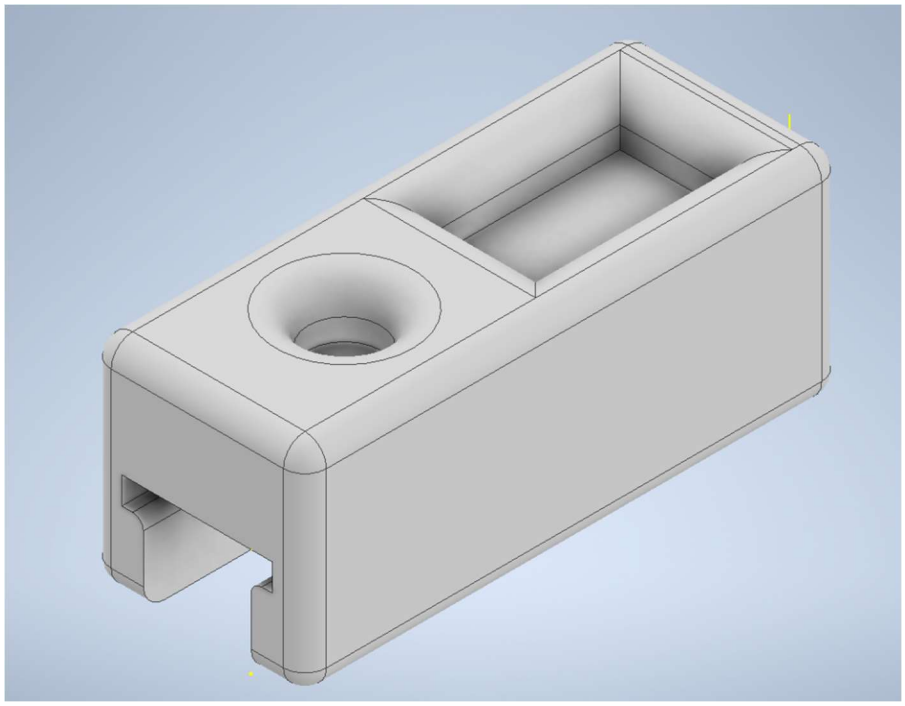
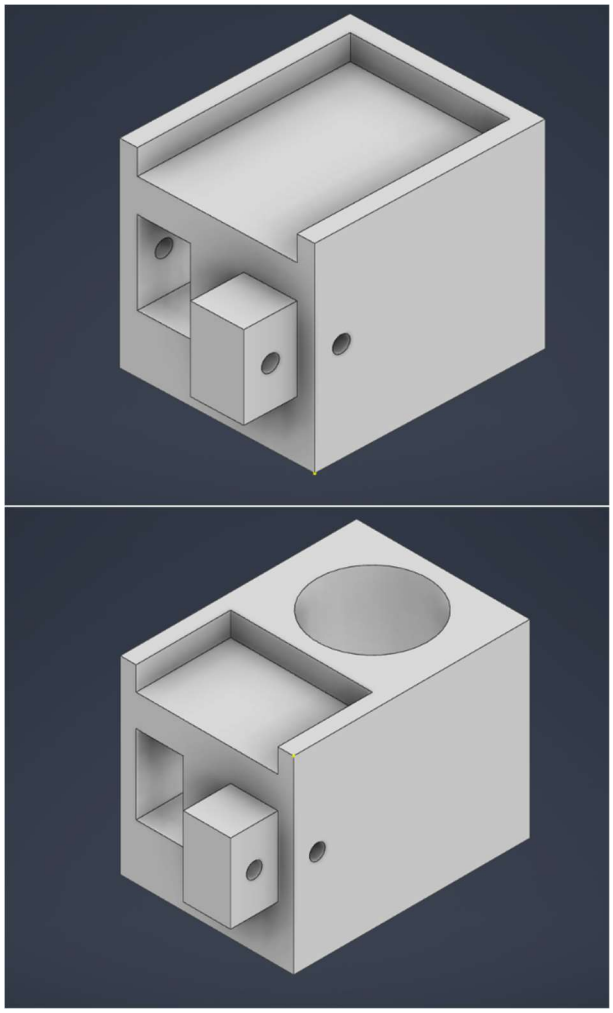


Figure 9. Initial prototype design in Autodesk Inventor.



Figures 10-11. Improved design with two components.

Figure 12. Low fidelity prototype used for testing plan.

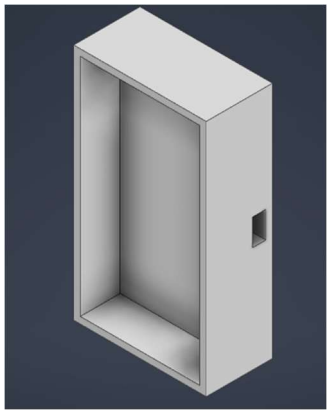


Figure 13. Basic structure of finalized prototype.

Final Drawings:

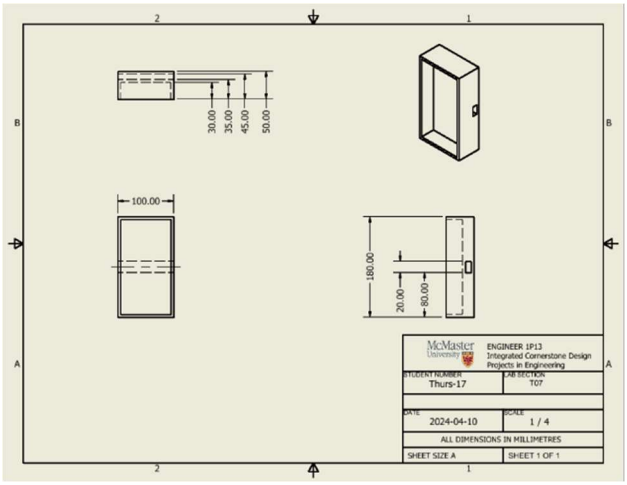
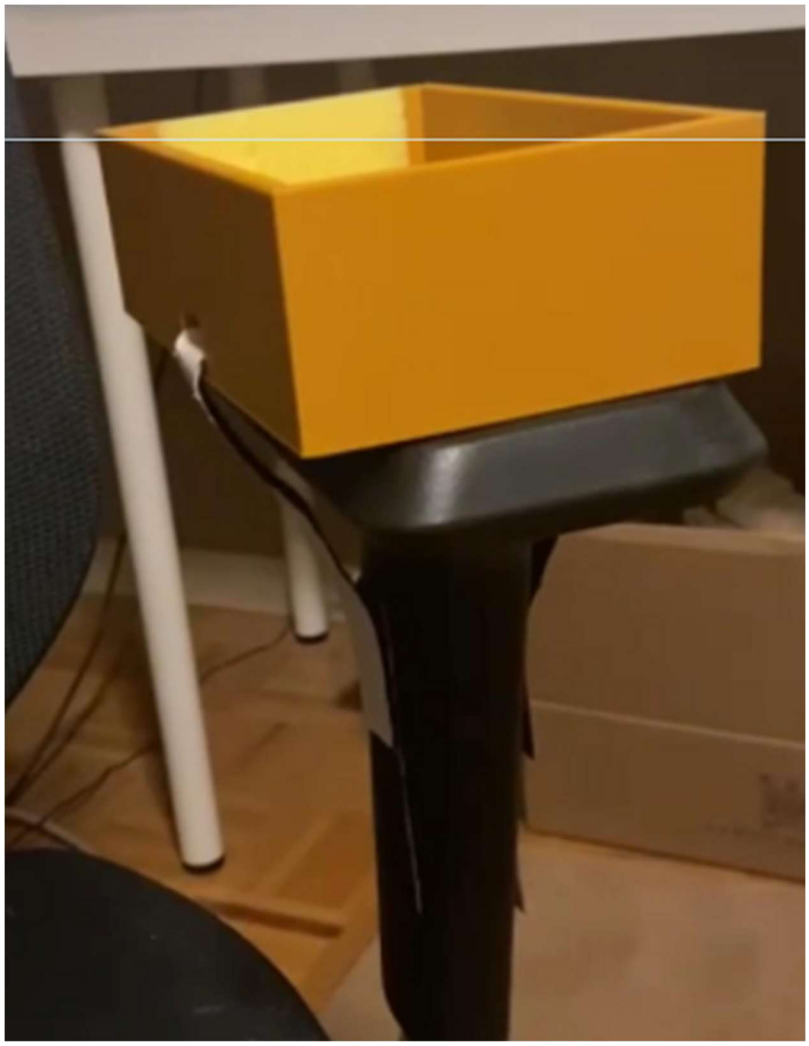


Figure 14. Engineering drawings of finalized prototype.

Final Prototype pictures:



Figures 15-16. Finalized prototype.

Bill of Materials:

Table 5. Bill of Materials

Material	**Cost**
PLA filament	$25 for one spool
Velcro	$1
Sponge	$1
Hot glue	$1
Double sided tape	$1

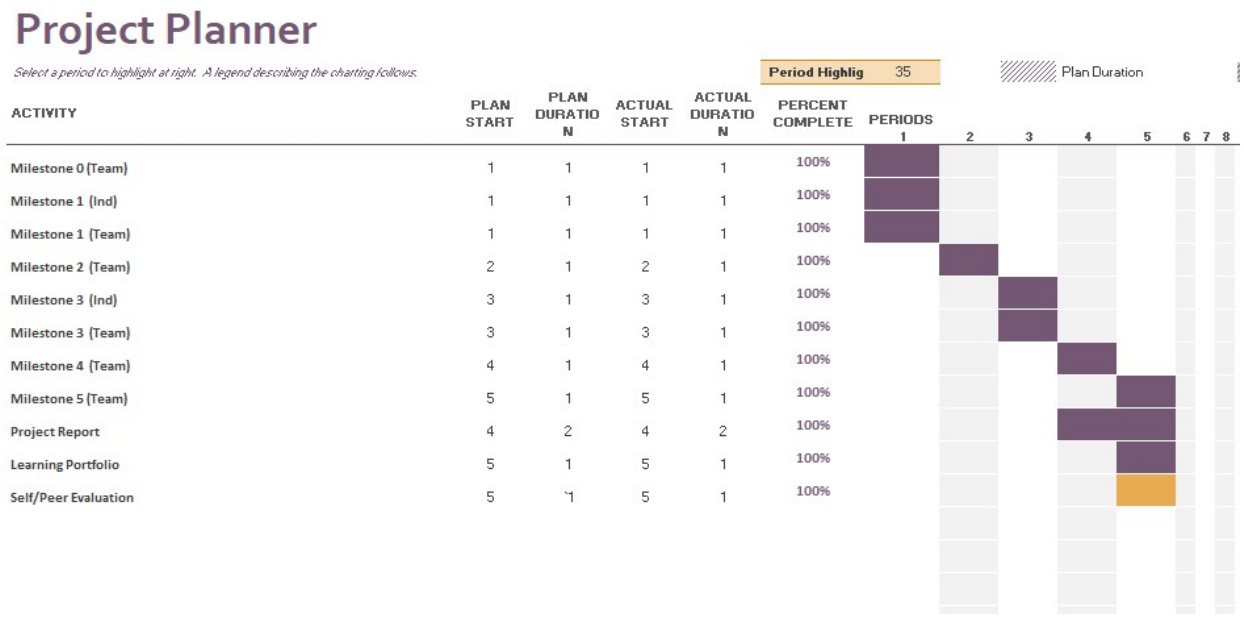
Appendix B: Project Schedule

Preliminary Gantt Chart:

ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Milestone 0 (Team)	1	1	0	0	100%
Milestone 1 (Individual)	1	1	0	0	100%
Milestone 1 (Team)	1	1	0	0	100%
Milestone 2 (Team)	4	8	0	0	0%
Milestone 3 (Individual)	4	2	0	0	0%
Milestone 3 (Team)	4	3	0	0	0%
Milestone 4 (Team)	5	4	0	0	0%
Milestone 5 (Team)	5	2	0	0	0%
Project Report	5	2	0	0	0%
Design Summary	6	5	0	0	0%
Learning Portfolio	6	1	0	0	0%
Self/Peer Evaluation	9	3	0	0	0%

Figure 17. Initial Gantt chart from beginning of project.

Final Gantt Chart:



ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Milestone 0 (Team)	1	1	1	1	100%
Milestone 1 (Ind)	1	1	1	1	100%
Milestone 1 (Team)	1	1	1	1	100%
Milestone 2 (Team)	2	1	2	1	100%
Milestone 3 (Ind)	3	1	3	1	100%
Milestone 3 (Team)	3	1	3	1	100%
Milestone 4 (Team)	4	1	4	1	100%
Milestone 5 (Team)	5	1	5	1	100%
Project Report	4	2	4	2	100%
Learning Portfolio	5	1	5	1	100%
Self/Peer Evaluation	5	1	5	1	100%

Figure 18. Final Gantt chart from end of project.

Logbook of Additional Meetings and Discussions:

Table 6. Logbook of Additional Meetings

Meeting #	Date/Time	Agenda	Discussions/Actions Taken
1	Wednesday April 3, 2024 2:30-4:30pm (in person)	-Confirm that final prototype is ready -Put together presentation for client pitch	-Ensured that prototype was ready to present -Completed presentation slides -Rehearsed presentation
2	Thursday April 4, 2024 10:20-10:40am (in person)	-Final rehearsal of client pitch	-Practiced presentation and demonstration of prototype

Appendix C: Scheduled Weekly Meetings

Weekly Design Studio Agendas:

Week 1:

- Brainstorm initial designs and determine which ones are feasible
- Have ideas reviewed for recommended changes

Week 2:

- Carry out functional analysis
- Have design review with Tas and discuss feedback

Week 3:

- Have TA meeting
- Discuss timeline for project
- Finish and finalize decision matrix

Week 4:

- Review design for better printing or find workarounds/alternatives for the design
- Decide if the current design is possible, and if it is feasible to stick with it
- Ask the TA/IAI for guidance and wisdom
-

Week 5:

- Finalize trimmed down design and find alternate place to print.
- Finish testing plan and optimization
- Start working on presentation
- Discuss budget and additional items to buy
- Assemble prototype

Weekly Design Studio Meeting Minutes:

Week 1:

- Attendance: Everyone is present
- Previous project experience is discussed
- Roles are assigned to each group member
- Preliminary project schedule (Gantt chart) is created
- Basic problem framing and testing plan development is carried out
- Problem statement is refined
- Action items: Topics are assigned for next week's research summary

Week 2:

- Attendance: Everyone is present
- Objectives are refined from milestone 1
- Functional analysis is carried out to narrow down design ideas

- Design review feedback:
    - Keep in mind that physical prototype must be created in short time frame.
    - Battery design is more realistic.
    - Avoid modifying main functionalities of wheelchair
    - Include unique features to make design stand out from existing solutions
    - Ensure design is in line with main objective of increasing client's independence
    - Ensure design is realistic and can have a prototype modelled after it
- Action items: Continue brainstorming and further modifying designs

Week 3:

- Attendance: Everyone is present
- Creating decision matrix to select one design to carry forward with and justify selection
- Created a specific project timeline and updated Gantt chart
- Design review feedback:
    - Reviewed refined project timeline.
        - Feedback – make sure we allocate enough time for 3D printing to account for any issues/long printing time.
    - Have to determine 3D printing location
        - Thode Makerspace has 3D printers that generally have shorter print times, but requires training and has limited time slots.
        - Mills library has slower 3D printers but more flexibility with time slots.
    - 3D printing details
        - Make sure 3D printing g-code is customized for whichever printer we select.
        - Include supports for parts of designs with rounded edges or other similar features
    - Material selection
        - Look into materials that can be added to improve phone holder's grip on wheelchair armrest.
    - Feedback for initial CAD design:
        - Confirm dimensions for wheelchair and for the phone/cup holder components.
        - Consider adjustable clamp to attach to chair so that it can accommodate wheelchairs of different sizes.
        - Incorporate indents to make phone easier to take out of holder.
- Action items: Confirming dimensions of design to prepare for printing and confirm 3D printing location

Week 4:

- Attendance: Everyone is present
- Go over details of refined prototype
- Refine objectives and constraints with metrics
- Review testing plans
- Design review feedback:
    - Concerns about height of prototype and if it would negatively impact convenience for client
    - Consider a mechanism for attachment on the side of the armrest rather than on top
    - Design lacks creativity

    - Would be considered a level 3 design rather than level 4 because of the low creativity
    - More unique features needed/better optimization of current features to achieve a level 4
    - Consider including extra features – e.g. consider client's personal style and aesthetic preferences
    - Clamping mechanism for attachment would be harder to manufacture but may be more convenient for client – however, since it has more moving parts it may be less durable
- Action items: Finalization of design and starting testing

Week 5:

- Attendance: Everyone is present
- Objectives, constraints, and testing plans are reviewed in detail
- Testing plan is carried out with low fidelity prototype since final prototype is not ready yet
- Laser cutting is discussed as alternate method of production
- Action items: Finalizing prototype and preparing presentation for client pitch

Appendix D: Design Studio Worksheets

ENGINEER 1P13:
PROJECT FOUR WORKSHEETS (TEAM)

Table of Contents

PROJECT FOUR MILESTONE ZERO: TEAM DEVELOPMENT AND PROJECT PLANNING

MILESTONE 0 – COVER PAGE

Team ID: Thurs-17

Please list full names and MacID's of all *present* Team Members.

Full Name:	MacID:
Yahya Zaher	zahery
Imaan Sheikh	sheiki6
Sampurna Saha	sahas31
Sameer Khichi	khichis

Insert your Team Portrait in the dialog box below.

MILESTONE 0 – TEAM CHARTER

Team ID: Thurs-17

Incoming Personnel Administrative Portfolio:

Prior to identifying Leads, identify each team members incoming experience with various **Project Leads**

	Team Member Name:	Project Leads
1.	Sampurna Saha	☐M ☐A ☐C ☐S
2.	Yahya Zaher	☐M ☐A ☐C ☐S
3.	Sameer Khichi	☐M ☐A ☐C ☐S
4.	Imaan Sheikh	✓M ✓A ☐C ✓S

To 'check' each box in the Project Leads column, you must have this document open in the Microsoft Word Desktop App (not the browser and not MS Teams)

Project Leads:

Identify team member details (Name and MACID) in the space below.

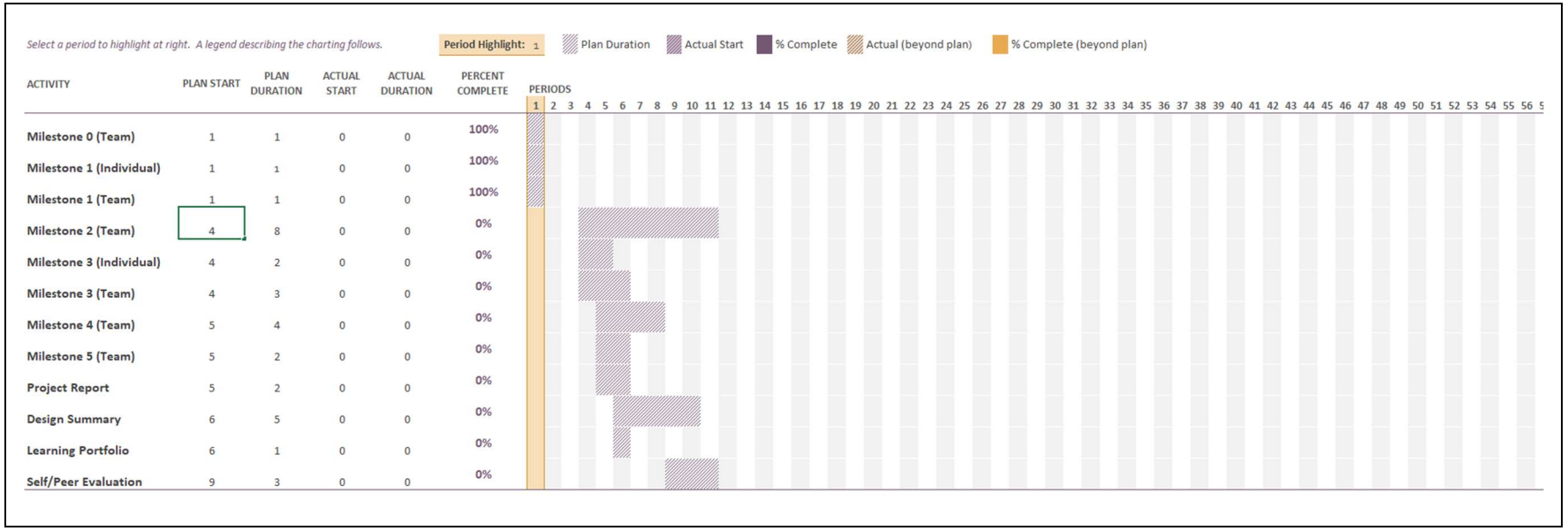
Role:	Team Member Name:	MacID
Manager	Sameer Khichi	khichis
Administrator	Yahya Zaher	zahery
Coordinator	Imaan Sheikh	sheiki6
Subject Matter Expert	Sampurna Saha	sahas31

MILESTONE 0 – PRELIMINARY GANTT CHART (TEAM MANAGER ONLY)

Team ID: Thurs-17

Full Name of Team Manager:	MacID:
Sameer Khichi	Khichis

Preliminary Gantt chart



MILESTONE 0 – PREVIOUS PROJECT EXPERIENCE

Team ID: Thurs-17

In the table below, detail each of your group members' experience and skills that will be useful in Project 4. This can include prototyping knowledge, software skills, modelling, testing experience and any other relevant information.

Team Member	**Skills**
Sampurna Saha	• Modelling: preliminary sketches, constraints for assembly, (modelling sub-team project 2) • Computing: basic python skills (computing project 1) • Designing
Imaan Sheikh	- Experience with modelling and graphics on Autodesk Inventor (modelling sub-team on project 2) – including sketching, modelling, prototyping, assembling, and engineering drawings - Experience computing using Python (computing sub-team on project 3)
Yahya Zaher	-Modelling (P3) -Basic python skills (P2)
Sameer Khichi	-Experience in coding, project 2 programming skills, along side previous programming knowledge in multiple languages. -AutoCAD skills in modelling and designing, project 1 and 3 experience along side external experience.

PROJECT FOUR MILESTONE ONE: PROBLEM FRAMING AND TEST PLAN

MILESTONE 1 – COVER PAGE

Team ID:	Thurs-17

Please list full names and MacID's of all *present* Team Members

Full Name:	MacID:
Yahya Zaher	zahery
Imaan Sheikh	sheiki6
Sameer Khichi	Khichis
Sampurna Saha	sahas31

MILESTONE 1.2 – PROBLEM FRAMING

Team ID: Thurs-17

1. As a team, come up with an initial problem statement and include it in the space below.
   - → Make use of your client notes to define your primary function(s)
   - → Remember to avoid solution-specific statements
     - Focus on what your design *should* do for the client in a general sense (not *how* to do it)

Develop improvements to the client's current wheelchair that provide safer and more convenient mobility options to cater to the client's needs by allowing for more independence in her daily life.

MILESTONE 1.3 – TESTING PLAN DEVELOPMENT

Team ID: Thurs-17

1. As a team, come up with 5 objectives and at least 1 constraint that your design should meet and justify the reasoning behind your choices.
   → Feel free to use such design tools as objectives trees, how/why ladders etc.

Justify your team's reasoning behind the choice of objectives:

Objective	Rationale
1. Driveable on uneven roads	This is to make the wheelchair safer for the client
2. To be able to raise the chair safely	This is to reduce the need for external assistance in order to reach/interact with things higher up. The raising wheelchair will give her more mobility and ease of access.
3. Minimize need for external mobility aids outside of the wheelchair itself	The client has the goal of achieving as much independence in daily life as possible, so providing additions to her wheelchair to allow her this independence without needing many devices would be beneficial.
4. Function well in any weather conditions	The wheelchair can carry out all its normal functions in any weather condition such as snow or rain, allowing her better and safer mobility in harsh weather conditions
5. Maximize protection of the battery	The client is currently experiencing issues with bad weather conditions impacting the internal workings of the wheelchair, and a protective casing for the battery would help combat this issue.
Constraint	Rationale
1. Cost	We don't have a lot of money, and one of the clients' complaints is that her wheelchair is too expensive to maintain.
2. Material	There is limited access to materials for our design, and there are some preexisting constraints surrounding material selection; the client mentioned skin sensitivity in relation to heating pads and systems, so selecting materials that do not interfere with these sensitivities is important (especially if the client will be in frequent direct contact with the design).
3. Battery power/life	Additional functions carried out by the wheelchair will require power from the battery that can potentially decrease the battery

	life throughout the day day. (as battery needs to be charged overnight and has a 24 hour battery life)
4. Strength of mechanism raising wheelchair	The strength of the mechanism that raises the chair of the wheelchair has to be able to support a certain weight.

2. Fill out the table below with associated metrics (including units) for each objective.
   Remember: Metrics should be something you can actually test or measure as part of your process (e.g., calculate weight of a part by iProperties in CAD, test results of a physical prototype).

Objective:	Driveable on uneven roads
Unit/Metric:	Does a cup of coffee quarter filled spill when driving on uneven roads? 1 to 10 (1 being least spilled 10 being all of it and the cup fell)

Objective:	To be able to raise the chair safely
Unit/Metric:	Newtons, Force

Objective:	Minimize need for external mobility aids outside of the wheelchair itself
Unit/Metric:	Amount of mobility tasks that the wheelchair assists the client with

Objective:	Function well in any weather conditions
Unit/Metric:	Distance travelled in harsh weather conditions (snow, rain...) (m)

Objective:	Maximize protection of the battery
Unit/Metric:	Battery life of the wheelchair's battery (hours)

Constraint:	Cost
Unit/Metric:	$ in dollars

Constraint:	Material
Unit/Metric:	Heat capacity of material (J/K)

3. Next, come up with a testing plan for evaluating these objectives using the metrics you identified. Describe what equipment/resources will be needed, time to complete the test and another other pertinent information to completing the task.
   → An example testing plan is provided to you on Avenue, titled "P4 Testing Plan Example"

Objective	Testing Method
1. Driveable on uneven roads	Drive it on uneven Road and observe if a cup of coffee spills from it which will tell us the stability of the wheelchair on uneven roads.
2. To be able to raise the chair safely	Test multiple weights by lifting them in the wheelchair and calculate the force that the mechanism can support
3. Minimize need for external mobility aids outside of the wheelchair itself	Test out with 10+ users and have them rank how many tasks can be carried out independently using the mechanism vs using a normal wheelchair.
4. Function well in any weather conditions	Drive wheelchair in various weather conditions and measure how far it travels in meters before getting stuck or facing an issue.
5. Maximize protection of the battery	Research different materials and designs for battery casings and calculate the heat capacity for each materials for the ideal design
Constraint	Testing Method
1. Cost	Compare prices of existing products to determine an acceptable range, accounting for any budget provided as well.
2. Materials	Further discuss topic of skin sensitivity with client and determine acceptable materials based on her past experiences (e.g. avoid certain materials that are known to cause irritation).

MILESTONE 1.4 – REFINED PROBLEM STATEMENT

Team ID: Thurs-17

1. As a team, create a refined problem statement using the objectives you have identified and justified. Outline the Who, Where, Why, and What elements of your problem statement. Then write the refined problem statement below.

- Who? – The client (Tiffany)
- Where? – Design should be suitable for the client to use everywhere, as the wheelchair is an essential device for her
- Why? – To improve safety and mobility
- What? – Wheelchair

Refined Problem Statement:

Develop additions to the client's current wheelchair to improve safety and convenience, design, and built integrity with built-in mobility aids to allow for more independence in the client's daily life and ensure that the wheelchair is suitable for use in various conditions and environments.

MILESTONE 1.5 – DESIGN EXPLORATION PREPARATION

Team ID: Thurs-17

1. As a team, discuss which topic each member will cover in the research summary. Then, fill out the table below.

Team Member	Research Topic
Yahya Zaher	Wheelchairs in uneven roads and Battery power
Imaan Sheikh	Skin sensitivity issues related to metal rods in spine and heating systems
Sameer Khichi	Chair lifting mechanism and design concepts and constraints to look out for. Investigating the methods to use to elevate the chair.
Sampurna Saha	Battery power on certain functions (listing mechanism), Enhancing wheelchair performance on harsh weather conditions

PROJECT FOUR MILESTONE TWO: DESIGN EXPLORATION AND DESIGN REVIEW #1

MILESTONE 2 – COVER PAGE

Team ID: Thurs-17

Please list full names and MacID's of all *present* Team Members

Full Name:	MacID:
Imaan Sheikh	sheiki6
Yahya Zaher	zahery
Sameer Khichi	khichis
Sampurna Saha	sahas31

MILESTONE 2.3 – FUNCTIONAL ANALYSIS

Team ID:	Thurs-17

Summary of changes:

In the space below, please highlight any changes that were made to your items in Milestone 1 (objectives, constraints, problem statements, etc.) Ensure you have at least **one constraint** if you don't already have one. Make sure you also explain and justify your reasons for making those changes. Consider additional client notes and the results of your independent research assignments when making potential changes. Make sure to include an **updated** Refined Problem Statement as well.

Changes from Milestone 1

- Objectives 1 and 2 (driveable on uneven roads and raising the chair safely) are being combined into one objective, which is to improve mobility. The former objectives 1 and 2 are subcategories of the new objective for mobility.
- Objectives 4 and 5 (function well under any weather conditions and maximize protection of battery) are being combined into one objective, which is to maximize durability. The former objectives 4 and 5 are subcategories of the new objective for durability.

1. Include a copy of your team's functional analysis below.

Function	**Means**					
Improves mobility	-Tires with improved traction	- improved seat mechanics and ability to lift and lower the chair.	--Compact Wheelchair	-Better/added suspension system.		
Minimizes need for external mobility aids	-umbrella holder.	-Built in storage	-Customizable attachments			
Maximizes durability	-Protective case for battery	-Snow tires/new tire design with better resistance to snow/slush	-Weather-resistant coating	Incorporate materials with high strength-weight ratio		

MILESTONE 2.5 – DESIGN REVIEW

Team ID:	Thurs-17

Design Review Comments: Use the space below to document feedback for your design

Include feedback from your faculty mentor, staff, or assigned TA/IAI in this row - Keep in mind that physical prototype must be created in short time frame. - Battery design is more realistic. - Avoid modifying main functionalities of wheelchair - Include unique features to make design stand out from existing solutions - Ensure design is in line with main objective of increasing client's independence
Include feedback from science students in this row. (if applicable) - Ensure design is realistic and can have a prototype modelled after it

PROJECT FOUR MILESTONE THREE: PROTOTYPING, DECISION MAKING AND DESIGN REVIEW #2

MILESTONE 3 – COVER PAGE

Team ID: Thurs-17

Please list full names and MacID's of all *present* Team Members

Full Name:	MacID:
Imaan Sheikh	sheiki6
Sameer Khichi	khichis
Sampurna Saha	sahas31
Yahya Zaher	zahery

MILESTONE 3.2 – DECISION MAKING

Team ID: Thurs-17

As a team, use a decision matrix to aid you in choosing two concepts to proceed with. Your concept titles should be descriptive (i.e., "Pencil with Hook" instead of "Design A"). If you had your Design Review **before** completing this decision matrix, use the feedback you were given from the review to influence your ratings of your concept(s).

Include your team's Decision Matrix below.

Criteria	**Weighting**	**CAD case with holes**		**CAD/printed phone holder**		**Cardboard prototype**		**CAD design 4 with hinge**	
		Score	Total	Score	Total	Score	Total	Score	Total
Durability	5	2.5	12.5	4	20	4	20	3.5	17.5
Lightweight	3	5	15	4	12	3	9	3.5	10.5
Physical design	4	3	12	3	12	3	12	4.5	18
Functionality	5	4.5	22.5	5	25	4.5	22.5	4	20
Creativity	3	3.5	10.5	3	9	2.5	7.5	4	12
Convenience	4	4	16	3	12	4	16	5	20
Total			88.5		90		87		98

Team ID:	Thurs-17

The numbers you associate with your criteria (objectives and constraints) will probably be an estimation at this point, so **your top two concepts may not always end up being the top two scoring from the decision matrix**. You should provide justification for your team's thought process in choosing the top two concepts. This should include, but is not limited to, explaining:

- → Your choice of decision matrix tool
- → Your rationale behind your choice of criteria
- → Why you prioritized criteria the way that you did (if ranking and/or weighing them)
- → What metrics you used to decide your scoring of concepts within the criteria
- → Present your top concept(s) during your Design Review
    - If you had your Design Review **before** completing this part of the worksheet, your top two concepts may or may not be the ones you presented during your Design Review
    - Include in your justification how the Design Review influenced your top concepts

	Insert your team's top two concepts below.
Concept 1:	CAD/printed phone holder
Concept 2:	CAD design 4 with hinge

Include your team's justification below.

- Phone holder design is top concept because it is convenient and functional
- Decided against battery case designs as they lack complexity and may not directly improve client's independence
- Need to incorporate more creative features on final phone holder design so that it differs from similar existing products
- Battery case designs have potential if features from each are combined, but phone holder design is more suited to our chosen objectives

MILESTONE 3.3 – REFINED PROJECT TIMELINE

Team ID: Thurs-17

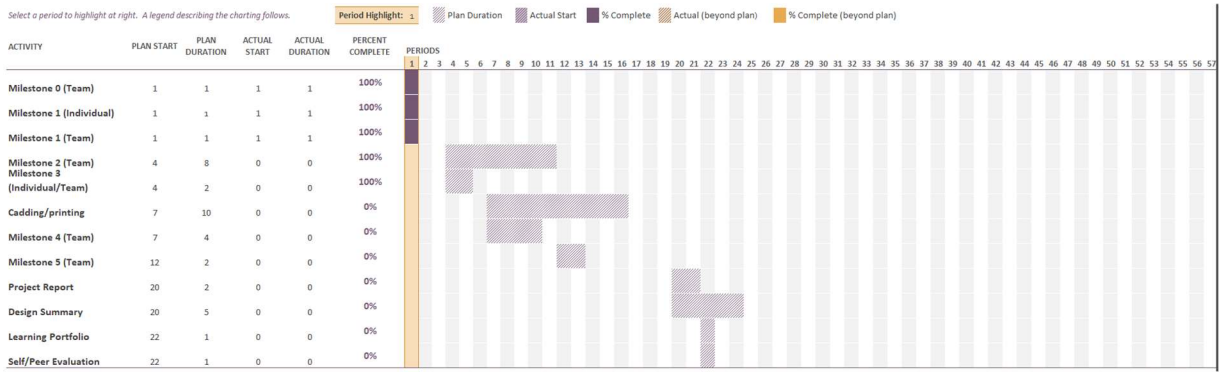
Include a list of all remaining tasks that need to be completed such that all final deliverables and remaining Milestones can be met. These may include but are not limited to:

- → Prototyping
- → Fabrication
- → Material Purchasing/Allocation

Be as specific as possible and allocate each task to a group member. There is no requirement on the number of outstanding tasks your group may have; ensure that the tasks encompass the remainder of the project and are achievable. Add these remaining tasks to your team Gantt chart and include an updated image below.

Task:	Time Needed to Complete:	Deadline to Complete By:	Assigned Group Member:
Brainstorm more features to the product	1.5 hour	Saturday, March 9	Everyone
Finding all dimensions	1 hour	Sunday, March 10	Sampurna
Adding/refining all the components to the CAD	1 hour	Tuesday, March 12	Sameer
Getting it ready 3D printing	1 hour	Thursday, March 14	Imaan
3D printing/assembling	3 + hours	Tuesday March 19	Everyone
Testing	1.5 hour	Thursday March 21	Everyone
Client pitch	1 hour	Thursday March 28	Everyone
Report	3 hours	Wednesday April 10	Everyone

Include an updated image of your Gantt chart:



Select a period to highlight at right. A legend describing the charting follows.

Period Highlight: 1 | Plan Duration | Actual Start | % Complete | Actual (beyond plan) | % Complete (beyond plan)

ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Milestone 0 (Team)	1	1	1	1	100%
Milestone 1 (Individual)	1	1	1	1	100%
Milestone 1 (Team)	1	1	1	1	100%
Milestone 2 (Team)	4	8	0	0	100%
Milestone 3 (Individual/Team)	4	2	0	0	100%
Cadding/printing	7	10	0	0	0%
Milestone 4 (Team)	7	4	0	0	0%
Milestone 5 (Team)	12	2	0	0	0%
Project Report	20	2	0	0	0%
Design Summary	20	5	0	0	0%
Learning Portfolio	22	1	0	0	0%
Self/Peer Evaluation	22	1	0	0	0%

PERIODS 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57

PROJECT FOUR MILESTONE FOUR: REFINED PROTOTYPING AND TESTING PLAN

MILESTONE 4 – COVER PAGE

Team ID: Thurs-17

Please list full names and MacID's of all *present* Team Members

Full Name:	MacID:
Yahya Zaher	zahery
Sameer Khichi	khichis
Imaan Sheikh	sheiki6
Sampurna Saha	sahas31

MILESTONE 4.1 – REFINED PROTOTYPE

Team ID: Thurs-17

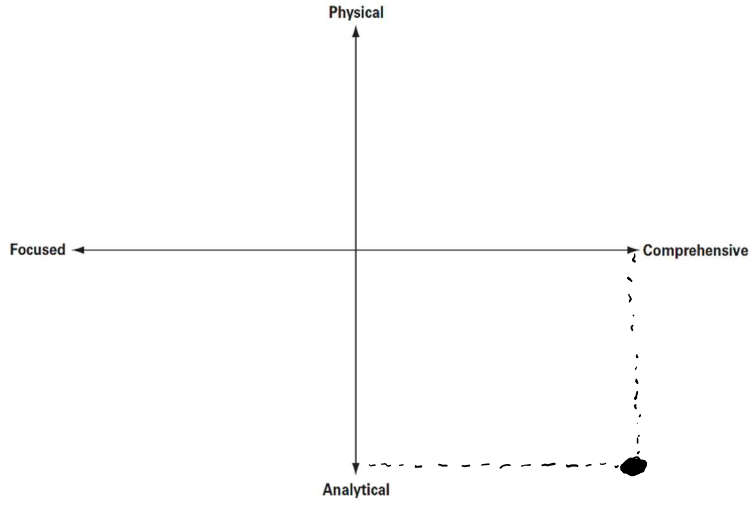
1. Create an outline for the creation of your refined prototype using the following worksheet.

Team ID: Thurs-17	MacID: Khichis

Write a short description of your refined prototype below.

Our refined prototype features a smaller cupholder to conventional cup/thermos size, as well as a phone holder scaled to fit the largest phones on the market. The edges of the attachment are filleted for an ergonomic look that would not compromise the wheelchair's mobility. The attachment has a clasp at the bottom designed to be relatively simple to use and is meant to keep the holder in place without falling off. The size of the design itself is small enough to make sure it is not uncomfortable to have in day-to-day life. The product requires a one-time assembly, this is done for ease of 3D printing and structural integrity.

Indicate where your prototype falls on the scale below.



Kind of Prototype:

☐ Physical or ✓ Analytical

☐ Focused or ✓ Comprehensive

Purpose of Prototype:

To create a device that will attach to the client's wheelchair and hold her phone and cups.

Level of Fidelity:

Medium fidelity

Include a list of objectives and metrics for your prototype below.

Objectives

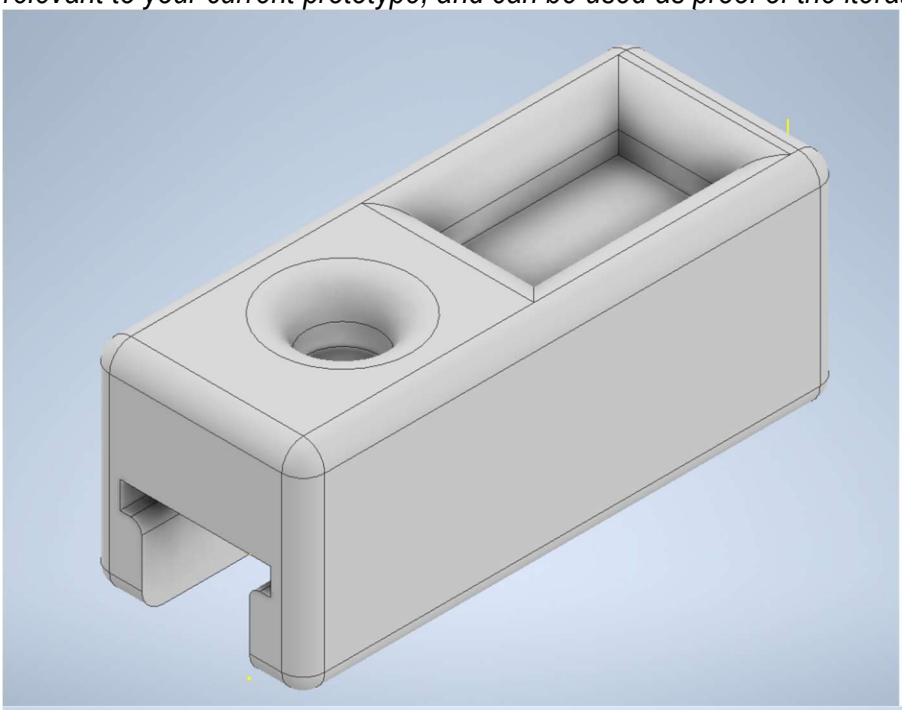
- High durability
- Lightweight
- Low cost
- Convenient

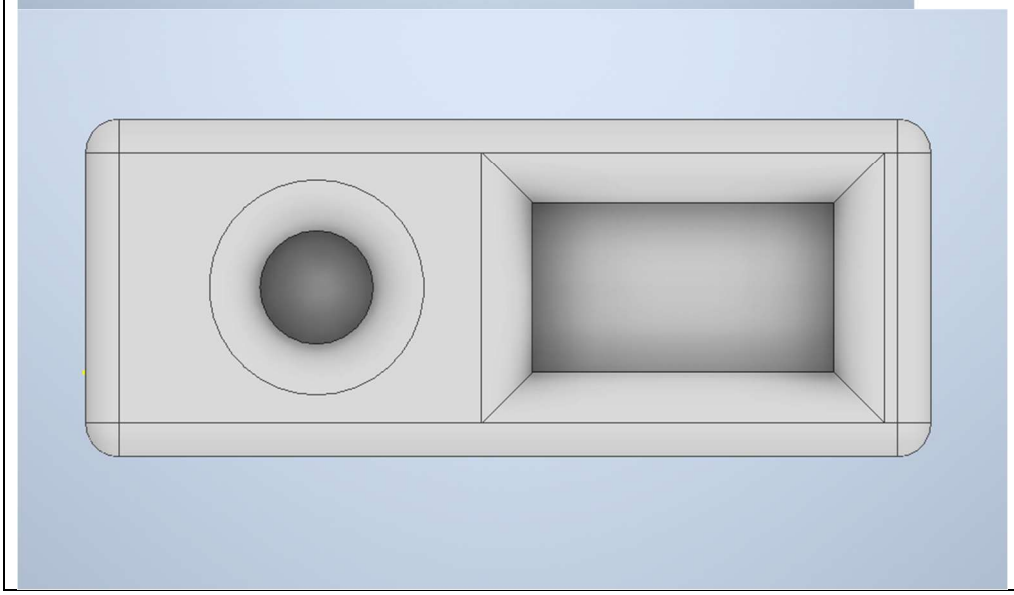
Metrics

- Weight (g/kg)
- Weight (g)
- CAD ($)
- User score

2. Take picture(s) of your refined prototype.
   → Include picture(s) of your previous prototypes(s) that you either decided to further refine or take elements from to create your refined prototype. Only include relevant previous prototypes
   → Insert your photo(s) as a Picture (Insert > Picture > This Device)
   → **<u>Do not include more than *two* pictures per page</u>**

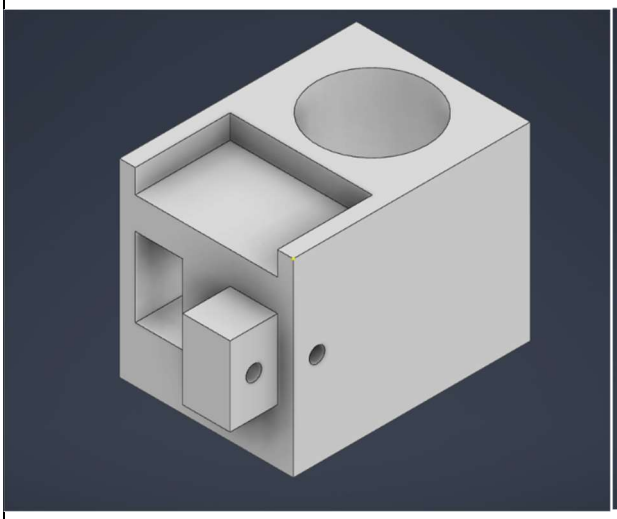
Insert picture(s) of your previous prototype(s) below. These should be the prototypes that are relevant to your current prototype, and can be used as proof of the iteration process

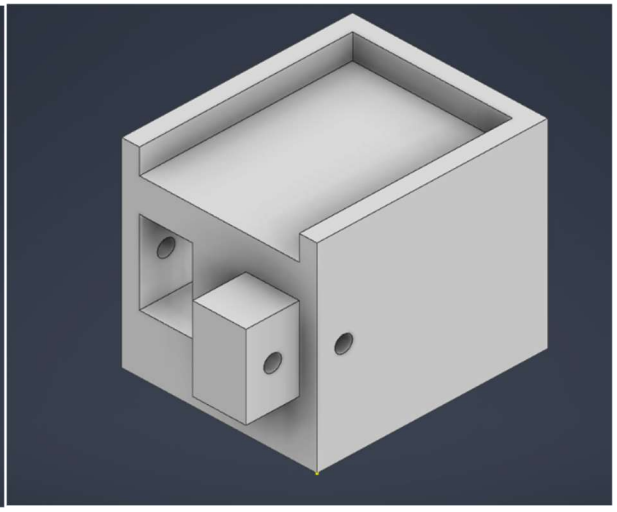


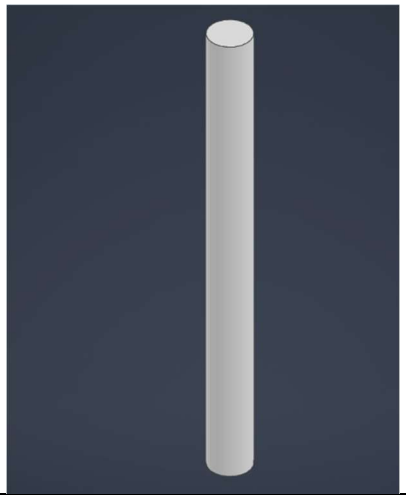


*Limit screenshots to no more than 2 per page. For additional screenshots, please copy and paste the above on a new page.

Insert picture(s) of your refined prototype below.







*Limit screenshots to no more than 2 per page. For additional screenshots, please copy and paste the above on a new page.

Team ID: Thurs-17

Include details on how design concept was refined (what feedback was incorporated, what features are different than previous refined concept (initial prototype), etc.).

Include details on your thought process and how the concept was refined below, with notes on relevant feedback that was incorporated ***(max. 200 words).***

There were a few changes we made to our initial design to ensure that it was better suited for the client's needs and would be suitable for 3D printing. Instead of designing the phone/cup holder in one piece, we divided it into two parts as well as a rod to hold the two components together. This allows us to print each piece separately and reduce print times. The dimensions of the phone holder and cup holder were also adjusted to match standard sizes of existing products, and there is some extra space around the edges of the phone holder to make it easier to pick up the phone from it. The attaching mechanism for the design remains the same for the most part, but will be further modified to include a component at the front of the device to prevent it from slipping off the end of the wheelchair's armrest. After the design is 3D printed, we plan to incorporate rubber on the bottom and inside the holders to improve grip.

MILESTONE 4.2 – PROTOTYPING TEST PLAN REFINEMENT

Team ID: Thurs-17

3. Detail your prototype testing plan. (**max. 500 words** TOTAL for present and future plan)
   - → You have already outlined the testing plan in Milestone One. You should examine this testing plan and consider whether it is still feasible, document refinements, and then outline the methodology and equipment you need to source for next week's execution of the plan.
   - → You should also document a future testing plan; document what refinements you would make and metrics you would like to examine if given more time and resources.
   - → Use IEEE referencing if any research is done.

*Insert your **Present Testing Plan** (how you will test your prototype).*

Durability: Test maximum weight it can hold/maximum weight that can be applied to it.

Lightweight: Measure weight of prototype and compare to the wheelchair's weight capacity. Compare its weight to other products on the market.

Cost: Compare prototype cost to prices of other similar existing products.

Convenient: Have 10-15 people try putting their phones/cups in it and give it a convenience score out of 10.

*Insert your **Future Testing Plan** (how you would test your prototype with the resources that you do not currently have available but could have in the future).*

Durability: Advanced material testing (chemical exposure, tensile testing, etc.)

Lightweight: Use finite element analysis (FEA) simulations to make the design lighter without sacrificing its strength.

Cost: Market analysis (observe how much people would buy the product for) to determine demand and expected cost of product and compare to other products.

Convenient: Extend user scoring system to have more people evaluate the prototype and target a larger variety of people in testing plan (e.g. obtain user scores specifically from people with spina bifida or other wheelchair users).

Team ID: Thurs-17

4. Fill out the table below, detailing each team member's contribution to this stage

Team Member's Full Name:	Contribution:
Imaan Sheikh	Testing plans, explanation of refined design concept, outline of refined prototype
Yahya Zaher	Testing plans, outline of refined prototype
Sameer Khichi	Testing plans, outline of refined prototype, improvements to initial prototype. Refined prototype model.
Sampurna Saha	Testing plans, outline of refined prototype, finalized dimensions for refined prototype

MILESTONE 4.3 – DESIGN REVIEW

Team ID: Thurs-17

Include your feedback from both your peers (or TAs/IAIs) and the science students below. Remember to make clear what concept(s) you're receiving feedback for. Use the name of the concept that is used from your decision matrix

Feedback for CAD/printed phone holder:

Include feedback from science students in this row. - Concerns about height of prototype and if it would negatively impact convenience for client - Consider a mechanism for attachment on the side of the armrest rather than on top -
Include feedback from your faculty mentor, staff, or assigned TA/IAI in this row - Design lacks creativity - Would be considered a level 3 design rather than level 4 because of the low creativity - More unique features needed/better optimization of current features to achieve a level 4 - Consider including extra features – e.g. consider client's personal style and aesthetic preferences - Clamping mechanism for attachment would be harder to manufacture but may be more convenient for client – however, since it has more moving parts it may be less durable

PROJECT FOUR MILESTONE FIVE: EXECUTION OF THE TEST PLAN AND FINALIZING THE DESIGN

MILESTONE 5 – COVER PAGE

Team ID: Thurs-17

Please list full names and MacID's of all *present* Team Members

Full Name:	MacID:
Imaan Sheikh	sheiki6
Yahya Zaher	zahery
Sameer Khichi	khichis
Sampurna Saha	sahas31

MILESTONE 5.1 - FINAL EVALUATION OF THE OBJECTIVES AND CONSTRAINTS

Team ID: Thurs-17

As a team, for the last time, restate the quantitative and qualitative objectives, along with constraints that you had stated in your refined testing plan of Milestone 4. If these objectives/constraints, metrics, and testing methods have changed over the course of your project, that is OK. Use the objectives/constraints, metrics, and testing methods that are most in line with your current design. You can refer to the Test Plan Guideline (can be found under P4 documents) for more details.

State your Quantitative Objectives and their Metrics below:

Low cost	CAD ($)
Lightweight	Grams
Durability	Grams/kilograms

State your Qualitative Objectives and their Metrics below:

Convenience	User score

State your Constraints and their Metrics below:

Size	Square millimeters
Materials	Number of materials readily available

Restate your current testing plan that you will be implementing today.

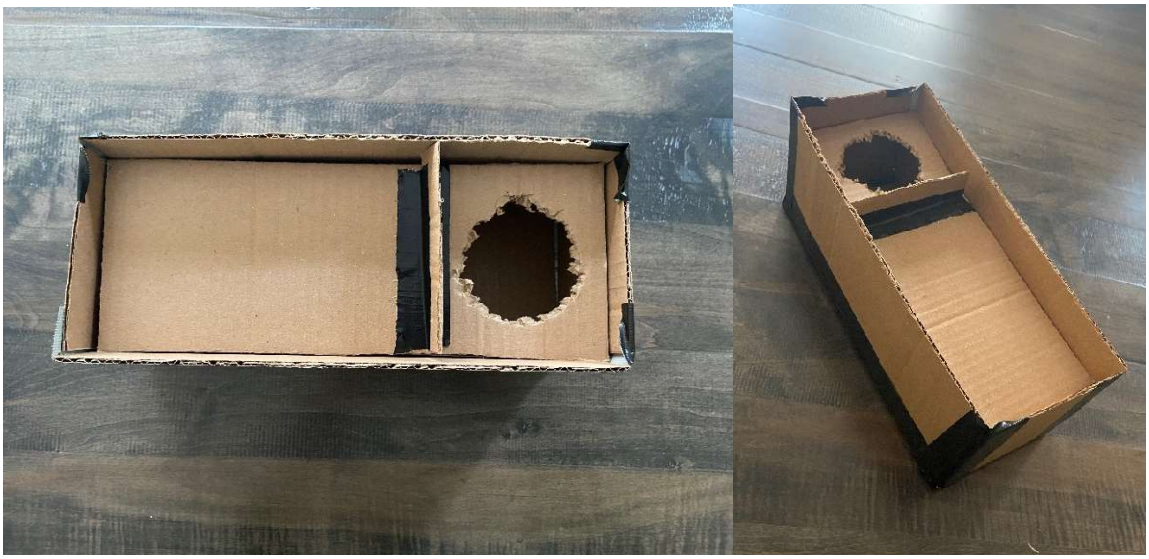
*Insert your **Present Testing Plan** (how you will test your prototype).* Durability: Test maximum weight it can hold/maximum weight that can be applied to it. Lightweight: Measure weight of prototype and compare to the wheelchair's weight capacity. Compare its weight to other products on the market. Cost: Compare prototype cost to prices of other similar existing products. Convenient: Have 10-15 people try putting their phones/cups in it and give it a convenience score out of 10.
State and justify any changes you made from last week. - Testing plan is unchanged from last week.

- Scales will be available to measure weight.
- User scores will be taken from fellow classmates.
- Cost will be roughly calculated and compared to market prices
- We will provide objects to work as weights and test durability

MILESTONE 5.2 – TESTING PLAN EXECUTION AND DISCUSSION

Team ID: Thurs-17

- This week, we ran into some difficulties regarding the 3D printing of our design.
- Our expected print time exceeded a reasonable amount, and we had to alter our design accordingly.
- For this week, we implemented our testing plan by creating a low fidelity prototype of our design using cardboard and duct tape.
- The low fidelity prototype can be seen in the images below:



Execute your testing plan for your Quantitative Objectives:

State and discuss the results of your testing plan in this box.

- The low fidelity prototype we used in testing fulfilled two out of our three quantitatively measured objectives.
- It was low cost, as the prototype was composed of cardboard and duct tape, which are inexpensive materials
- It was lightweight, as the materials used are not very heavy.
- This makes it easier for the client to handle and prevents any issues with attaching the device to the wheelchair arm.
- It was not extremely durable as a result of the materials used.
- However, the final prototype will be made of more durable material than this low fidelity prototype (PLA filament rather than cardboard), which should combat this issue.

Execute your testing plan for your Qualitative Objectives:

State and discuss the results of your testing plan in this box.

- Our qualitative objective for this prototype was convenience.
- The planned metric for this objective was user score, in which people would rate the convenience of the design on a number scale.
- This design achieves high convenience scores by providing both a phone holder and cupholder for the client's wheelchair.

Execute your testing plan for your Constraints:

State and discuss the results of your testing plan in this box.

- Size was one of the constraints for this design, as the phone/cup holder prototype needs to fit on the client's wheelchair arm without restricting her movement or being unbalanced.
- This was taken into account by using specific dimensions to accommodate the largest phone sizes as well as the standard cup size, and by customizing the size of the entire device according to standard wheelchair arm measurements.
- The low fidelity prototype created did not have the exact measurements incorporated in our CAD model, but succeeded within the constraints by comfortably fitting a phone and cup in their designated spots.
- Material was the other constraint, as we were limited in which materials could easily be used in the fabrication of this design.
- Since the low fidelity prototype consisted of cardboard, we cannot yet test the effectiveness of the materials that will be used in our final prototype.

As a team, discuss the results of your testing plan. How did your design do? Did it meet all expectations you had from your design? Did you go through any iteration based on the execution and the results if your test plan? How did the test plan influence your iterative process? Remember, focus on the overall functionality of your design rather than the aesthetic quality.

State and discuss the modifications of your design in this box.

- We ran into some difficulties regarding the 3D printing of our design.
- Our expected print time exceeded a reasonable amount, and we had to alter our design accordingly.
- For this week, we implemented our testing plan by creating a low fidelity prototype of our design using cardboard and duct tape.
- We plan to modify our design by reducing the amount of material used and laser cutting instead of 3D printing.
- This will be in line with our objectives by reducing the cost of the prototype and making it more lightweight.
- Attempting to implement the test plan with our low fidelity prototype highlighted some potential concerns such as durability and material selection, which we are altering before proceeding with laser cutting/3D printing.

ENGINEER 1P13:
PROJECT FOUR WORKSHEETS (INDIVIDUAL)

Table of Contents

PROJECT FOUR MILESTONE ONE: PROBLEM FRAMING AND TEST PLAN

MILESTONE 1.1 – CLIENT NOTES

Team ID: Thurs-17

Complete this worksheet individually before coming to Lab A for Week 6.

1. Include your client notes from the introductory client visit

Name: Imaan Sheikh	MacID: sheiki6

- Met client for the first time
- General client info:
  > 33 years old
  > Works in Walmart
  > Diagnosed with spina bifida at birth – causes difficulties with daily tasks and activities
  > No sensation and full paralysis below the waist – upper body retains normal function
  > Has a nurse and personal support worker (PSW)
  > Has two metal rods in back for spine straightening – they cause issues with temperature in bad weather conditions
  > Utilizes devices including a power wheelchair and a reacher grabber device
  > Encounters difficulty when using both devices – bad weather conditions prevent proper function of the wheelchair, it is limited by its size in doorways, and has battery issues sometimes, and the reacher grabber is limited to use in specific places and cannot be used at work.
  > Hobbies include dance, going out with friends, and martial arts
- Main goals include resolving some of the issues with current devices, improving safety with power wheelchair, and gaining more independence in daily tasks

PROJECT FOUR MILESTONE TWO: DESIGN EXPLORATION AND DESIGN REVIEW #1

MILESTONE 2.1 – CLIENT NOTES

Team ID: Thurs-17

Complete this worksheet individually before coming to Lab A for Week 7.

Include your client notes from the introductory client visit

Name: Imaan Sheikh	MacID: sheiki6

Regarding grabber tool:

- Current grabber tool capacity is < 5 pounds
- Any grabber tool design should not exceed 10 pounds, as that would become difficult to maneuver
- A length of 0.5 m would be ideal, as well as retractable properties
- Client currently stores grabber tool in bag or holds it in lap – can be inconvenient due to its size
- Storage options are limited – a retractable design would be beneficial

Regarding wheelchair:

- Has had experiences with wheelchair slipping off sidewalk – snow tires or another similar addition would be beneficial
- Wheelchair has limited storage
- Wheelchair needs to be plugged into outlet – needs portable battery
- Part of the reason wheelchair should be changed is growth – it causes pain now
- *Reference wheelchair dimensions (on Avenue) in any designs

Other:

- Relies on personal support worker (PSW) for daily tasks (e.g. changing clothes)
- Has had issues with public transport due to delays in times and bad communication – prefers using HSR as a result of this
- Often decorates wheelchair
- Prioritizes functionality, but values aesthetics and personal taste as well
- Also considers the way decorations impact others' perception of her
- Can reach to wheelchair handles and top of feet
- Has more strength in right arm

MILESTONE 2.2 – RESEARCH ASSIGNMENT

Team ID: Thurs-17

Complete this worksheet before Lab A for Week 7.

- State the question you plan to answer through your research
- Summarize your research findings (answer). Your answer should be a coherent, well-written summary of your research, not a "brain dump".
- You may include images, but don't forget to cite them properly.
- Aim for a length of about 500 words
- Properly cite your sources using IEEE formatted references and in-text citations. For information on referencing formats and choosing sources, see Design and Communication Workshop 1.

Name: Imaan Sheikh	MacID: sheiki6

What is your question?

Which properties will be most important to consider when selecting the safest and most effective materials for the client's needs?

What is your answer?

Material selection is an important step in the design process for this project. At this stage, it is difficult to pinpoint which specific materials will be used in the final prototype, as we have not yet progressed to solution-oriented discussions of our design. However, preliminary research regarding common materials used in relevant devices is significant in helping build understanding of existing solutions as well as the advantages and disadvantages of different materials. The aim is to select materials that are functional, cost-effective, and safe, while accounting for the skin sensitivity the client is experiencing.

During the first meeting, there was a focus on three main mechanisms used by the client as mobility aids: a power wheelchair, a reacher-grabber device, and metal rods used for straightening in her spine. The most common materials used in the manufacturing of wheelchairs are steel, aluminum, and titanium [1]. These materials are usually selected because of their lightweight properties, strength-to-weight ratios, and resistance to corrosion [1]. These properties ensure that the wheelchair is easy to maneuver and long-lasting. Considering that the wheelchair is often exposed to inclement weather conditions and moves through snow and slush, having materials that can withstand contact with different substances is crucial.

Apart from her wheelchair, the client also utilizes a grabber tool to pick up and put down items. These devices can be made from a variety of materials, but the most popular ones currently on the market usually consist of aluminum, steel, rubber, and plastic [2]. The selection of metals can

likely be attributed to the same strength-to-weight ratios and lightweight properties that make them a common choice in wheelchairs. Additionally, rubber is often incorporated to improve grip strength [2]. These aspects are important to consider during the material selection process, as they reduce strain for the client and minimize risks of overexertion during use.

At a young age, the client underwent surgery and had two metal rods implanted in her back to straighten her spine. While it has not been specified what materials these rods consist of, it is important to note that they can become very cold in extreme weather. The client is limited in her options to treat this issue, as heat pads and hot water bottles trigger her skin sensitivities. This information is crucial in the material selection stage, as it indicates that heat capacities of any material chosen need to be accounted for. Materials with higher heat capacities would be ideal, as they would require more heat to change temperature and would therefore be less likely to become too hot and cause discomfort to the client.

In short, there are a few material properties that will take priority during material selection for this design. Regardless of which type of solution is created, choosing materials that are lightweight and have high strength-to-weight ratios is important in ensuring that the device is easy to maneuver and does not cause difficulties for users with limited mobility. Additionally, materials like rubber would be beneficial if the device is used for picking up or holding items, and a high heat capacity is important no matter what the specific purpose of the device is.

List of sources:

[1] "Wheelchair | Mobility, Accessibility & Benefits | Britannica," *Encyclopædia Britannica*. 2024. Accessed: Feb. 27, 2024. [Online]. Available: https://www.britannica.com/topic/wheelchair

[2] "Best Reacher Grabber Tool ~ 6 Best Tools for Grabbing (reviewed)," *Gadget Review*, Nov. 15, 2023. https://www.gadgetreview.com/best-reacher-grabber-tool#-5-fitplus-premium-grabber-reacher-tool (accessed Feb. 27, 2024).

MILESTONE 2.2 – INITIAL CONCEPT EXPLORATION

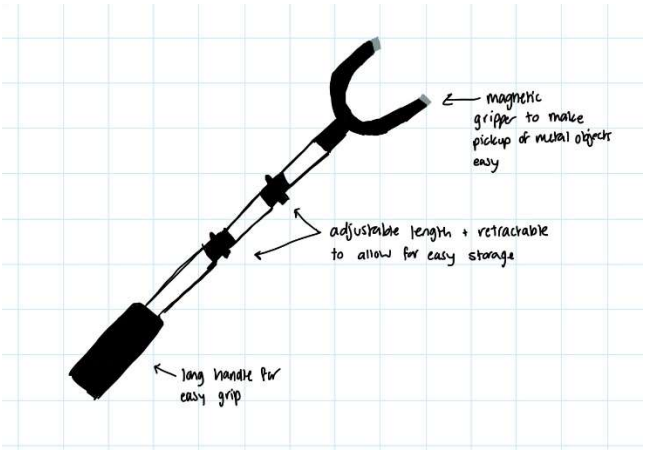
Team ID: Thurs-17

Complete this worksheet before Lab A for Week 7.

1. Include multiple images of your **initial** concept exploration, if needed
   → Include necessary annotations to help in the communication of your ideas
   → These can be photos of hand sketches, photos of initial prototypes, screen grabs of basic CAD models
   → Include your Team Number, Name and MacID on *each* concept image
2. Insert your photo(s) as a Picture (Insert > Picture > This Device)
3. **Do not include more than *two* concept images per page**

Name: Imaan Sheikh	MacID: sheiki6

Insert screenshot(s) of your concept below.



- My initial concept exploration includes design ideas for improvements to both the client's grabber tool and wheelchair.
- Initial concepts for the grabber tool include features to extend and retract the tool to allow for easier storage and farther reach, as well as magnetic grippers to hold metal objects
- Initial concepts for the wheelchair consist of tires with increased traction to prevent slipping in snow/slush and on uneven roads.

MILESTONE 2.4 – REFINED CONCEPT EXPLORATION

Team ID:	Thurs-17

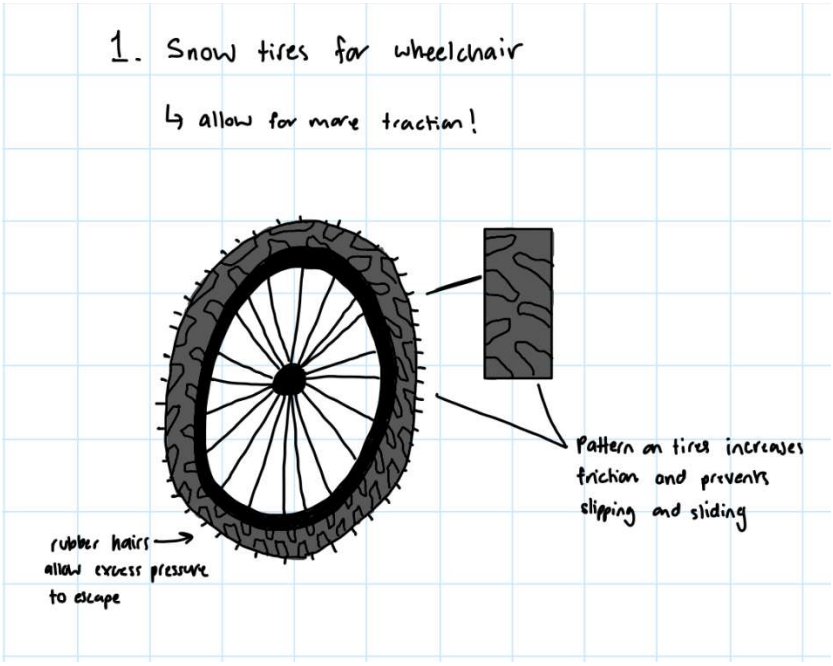
Complete this worksheet during Lab A for Week 7.

4. Include multiple images of your **refined** concept exploration, if needed
   - → Include 2 distinct concepts based on the functional analysis
   - → Include necessary annotations to help in the communication of your ideas
   - → These can be photos of hand sketches, photos of initial prototypes, screen grabs of basic CAD models
   - → Include your Team Number, Name and MacID on *each* concept image
5. Insert your photo(s) as a Picture (Insert > Picture > This Device)
6. **Do not include more than *two* concept images per page**

Concept 1:

Name: Imaan Sheikh	MacID: sheiki6

Insert screenshot(s) of your concept below.

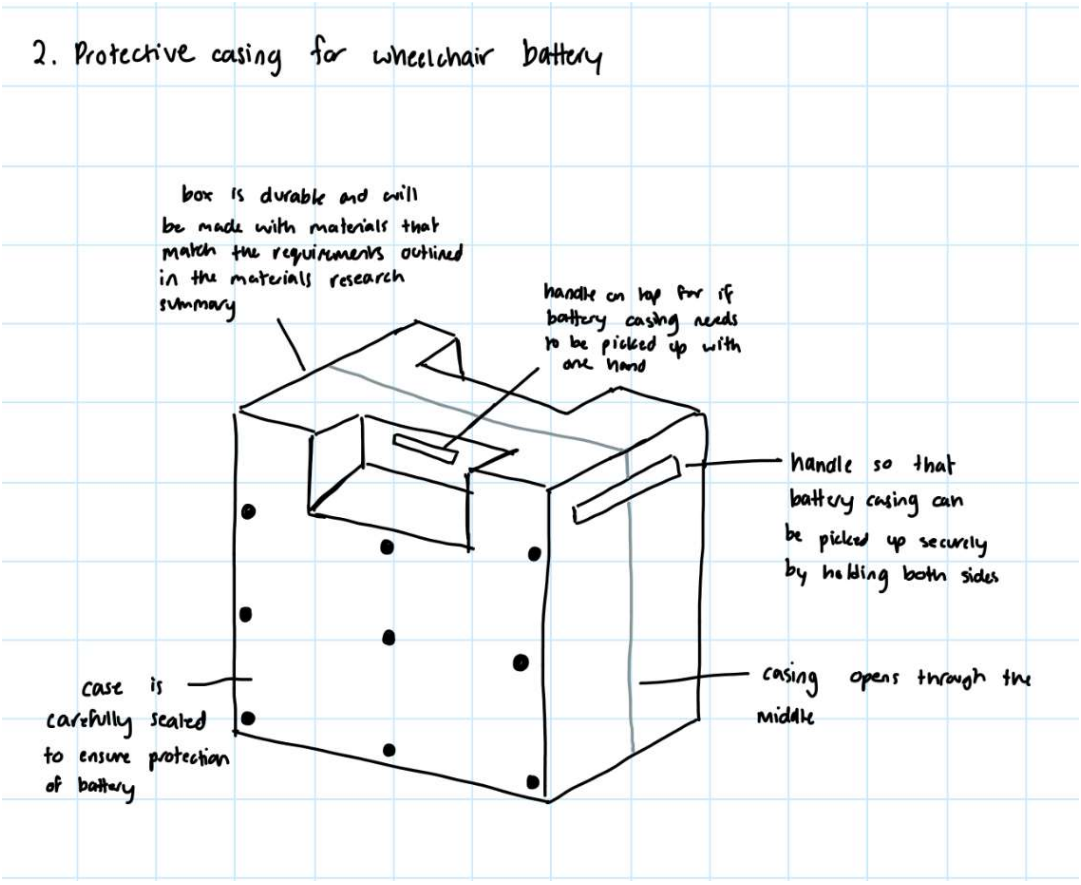


Team ID: Thurs-17

Concept 2:

Name: Imaan Sheikh	MacID: sheiki6

Insert screenshot(s) of your concept below.



PROJECT FOUR MILESTONE THREE: PROTOTYPING, DECISION MAKING AND DESIGN REVIEW #2

MILESTONE 3.1 – REFINED CONCEPT: INITIAL PROTOTYPE

Team ID: Thurs-17

Complete this worksheet individually before coming to Design Studio/Lab A for Week 8.

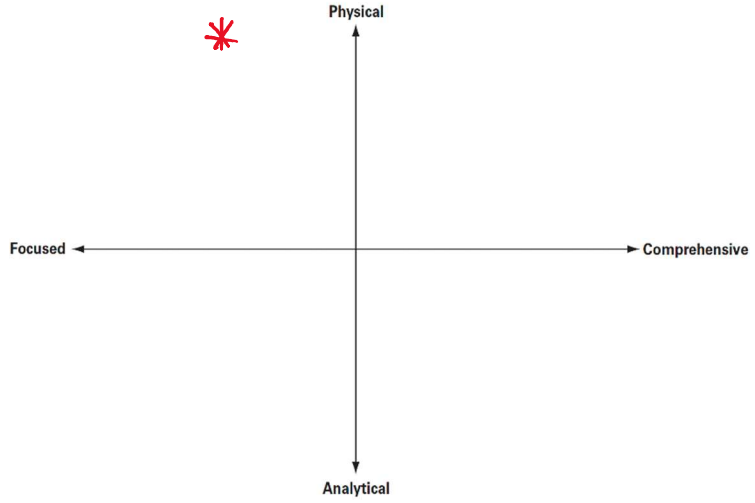
1. Write a small description of your initial prototype. Be sure to include what problem it aims to solve, how your initial prototype will be fabricated, and what functionality will be included and omitted in this initial prototype.
2. Classify whether your prototype is Physical or Analytical, and Focused or Comprehensive. Include the purpose of this prototype in the context of project 4 and the level of fidelity (low, medium, or high fidelity)
   - → **Physical vs. Analytical:** Physical prototypes are tangible artifacts that are created to approximate the final product. Analytical prototypes are non-tangible and represent the product using usually visual or mathematical models.
   - → **Focused vs. Comprehensive:** Focused prototypes implement only one or a few of the attributes of the final product. Comprehensive prototypes aim to implement most, if not all of the attributes of the final product.
3. Create a list of objectives and metrics for your initial prototype. There is no required amount of objectives or metrics, so long as the list is comprehensive.
4. Create a rough experimental plan for how you might test your prototype. Consider the methods you might use to test various objectives, how you will measure how effective each test proves to be and how realistic it would be to implement. This does not need to be detailed plan but should consider several of your objectives for the prototype.
5. Take picture(s) of your refined concept (initial prototype)
   - → Insert your photo(s) as a Picture (Insert > Picture > This Device)
   - → **Do not include more than *two* refined concept pictures per page**
   - → Include details on how concept was refined (what feedback was incorporated, what features are different than previous concept exploration, etc.)
   - → You can continue this process within the allocated time of the LabA/DS and seek feedback and discussions from your team members and/or the instructional team (IAIs, TAs, etc.).

Name: Imaan Sheikh	MacID: sheiki6

Write a short description of your initial prototype below.

- Low fidelity physical prototype of a protective casing for the wheelchair battery
- Aims to improve client's independence by reducing risks of battery damage – therefore minimizing reliance on other people or assistive devices
- Made of cardboard and tape
- Has a cubic shape with a removable handle for easy transportation
- Design will be modelled to closely fit shape of client's wheelchair battery
- Top opens to move battery in and out – in final model, a sliding top or similar mechanism may be a good design concept

Indicate where your prototype falls on the scale below.



Kind of Prototype:

✓ Physical or ☐ Analytical

✓ Focused or ☐ Comprehensive

Purpose of Prototype:

Protect wheelchair battery

Level of Fidelity:

Low fidelity

Include a list of objectives and metrics for your prototype below.

Objectives	Metrics
• Maximize protection of battery / High durability • Minimize battery's exposure to anything damaging • Affordable • Be lightweight	• Maximum force it can withstand • Surface area (cm^2) • Cost ($) • Weight (kg)

Include a rough experimental plan on how you might test your prototype below.

- Protection/durability – calculate force needed to scratch/break casing
- Minimizing exposure – determine how much of the battery's surface area is covered by casing (ideally all of it)

- Affordability – consider during material selection, and compare cost to similar existing products
- Lightweight – determine weight of casing and battery (separately and together) and compare to client's and PSW's capabilities

Insert picture(s) of your refined concept (initial prototype) below.


PROJECT FOUR FINAL DELIVERABLE: PROJECT REFLECTION

The activities in this handout are intended to be completed by the end of the project 4. You will apply what you learn in Design Communication Workshop 4 to complete this task.

Submission Details

Each Team Member: upload your reflection essay as a PDF to the Avenue Dropbox titled P4 Reflection using the MacID_P4_Reflection.pdf as naming convention

Grading of Reflection

Your reflection assignment is worth 1 mark of your total Project-4 grade (12.5%). Rubric is provided on Avenue to Learn.

If you need to review the content, go back to Design Communication Workshop 4 and/or go through the online reflecti0on module. Here is the link:
https://ecampusontario.pressbooks.pub/engineeringreflectiontoolkit/

Reflection Activity

Consider your experience with the design process as a first-year engineering student working on Project 4 over the past couple of months in ENG 1P13. After exploring the client's challenges and gaining insights, your team, decided to focus on one area to improve our client's daily life. You have defined the problem in a problem statement that included objectives, constraints, etc. Through this exploration, you performed a functional analysis that was used to come up with different alternative ways to solve the problem. Your team needed to make a decision between the different alternatives, and you tested your ideas for feasibility. You have been encouraged to iterate as you gained deeper insight and developed empathy for the client. Through the process of iteration, you have had the opportunity to improve upon your ideas. Engineers are continually iterating through the design process. Informed designers are involved in continual learning: learning by doing, learning from brainstorming and prototyping, learning by iteration and from feedback and failure, learning by noticing and troubleshooting, learning by drawing and dialoging about ideas, materials, and people. While iteration is an informal form of reflection, you will deepen your understanding of what you have learned through formal reflection. All of these emphasize the metacognitive and reflective practice aspects of learning through design (Lawson & Dorst, 2009; Crismond & Adams, 2012).

Part 1: What?

In this section you will describe a critical incident that you will be reflecting on as related to the "Generating/Testing ideas" and "Decision-making". For each of these steps of the design process:

In three to five sentences, identify and describe ONE critical incident, breakthrough or big thought-provoking moment that either challenged your assumptions, had a positive impact on you or validated your understanding of the design process. Here are some questions to consider.

Generating & Testing Ideas:

- How did you go about exploring ideas?
- How deeply did you explore your design options?
  - How much research?
  - Did you look into Biomimicry tools?
  - Did you consider any "What if?" questions in your explorations?
- Did you test your ideas?
- If yes, how did you test your ideas?
  - What were you trying to test (e.g., desirability, feasibility, etc.)?
  - What tool/ method did you use? (physical prototype, CAD model, etc.)
  - How much time did you spend on testing each idea?
  - How many ideas did you test?
  - How many prototypes did you make for testing each idea?
  - Did you test your ideas early on or waited until you had more details of the ideas?
- What was one challenge that you faced in the testing process of the design? (we encourage you to write more than one challenge). And What did you do to solve that challenge? (you can attach photos to explain your attempted solutions)
- From the results of our testing, one change we made to improve our design solution was … (add your response) and this change made our design solution better because … (add your response).

Response:

During the design process of project 4, I faced a few challenges with the fabrication of the prototype. The initial design had an estimated print time of around 60 hours, which was not at all feasible given the time and cost constraints of the project. My initial solution to this was to try laser cutting instead; however, some aspects of the design did not translate well into laser cutting and would still need to be printed. My group and I ended up designing and 3D printing a simpler prototype with a shorter print time and adding extra unique features Page 5 of 11 afterwards. This ended up being beneficial because it provided an opportunity to explore different materials outside of PLA filament and explore solutions we may not have considered otherwise.

Decision Making:

- What happened during decision-making?
  - Where in the process, relative to the design process steps, did you make decisions?

- What were the decisions about? Decisions could be about the process (e.g., how much searching of the design space was enough?) or about the design (e.g., which alternative to prototype).
- How many options did you have to choose from?
- How many criteria did you have to compare the options? How did you choose those criteria?
- What tools did you use to make a decision?

➢ At what stage did you make a decision?
➢ When did this experience take place? Did you already have one final solution in mind or you were still exploring the ideas?
➢ What challenges did you face during decision-making process?

Response:

The nature of project 4 required me to engage in decision making processes frequently throughout the design process. The first instance of decision making was fairly early on, when my group had to decide which of the client's issue to target and how to approach the problem. We made this decision by focusing on the client's main objective (increasing independence) and exploring ways to fulfill that goal. Decision making was also significant in material selection and fabrication processes; for example, when we encountered issues with 3D printing and needed to make the decision to try laser cutting when our first choice did not work out. At this point, when the 3D print and laser cutting processes were not working with our initial design, I made the decision to design a new prototype that addressed the issues we faced with the previous one and consider incorporating different materials.

Part 2: "So What?"

In this section you will explore what you learned and describe why this incident matters to you.

In three to five sentences, discuss what you learned from this incident about idea generation, testing ideas, and decision making and that either surprised you, made you confront a misconception, or improved your understanding of the design process.

To help you think about this, consider the following:

- What was the outcome of early or late testing processes?
- Do you think delaying any of your decision-making may have improved the design?
- Could you have collected better observations or data that would have led to better decisions?
- Did you repeat your decision-making process at any other stage?

Response:

When the time came to begin the initial testing process with our physical prototype, we ran into issues with our design and resorted to carrying out our testing plan with a low-fidelity prototype. Interestingly, this worked out to our benefit as it allowed us to explore issues related to material; the low-fidelity prototype was made of cardboard and therefore did not meet the objectives of high durability and strength. This led us to more carefully consider how material selection would impact the function and durability of our prototype. Additionally, our initial testing processes regarding the convenience of our prototype led us to incorporate new features to improve convenience in our final design.

In two to three sentences, explain why these new insights are important to you.

Response:

The testing processes carried out in this project highlighted weaknesses in our design at different stages and encouraged us to consider our design more carefully with respect to the relevant objectives. Additionally, considering the thoughts and opinions of others (e.g. when collecting user scores on the convenience of our prototype) was significant in helping me understand different perspectives and consider our design and prototype in ways I may not have otherwise.

Part 3: "Now What?"

In two to three sentences, discuss how you will integrate this new insight into future design projects, including next week prototyping and design review 2 where you still have a chance to improve your design. To help you think about this, consider the following:

- I learned that... (Express and important learning, not a statement of fact)
- This learning matters because... (Consider how this learning has value to you as an engineer)
- How will I apply my learning?
- How will I design differently next time?
- How will I deal with a similar situation in the future?
- Considering this learning, I will... (Set specific, assessable goals; consider benefits and challenges involved in this plan)

Response:

During this project, I learned about the importance of testing the practical applications of my work early in the design process. When designing the prototype for this project, I spent a lot of time making refinements to the design without stopping to consider how the actual fabrication process would occur. In future design projects, I plan to account for this by implementing testing plans beginning in the early stages of the design process so that major issues with prototypes are caught early.

In two to three sentences, describe the possible benefits and challenges involved in your plan.

Response:

The benefits of the plan that I outlined in the last section are that it would prevent me from moving forward with designs that may not be feasible to produce and would encourage me to consistently keep sight of the objectives and end goals throughout my projects. However, there may be challenges encountered with constantly creating and implementing test plans, as this would require significant time and resources.

References:

Lawson, B., & Dorst, K. (2009). Design expertise. Oxford, UK: Architectural Press.

Crismond, D. P., & Adams, R. S. (2012). The informed design teaching and learning matrix. Journal of Engineering Education, 101 (4), 738-797.

ENGINEER 1P13:
PROJECT FOUR WORKSHEETS (INDIVIDUAL)

Table of Contents

PROJECT FOUR MILESTONE ONE: PROBLEM FRAMING AND TEST PLAN

MILESTONE 1.1 – CLIENT NOTES

Team ID: Thurs-17

Complete this worksheet individually before coming to Lab A for Week 6.

1. Include your client notes from the introductory client visit

Name: Sameer Khichi	MacID: Khichis
- Tiffinay, the client is paralyzed from the waist down seeking ways to make her day-to-day life tasks easier. - She is looking for trying something new rather than improving something she already has. This means the most ideal course of action is tackling a problem she has that hasn't been solved yet and trying to design an aid that will help solve this issue. - Height is sometimes a problem; she has trouble reaching plugs and cross walk buttons. - Her wheelchairs mobility might also be an issue when it comes to snow and harsh weather, this is also costly when it comes to repairs. - She would like it if we could incorporate her hobbies as part of our design for her, this includes karate or some similar martial art and dancing. - She is also looking to get back to driving as well, maybe there could be a device to help her start driving again. - She already has equipment to reach in front of her and grab things off the floor, but if there was a way to improve this as it does not look like it works well. - We could create something to make her wheel-chair safer on the road for her and other drivers. - We could also think of ways to make additions to her wheelchair to make it better.	

PROJECT FOUR MILESTONE TWO: DESIGN EXPLORATION AND DESIGN REVIEW #1

MILESTONE 2.1 – CLIENT NOTES

Team ID: Thurs-17

Complete this worksheet individually before coming to Lab A for Week 7.

Include your client notes from the introductory client visit

Name: Sameer Khichi	MacID: Khichis
- Tiffany has trouble reaching the high counters in the kitchen. (this is not really something we can help other than raising her wheelchair's seat) - Her left arm is weaker than her right, - We could incorporate a phone stand into our enhanced wheelchair design. - Her current grippers weight is 5 pounds. - She has trouble with things getting stuck in her wheelchairs pins on the wheels. (This is something we could address when redesigning the wheelchairs wheels.) - She has trouble gripping things that are a certain shape. Spherical shapes are difficult to grip. - She has difficulty twisting door handles. - There are no outlets to charge the battery. She has to carry a spare battery around.	

MILESTONE 2.2 – RESEARCH ASSIGNMENT

Team ID:	Thurs-17

Complete this worksheet before Lab A for Week 7.

- State the question you plan to answer through your research
- Summarize your research findings (answer). Your answer should be a coherent, well-written summary of your research, not a "brain dump".
- You may include images, but don't forget to cite them properly.
- Aim for a length of about 500 words
- Properly cite your sources using IEEE formatted references and in-text citations. For information on referencing formats and choosing sources, see Design and Communication Workshop 1.

Name: Sameer	MacID: Khichis

What is your question?

Testing plan…How could the wheelchair be tested for comfort and ensure each component is effective and robust to maximize reliability as well as assistance.

What is your answer?

- Like cars wheelchairs have seating positions which need to be tested with available space for legs and width of the seat itself, while also testing what kind of adjustments there are. We are aiming to make the wheelchairs seat move up and down which should be tested with adequate weight to test reliability.
- Lumbar support should also be tested by multiple people to ensure it is adequate. This includes the cushioning and the reliability of the material used for the seat.
- Most wheelchairs are tested in a crash to ensure how robust and safe they are, this can be done in a simulation at a certain speed. Then this can be compared to the statistics of the current organization that tests wheelchairs. (this is listed in the sources)
- The wheelchair should also be tested in bad weather conditions, such as extreme cold, snow and rain, this all can be done through computer simulation such as AutoCAD or Quanser. The battery's condition should be monitored as it does not hold power as well in the cold. This would be a good test of how well the materials were chosen for the battery casing. The mobility will also be tested in the snow through computer simulation as well.

List of sources:

[1]
B. Preston, "What Makes a Car Really Comfortable," *Consumer Reports*, Apr. 08, 2021. https://www.consumerreports.org/cars/buying-a-car/what-makes-a-car-really-comfortable-a1023929368/#:~:text=Driving%20position%3A%20With%20each%20car,around%20you%2C%E2%80%9D%20Shenhar%20says . (accessed Feb. 27, 2024).

[2] "More on Wheelchair Transit Safety Standards | Sunrise Medical," *Sunrise Medical*, 2016. https://www.sunrisemedical.ca/education-in-motion/clinical-corner/march-2016/more-on-wheelchair-transit-safety-standards#:~:text=Both%20the%20RESNA%20WC19%20and,%2C%2020%2Dg%20frontal%20impact. (accessed Feb. 27, 2024).

[1]
"Preparing Your Wheelchair for Snow | Gillette Children's," *Gillettechildrens.org*, 2024. https://www.gillettechildrens.org/stories/preparing-your-wheelchair-for-snow#:~:text=Manual%20Wheelchair%20Snow%20Tips,months%20on%20quick%2Dmount%20wheels (accessed Feb. 27, 2024).

MILESTONE 2.2 – INITIAL CONCEPT EXPLORATION

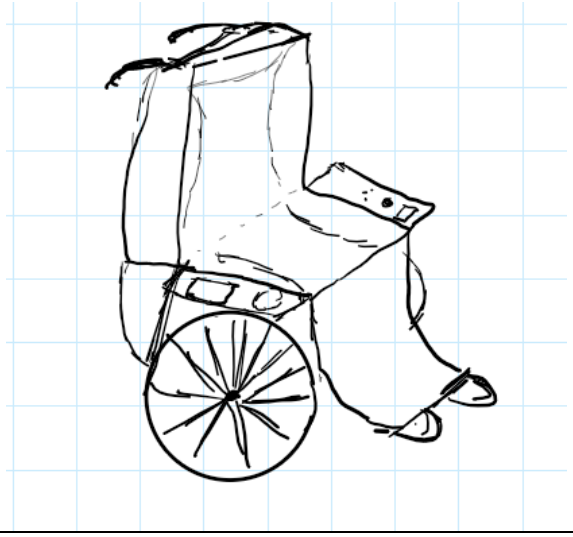
Team ID:	Thurs-17

Complete this worksheet before Lab A for Week 7.

1. Include multiple images of your **initial** concept exploration, if needed
   → Include necessary annotations to help in the communication of your ideas
   → These can be photos of hand sketches, photos of initial prototypes, screen grabs of basic CAD models
   → Include your Team Number, Name and MacID on *each* concept image
2. Insert your photo(s) as a Picture (Insert > Picture > This Device)
3. **Do not include more than *two* concept images per page**

Name: Sameer Khichi	MacID: Khichis

Insert screenshot(s) of your concept below.



MILESTONE 2.4 – REFINED CONCEPT EXPLORATION

Team ID: Thurs-17

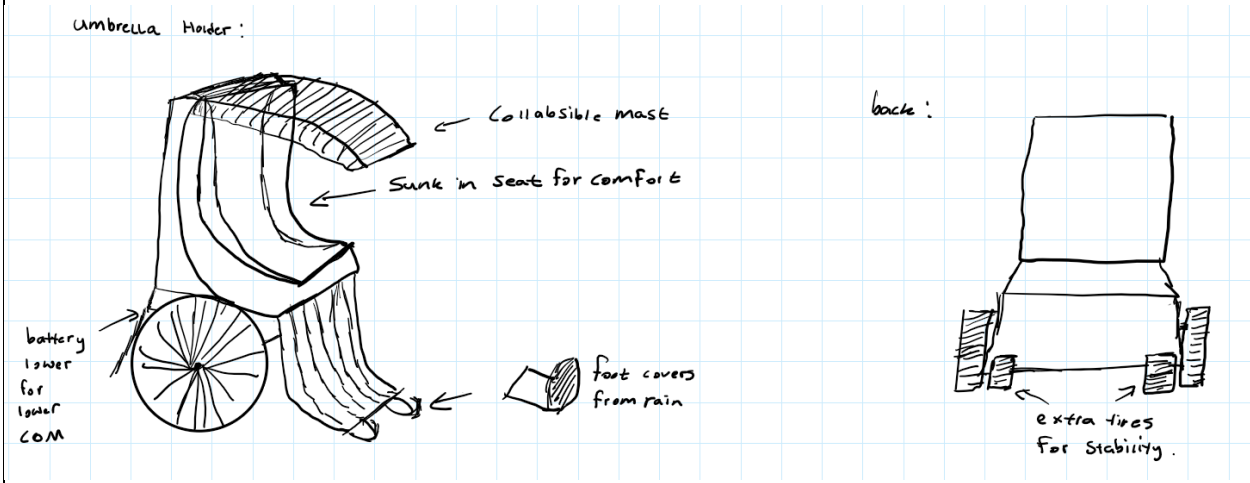
Complete this worksheet <u>during</u> Lab A for Week 7.

4. Include multiple images of your **refined** concept exploration, if needed
   - → Include 2 distinct concepts based on the functional analysis
   - → Include necessary annotations to help in the communication of your ideas
   - → These can be photos of hand sketches, photos of initial prototypes, screen grabs of basic CAD models
   - → Include your Team Number, Name and MacID on *<u>each</u>* concept image
5. Insert your photo(s) as a Picture (Insert > Picture > This Device)
6. **<u>Do not include more than *two* concept images per page</u>**

Concept 1:

Name: Sameer Khichi	MacID: Khichis

Insert screenshot(s) of your concept below. (Umbrella Holder)

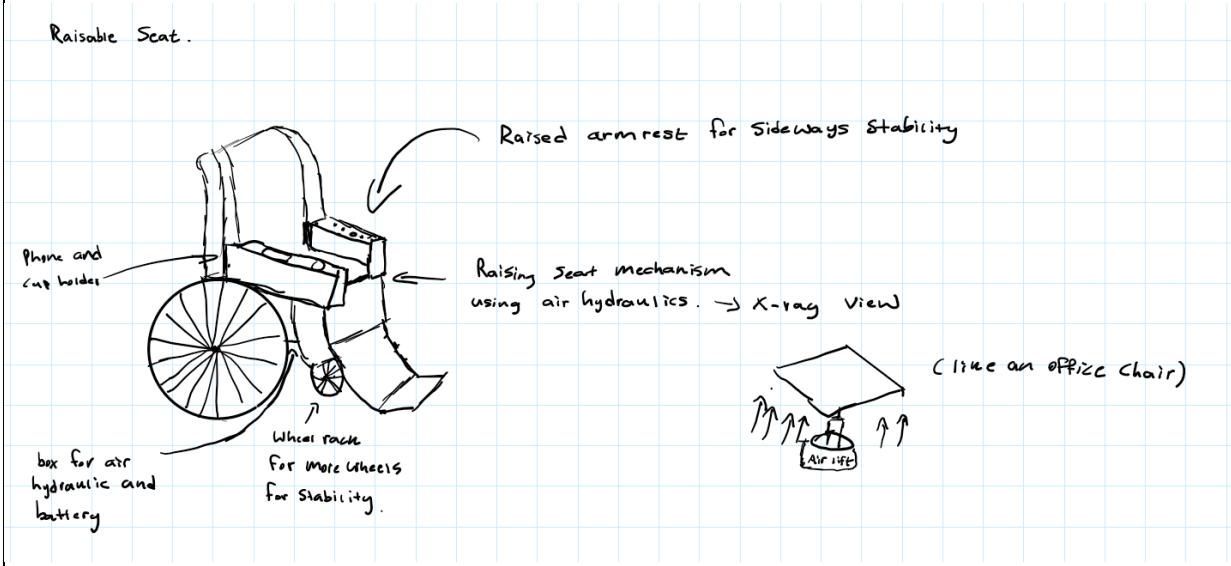


Team ID:	Thurs-17

Concept 2:

Name: Sameer Khichi	MacID: Khichis

Insert screenshot(s) of your concept below. (Seat raiser)



PROJECT FOUR MILESTONE THREE: PROTOTYPING, DECISION MAKING AND DESIGN REVIEW #2

MILESTONE 3.1 – REFINED CONCEPT: INITIAL PROTOTYPE

Team ID: Thurs-

Complete this worksheet individually before coming to Design Studio/Lab A for Week 8.

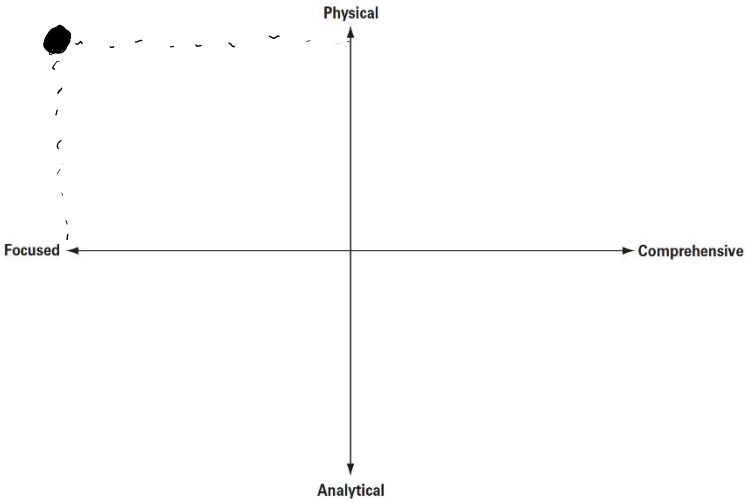
1. Write a small description of your initial prototype. Be sure to include what problem it aims to solve, how your initial prototype will be fabricated, and what functionality will be included and omitted in this initial prototype.
2. Classify whether your prototype is Physical or Analytical, and Focused or Comprehensive. Include the purpose of this prototype in the context of project 4 and the level of fidelity (low, medium, or high fidelity)
   - → **Physical vs. Analytical:** Physical prototypes are tangible artifacts that are created to approximate the final product. Analytical prototypes are non-tangible and represent the product using usually visual or mathematical models.
   - → **Focused vs. Comprehensive:** Focused prototypes implement only one or a few of the attributes of the final product. Comprehensive prototypes aim to implement most, if not all of the attributes of the final product.
3. Create a list of objectives and metrics for your initial prototype. There is no required amount of objectives or metrics, so long as the list is comprehensive.
4. Create a rough experimental plan for how you might test your prototype. Consider the methods you might use to test various objectives, how you will measure how effective each test proves to be and how realistic it would be to implement. This does not need to be detailed plan but should consider several of your objectives for the prototype.
5. Take picture(s) of your refined concept (initial prototype)
   - → Insert your photo(s) as a Picture (Insert > Picture > This Device)
   - → **Do not include more than *two* refined concept pictures per page**
   - → Include details on how concept was refined (what feedback was incorporated, what features are different than previous concept exploration, etc.)
   - → You can continue this process within the allocated time of the LabA/DS and seek feedback and discussions from your team members and/or the instructional team (IAIs, TAs, etc.).

Name: Sameer Khichi	MacID: Khichis

Write a short description of your initial prototype below.

Essentially what the prototype is meant to be is an attachment that can be slid onto the wheelchairs arm rest which has a built in cupholder and phone holder. The design is simple, easy to use and fully functional, addressing something that the client mentioned would be helpful.

Indicate where your prototype falls on the scale below.



Kind of Prototype:

☐ Physical or ☐ Analytical

☐ Focussed or ☐ Comprehensive

Purpose of Prototype: To adhere to the clients desire to have a place to keep her phone and drink.

Level of Fidelity: High

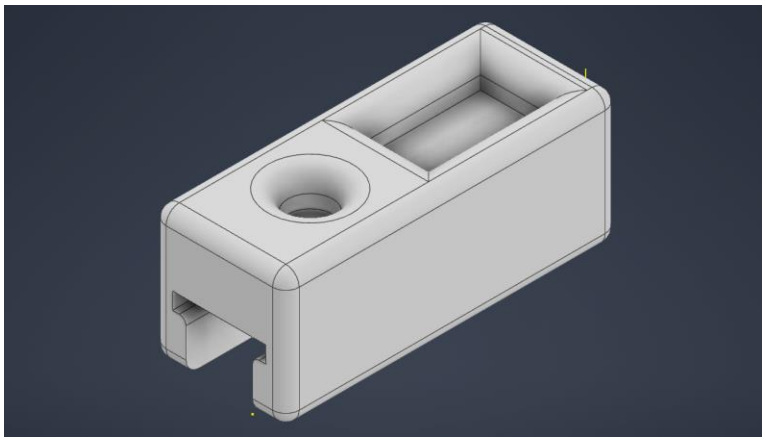
Include a list of objectives and metrics for your prototype below.

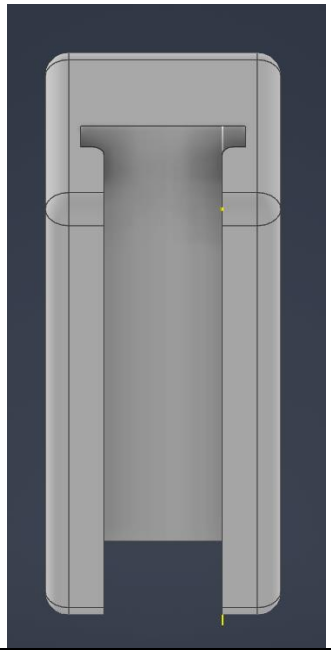
Objectives	Metrics
• **Durable**	• **Level of pressure design can take**
• **lightweight**	• **kg**
• **Functional**	• **mm – fits larger phones and big cups**
• **Physical dimensions**	• **mm-fits the wheelchair**
• **Convenience**	• **Joules. How much effort is required to remove and add it.**

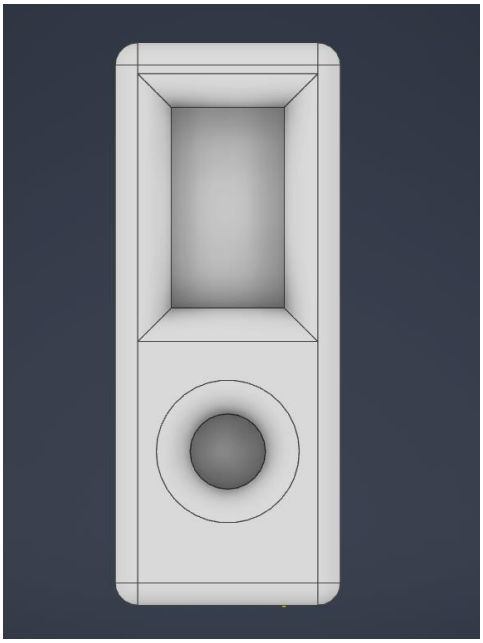
Include a rough experimental plan on how you might test your prototype below.

Ways to test the prototype is by modeling and printing a prototype design of the attachment and testing it on different wheelchair's armrests. Then to test the functionality of the device, a selection of different sized phones can be used to see if they fit easy. To test convenience of the product, multiple different people can be asked to test the product reporting if they found using it easy. Finally, durability can be tested by using programs like AutoCAD and simulating different scenarios seeing if the product survives.

Insert picture(s) of your refined concept (initial prototype) below.







PROJECT FOUR FINAL DELIVERABLE: PROJECT REFLECTION

The activities in this handout are intended to be completed by the end of the project 4. You will apply what you learn in Design Communication Workshop 4 to complete this task.

Submission Details

Each Team Member: upload your reflection essay as a PDF to the Avenue Dropbox titled P4 Reflection using the MacID_P4_Reflection.pdf as naming convention

Grading of Reflection

Your reflection assignment is worth 1 mark of your total Project-4 grade (12.5%). Rubric is provided on Avenue to Learn.

If you need to review the content, go back to Design Communication Workshop 4 and/or go through the online reflecti0on module. Here is the link:
https://ecampusontario.pressbooks.pub/engineeringreflectiontoolkit/

Reflection Activity

Consider your experience with the design process as a first-year engineering student working on Project 4 over the past couple of months in ENG 1P13. After exploring the client's challenges and gaining insights, your team, decided to focus on one area to improve our client's daily life. You have defined the problem in a problem statement that included objectives, constraints, etc. Through this exploration, you performed a functional analysis that was used to come up with different alternative ways to solve the problem. Your team needed to make a decision between the different alternatives, and you tested your ideas for feasibility. You have been encouraged to iterate as you gained deeper insight and developed empathy for the client. Through the process of iteration, you have had the opportunity to improve upon your ideas. Engineers are continually iterating through the design process. Informed designers are involved in continual learning: learning by doing, learning from brainstorming and prototyping, learning by iteration and from feedback and failure, learning by noticing and troubleshooting, learning by drawing and dialoging about ideas, materials, and people. While iteration is an informal form of reflection, you will deepen your understanding of what you have learned through formal reflection. All of these emphasize the metacognitive and reflective practice aspects of learning through design (Lawson & Dorst, 2009; Crismond & Adams, 2012).

Part 1: What?

In this section you will describe a critical incident that you will be reflecting on as related to the "Generating/Testing ideas" and "Decision-making". For each of these steps of the design process:

In three to five sentences, identify and describe ONE critical incident, breakthrough or big thought-provoking moment that either challenged your assumptions, had a positive impact on you or validated your understanding of the design process. Here are some questions to consider.

Generating & Testing Ideas:

- How did you go about exploring ideas?
- How deeply did you explore your design options?
  - How much research?
  - Did you look into Biomimicry tools?
  - Did you consider any "What if?" questions in your explorations?
- Did you test your ideas?
- If yes, how did you test your ideas?
  - What were you trying to test (e.g., desirability, feasibility, etc.)?
  - What tool/ method did you use? (physical prototype, CAD model, etc.)
  - How much time did you spend on testing each idea?
  - How many ideas did you test?
  - How many prototypes did you make for testing each idea?
  - Did you test your ideas early on or waited until you had more details of the ideas?
- What was one challenge that you faced in the testing process of the design? (we encourage you to write more than one challenge). And What did you do to solve that challenge? (you can attach photos to explain your attempted solutions)
- From the results of our testing, one change we made to improve our design solution was … (add your response) and this change made our design solution better because … (add your response).

Response:

One very critical incident that occurred during project 4 was when our group was required to a complete rehaul on our design and construction process. Initially we had a finalized design that was perfectly sized for the purpose we were using it for. Then when we went to 3D print the design, our print time was far too long which we had wished we were warned about beforehand when initially presenting our idea. After this incident all our assumptions on how our design would turn out were completely stumped and we were very discouraged as all our Page 5 of 12 work thus far has turned out worthless. Moving forward to solve this issue we redesigned our product for laser cutting, essentially meaning we had to CAD the design in a different way, which also got shot down when they were denied for laser cutting. Then finally we cut down our design as much as possible, cutting out features to have it printed through external means.

Decision Making:

- What happened during decision-making?
  - Where in the process, relative to the design process steps, did you make decisions?
  - What were the decisions about? Decisions could be about the process (e.g., how much searching of the design space was enough?) or about the design (e.g., which alternative to prototype).
  - How many options did you have to choose from?
  - How many criteria did you have to compare the options? How did you choose those criteria?
  - What tools did you use to make a decision?
- At what stage did you make a decision?
- When did this experience take place? Did you already have one final solution in mind or you were still exploring the ideas?
- What challenges did you face during decision-making process?

Response:

During this time, we had to make a lot of crucial decisions about our project and how we wanted it to turn out. We discussed what features we wanted to preserve alongside what we were willing to sacrifice to make it feasible. Initially we talked about if we were to start over with a new idea or try and save what we already have. One of the main things that we had to give up was half the design, the cup holder aspect. In doing so we also had to thin the design further to give up the comfort of having more space and storage to make it possible to print it. Finally we had to make the decision to stick with trying to 3D print the product rather than experimenting with other materials which was dangerous as if this didn't work out, we would be left with no product and most likely a bad mark.

Part 2: "So What?"

In this section you will explore what you learned and describe why this incident matters to you.

In three to five sentences, discuss what you learned from this incident about idea generation, testing ideas, and decision making and that either surprised you, made you confront a misconception, or improved your understanding of the design process.

To help you think about this, consider the following:

- What was the outcome of early or late testing processes?
- Do you think delaying any of your decision-making may have improved the design?
- Could you have collected better observations or data that would have led to better decisions?
- Did you repeat your decision-making process at any other stage?

Response:

One of the biggest things that I have learned from this incident is to look further than TA and IAI feedback and identify key issues to note that I may or may not run into when going about creating a product. I have learned that sacrificing the perfect visualization and compromising when designing to make ideas possible to create rather than being fixed on design may not even be possible. Finally, I learned that sometimes simplicity beats a product drenched in gimmicky features.

In two to three sentences, explain why these new insights are important to you.

Response:

These insights are important to me as I know have learned to create workarounds quickly under pressure. I also realize I need to consider more factors when creating and dimensioning designs such as how realistic it is to print, how much it will cost and how long it will take. I now also realize that I should spend less time how to make additions to designs and focus more on making what I have feasible.

Part 3: "Now What?"

In two to three sentences, discuss how you will integrate this new insight into future design projects, including next week prototyping and design review 2 where you still have a chance to improve your design. To help you think about this, consider the following:

- I learned that... (Express and important learning, not a statement of fact)
- This learning matters because... (Consider how this learning has value to you as an engineer)
- How will I apply my learning?
- How will I design differently next time?
- How will I deal with a similar situation in the future?
- Considering this learning, I will... (Set specific, assessable goals; consider benefits and challenges involved in this plan)

Response:

These insights are very important to me as it will go on and serve me in future design projects, helping me identify where I could possibly go wrong before it catastrophically fails. Moreover, these experiences show me how to conduct myself and my ideas when presenting them to group members, while trying to accommodate everyone's ideas where they can be. As an engineer I aspire to be able to formulate design concepts with easy while being able to predict where I will face hardships, and working towards fixing them before they even begin.

In two to three sentences, describe the possible benefits and challenges involved in your plan.

Response:

One of the biggest challenges Is the ability to stand by these claims I am making and staying consistent. In a group it can be easy to rely and lay back on extended time limits or other group members, but I must stay focused on conducting myself to the best of my ability. One of the biggest benefits in my plan is how much I can incorporate it into my future as a software engineer when I am in groups for design projects working on things that will reflect how good of an engineer I am or can be. Though it will be challenging to essentially be a perfect human being I sure can try to solve problems before they even happen.

References:

Lawson, B., & Dorst, K. (2009). Design expertise. Oxford, UK: Architectural Press.

Crismond, D. P., & Adams, R. S. (2012). The informed design teaching and learning matrix. Journal of Engineering Education, 101 (4), 738-797.

PROJECT FOUR MILESTONE ONE: PROBLEM FRAMING AND TEST PLAN

MILESTONE 1.1 – CLIENT NOTES

Team ID: Thurs-17

Complete this worksheet individually before coming to Lab A for Week 6.

1. Include your client notes from the introductory client visit

Name: Sampurna Saha	MacID: sahas31

- *Spina bifida, only top half of the body is functional*
- *Prone to infections, and does not drink water*
- *Uses DARS transportation*
- *Faces issues such as wheelchair buckle easily snapping when transferring, the vendor took 1-2 weeks to safety check wheelchair*
- *Uses arm lever at home but cant at work, its also difficult to grab a lot of objects as not all shapes can fit into the clamp*

- *Can't operate wheelchair on icy or snowy roads, wheels get stuck, water gets into battery and shuts down*
- *Very expensive: 5 batteries $500 each*
- *Batteries charge overnight and last 24 hours*
- *Getting indoor not accessible with buttons make it hard to come in*
- *Doors need to be a certain width to fit wheelchair through*
- *Uneven roads (rocks and gravels) is hard it maneuver wheelchair and dangerous*
- *Metal rods in her back make her cold specially when she works outside in Walmart to greet people*
- *Shower chair not strudy*
- *Dangerous in case of fire as she can only use lift*

PROJECT FOUR MILESTONE TWO: DESIGN EXPLORATION AND DESIGN REVIEW #1

MILESTONE 2.1 – CLIENT NOTES

Team ID:	Thurs-17

Complete this worksheet individually before coming to Lab A for Week 7.

Include your client notes from the introductory client visit

Name: Sampurna Saha	MacID: sahas31

- *Having whole arm fit armrest (foam and plastic is slightly comfy)*
- *HSR is convenient for her, requires a lot of effort to find accessible routes*
    - *Paperworks and interviews*
- *Finding more ways to charge wheelchair*
- *Battery of wheelchair can be drained fast by trying to charge her phone from it*
- *Charging wheelchair directly from the outlet*
- *Backpack on handle bar makes it easy to reach*
- *Cant reach stove top or counter*
- *Grabber can't be used such as when paper flat on ground or certain shapes of objects*
- *She is right handed*
- *Wheelchair: edge3*
- *Latex sensitivity*
- *Certain weights can only be attached to wheelchair (not too heavy)*
- *Cupholder blocked by door and snapped off*
- *Grabber is durable*

MILESTONE 2.2 – RESEARCH ASSIGNMENT

Team ID: Thurs-17

Complete this worksheet before Lab A for Week 7.

- State the question you plan to answer through your research
- Summarize your research findings (answer). Your answer should be a coherent, well-written summary of your research, not a "brain dump".
- You may include images, but don't forget to cite them properly.
- Aim for a length of about 500 words
- Properly cite your sources using IEEE formatted references and in-text citations. For information on referencing formats and choosing sources, see Design and Communication Workshop 1.

Name: Sampurna Saha	MacID: sahas31

What is your question?

How does Spina Bifida affect an individual and how do they navigate through their lives?

What is your answer?

Spina bifida is defect caused at birth affecting the spinal cord and the nervous system. At birth the spinal column does not form properly, which exposes the spinal cord and spinal nerves. This leaves individuals at high risk and results in progressive neurologic injury. [3]. Individuals suffer due to this condition incredibly in their day to day lives from work to school. It often results in numbness or even leading to paralysis the hips down. As it also damages the nerves system, it affects their control movement. They also suffer from great pain and discomfort on their back as Spina bifida can lead to scoliosis, kyphosis and lordosis. In addition to mobility issues they are also at a risk of urinary infections due to having poor bladder and bowel control, requiring them to use the bathroom more frequently. [4]

People often get surgeries to treat most of these conditions but it does not always result in regaining full control movements. Children diagnosed with Spina bifida attends physical therapy which can help with the condition and allow feeling on their legs, but the benefits and effect of physical therapy decreases for adults. Most people resort to using wheelchairs, braces and walkers for movement. Some people use accessibility tools as well to navigate through day to day tasks. They also require regular medical care and help of family or professionals who sometimes stay by their side constantly to help them with daily tasks. [1]. It is essential to develop technology to further help them become more independent as spina bifida does not only affect physically but also mentally. They struggle with isolation as developing meaningful relationship becomes hard

since they feel dependent on caregivers. It is also highly recommended to seek constant mental therapy alongside physical therapy. [2]

List of sources:

[1] "Self-management and Independence Guideline," Spina Bifida Association, https://www.spinabifidaassociation.org/resource/self-management/ (accessed Mar. 4, 2024).

[2] "Living with spina bifida (young adults)," Centers for Disease Control and Prevention, https://www.cdc.gov/ncbddd/spinabifida/adult.html (accessed Feb. 27, 2024).

[3] The Children's Hospital of Philadelphia, "Spina bifida causes, symptoms and treatment," Children's Hospital of Philadelphia, https://www.chop.edu/conditions-diseases/spina-bifida#:~:text=Spina%20bifida%20is%20a%20birth,central%20nervous%20system%20birth%20defect. (accessed Feb. 27, 2024).

[4] "Spina bifida life expectancy, causes, symptoms & treatment," POBAR, https://www.pobar.org/spina-bifida-causes-treatment#:~:text=For%20those%20who%20don't,%2C%20movement%2C%20and%20even%20learning. (accessed Feb. 27, 2024).

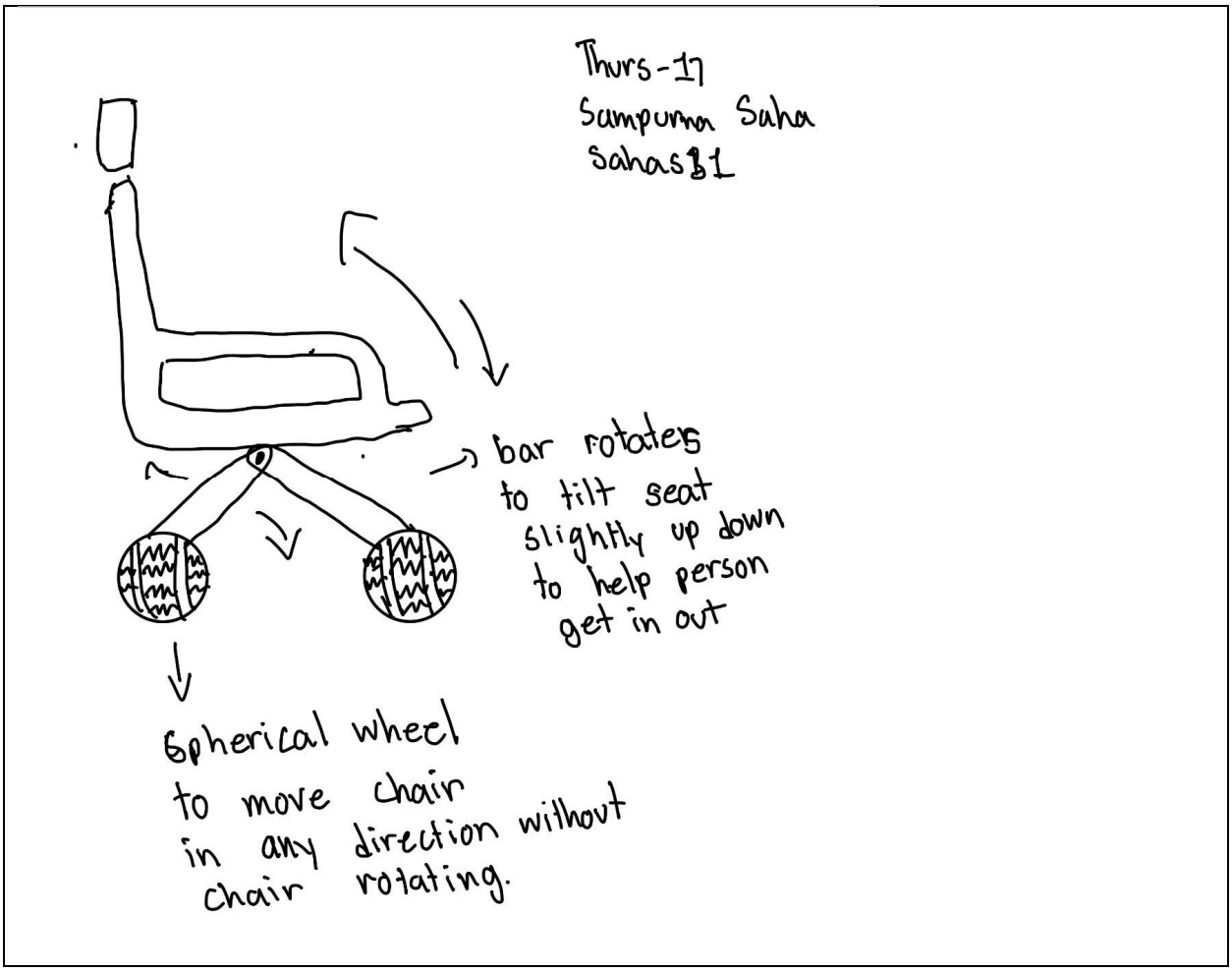
MILESTONE 2.2 – INITIAL CONCEPT EXPLORATION

Team ID:	Thurs-17

Complete this worksheet before Lab A for Week 7.

1. Include multiple images of your **initial** concept exploration, if needed
   → Include necessary annotations to help in the communication of your ideas
   → These can be photos of hand sketches, photos of initial prototypes, screen grabs of basic CAD models
   → Include your Team Number, Name and MacID on *each* concept image
2. Insert your photo(s) as a Picture (Insert > Picture > This Device)
3. **Do not include more than *two* concept images per page**

Name: Sampurna Saha	MacID: sahas31
Insert screenshot(s) of your concept below.	


Thurs-17
Sampurna Saha
Sahas31
bar rotates to tilt seat slightly up down to help person get in out
Spherical wheel to move chair in any direction without chair rotating.

→ grips to travel on snow and uneven roads

Tchurs - 17
Sampurna Saha
Sahas 31

MILESTONE 2.4 – REFINED CONCEPT EXPLORATION

Team ID:	Thurs-17

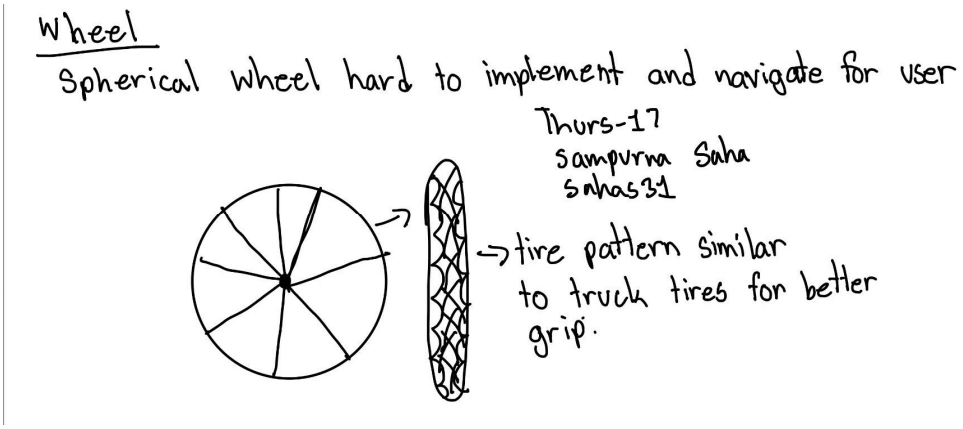
Complete this worksheet <u>during</u> Lab A for Week 7.

4. Include multiple images of your **refined** concept exploration, if needed
   - → Include 2 distinct concepts based on the functional analysis
   - → Include necessary annotations to help in the communication of your ideas
   - → These can be photos of hand sketches, photos of initial prototypes, screen grabs of basic CAD models
   - → Include your Team Number, Name and MacID on <u>*each*</u> concept image
5. Insert your photo(s) as a Picture (Insert > Picture > This Device)
6. **<u>Do not include more than *two* concept images per page</u>**

Concept 1:

Name: Sampurna Saha	MacID: sahas31

Insert screenshot(s) of your concept below.



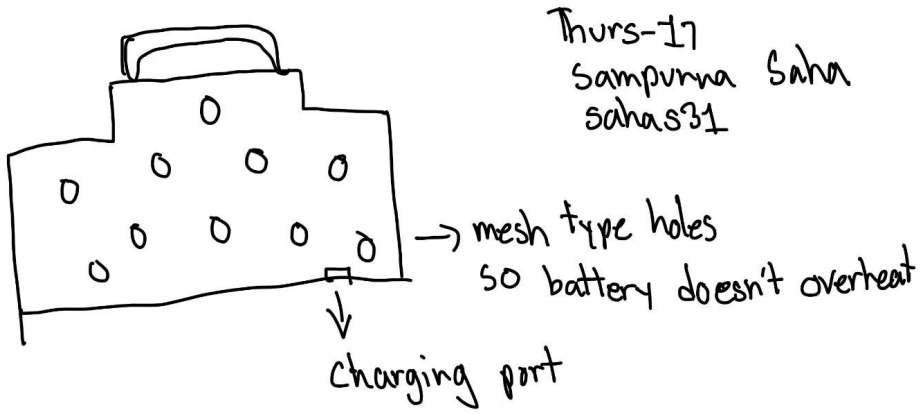
Team ID:	Thurs-17

Concept 2:

Name: Sampurna Saha	MacID: sahas31

Insert screenshot(s) of your concept below.

Battery case to protect the battery so that she can go out in any weather condition increasing accessibility.



PROJECT FOUR MILESTONE THREE: PROTOTYPING, DECISION MAKING AND DESIGN REVIEW #2

MILESTONE 3.1 – REFINED CONCEPT: INITIAL PROTOTYPE

Team ID: Thurs-17

Complete this worksheet individually before coming to Design Studio/Lab A for Week 8.

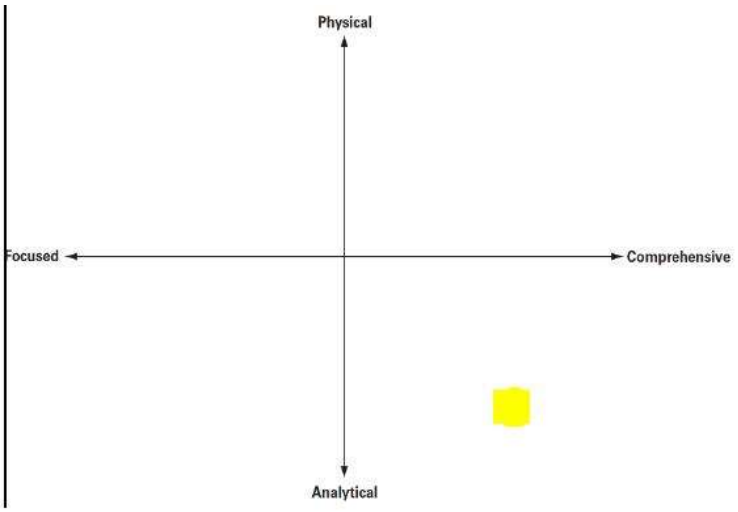
1. Write a small description of your initial prototype. Be sure to include what problem it aims to solve, how your initial prototype will be fabricated, and what functionality will be included and omitted in this initial prototype.
2. Classify whether your prototype is Physical or Analytical, and Focused or Comprehensive. Include the purpose of this prototype in the context of project 4 and the level of fidelity (low, medium, or high fidelity)
   - → **Physical vs. Analytical:** Physical prototypes are tangible artifacts that are created to approximate the final product. Analytical prototypes are non-tangible and represent the product using usually visual or mathematical models.
   - → **Focused vs. Comprehensive:** Focused prototypes implement only one or a few of the attributes of the final product. Comprehensive prototypes aim to implement most, if not all of the attributes of the final product.
3. Create a list of objectives and metrics for your initial prototype. There is no required amount of objectives or metrics, so long as the list is comprehensive.
4. Create a rough experimental plan for how you might test your prototype. Consider the methods you might use to test various objectives, how you will measure how effective each test proves to be and how realistic it would be to implement. This does not need to be detailed plan but should consider several of your objectives for the prototype.
5. Take picture(s) of your refined concept (initial prototype)
   - → Insert your photo(s) as a Picture (Insert > Picture > This Device)
   - → **Do not include more than *two* refined concept pictures per page**
   - → Include details on how concept was refined (what feedback was incorporated, what features are different than previous concept exploration, etc.)
   - → You can continue this process within the allocated time of the LabA/DS and seek feedback and discussions from your team members and/or the instructional team (IAIs, TAs, etc.).

Name: Sampurna Saha	MacID: sahas31

Write a short description of your initial prototype below.

A battery case with a handle that will protect the battery from rough weather conditions. It has mesh holes to let out heat for when the battery overheats. It has a charging port so that the battery can be charged from within the case.

Indicate where your prototype falls on the scale below.



Kind of Prototype:

☐ Physical or ☐ Analytical

☐ Focussed or ☐ Comprehensive

Purpose of Prototype:

To protect the battery

Level of Fidelity:

Low fidelity

Include a list of objectives and metrics for your prototype below.

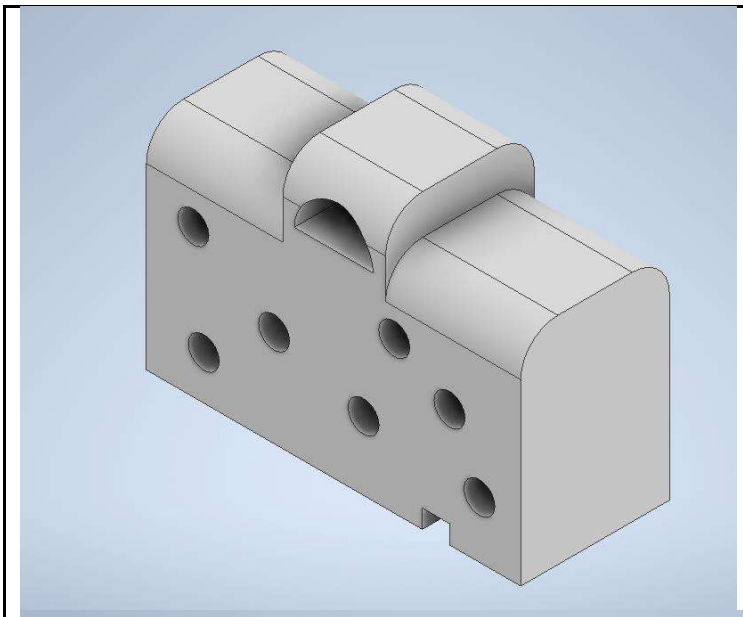
Objectives	Metrics
• **High strength**	• **Pa**
• **Durability**	• **Meters**
• **Minimize cost**	• **$**
• **Maximize battery safety**	• **Hours battery lasts**
•	•

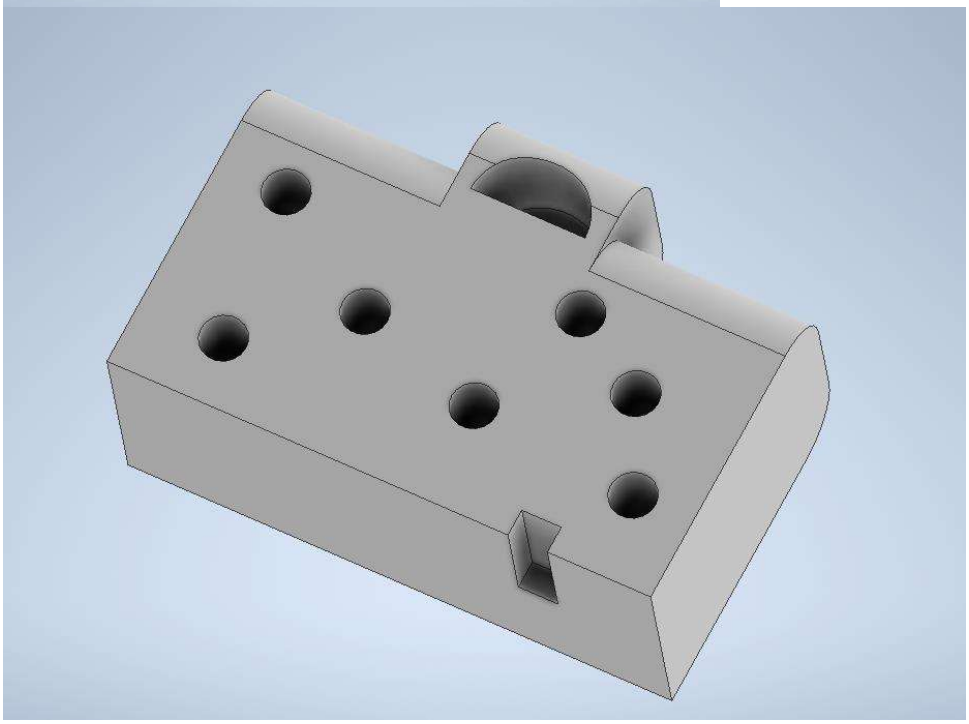
Include a rough experimental plan on how you might test your prototype below.

Put something inside the case and drop it from different heights to see how durable it is. (m)

Also test with putting something inside the case and how much water or other substances can get into it.

Insert picture(s) of your refined concept (initial prototype) below.





PROJECT FOUR FINAL DELIVERABLE: PROJECT REFLECTION

The activities in this handout are intended to be completed by the end of the project 4. You will apply what you learn in Design Communication Workshop 4 to complete this task.

Submission Details

Each Team Member: upload your reflection essay as a PDF to the Avenue Dropbox titled P4 Reflection using the MacID_P4_Reflection.pdf as naming convention

Grading of Reflection

Your reflection assignment is worth 1 mark of your total Project-4 grade (12.5%). Rubric is provided on Avenue to Learn.

If you need to review the content, go back to Design Communication Workshop 4 and/or go through the online reflecti0on module. Here is the link:
https://ecampusontario.pressbooks.pub/engineeringreflectiontoolkit/

Reflection Activity

Consider your experience with the design process as a first-year engineering student working on Project 4 over the past couple of months in ENG 1P13. After exploring the client's challenges and gaining insights, your team, decided to focus on one area to improve our client's daily life. You have defined the problem in a problem statement that included objectives, constraints, etc. Through this exploration, you performed a functional analysis that was used to come up with different alternative ways to solve the problem. Your team needed to make a decision between the different alternatives, and you tested your ideas for feasibility. You have been encouraged to iterate as you gained deeper insight and developed empathy for the client. Through the process of iteration, you have had the opportunity to improve upon your ideas. Engineers are continually iterating through the design process. Informed designers are involved in continual learning: learning by doing, learning from brainstorming and prototyping, learning by iteration and from feedback and failure, learning by noticing and troubleshooting, learning by drawing and dialoging about ideas, materials, and people. While iteration is an informal form of reflection, you will deepen your understanding of what you have learned through formal reflection. All of these emphasize the metacognitive and reflective practice aspects of learning through design (Lawson & Dorst, 2009; Crismond & Adams, 2012).

Part 1: What?

In this section you will describe a critical incident that you will be reflecting on as related to the "Generating/Testing ideas" and "Decision-making". For each of these steps of the design process:

In three to five sentences, identify and describe ONE critical incident, breakthrough or big thought-provoking moment that either challenged your assumptions, had a positive impact on you or validated your understanding of the design process. Here are some questions to consider.

Generating & Testing Ideas:

- How did you go about exploring ideas?
- How deeply did you explore your design options?
  - How much research?
  - Did you look into Biomimicry tools?
  - Did you consider any "What if?" questions in your explorations?
- Did you test your ideas?
- If yes, how did you test your ideas?
  - What were you trying to test (e.g., desirability, feasibility, etc.)?
  - What tool/ method did you use? (physical prototype, CAD model, etc.)
  - How much time did you spend on testing each idea?
  - How many ideas did you test?
  - How many prototypes did you make for testing each idea?
  - Did you test your ideas early on or waited until you had more details of the ideas?
- What was one challenge that you faced in the testing process of the design? (we encourage you to write more than one challenge). And What did you do to solve that challenge? (you can attach photos to explain your attempted solutions)
- From the results of our testing, one change we made to improve our design solution was … (add your response) and this change made our design solution better because … (add your response).

Response:

Project 4 consisted of a vigorous process of testing and remaking our product. Our initial prototype consisted of altering the wheelchair, which after our design review we learned is too complicated and unrealistic to implement within the time I think our team tried to focus on solving too many of the clients concerns at once and resulted in us having to restart with planning for a new prototype. When we had to restart all the way from the beginning by brainstorming, I felt very overwhelmed and worried that our group was falling behind and will not be able to 3D print or laser cut in time.

Decision Making:

- What happened during decision-making?
  - Where in the process, relative to the design process steps, did you make decisions?
  - What were the decisions about? Decisions could be about the process (e.g., how much searching of the design space was enough?) or about the design (e.g., which alternative to prototype).
  - How many options did you have to choose from?
  - How many criteria did you have to compare the options? How did you choose those criteria?
  - What tools did you use to make a decision?
- At what stage did you make a decision?
- When did this experience take place? Did you already have one final solution in mind or you were still exploring the ideas?
- What challenges did you face during decision-making process?

Response:

I had to take time and materials into consideration when creating the new prototype and as a group we decided to start over with something that can just be an attachment to the wheelchair. Even after the first prototype we CADed multiple protoypes after as the printing time was also an important factor to consider. Most of our CAD models were around 2 days for printing time, which isn't feasible for us to print in lab or Thode. This made us change our prototype to make it with less precision cutting and as small as possible. The time constraint also influenced my decision making process to suggest switching from 3D printing to laser cutting by splitting our model into multiple parts.

Part 2: "So What?"

In this section you will explore what you learned and describe why this incident matters to you.

In three to five sentences, discuss what you learned from this incident about idea generation, testing ideas, and decision making and that either surprised you, made you confront a misconception, or improved your understanding of the design process.

To help you think about this, consider the following:

- What was the outcome of early or late testing processes?
- Do you think delaying any of your decision-making may have improved the design?
- Could you have collected better observations or data that would have led to better decisions?
- Did you repeat your decision-making process at any other stage?

Response:

Since our group was very relied on 3D printing it was very hard for us to test a physical prototype. I had to make a lot of alterations to our CAD to make it eligible for 3D printing and we almost ran out of time to meet the final deadline. So, I feel that if we had done earlier testing and considered the print time as we went along, we would have room to make improvements to our final design.

In two to three sentences, explain why these new insights are important to you.

Response:

These new insights are important to me because they showed me that it is crucial to stick to the design process. It is the most effective to test every aspect of our design and consider having enough time to also test the final prototype.

Part 3: "Now What?"

In two to three sentences, discuss how you will integrate this new insight into future design projects, including next week prototyping and design review 2 where you still have a chance to improve your design. To help you think about this, consider the following:

- I learned that... (Express and important learning, not a statement of fact)
- This learning matters because... (Consider how this learning has value to you as an engineer)
- How will I apply my learning?
- How will I design differently next time?
- How will I deal with a similar situation in the future?
- Considering this learning, I will... (Set specific, assessable goals; consider benefits and challenges involved in this plan)

Response:

The most important thing I learned is that it is crucial to test your prototype constantly from early on rather then settling on an idea and testing it. It was also very helpful for me to consult with others about the design as they can provide further insights that I haven't thought of.

In two to three sentences, describe the possible benefits and challenges involved in your plan.

Response:

I can apply this learning to help develop further projects as I will know better on how to approach the problem. Consulting with others will also help me broaden my perspective and come up with better innovate designs.

References:

Lawson, B., & Dorst, K. (2009). Design expertise. Oxford, UK: Architectural Press.

Crismond, D. P., & Adams, R. S. (2012). The informed design teaching and learning matrix. Journal of Engineering Education, 101 (4), 738-797.

PROJECT FOUR MILESTONE ONE: PROBLEM FRAMING AND TEST PLAN

MILESTONE 1.1 – CLIENT NOTES

Team ID: Thurs-17

Complete this worksheet individually before coming to Lab A for Week 6.

1. Include your client notes from the introductory client visit

Name: Yahya Zaher	MacID: zahery
- *Lack of a backup battery hampers day-to-day operations.* - *Appliances have been adjusted to accommodate her height.* - *Rain poses a challenge for the chair; it is shielded with a plastic bag to prevent panel damage.* - *The console is difficult to control, necessitating a covering bag.* - *Salt negatively impacts the wheels and the underside of the chair.*	

PROJECT FOUR MILESTONE TWO: DESIGN EXPLORATION AND DESIGN REVIEW #1

MILESTONE 2.1 – CLIENT NOTES

Team ID:	Thurs-17

Complete this worksheet individually before coming to Lab A for Week 7.

Include your client notes from the introductory client visit

Name: Yahya Zaher	MacID: zahery

- *The console offers good visibility, but it got damaged when collided with, though it's still functional.*
- *To safeguard the console from water, a garbage bag is placed over it.*
- *Kitchen items are inconveniently placed too high, making it challenging to operate the stove or oven.*
- *A phone mount is needed as she currently rests her phone on the footplates.*
- *The 7-10 pound battery is hard to hold for extended periods.*
- *Limited storage around the wheelchair; important items stored around footplates, leading to incidents like losing her wallet.*
- *Bag frequently gets stuck between the pins, hitting the wheels and causing complications.*
- *Two grabbers are strategically placed in the house, primarily used for reaching sweaters.*
- *Difficulty fully flexing her left hand and struggles with opening doors due to limited range.*
- *Twisting around to pick up bags is an impossible task for her.*

MILESTONE 2.2 – RESEARCH ASSIGNMENT

Team ID:	Thurs-17

Complete this worksheet before Lab A for Week 7.

- State the question you plan to answer through your research
- Summarize your research findings (answer). Your answer should be a coherent, well-written summary of your research, not a "brain dump".
- You may include images, but don't forget to cite them properly.
- Aim for a length of about 500 words
- Properly cite your sources using IEEE formatted references and in-text citations. For information on referencing formats and choosing sources, see Design and Communication Workshop 1.

Name: Yahya Zaher	MacID: zahery

What is your question?

What kind of technology is already available for wheelchair users for uneven roads?

What is your answer?

Wheelchairs designed for uneven roads utilize advanced suspension systems and features like large, air-filled tires to enhance stability and provide a smoother ride. These mechanisms help users navigate challenging terrains by minimizing the impact of uneven surfaces.

Battery power plays a critical role in ensuring optimal wheelchair performance in such conditions. Lithium-ion batteries are commonly employed for their high energy density and lightweight nature, contributing to extended range and durability. Smart battery management systems (BMS) monitor and regulate battery performance, preventing issues like overcharging and optimizing energy utilization.

Innovative designs include regenerative braking systems, which convert energy dissipated during braking back into electrical power, replenishing the wheelchair's battery. This not only improves overall efficiency but also supports sustainability by reducing the need for frequent recharging.

Additionally, the development of wheelchairs for uneven terrains involves the integration of intelligent control systems. These systems utilize sensors and feedback mechanisms to continuously assess the wheelchair's environment and adjust the suspension and other features in real-time. This adaptability enhances user comfort and safety by responding to changes in terrain, such as bumps, inclines, or declines.

Material science is another crucial aspect in the construction of off-road wheelchairs. Lightweight yet durable materials, such as high-strength aluminum alloys or carbon fiber composites, are often used to achieve the desired balance between robustness and maneuverability. These materials contribute to the overall performance of the wheelchair by minimizing weight while ensuring structural integrity.

List of sources:

[1]
"Vibration & Shock Absorbing Wheelchair Suspension Wheels - Living Spinal," *livingspinal.com*. https://livingspinal.com/suspension-wheels-shock-and-vibration-absorbing/ (accessed Feb. 26, 2024).
[2]
P. P. Team, "Rough terrain wheelchairs vs outdoor models – a direct comparison.," *Passionate People by Invacare*, Mar. 28, 2019. https://passionatepeople.invacare.eu.com/rough-terrain-wheelchairs-vs-outdoor-models-a-direct-comparison/ (accessed Feb. 26, 2024).

MILESTONE 2.2 – INITIAL CONCEPT EXPLORATION

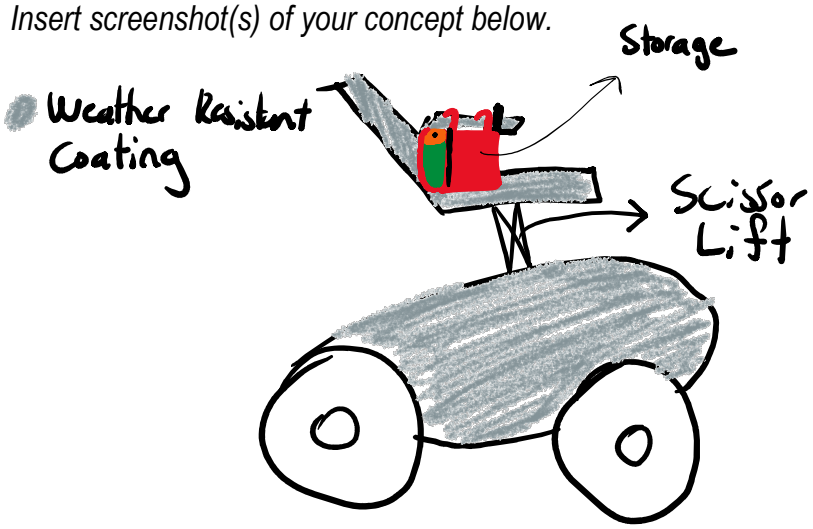
Team ID:	Thurs-17

Complete this worksheet before Lab A for Week 7.

1. Include multiple images of your **initial** concept exploration, if needed
   → Include necessary annotations to help in the communication of your ideas
   → These can be photos of hand sketches, photos of initial prototypes, screen grabs of basic CAD models
   → Include your Team Number, Name and MacID on *each* concept image
2. Insert your photo(s) as a Picture (Insert > Picture > This Device)
3. **Do not include more than *two* concept images per page**

Name: Yahya Zaher	MacID: zahery

Insert screenshot(s) of your concept below.



MILESTONE 2.4 – REFINED CONCEPT EXPLORATION

Team ID:	Thurs-17

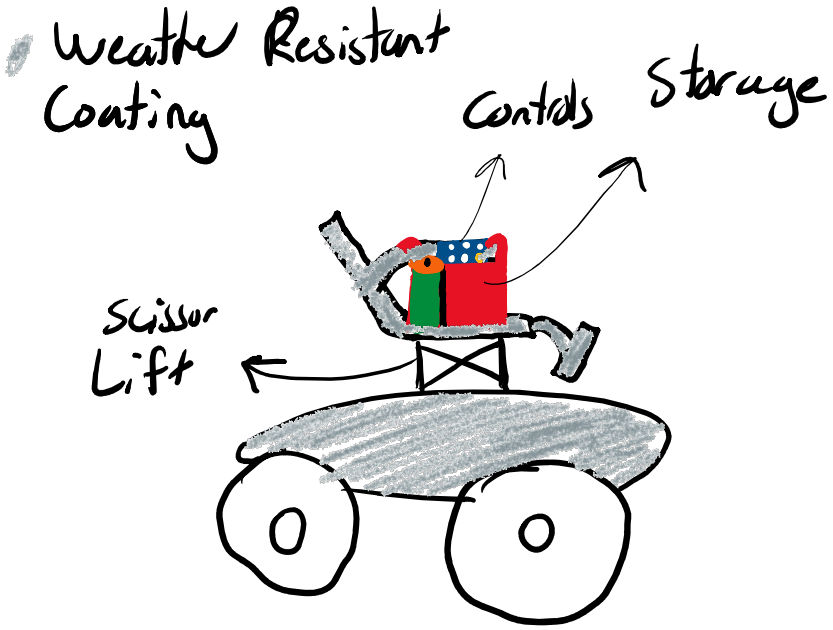
Complete this worksheet <u>during</u> Lab A for Week 7.

4. Include multiple images of your **refined** concept exploration, if needed
   - → Include 2 distinct concepts based on the functional analysis
   - → Include necessary annotations to help in the communication of your ideas
   - → These can be photos of hand sketches, photos of initial prototypes, screen grabs of basic CAD models
   - → Include your Team Number, Name and MacID on *<u>each</u>* concept image
5. Insert your photo(s) as a Picture (Insert > Picture > This Device)
6. **<u>Do not include more than *two* concept images per page</u>**

Concept 1:

Name: Yahya Zaher	MacID: zahery

Insert screenshot(s) of your concept below.

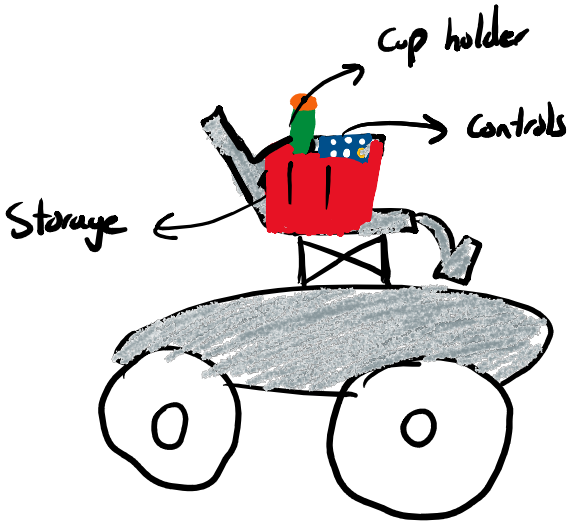


Team ID:

Concept 2:

Name:	MacID:

Insert screenshot(s) of your concept below.



PROJECT FOUR MILESTONE THREE: PROTOTYPING, DECISION MAKING AND DESIGN REVIEW #2

MILESTONE 3.1 – REFINED CONCEPT: INITIAL PROTOTYPE

Team ID: Thurs-17

Complete this worksheet individually before coming to Design Studio/Lab A for Week 8.

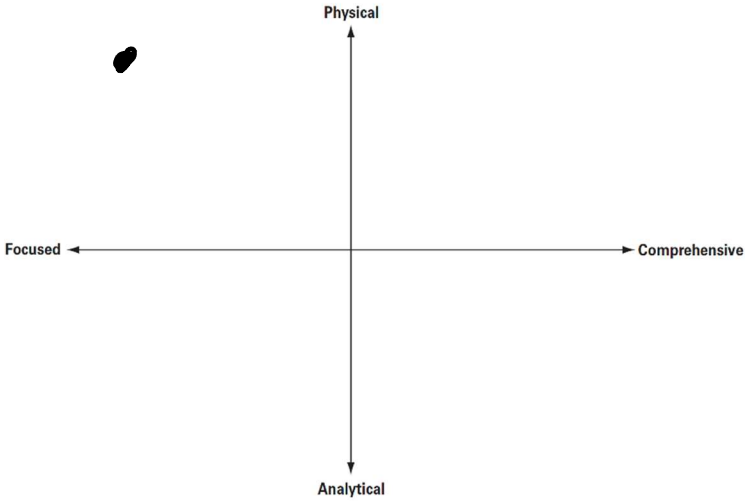
1. Write a small description of your initial prototype. Be sure to include what problem it aims to solve, how your initial prototype will be fabricated, and what functionality will be included and omitted in this initial prototype.
2. Classify whether your prototype is Physical or Analytical, and Focused or Comprehensive. Include the purpose of this prototype in the context of project 4 and the level of fidelity (low, medium, or high fidelity)
   - → **Physical vs. Analytical:** Physical prototypes are tangible artifacts that are created to approximate the final product. Analytical prototypes are non-tangible and represent the product using usually visual or mathematical models.
   - → **Focused vs. Comprehensive:** Focused prototypes implement only one or a few of the attributes of the final product. Comprehensive prototypes aim to implement most, if not all of the attributes of the final product.
3. Create a list of objectives and metrics for your initial prototype. There is no required amount of objectives or metrics, so long as the list is comprehensive.
4. Create a rough experimental plan for how you might test your prototype. Consider the methods you might use to test various objectives, how you will measure how effective each test proves to be and how realistic it would be to implement. This does not need to be detailed plan but should consider several of your objectives for the prototype.
5. Take picture(s) of your refined concept (initial prototype)
   - → Insert your photo(s) as a Picture (Insert > Picture > This Device)
   - → **Do not include more than *two* refined concept pictures per page**
   - → Include details on how concept was refined (what feedback was incorporated, what features are different than previous concept exploration, etc.)
   - → You can continue this process within the allocated time of the LabA/DS and seek feedback and discussions from your team members and/or the instructional team (IAIs, TAs, etc.).

Name: Yahya Zaher	MacID: zahery

Write a short description of your initial prototype below.

The prototype focuses on a battery cover with a hinge in the middle-bottom section, tailored for electric wheelchairs. This design aims to simplify the process of removing and replacing wheelchair batteries, enhancing accessibility for users.

Indicate where your prototype falls on the scale below.



Kind of Prototype:

☐ Physical or ☐ Analytical

☐ Focussed or ☐ Comprehensive

Purpose of Prototype:

The purpose of the prototype is to improve the user experience for electric wheelchair users by providing a more convenient and efficient method for battery replacements.

Level of Fidelity:

Medium Fidelity

Include a list of objectives and metrics for your prototype below.

Objectives

- Durability
- Lightweight
- Convenience

Metrics

- Number of cycles the hinge mechanism endures before showing signs of wear (Number of months)
- Weight of the prototype in comparison to standard battery covers (Kg)
- Time taken for battery removal and replacement, as well as user satisfaction ratings (minutes)

Include a rough experimental plan on how you might test your prototype below.

Durability Testing:

a. Objective: Assess the resilience of the hinge mechanism.

b. Method: Subject the prototype to a predetermined number of cycles simulating the opening and closing motion, gradually increasing stress levels.

c. Metric: Record the number of cycles endured before signs of wear appear.

d. Evaluation: Analyze the results to ensure the prototype withstands a sufficient number of cycles.

Weight Optimization:

a. Objective: Minimize weight without compromising durability.

b. Method: Experiment with different lightweight materials and design modifications, ensuring they meet durability standards.

c. Metric: Compare the weight of the optimized prototype with standard battery covers.

d. Evaluation: Determine the extent to which weight reduction is achieved without sacrificing durability.

Usability and Satisfaction Testing:

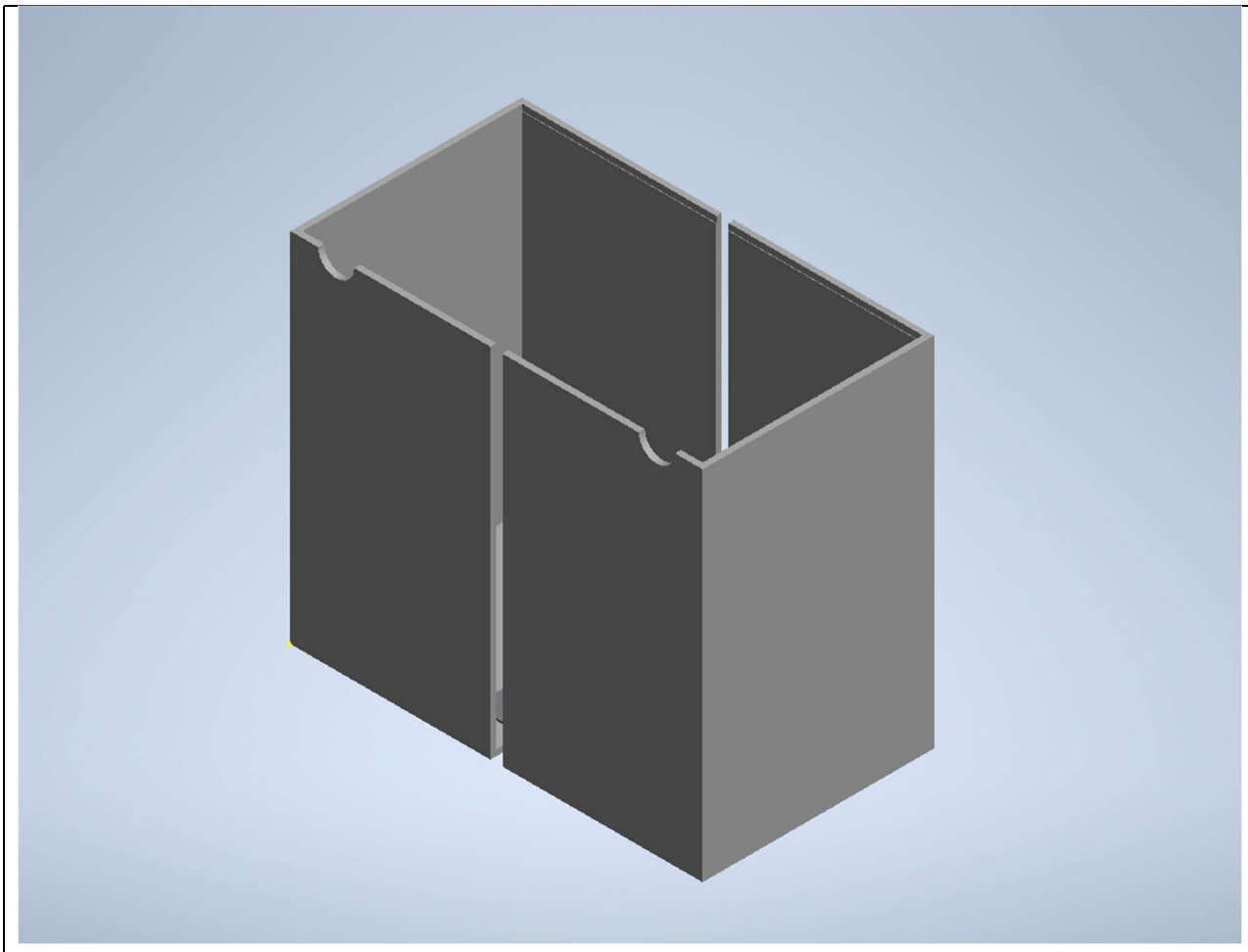
a. Objective: Evaluate the convenience and user-friendliness of the prototype.

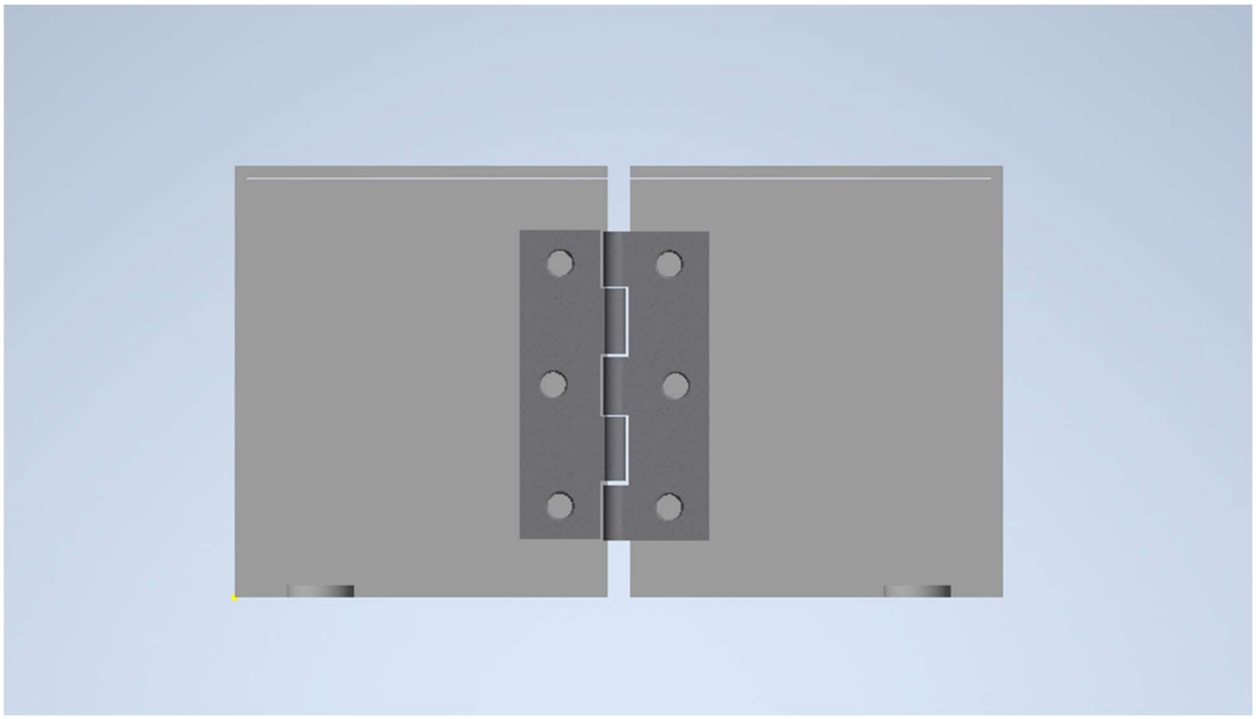
b. Method: Conduct usability tests with participants performing battery removal and replacement tasks.

c. Metric: Measure the time taken for tasks and collect user satisfaction ratings through surveys.

d. Evaluation: Analyze usability metrics and feedback to refine the design for optimal user experience.

Insert picture(s) of your refined concept (initial prototype) below.





Part 1: What?

In this section you will describe a critical incident that you will be reflecting on as related to the "Generating/Testing ideas" and "Decision-making." For each of these steps of the design process:

In three to five sentences, identify and describe ONE critical incident, breakthrough or big thought-provoking moment that either challenged your assumptions, had a positive impact on you or validated your understanding of the design process.

Here are some questions to consider:

Generating & Testing Ideas:

- How did you go about exploring ideas?
- How deeply did you explore your design options?
  - How much research?
  - Did you look into Biomimicry tools?
  - Did you consider any "What if?" questions in your explorations?
- Did you test your ideas?
- If yes, how did you test your ideas?
  - What were you trying to test (e.g., desirability, feasibility, etc.)?
  - What tool/ method did you use? (physical prototype, CAD model, etc.)
  - How much time did you spend on testing each idea?
  - How many ideas did you test?
  - How many prototypes did you make for testing each idea?
  - Did you test your ideas early on or waited until you had more details of the ideas?
- What was one challenge that you faced in the testing process of the design? (we encourage you to write more than one challenge). And What did you do to solve that challenge? (you can attach photos to explain your attempted solutions)
- From the results of our testing, one change we made to improve our design solution was … (add your response) and this change made our design solution better because … (add your response).

Your response:

During testing, I tried out ideas to see if they were practical and easy to use. I made physical prototypes and spent a few days testing each one to see how well it worked. I tried different ideas and made multiple prototypes for each. I started testing early to improve the design as I went along. I had to choose between using a clasp or Velcro to attach the phone holder to the wheelchair. Velcro was easier, but making sure it stuck without damaging the wheelchair

was a challenge. I tested different Velcro types until I found one that worked well. Choosing Velcro made the design better for wheelchair users.

Decision Making:

- What happened during decision-making?
  - Where in the process, relative to the design process steps, did you make decisions?
  - What were the decisions about? Decisions could be about the process (e.g., how much searching of the design space was enough?) or about the design (e.g., which alternative to prototype).
  - How many options did you have to choose from?
  - How many criteria did you have to compare the options? How did you choose those criteria?
  - What tools did you use to make a decision?
- At what stage did you make a decision?
- When did this experience take place? Did you already have one final solution in mind or you were still exploring the ideas?
- What challenges did you face during decision-making process?

Your response:

During decision-making, we had to choose things like how to attach the phone holder and whether to add a cup holder. We made these choices throughout the design process, considering factors like usability and user needs. We weighed different options and criteria, using tools like brainstorming and user feedback. This happened while we were still exploring ideas, not settled on one solution yet. Challenges included balancing priorities and figuring out which features mattered most to users.

Part 2: "So What?"

In this section you will explore what you learned and describe why this incident matters to you.

In three to five sentences, discuss what you learned from this incident about idea generation, testing ideas, and decision making and that either surprised you, made you confront a misconception, or improved your understanding of the design process.

To help you think about this, consider the following:

- What was the outcome of early or late testing processes?
- Do you think delaying any of your decision-making may have improved the design?
- Could you have collected better observations or data that would have led to better decisions?
- Did you repeat your decision-making process at any other stage?

Your response:

Testing early was key. I used to think detailed designs were better, but trying things out sooner helped me fix problems early on. Decisions about what users need are crucial from the start. While delaying decisions might refine the design, I see now that constantly collecting data helps make better choices at every stage.

In two to three sentences, explain why these new insights are important to you.

Your response:

These new insights are important to me because they highlight the value of an iterative design process and the importance of prioritizing user needs. Understanding the significance of early testing and continuous data collection allows me to be more efficient in my design approach and ensure that I address potential issues before they become more challenging to resolve. By embracing these insights, I can create more effective and user-centric designs in the future.

Part 3: "Now What?"

In two to three sentences, discuss how you will integrate this new insight into future design projects. To help you think about this, consider the following:

- I learned that... (Express and important learning, not a statement of fact)
- This learning matters because... (Consider how this learning has value to you as an engineer)
- How will I apply my learning?
- How will I design differently next time?
- How will I deal with a similar situation in the future?
- Considering this learning, I will... (Set specific, assessable goals; consider benefits and challenges involved in this plan)

Your response:

I realized testing early and getting user feedback is crucial. It ensures my designs meet users' needs better. Next time, I'll focus on early testing and keep getting feedback to make my designs better.

In two to three sentences, describe the possible benefits and challenges involved in your plan.

Your response:

Testing early and getting user feedback helps make better designs. But it can be tough to balance with deadlines and figuring out how to use all the feedback.