Design Project 4 – Power in Community

WinTire

ENGINEER 1P13 – Integrated Cornerstone Design Projects in Engineering

Tutorial T12

Team Friday-43

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Submitted: April 10, 2024

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

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Academic Integrity Statement

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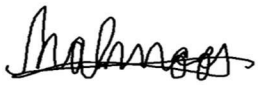
Noor Ahmed 400517077



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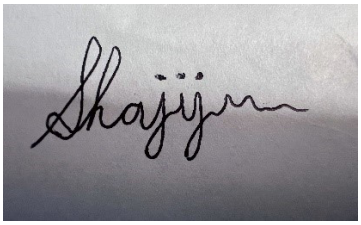
Shajijan Narendran 400529644



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Aman Minhas 400512313

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Executive Summary

Within the past five years, Canada has witnessed a significant increase in the severity of its climate conditions, causing disruptions to the daily lives of its citizens. With Canada warming at twice the global rate, individuals who rely on a wheelchair for everyday mobility must frequently deal with harsh rainfall and storms which can pose challenges [1]. Such adversities create significant barriers within a wheelchair user's transportation due to the inefficiency of the current tire model.

A common tire model has an absence of treads and extensions to assist the wheelchair in pushing through snow and salt while also maintaining the ability to transport over ice and slipper conditions. Due to the frigid winter season, the traction on wheelchair tires averages a lifespan of 12-36 months [2]. To avoid the annual costs of repurchasing required winter equipment along with increasing efficiency of combatting the inconsistent forecast, manufacturing a design which aids Tiffany's ability to navigate in adverse weather conditions to ultimately enhance her quality of life, ensuring durability and accessibility throughout. Our team tackled those adversities through creating the WinTire, a tire add-on for wheelchair users combatting the winter season. The prototype consists of a circular metal grid, bound to fit any wheel through the adaptable circumference, metal L shaped rods placed 4 inches apart, responsible for the displacement of the ground content, which are all attached through the securing of a thin metal wire.

Through the durable material of aluminum metal, the WinTire has been thoroughly considered for increased longevity against the harshest conditions along with general damage such as rusting. Aluminum alloy has an average life span of over 40 years, furthering the longevity of the product and fulfilling the objective to minimize cost and time [3]. Overtime, the cost of purchasing the WinTire outweighs the cost and time associated with the hassle purchasing an annual tire replacement. While current solutions such as tire chains exist, they are inefficient regarding the transportation of snow over 5cm, furthering the limitations wheelchair users face. Through the sweeping motion provided by the L shaped rods, the WinTire combats heaps of snow as our testing plans reported an average displacement of 3 grams per rotation.

Throughout prototyping the WinTire, the limitations due to time and cost of the materials to complete the functions to perfection hindered the final product. As transportation over ice was one of the main concerns, the ideal material of the L shaped rods would be rubber which increases the friction against the slippery surface and creates traction [4]. Although, due to over-budget cost and limited access to the specific materials, such adjustments could not be made. WinTire offers a promising solution minimizing the cost and time through durable resources along with accessible installation allowing greater independence for wheelchair users like Tiffany navigating the harsh weather conditions of Canada.

Background Information

Client and Problem Information

Figure 1: Our Client Tiffany

For Project 4, students partaking in the ENGINEER 1P13 course have the opportunity to collaborate with and serve the perseverant client, Tiffany. She is now 33 years old and was diagnosed with Spina Bifida at birth which occurs when the spine and spinal cord don't form properly. As a result, she is prevented from experiencing any movement in body parts below the waist and has had two metal rods inserted in her back to straighten her spine [5].

A nurse and personal support worker aid Tiffany in some daily tasks like getting dressed. Tiffany utilizes a power wheelchair in her everyday life, although it has brought ease into her life, it has several weak components, such as an unaccommodating width that makes many doors inaccessible for her along with its deterred function in winter conditions. Snow and slush pose dangers of wheel skidding and internal chair damage. For her financial independence, she has a Job at her local Walmart, working as both a shelve stocker and a greeter. Tiffany is a very lively character, she enjoys time with friends, dance lessons, and many hobbies such as martial arts. In her day-to-day life, she also utilizes a Reacher-Grabber arm at home which allows her to pick up and place items that are normally out of her range. She also faces skin sensitivity which prevents her from using heating pads that can ensure the rods in her back don't get too cold in winter. Tiffany aims to achieve greater independence in her life with a priority on safety [5].

Despite her medical condition, Tiffany continues to live and enjoy her life unwilling to be defined by her medical condition. Her story showcases the many struggles people with "(dis)ability" face and as she continues to push and fight through the many adversities life has thrown at her she demonstrates that people with disability can too overcome challenges and achieve their goals.

The difficulties that Tiffany faced with operating her wheelchair during the winter season stood out to the team. The team identified the problem of the deterred functionality coupled with the safety risks of Tiffany's wheelchair tires in winter conditions. Instantly, this problem was declared the focal purpose of the design solution for Project 4.

Existing Solutions

Upon gathering information about Tiffany, it came to the team's attention that winters are extremely difficult for Tiffany to navigate with her wheelchair as the wheelchair wheels fail to provide ample strength, grip, and traction needed to combat winter conditions safely and efficiently. To build a design solution pertaining to the identified problem, extensive research was conducted on existing solutions and products in the market that helped equip wheelchair users for safe navigation in winter conditions.

Winter wheelchairs, tire chains, tire covers, and snow cleats are among many of the products available in the marketplace today to enhance mobility in winter conditions. Several companies sell tire chains to attach onto tires for increased traction in snowy and icy conditions, however, this product is targeted toward car tires and can only be used in snowy and icy conditions as it can cause damage to clear roads and surfaces [6]. Also, there are not any reliable tire chains available for wheelchair users on the market currently. Winter wheelchairs, such as the GRIT Freedom chair are available in the market for a minimum of four thousand dollars, but they are strictly equipped to heighten mobility in winter with their snow-ready design [7]. These wheelchairs fall short when it comes to handling other weather conditions and various terrains, and they also prompt users to switch to different wheelchairs once they leave winter conditions. Tire covers are also available in the market with the sole aim of combatting snow and rain, these are easy to attach and detach from existing tries, however, they are only suitable for certain wheelchair makes and models and there is very restricted availability on the sizes available for these products [8]. Lastly, snow cleats are also in the market, they are reusable and detachable, with

Figure 2: The GRIT Freedom Wheelchair [6].

Figure 3: The FOLD & GO Snow Cleats [8].

metal features allowing for extra traction in deep snow. This product is only available for wheelchairs from a specific company and cannot be used on concrete, asphalt, or wooden ramps as the product will flatten and break [9].

Despite the availability of the above-discussed products, they are not widely accessible to most wheelchair users, due to their high price, exclusivity, and limited functionality under all circumstances. After careful consideration of existing products, the team's discussion led to a design solution that was centered around the idea of a winter tire add-on. The team aimed to make this design solution unique from all the existing solutions by setting objectives and constraints (later discussed) that allowed it to be a safe, reliable, and highly viable option for all wheelchair users.

Problem Framing

Tiffany experiences significant adversity due to her condition, Spina Bifida, which obligates her to a wheelchair. Harsh weather conditions caused by snow and salt wear down her tires which present a multifaceted challenge in creating an effective solution to ultimately enhance her mobility outdoors. With this problem, numerous objectives and constraints arise. Our primary objectives include durability, efficiency, and longevity. Seeing that our tire attachment is undergoing profuse amounts of stress, it is necessary that our design can withstand the stress and not plastically deform. It is also essential that our design is efficient enough to satisfy all of Tiffany's demands and more as her adventures will lead her through various conditions. Additionally, longevity is a main objective to ensure that our attachment can traverse numerous surfaces such as snow, salt, gravel, concrete, grass, pavement, etc. without hindering the efficiency of the design or damaging the attachment. However, due to the budget given for our design, cost was the main constraint.

Conceptual Design

The initial concept for the design was to implement a convey belt style cover for Tiffany's primary and secondary wheels that would be used during the winter months to help her deal with the snowy and icy weather conditions. She talked about how her battery's close proximity to the ground would damage it as well as the fact that she often needed the help of caregiver to complete her trips to work. In our initial design, we envisioned the treads as trapezoidal pegs that raise her height off the ground as well as push snow backwards as she travelled. In our refined initial prototype, we included tips on each individual tread to serve as a symbolic representation of the traction the final design would need to have in order to resist slipping (Fig. 4). An important aspect of our conceptual design was its ability to provide a smooth driving sensation for the user, as the performance of the design would be meaningless if it did not enhance Tiffany's quality as well as her overall independence. In our morph chart, we tinkered with ideas like an internal heating system within the treads and chains to secure Tiffany's wheel to our design; ultimately, the decision was made to keep the design reduced to the core objectives.

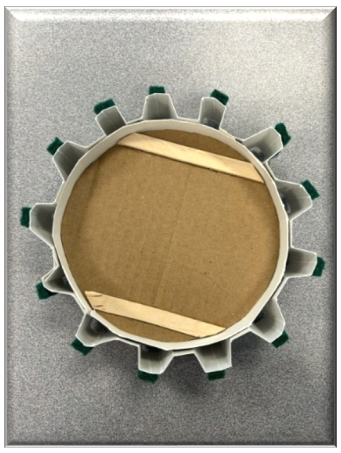


Figure 4 – Refined Initial Prototype

To stand out from other similar existing designs, we focused on the portability of the design to easily attach and detach from the wheel. Through the use of a decision matrix, the main design components that remained after the first round of revision was a connective piece – whether it be tubing or chain – to keep the design in place and edged, rod-like pieces that would displace snow and salt. When presented to TAs, IAIs, and science students, they were primarily concerned about how the treads would damage interior flooring, considering Tiffany would eventually need to go inside with the treads on at some point to take them off. This proved to be a key part of the design process as we needed to add a part to the design that would soften the damage done to combat the sharpness of the metal. This element would be added in later iterations of the design.

Final Proposed Design

The final design of our snow removal device, named WinTire, bridged innovative design with efficient functionality to provide a solution that exceeds expectations at an affordable rate. At its core, WinTire consists of a circular grid meticulously constructed to optimize snow removal efficiency, L-Bars to carry out the snow-removal and aluminum wire to keep it all together. The circular grid, as depicted in (Fig. #), is strategically designed to accommodate the placement of cut-L bars with precision.

Bill of Materials

Date of Purchase	Description	Total ($)
2024-09-03	1x L-Bar, 1x Aluminum Grid	$32.53
2024-12-03	3x L-Bar	$20.05
2024-12-04	7x 1kg Bag of Rice	$17.01
2024-04-04	1x Pink Spray Paint	$18.07
		$87.66

Fig.5 Bill of Materials

Specifications:

- Total Cost: $87.66 (as per Bill of Materials, Fig.5)

- Capacity: Holds up to 8 kg of weight (Fig. 7)

- Snow Removal Efficiency: Approximately 4 inches of snow per rotation (Fig. 8)

- Durability: Estimated lifespan of 5 years (Fig. 9)

Construction and Development Methods:

The construction of WinTire began with the assembly of the circular grid, ensuring its diameter perfectly aligned with the intended design. This initial step was pivotal, as it dictated the optimal spacing for the cut L-bars along the calculated circumference of the tire. The arrangement of these bars, detailed in (Fig. 6), was crucial for maximizing the use of the 36-inch L-bars acquired for the project.

The testing of our prototype further guided our construction decisions. Using 1kg bags of rice (Fig. 7), we were astounded to find that WinTire could withstand an impressive 8 kg of weight. This testing not only validated our design but also assured us of its durability and load-bearing capacity.

Fig.6: Initial L-Bar Arrangement

The testing plan for WinTire was comprehensive, focusing on key metrics such as load capacity (*in kg*), snow removal efficiency (*inch / rotation*), and product longevity (*years*). Our device surpassed expectations in each aspect. The load testing revealed an impressive capacity of 8 kg (Fig.7), ensuring its ability to handle heavy snowfall without compromise.

In terms of snow removal efficiency, WinTire proved its effectiveness by clearing approximately 4 inches of snow per rotation (Fig. 5). This metric was crucial for ensuring swift and thorough snow removal, especially in varying weather conditions.

Fig.7 Load Capacity Testing

Addressing the constraint of material durability, our Granta Material selection chart guided us towards aluminum, balancing cost-effectiveness with resilience. However, rust emerged as a potential issue during testing. To mitigate this, we coated WinTire with a rust-protective paint, ensuring longevity and customer satisfaction throughout the seasons.

Moving forward, our focus lies on enhancing user experience and indoor usability. The addition of a rubber sheath to the L-bars (Fig. 8) will enable WinTire to traverse indoor surfaces without causing any damage, expanding its utility for users like Tiffany.

Fig.9 Final Product: WinTire

Conclusion

All in all, the WinTire materialized into a fully fledged prototype with several design elements that were carried over from our initial brainstorm combined with ideas gathered throughout the design process. The final refined prototype is entirely capable of displacing snow, as was primarily intended, and could seamlessly attach and detach from the wheel that we had brought in for demonstration. If given extra time, the first element we would incorporate would be the polymer tips that would over the aluminum L-shaped rods to prevent rust and damage to interior flooring. The most effective material would have been an industry grade polymer; however, it still could have been possible to add a material that symbolically

represents the function of the polymer coating. This minor change does not affect the design's overall ability to perform its functions as this was merely to help with longevity. Additionally, our final test plan could have been altered so that we had a clearer understanding of how smoothly the design could have rolled in junction with the wheel. By using wooden supports in place on the wheel, the design lost its shape over time and became less functional. In spite of this, the design still proved to effectively move through snow and salt.

Through completion of this project, we learned about the importance of solidifying a testing plan that thoroughly tests several aspects of a design at once as well as making key observations about its performance. The testing plan that we developed ultimately revealed critical errors within the design that we were then able to change when we demonstrated the final refined prototype. One of the changes being a better method of keeping the design from spinning off the wheel. By having every member of the group available and actively engaged with the work, the decisions made throughout the design process felt more justified and assured as they were backed by several opinions. In the future, it may be more effective to allocate more time to testing and undergo several test plans to ensure that the design is able to perform the several tasks it was meant to do.

Reference List

[1] Natural Resources Canada, "Canada's Changing Climate Report", 2020. [Online]. Available: https://changingclimate.ca/site/assets/uploads/sites/2/2020/06/CCCR_FULLREPORT-EN-FINAL.pdf. [Accessed: Apr. 10, 2024].

[2] Azeem Meruani, "Tweel™ Technology Tires for Wheelchairs and Instrumentation for Measuring Everyday Wheeled Mobility," M.S. thesis, Dept. Mech. Eng., Georgia Inst. Tech., Atlanta, GA, USA, 2006. [Online]. Avaliable: https://repository.gatech.edu/server/api/core/bitstreams/955a5199-045e-41e8-8f51-c44c5952e91e/content [Accessed: Apr. 10, 2024]

[3] "How sustainable is aluminium?," Comhan.com, 2018. Available: https://www.comhan.com/en/blog/news/how-sustainable-aluminium [Accessed: Apr. 10, 2024]

[4] Tyreright, "Tyre Traction Matters: How it Affects Road Grip and Manoeuvring | Tyreright," Tyreright.com.au, Aug. 31, 2023. Available: https://tyreright.com.au/expert-tips/tyre-traction-matters-how-it-affects-road-grip-and-manoeuvring/ [Accessed: Apr. 10, 2024]

[5] "P4- Project Module", class notes for 1P13, pg. 1-30, Engineering, McMaster University, Winter Term, 2024.

[6] "Snow Tires Vs. Chains: Here's All You Need To Know," GT Radial. [Online]. Available: https://www.gtradial-us.com/blog/snow-tires-vs-chains-heres-all-you-need-to-know/#:~:text=They%20provide%20increased%20traction,are%20a%20one%2Dtime%20purchase. [Accessed April 9, 2024]

[7] "Using the GRIT Freedom Chair in the Snow," GRIT. [Online]. Available: https://www.gogrit.us/snow-wheelchair. [Accessed April 9, 2024]

[8] "retyre Traction Wheelchair Tire Covers for Snow & Rain | Wheelchair Accessories," MyMobilityStore. [Online]. Available: https://mymobilitystore.com/. [Accessed April 9, 2024]

[9] "FOLD + GO Snow Cleats," FOLD&GO Electric Wheelchairs. [Online]. Available: https://www.foldandgowheelchairs.com/travel-friendly/fngo-snow-cleats/. [Accessed April 9, 2024]

[10] Autodesk® Inventor 2024 LT™ software, Autodesk, Inc, 2023 (www.autodesk.com).

[11] Ansys GRANTA EduPack software, ANSYS, Inc., Cambridge, UK, 2023 (www.ansys.com/materials)

Appendices

Appendix A: Supporting Documents

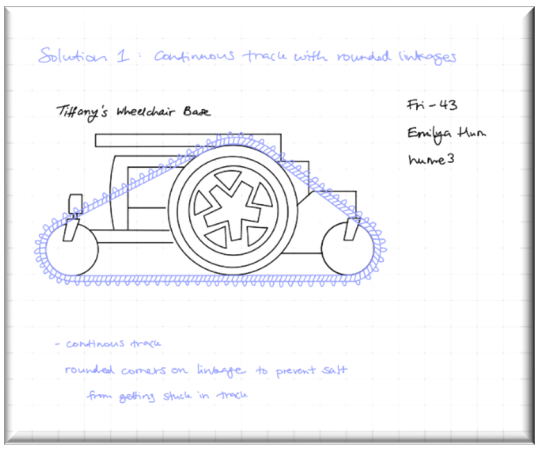
Section 1

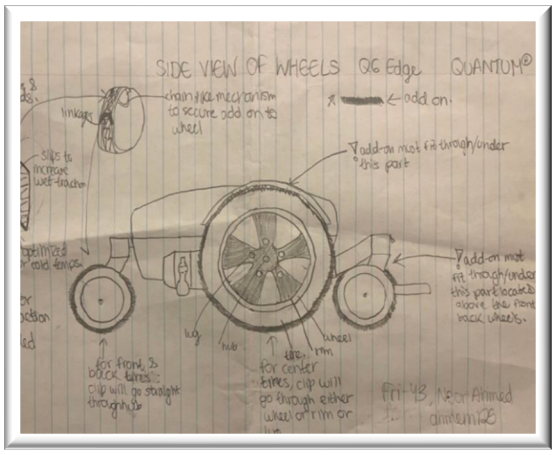
GRIT Freedom Wheelchair (winter wheelchair)

Snow Cleats

Section 2

Preliminary sketches:

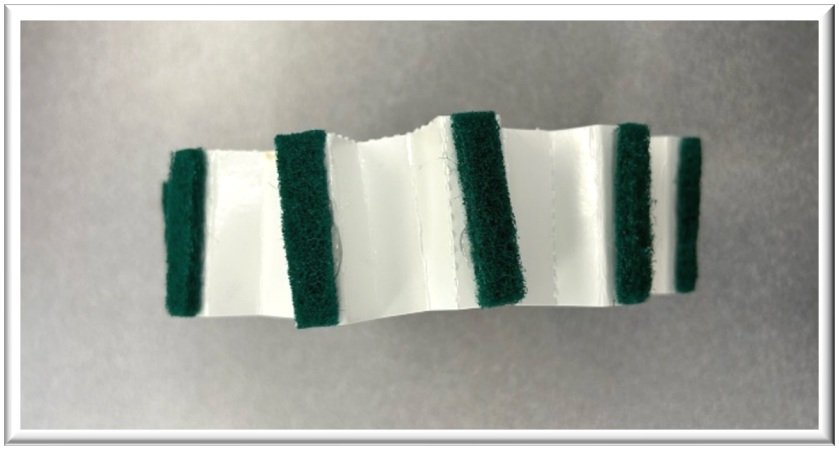


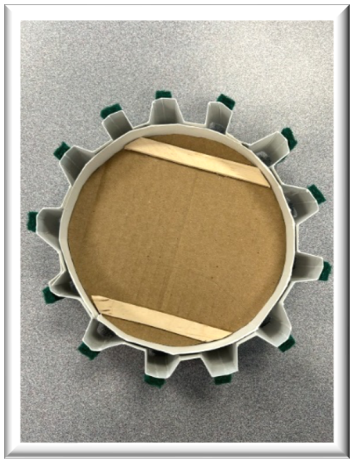


Initial Prototypes:

Trapezoidal treads and sponges mimicking traction feature stood out to the team.

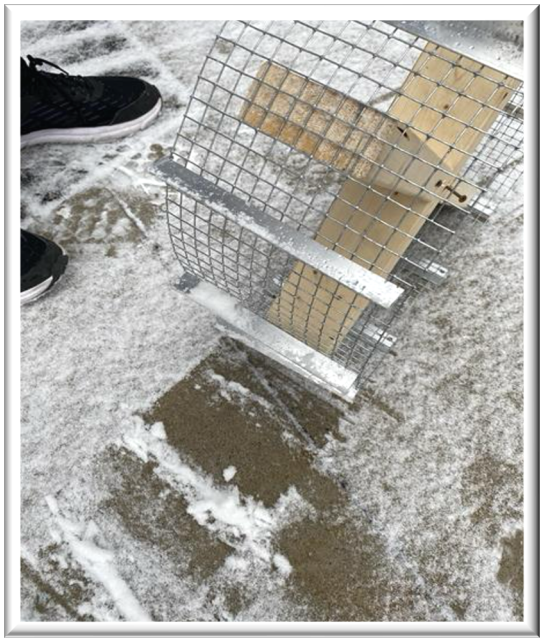
Refined Initial Prototype:





Popsicles and carboard inner frame were added for stability, strength and maintaining shape, sponge material was inserted on the edges of the treads for increased traction and grip.

Further Refined Prototype:



Design Review #1 Notes:

feedback from your faculty mentor, staff, or assigned TA/IAI in this row

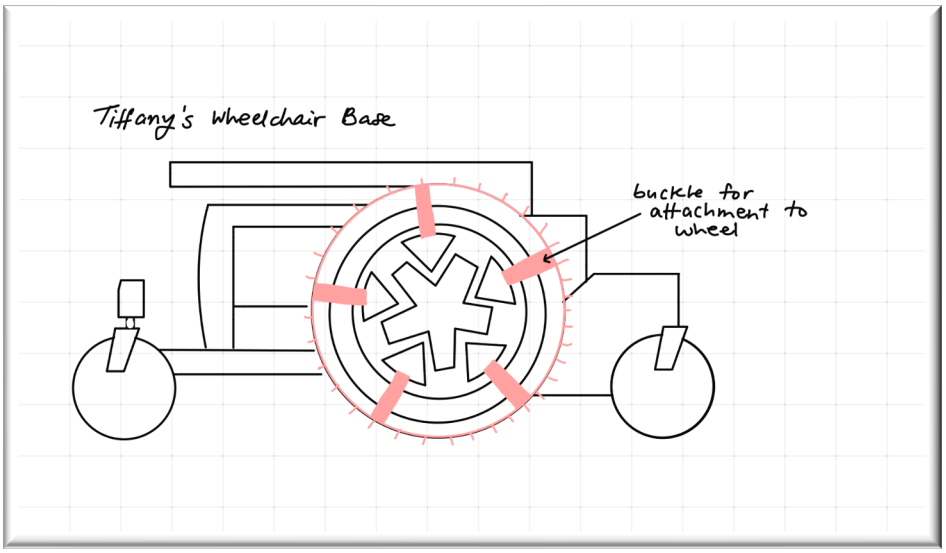
- How will this be installed and maintained?
- Conveyor belt style seems a bit challenging.
- Understand the function/purpose of each wheel.
    - Do some stay stationary and solely translational while others have rotational features.
        - Which wheels **NEED** the traction belt around them? Can some wheel's not have them while serving the overall purpose.
- Do some research into the material of the add-on.
    - Rubber and Rubber → too high of a friction against each other causing little to no movement.
    - Consider maintenance, flexibility, and overall cost.
- Compare strength and maintenance, weigh the importance of both factors.
    - Have a strong product while having weaker maintenance.
    - Have an easily maintained product while having a weaker overall product

feedback from science students in this row. (if applicable) □ *Easy maintenance and repair* o *Review costs, accessibility of replacements, and maintenance procedures* □ *Tiffany mentioned a previous incident where she was alone, and her belt snapped.* o *To combat, our team's design must be easy to repair and avoid dependance on other.*

Design Review #2 Notes:

feedback from science students in this row. - Asked whether the tire add on is equipped for use during various weather conditions, such as snow. - Our answer was to ensure to use a weather resistant material coated over the body of the add on allowing for use and function for various weather conditions.
feedback from your faculty mentor, staff, or assigned TA/IAI in this row - *Were curious as to how the add-on will attach to the actual wheel.* - *Concerned that final L shape rod may not be safe for all terrains including floors* - *Try to make the final design the right size according to the actual wheelchair tire and complete it, we may also use a* - *Ensure the material you use for the add-on is ice, water, and salt-resistant* - *Try to make the add-on cleanable* - *Do your research to determine the material choice, and have research to back up any design choices.* - *However, it is not necessary to coat the final design as long as research is done to back up the planned/anticipated design and material decisions.*

Refined Sketch Upon Testing Plan Execution:



Feature added to account for attachability objective of design solution.

Final Design:

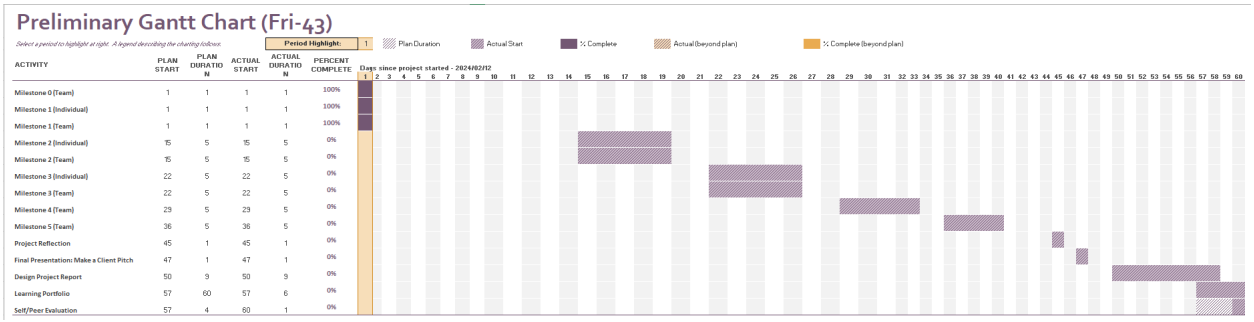
New features: Pink colour, attachment mechanism, and a tire is inserted inside demonstrating functionality.

Section 3 (Final Prototype Documents)

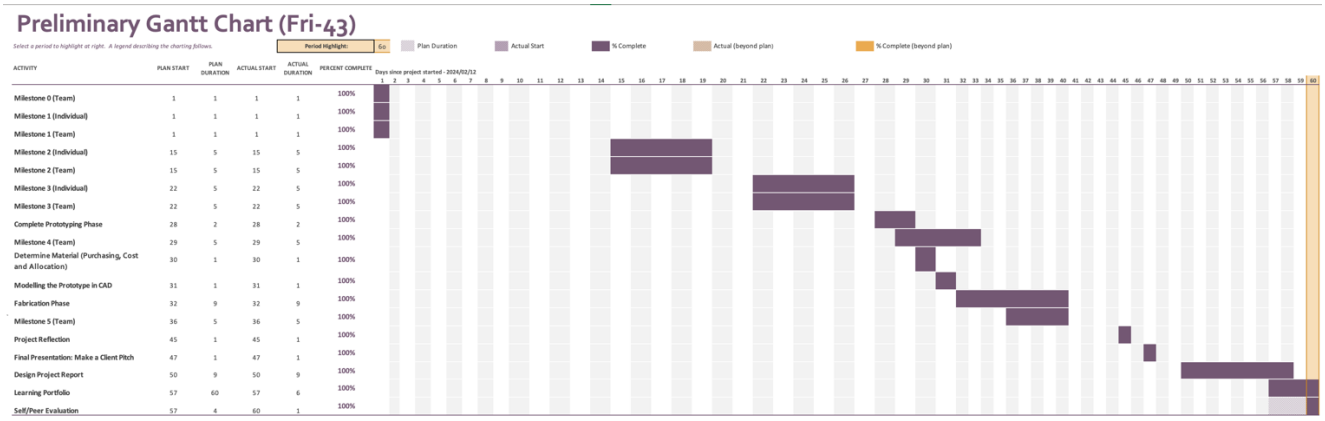
Bill of Materials		
Date of Purchase	Description	Total ($)
2024-09-03	1x L-Bar, 1x Aluminum Grid	$32.53
2024-12-03	3x L-Bar	$20.05
2024-12-04	7x 1kg Bag of Rice	$17.01
2024-04-04	1x Pink Spray Paint	$18.07
		$87.66

Appendix B: Project Schedule

Preliminary Gantt Chart (Emilya)



Final Gantt Chart (Aman)



Appendix C: Scheduled Weekly Meetings

ENGINEER 1P13
MEETING WITH TEAM 43 - FRIDAY, FEB. 16, 2024

Attendance

Role	Name	Mac ID	Attendance (Yes/No)
Manager	**Emilya Hum**	**hume3**	**Yes**
Administrator	**Aman Minhas**	**Minhaa18**	**Yes**
Coordinator	**Noor Ahmed**	**Ahmem125**	**Yes**
Subject Matter Expert	**Shadi El-Fares**	elfaress	**Yes**
Subject Matter Expert	**Shajijan Narendran**	**narends**	**Yes**

Agenda Items

1. Milestone 0 & 1: Team Development, Problem Framing and Test Plan

Meeting Minutes

1. **Intros**
2. **Assign Project Leads (Team Charter)**
3. **Fill out previous project experience**
4. **Created initial problem statement**
5. **Testing Plan Development**
6. **Set Objectives for design solution: Durability, Portability, Longevity, Battery life, Accessible & Safe**
7. **Constraint for design solution: Weight**
8. **Objectives + Corresponding Metrics (inventor simulations, travelling difficulty, years, battery efficiency, pounds)**
9. **initial testing plans for each objective**
10. **Design Solution in mind: Reacher Grabber Type of Mechanism**
11. **Finalize Refined Problem Statement**

12. **Decided on individual research assignment topics**

Post-Meeting Action Items

1. *Complete Preliminary Gantt Chart(Emilya)*
2. Work on Research Assignments
3. Continue brainstorming design solution
4. Work on individual Milestones
5. Milestone Submission(Aman)

ENGINEER 1P13
MEETING WITH TEAM 43 - FRIDAY, MAR. 1, 2024

Attendance

Role	Name	Mac ID	Attendance (Yes/No)
Manager	**Emilya Hum**	**hume3**	**Yes**
Administrator	**Aman Minhas**	**Minhaa18**	**Yes**
Coordinator	**Noor Ahmed**	**Ahmem125**	**Yes**
Subject Matter Expert	**Shadi El-Fares**	elfaress	**Yes**
Subject Matter Expert	**Shajijan Narendran**	**narends**	**Yes**

Agenda Items

2. Milestone 2: Design Exploration & Design Review #1

Meeting Minutes

1. Discussed Findings from research assignments
2. Complete change of plans
3. No longer executing a Reacher-grabber kind of design solution
4. Switched to a winter tire add-on design solution
5. **Complete Summary of changes: Functional Analysis**
6. **Complete Updated Refined Problem Statement**
7. **Gather info from research assignments, including info on the client, existing solutions in the market, patents, and materials**
8. **Update Objectives and Constraints**
9. **Design Review**
10. **Notes + Feedback from Ta's during design review**

Post-Meeting Action Items

1. *Complete functional analysis, input means for decided functions*

2. *Reflect on feedback, and find ways to incorporate feedback into the proposed design solution*
3. Conduct further research as prompted by the TAs to determine potential material for the design solution
4. Conduct further research into wheelchair wheels and each wheel's purpose
5. Compare the importance of each objective for example Strength Vs. Easy Maintenance
6. Milestone Submission(Aman)

ENGINEER 1P13
MEETING WITH TEAM FRI-43 - FRI, MAR. 8, 2024

Attendance

Role	Name	Mac ID	Attendance (Yes/No)
Manager	**Emilya Hum**	**hume3**	**Yes**
Administrator	**Aman Minhas**	**Minhaa18**	**Yes**
Coordinator	**Noor Ahmed**	**Ahmem125**	**Yes**
Subject Matter Expert	**Shadi El-Fares**	elfaress	**Yes**
Subject Matter Expert	**Shajijan Narendran**	**narends**	**Yes**

Agenda Items

1. Milestone 3: Prototyping and Decision Making
2. Determine which 2 concepts to proceed with for the design solution

Meeting Minutes

1. Decision matrix to identify the 2 most optimal design concepts
2. Determine Matrix Criterion, weighing, and each prototype's score
3. Criterion: Ice & Snow Traction, Push Back Snow, Durable/Strong, Reduced sticking of salt to tread, latches onto wheel, and smooth driving sensation
4. Top Concepts. 1) Trapezoidal treads with connective tubing 2) Rounded edge tire treads
5. A concept that focused on the entire body of the add-on along with a prototype that focused on the tire/tread feature of the prototype scored the highest in the decision matrix
6. Created Refined Project Timeline, allocated tasks to each member and deadlines for each task
7. Complete + Update Gantt Chart (Emilya)

Post-Meeting Action Items

1. Complete Prototyping Phase
2. Combine elements from both top concepts
3. Begin design, material, and fabrication phase
4. Milestone Submission(Aman)

ENGINEER 1P13
MEETING WITH TEAM 43 - FRIDAY, MAR. 15, 2024

Attendance

Role	Name	Mac ID	Attendance (Yes/No)
Manager	**Emilya Hum**	**hume3**	**Yes**
Administrator	**Aman Minhas**	**Minhaa18**	**Yes**
Coordinator	**Noor Ahmed**	**Ahmem125**	**Yes**
Subject Matter Expert	**Shadi El-Fares**	elfaress	**Yes**
Subject Matter Expert	**Shajijan Narendran**	**narends**	**Yes**

Agenda Items

1. Milestone 4: Refined Prototyping and Testing Plan & Design Review #2
2. Testing Plan
3. Desing Review

Meeting Minutes

1. Description of Refined Prototype
2. Finalized name for solution: The “WinTire”
3. **Determine the kind, purpose, and level of fidelity of the prototype**
4. **Medium Level Fidelity**
5. **Physical + Comprehensive Prototype**
6. **List objectives + metrics for prototype**
7. **Objectives: Flexibility, Durability, Portability, and Grip**
8. **Metrics: Weight, Cost, and Angular Velocity**
9. **Elements from various initial prototypes are incorporated and combined into the refined prototype**

10. **Rough Parts of sponge added to add-on treads to increase grip + ice traction, Indents in the add-on frame allow for more flexibility, Popsicle sticks acted as support structures, Paper Clip features act as attachment mechanisms**
11. **Create a Present Testing plan + Future Testing Plan**
12. **Feedback from Design Review**

Post-Meeting Action Items

1. Understand and try to incorporate feedback from the design review into the actual design solution/prototype
2. Refine the Testing plan + appropriate sources/references
3. Milestone Submission(Aman

ENGINEER 1P13
MEETING WITH TEAM 43 - FRIDAY, MAR. 22, 2024

Attendance

Role	Name	Mac ID	Attendance (Yes/No)
Manager	**Emilya Hum**	**hume3**	**Yes**
Administrator	**Aman Minhas**	**Minhaa18**	**Yes**
Coordinator	**Noor Ahmed**	**Ahmem125**	**Yes**
Subject Matter Expert	**Shadi El-Fares**	elfaress	**Yes**
Subject Matter Expert	**Shajijan Narendran**	**narends**	**Yes**

Agenda Items

1. Milestone 5: Execution of the Test Plan and Finalizing the Design

Meeting Minutes

1. **Conduct Final Evaluation of Objectives and Constraints**
2. **Quantitative and Qualitative Objectives + Metrics**
3. **Constraints + Metrics**
4. **Testing Plan for immediate implementation**
5. **Testing Plan Execution**
6. Tire add-on inner frame should have had a circular inner frame to better replicate the support of the tire
7. Add a material to cover L-shaped metal features to prevent damage to surfaces.
8. Add-on could hold 7kg without permanent deformation
9. L-shaped features successfully pushed back snow and ice
10. Add-on did not break and displayed flexibility

Post-Meeting Action Items

1. Testing Plan Discussion

2. Results + Images for durability, efficiency, and longevity objectives tested for in testing plan
3. Discuss Results for aspects of the testing plan pertaining to constraints
4. *Find a Tire like item to put inside add-on*
5. *Material to cover add-on*
6. Edit and submit Milestone(Aman)

ENGINEER 1P13
MEETING WITH TEAM 43 - FRIDAY, MAR. 29, 2024

Attendance

Role	Name	Mac ID	Attendance (Yes/No)
Manager	**Emilya Hum**	**hume3**	**Yes**
Administrator	**Aman Minhas**	**Minhaa18**	**Yes**
Coordinator	**Noor Ahmed**	**Ahmem125**	**Yes**
Subject Matter Expert	**Shadi El-Fares**	elfaress	**Yes**
Subject Matter Expert	**Shajijan Narendran**	**narends**	**Yes**

Agenda Items

1. Presentation prep-time

Meeting Minutes

1. Finalize color of prototype
2. Begin Presentation Slides
3. Create Presentation Script, and assign parts

Post-Meeting Action Items

1. Buy Spray-paint (Noor)
2. Refine Presentation (All)
3. Practice assigned parts (All)

ENGINEER 1P13
MEETING WITH TEAM 43 - FRIDAY, APRIL 5, 2024

Attendance

Role	Name	Mac ID	Attendance (Yes/No)
Manager	**Emilya Hum**	**hume3**	**Yes**
Administrator	**Aman Minhas**	**Minhaa18**	**Yes**
Coordinator	**Noor Ahmed**	**Ahmem125**	**Yes**
Subject Matter Expert	**Shadi El-Fares**	elfaress	**Yes**
Subject Matter Expert	**Shajijan Narendran**	**narends**	**Yes**

Agenda Items

1. Presentation practice
2. Final Presentation (Pitch)

Meeting Minutes

1. **Assign Parts for Presentation**
2. **Run through the presentation several times**
3. **Last-minute changes needed to be made**

Post-Meeting Action Items

1. Complete Self and Peer Reviews (All)
2. Assign Parts to each member for Final Project Report(All)

Relevant External Entries

March 19th

- Im here Aman Minhas by Shajijan Narendran (1:37 PM)
- okay coming! by Aman Minhas (1:37 PM)

- Begin Reference, I'll come when everyone el... by Aman Minhas (1:42 PM)
- Looks good, so like I told Shajijan. I'll h... by Shadi El-Fares (2:36 PM)
- Ok average is 7 so we can go with that by Shadi El-Fares (2:37 PM)
- Yea ok by Shajijan Narendran (2:37 PM)
- But wheel diameter hasn't changed just to c... by Shadi El-Fares (2:37 PM)
- We are still 10in radius by Shadi El-Fares (2:38 PM)
- Ye the diameter is still 10 inches by Shajijan Narendran (2:41 PM)
- Ok cool, I only need to buy 2 more the by Shadi El-Fares (2:43 PM)
- Just re did the calculation, only need to b... by Shadi El-Fares (2:44 PM)
- Does anyone have Last chemistry lab flowchart in good handwriting by Shadi El-Fares (4:20 PM)

March 20th

- Do you still want it by Shajijan Narendran (1:43 PM)
- I didn't read this till now also what time ... by Shajijan Narendran (1:44 PM)
- after the lab no? by Noor Ahmed (1:44 PM)
- yeah we're meeting at lp after lab aren't w by Emilya Hum (2:34 PM)
- I had some of this stuff written down: What if there is a constraint on the obtainable materials due to the load bearing capacity. As in we can't source materials that can actually hold the subject's weight. by Shadi El-Fares (5:43 PM)
- what would the metric be by Shajijan Narendran (8:14 PM)
- is it like young's modulus and the other one by Shajijan Narendran (8:14 PM)
- emilya & i are going to work on the prototy... by Aman Minhas (10:20 PM)
- my food comes at 11:30 by Emilya Hum (10:35 PM)
- I can work on it now by Emilya Hum (10:35 PM)
- LOOL OKAY OKAY EAT GURLIE DONT WORRY by Aman Minhas (10:35 PM)
- if you're available by Emilya Hum (10:35 PM)
- Wait by Aman Minhas (10:35 PM)
- i don't wanna work on it now by Aman Minhas (10:35 PM)
- i'm in tutoring by Aman Minhas (10:35 PM)
- kinda by Aman Minhas (10:35 PM)
- ohhh okie by Emilya Hum (10:35 PM)
- I'll just bring the food w me by Emilya Hum (10:35 PM)
- anyways, we can do after you eat if that wo... by Aman Minhas (10:35 PM)
- but idk if the rest of our group is awake tbh by Aman Minhas (10:36 PM)
- when is your tutoring done by Emilya Hum (10:36 PM)
- 11:00 by Aman Minhas (10:37 PM)
- ok ok is everyone joining the meet or just ... by Emilya Hum (10:39 PM)
- no no it's a group effort by Aman Minhas (10:39 PM)
- group consensus by Aman Minhas (10:39 PM)
- Im awake i can join by Noor Ahmed (10:40 PM)
- i think it makes sense for us to grind it o... by Aman Minhas (10:40 PM)
- ok by Noor Ahmed (10:40 PM)
- we'll see thougy by Aman Minhas (10:40 PM)
- Shajijan Narendran and Shadi El-Fares ar... by Emilya Hum (10:41 PM)

Appendix D: Sources Material Database

[1] ”Wheelchair Market Size, Share & Trends Analysis Report,” Grand View Research, 2021. [Online]. Available: https://www.grandviewresearch.com/industry-analysis/wheelchairmarket#:~:text=The%20global%20wheelchair%20market%20size,and%20operations%20in%20different%20regions. [Accessed March. 3, 2024]

[2] “Different Types of Wheelchairs,” Redman. [Online]. Available: https://www.redmanpowerchair.com/different-types-of-wheelchairs/. [Accessed March. 3, 2024]

[3] “Types of Wheelchairs, “ United Spinal Association. [Online]. Available: https://www.spinalcord.org/disability-products-services/types-of-wheelchairs/. [Accessed March. 3, 2024]

[4] “Wheelchair Winter Tyres,” invictus active. [Online]. Available: https://www.invictusactive.com/wheelchair-winter-tyres/#:~:text=These%20wheelchair%20winter%20tyres%20have%20enlarged%20outer%20lugs%20that%20increase,puncture%20protection%20called%20K%20guard. [Accessed March. 3, 2024]

[5] “The Best Reacher Grabber Tools of 2024,” Reviewed USA Today. [Online]. Available: https://reviewed.usatoday.com/lifestyle/best-right-now/the-best-reacher-grabbers. [Accessed March. 3, 2024]

[6] “P4- Project Module”, class notes for 1P13, pg. 1-30, Engineering, McMaster University, Winter Term, 2024.

[7] “Snow Tires Vs. Chains: Here’s All You Need To Know,” GT Radial. [Online]. Available: https://www.gtradial-us.com/blog/snow-tires-vs-chains-heres-all-you-need-to-know/#:~:text=They%20provide%20increased%20traction,are%20a%20one%2Dtime%20purchase. [Accessed April 9, 2024]

[8] “Using the GRIT Freedom Chair in the Snow,” GRIT. [Online]. Available: https://www.gogrit.us/snow-wheelchair. [Accessed April 9, 2024]

[9] “retyre Traction Wheelchair Tire Covers for Snow & Rain | Wheelchair Accessories,” MyMobilityStore. [Online]. Available: https://mymobilitystore.com/. [Accessed April 9, 2024]

[10] “FOLD + GO Snow Cleats,” FOLD&GO Electric Wheelchairs. [Online]. Available: https://www.foldandgowheelchairs.com/travel-friendly/fngo-snow-cleats/. [Accessed April 9, 2024]

[11] Autodesk® Inventor 2024 LT™ software, Autodesk, Inc, 2023 (www.autodesk.com).

[12] Ansys GRANTA EduPack software, ANSYS, Inc., Cambridge, UK, 2023

(www.ansys.com/materials)

[13] “Spina Bifida,” National Institute of Neurological Disorders and Stroke, 2024. https://www.ninds.nih.gov/health-information/disorders/spina-bifida (accessed Feb. 26, 2024).

[14] “Does Body Metal Cause Pain in Cold Weather?,” Direct Orthopedic Care, 2019.

https://www.directorthocare.com/does-body-metal-cause-pain-in-cold-weather/ (accessed Feb. 26, 2024).

[15] A. Pulrang, “Why Is Accessibility Still A Problem? What Can We Do About It?,” Forbes, Oct. 12, 2022. Accessed: Feb. 26, 2024. [Online]. Available: https://www.forbes.com/sites/andrewpulrang/2019/11/21/why-is-accessibility-still-a-problem-what-can-we-do-about-it/?sh=7920b727f23a

[16] Quantum Rehab, “Edge® 3 Wheelchair Base | Quantum Rehab® :: Electric Wheelchairs,” Quantum - The Rehab Power Chair Solutions Company, 2024. https://www.quantumrehab.com/quantum-power-bases/edge-3.asp (accessed Mar. 03, 2024).

[17] J. Ripat et al., “Winter Mobility and Community Participation Among People Who Use Mobility Devices: A Scoping Review,” Archives of Rehabilitation Research and Clinical Translation, vol. 2, no. 1, pp. 100018–100018, Mar. 2020, doi: https://doi.org/10.1016/j.arrct.2019.100018.

[18] J. Albright. *“Systems and Methods for Providing Information Pertaining to Physical Infrastructure of a Building or Property,”* US 20130205257A, Apr 25, 2017, https://patents.google.com/patent/US20130205257A1/en, Accessed Feb 26, 2024. [Online]

[19] J. E. Beard et al. “*Full Access Wheelchair,”* US 5601302A, Sep 21, 1995, https://patents.google.com/patent/US5601302A/en, Accessed Feb 26, 2024. [Online]

[20] D.E. Tedesco et al. *“Methods for remote assistance of disabled persons having at least two remote individuals which receive different indications,”* US 9202360B1, Feb 11, 2014, https://patents.google.com/patent/US9202360B1/en, Accessed Feb 26, 2024. [Online

Appendix E: Design Studio Worksheets

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ENGINEER 1P13 – Project Four: *Power in Community*

-ENGINEER 1P13: PROJECT FOUR WORKSHEETS (TEAM)

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ENGINEER 1P13 – Project Four: *Power in Community*

Table of Contents

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ENGINEER 1P13 – Project Four: *Power in Community*

PROJECT FOUR MILESTONE ZERO: TEAM DEVELOPMENT AND PROJECT PLANNING

MILESTONE 0 – COVER PAGE

Team ID: Fri-43

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

Full Name:	MacID:
Aman Minhas	minhaa18
Noor Ahmed	ahmem125
Emilya Hum	hume3
Shajijan Narendran	narends
Shadi El-Fares	elfaress

`

Insert your Team Portrait in the dialog box below.

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ENGINEER 1P13 – Project Four: *Power in Community*

MILESTONE 0 – TEAM CHARTER

Team ID: Fri-43

Incoming Personnel Administrative Portfolio:

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

	Team Member Name:	Project Leads
1.	Emilya Hum	☐ M ☒ A ☒ C ☐ S
2.	Noor Ahmed	☒ M ☒ A ☐C ☒ S
3.	Aman Minhas	☒ M ☒ A ☒ C ☐ S
4.	Shajijan Narendran	☒ M ☒ A ☒ C ☐ S
5.	Shadi El-Fares	☒ 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	Emilya Hum	hume3
Administrator	Aman Minhas	minhaa18
Coordinator	Noor Ahmed	ahmem125
Subject Matter Expert	Shajijan Narendran	narends
Subject Matter Expert	Shadi El-Fares	elfaress

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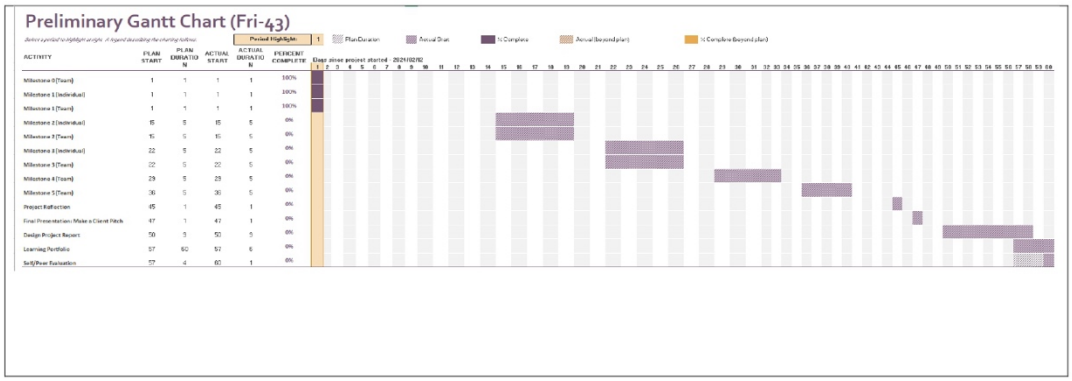
ENGINEER 1P13 – Project Four: *Power in Community*

MILESTONE 0 – PRELIMINARY GANTT CHART (TEAM MANAGER ONLY)

Team ID: Fri-43

Full Name of Team Manager:	MacID:
Emilya Hum	hume3

Preliminary Gantt chart



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ENGINEER 1P13 – Project Four: *Power in Community*

MILESTONE 0 – PREVIOUS PROJECT EXPERIENCE

Team ID: Fri-43

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**
Emilya Hum	- Java, Python, Turing - Inventor, AutoCAD, Revit - P2 Computation team - P3 Modelling team
Noor Ahmed	- Modelling team for P2 - Computing team for P3 - Experience in Python and AutoCAD

Aman Minhas	- P3 Modeling Team
	  ○ Autodesk Inventor
	- P2 Computing Team
	  ○ Python

Shajijan Narendran	- Java, Python - Inventor, Solidworks
Shadi El-Fares	- Python, Various Web Development Frameworks (JS, HTML, CSS) - Inventor, AutoCAD - ROS2, C++

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ENGINEER 1P13 – Project Four: *Power in Community*

PROJECT FOUR MILESTONE ONE: PROBLEM FRAMING AND TEST PLAN

MILESTONE 1 – COVER PAGE

Team ID: Fri-43

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

Full Name:	MacID:
Shadi El-Fares	elfaress
Noor Ahmed	ahmem125
Emilya Hum	hume3
Shajijan Narendran	narends
Aman Minhas	Minhaa18

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ENGINEER 1P13 – Project Four: *Power in Community*

MILESTONE 1.2 – PROBLEM FRAMING

Team ID: Fri-43

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)

To aid Tiffany in her day-to-day task while feeling as comfortable as possible, without restricting her capabilities.

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ENGINEER 1P13 – Project Four: *Power in Community*

MILESTONE 1.3 – TESTING PLAN DEVELOPMENT

Team ID: Fri-43

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. Durability	Withstand excessive weight and unforeseen weather conditions.
2. Portable	Should be able to travel with ease without disrupting others.
3. Longevity	Should last for years on end without requiring replacement / fractures while working perfectly.
4. Battery Life	Should last approximately 8 hours on a full charge, to assist over a full-working day.
5. Accessible and Safe	Allows for convenient daily use without putting health or comfort at risk
Constraint	Rationale
1. Weight	Design must not exceed 10 lbs.

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:	Durable
Unit/Metric:	Run various stimulations in Inventor.

Objective:	Portable
Unit/Metric:	Is not difficult to travel with.

Objective:	Longevity
Unit/Metric:	Years

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Objective:	Battery Life
Unit/Metric:	Time the battery lasts in minutes

Objective:	Accessible and Safe
Unit/Metric:	Should not hurt others around her, or herself.

Constraint:	Weight
Unit/Metric:	Pounds

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"

mive	Testing Method
1. Durable	We need to test the max carrying capacity of the arm.
2. Portable	Have someone in a rolling-chair carry the arm and receive input on how comfortable they are. This will mimic Tiffany's response.
3. Longevity	We can test if any structural fractures happen over the testing period.
4. Battery Life	Have the motors run repeatedly over a span of 8-hours.
5. Accessible and Safe	Ensure sharp edge safety for others through testing the interaction with materials and pressure tests.
Constraint	
1. Weight	Have Tiffany hold the arm and ask her if it is too heavy for her.

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ENGINEER 1P13 – Project Four: *Power in Community*

MILESTONE 1.4 – REFINED PROBLEM STATEMENT

Team ID: Fri-43

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? – Tiffany
- Where? – Everyday and workplace
- Why? – alternatives not safe for public (sharp) and not portable friendly
- What? – aid her arm mobility

Refined Problem Statement:

Tiffany's limited arm mobility, in addition to factors such as accidentally bumping into pedestrians, adverse weather conditions, and the necessity for portability, presents a multifaceted challenge in creating an effective solution to enhance her day-to-day life.

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ENGINEER 1P13 – Project Four: *Power in Community*

MILESTONE 1.5 – DESIGN EXPLORATION PREPARATION

Team ID: Fri-43

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
Shadi El-Fares	Motor Control
Noor Ahmed	Existing Solutions
Emilya Hum	Materials
Aman Minhas	Client Overview
Shajijan Narendran	Patents

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ENGINEER 1P13 – Project Four: *Power in Community*

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

MILESTONE 2 – COVER PAGE

Team ID: Fri-43

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

Full Name:	MacID:
Emilya Hum	hume3
Shadi El-Fares	elfaress
Noor Ahmed	ahmem125
Shajijan Narendran	narends
Aman Minhas	minhaa18

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ENGINEER 1P13 – Project Four: *Power in Community*

MILESTONE 2.3 – FUNCTIONAL ANALYSIS

Team ID: Fri-43

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

- Initial design included motors, and Arduino motor circuits to control expandable and retractable functionality or arm. The change to the newer design does not include motors as it can be done, in a simpler manner. Reducing the complexity of the design as well as increasing user accessibility.

Major Design Change:

- Instead of an expendable / retractable arm the team has moved towards an add-on to the tires that will prevent the snow that surrounds the tires. The new design will essentially be military-style treads that push snow back and allow for snow clearance while driving.

Updated Refined Problem Statement:

- Tiffany's condition, Spina Bifida, which requires her to rely on a wheelchair faces significant adversity due to snow and salt placed on the roads wearing down the tires presents a multifaceted challenge in creating an effective solution to enhance her outdoors mobility.

Individual Research Assignment:

- Client Overview: Researching into Spina Bifida and the obstacles it creates for Tiffany.
  - Movement in the winter months, especially in Canada, becomes a great obstacle. Due to limited traction between wheels and snow or ice, Tiffany finds challenges with transportation within those months.
  - To improve her independence, ensuring her wheelchair is safe and reliable no matter the road conditions is important.
- Motor Control: Researching how the retractable / expandable portions of the arm would work.
  - Controlling multiple motors with Arduino would allow for precise coordination in the expand / retract functions. This would also help in automation, providing benefits like complex movements and increased load capacity, achieved through motor selection, drivers, power supply, and programming for optimal operation.
  - .
- Existing Solutions: An analysis of the pre-existing products that may serve as potential solutions to challenges faced by Tiffany.
  - Several products exist to help improve the mobility and accessibility of individuals who use wheelchairs.
  - Some wheelchairs are crafted in a unique way that allows them to handle any terrain. Winter Tires also exist for wheelchairs. A wheelchair model exists that has a tracking device and navigation device embedded within. Several Reacher grabber devices exist, some employ magnets, suction cups or hooks, and claws.

- While several Reacher Grabber Devices exist, no such product has yet been devised to act as a winter add-on to wheelchair tires.

- Patents: Researching existing patents that might prevent us from creating designs/concepts with too much overlap
  - Examples include mechanisms that adjust the height of the wheelchair to improve the user's accessibility, software programs that display info about a location's accessibility, and dynamic communication methods between users and their caregivers
  - Potential solutions/designs need to be distinct from the patents by incorporating several elements
- Materials: Research which materials are best for a portable gripper so that is it durable and lightweight
  - Analysis of Granta EduPack charts and data suggests that there are various materials that are lightweight and durable. The materials that appeared to be more ideal included cast iron (ductile (nodular), steel (medium carbon, high carbon, and low alloy), aluminium alloys, bamboo and wood. Aluminium alloys are the best material for a portable gripper because it is durable while not being too heavy or expensive when compared to its alternatives.

Updated Objectives & Constraints:

- Constraint: Cost
- Durability: Ability to stay strong under extra weight
- Portability: Retractable design that allows for storage during off season
- Longevity: Withstand harsh weather such as slush, snow, ice, rain, hail, etc.
- Grip: Ensure traction of add-on is sufficient for snow ploughing

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

Function	Means					
Push Snow Back	Perpendicular edges sticking out of each linkage to push back snow on each	Utilize material with greater use of friction to reduce salt size on impact.	Chain the wheels to increase contact with ground.	Rotating blades/paddles		
Reduce the Sticking of Salt to Tread	Rounded Corners of each linkage to reduce opening for salt to be stuck.	Cut out portions that reduce the space of where salt may get cut.	Heated belt	Frictionless material		
Smooth Driving Sensation	Adjacent Corners to linkages to reduce drop per rotation.	Rounded edges on the "stuck-out" portion to soften the impact to ground.	Tire studs & chains for snow	Flexible Material		

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ENGINEER 1P13 – Project Four: *Power in Community*

MILESTONE 2.5 – DESIGN REVIEW

Team ID: Fri-43

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
• How will this be installed and maintained?
• Conveyor belt style seems a bit challenging.
• Understand the function/purpose of each wheel.
  ○ Do some stay stationary and solely translational while others have rotational features.
  ▪ Which wheels **NEED** the traction belt around them? Can some wheel's not have them while serving the overall purpose.
• Do some research into the material of the add-on.
  ○ Rubber and Rubber → too high of a friction against each other causing little to no movement.
  ○ Consider maintenance, flexibility, and overall cost.
• Compare strength and maintenance, weigh the importance of both factors.
  ○ Have a strong product while having weaker maintenance.
  ○ Have an easily maintained product while having a weaker overall product

Include feedback from science students in this row. (if applicable)
• *Easy maintenance and repair*
  ○ *Review costs, accessibility of replacements, and maintenance procedures*
• *Tiffany mentioned a previous incident where she was alone, and her belt snapped.*
  ○ *To combat, our team's design must be easy to repair and avoid dependance on other.*

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ENGINEER 1P13 – Project Four: *Power in Community*

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

MILESTONE 3 – COVER PAGE

Team ID: Fri-43

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

Full Name:	MacID:
Shadi El-Fares	elfaress
Aman Minhas	minhaa18
Emilya Hum	hume3
Noor Ahmed	ahmem125
Shajijan Narendran	narends

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MILESTONE 3.2 – DECISION MAKING

Team ID: Fri-43

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.

		Prototypes									
		Big Circle Design with popsicle sticks for traction		Circle with twine and triangular sponges attached along circumference		Trapezoidal treads with connective tubing		Rounded edge tire treads		Cylindrical Wheel with Treads	
Criteria	**Weighting**	**Score**	**Total**	**Score**	**Total**	**Score**	**Total**	**Score**	**Total**	**Score**	**Total**
Ice and snow traction	5	2	10	3	15	4	20	4	20	4	20
Push back snow	2	2	4	4	8	3	6	5	10	3	6
Durable/Strong	4	4	16	3	12	4	16	3	12	4	16
Reduce the Sticking of Salt to Tread	3	4	12	2	6	3	9	3	9	4	12
Latches onto wheel	5	4	20	2	10	4	20	4	20	2	10
Smooth Driving Sensation	3	4	12	2	6	3	9	4	12	3	9
Total			**74**		**57**		**80**		**83**		**73**

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Team ID: Fri-43

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:	Trapezoidal treads with connective tubing
Concept 2:	Rounded edge tire treads

Include your team's justification below.
The final team consensus was justified through decision matrix above.

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MILESTONE 3.3 – REFINED PROJECT TIMELINE

Team ID: Fri-43

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:
Complete prototyping phase – Find circular object to fit AROUND prototype	3 Hours	Monday, March 11 2024	Emilya & Aman
Design Phase: Transfer prototype to CAD – visualize, sizing, etc.	3 Hours	Wednesday, March 13 2024	Emilya
Material Phase: Determine Material (Purchasing, cost, allocation)	1 Hour	Tuesday, March 12 2024	Aman, Emilya, Noor, Shadi, Shajijan
Fabrication Phase	TBD	Sunday, March 24 2024	Aman, Emilya, Noor, Shadi, Shajijan
Testing Period	4.5 Hours	Friday, March 29 2024	Aman, Emilya, Noor, Shadi, Shajijan
Presentation Prep	3 Hours	Saturday, March 30 2024	Aman, Emilya, Noor, Shadi, Shajijan

Include an updated image of your Gantt chart:

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PROJECT FOUR MILESTONE FOUR: REFINED PROTOTYPING AND TESTING PLAN

MILESTONE 4 – COVER PAGE

Team ID: Fri-43

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

Full Name:	MacID:
Aman Minhas	minhaa18
Emilya Hum	hume3
Noor Ahmed	ahmem125
Shadi El-Fares	elfaress
Shajijan Narendran	narends

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MILESTONE 4.1 – REFINED PROTOTYPE

Team ID: Fri-43

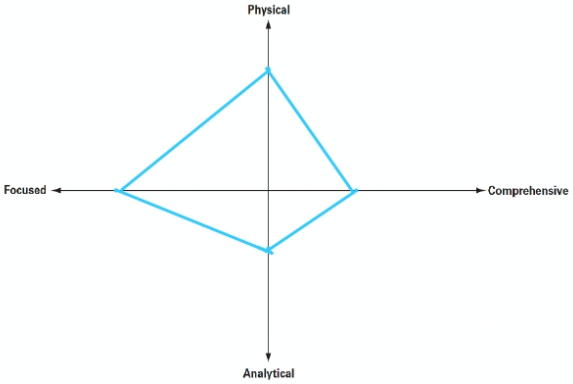
1. Create an outline for the creation of your refined prototype using the following worksheet.

Team ID: Fri-43	MacID: ahmem125, hume3, minhaa18, elfaress, narends

Write a short description of your refined prototype below.
Name: WinTire

Circular tire add on, made with paper, cardboard, sponge and popsicle sticks. Indents in circular frame of add on made with paper act as features to enhance traction. Sponge cutouts replicate tire treads that aim to improve add on grip for various terrains. Cardboard and popsicle to help reinforce add on shape and increase strength allowing for more load.

Indicate where your prototype falls on the scale below.



Kind of Prototype:
☐ Physical or ☐ Analytical
☐ Focused or ☐ Comprehensive

Purpose of Prototype:
To provide a general physical model of the design that helps envision the important aspects of the final product as well as an aid to determine areas of improvement and potential features that may enhance the design and function.

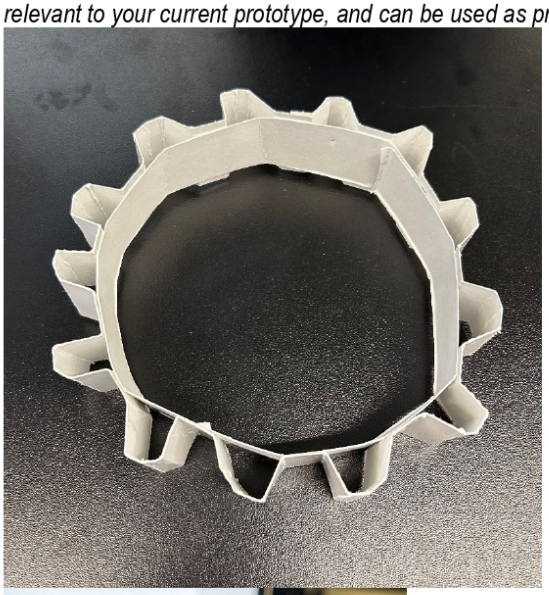
Level of Fidelity:
Medium Level

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

Objectives	Metrics
☐ **Flexibility**	☐ **Weight**
☐ **Durability**	☐ **Cost**
☐ **Portability**	☐ **Angular Velocity**
☐ **Grip**	

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)
   → **Do not include more than *two* pictures per page**

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



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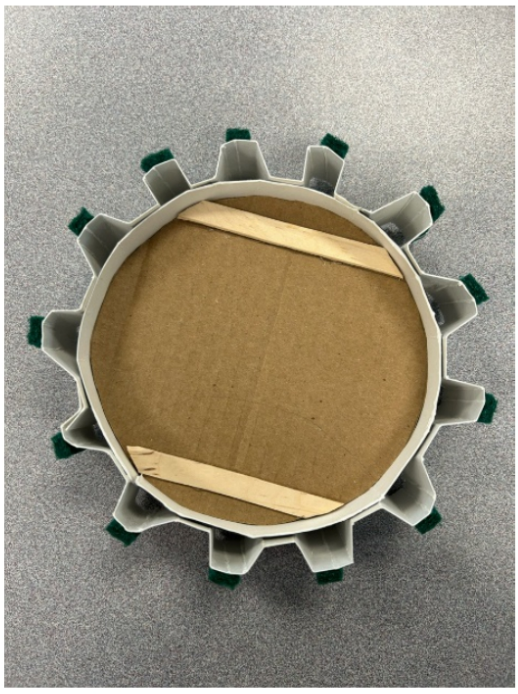
*Limit screenshots to no more than 2 per page. For additional screenshots, please copy and paste the above on a new page.

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.

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Team ID: Fri-43

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).***

The design concept was refined by incorporating elements of initial protypes, feedback, and evolving ideas. Ice and snow traction is a key function, for our design concept to emanate this function, the rough parts of a sponge were attached to the tire treads. This improves the add-on's ice and snow traction, which helps the prototype achieve the highly important objective: Grip. The indents in the circular frame of the add-on, play a dual role as they act as treads and a feature responsible for the vital objective of flexibility. These indents have a certain level of flexibility which helps absorb impact and handle uneven road surfaces providing a smooth drive. To align with the objective of durability, popsicle sticks acted as support structures near the inner area of the circular frame, which helped maintain shape and handle load without deformation. The flexibility in the circular frame increased durability as it helped dissipate the force experienced by the tire while preventing the risk of add-on snapping. TA feedback regarding attachment was addressed with paper clip features incorporated as attachment mechanisms allowing for the add-on to attach securely to the tire through both its lug and hub.

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MILESTONE 4.2 – PROTOTYPING TEST PLAN REFINEMENT

Team ID: Fri-43

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).*

Test Plan 1

The tire add-on will move tested in numerous conditions, e.g. on grass, concrete, and most importantly in the snow. Testing the prototype in various conditions will create a conducive production environment to satisfy Tiffany's demands.

Test Plan 2

The tire add-on will be tested for durability through applying increments of weight, through wooden blocks or other standardized material weighing 15g. This will test the maximum viable weight the add-on can withstand with fracturing, further concluding if extra support joints or fine-tuning is needed.

*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).*

Several winter tire manufacturers test traction, grip, and brake handling on artificially simulated tracks at slow speeds [1]. The conditions on these tracks vary greatly, from wet to icy to snowy. To simulate snowy conditions, the prototype will be manually rolled through a track consisting of crumpled paper. Metrics to be recorded include the time it takes, in seconds, for the wheel to come to a stop after rolling at a constant speed. Another important metric would be the weight of the snow displaced in grams. Since paper has both a different density and material properties to that of snow, approximations will have to be made to determine the effectiveness of the treads. Qualitative observations would be the degree of smoothness at which the prototype moves as well as how easily it is able to attach to the wheel.

References:

[1] "Products," Testing winter tires, https://www.continental-tires.com/products/b2c/tire-knowledge/testing-winter-tires/ (accessed Mar. 11, 2024).

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Team ID: Fri-43

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

Team Member's Full Name:	Contribution:
Aman Minhas	Refined Prototype, Test Plan 2, Final Product
Shadi El-Fares	Test Plan 1, Final Product
Emilya Hum	Prototype, Refined Prototype
Shajijan Narendran	Reference, Future Testing Plan
Noor Ahmed	Name, Refined concept summary (200 words)

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MILESTONE 4.3 – DESIGN REVIEW

Team ID: Fri-43

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

Include feedback from science students in this row. - Asked whether the tire add on is equipped for use during various weather conditions, such as snow. - Our answer was to ensure to use a weather resistant material coated over the body of the add on allowing for use and function for various weather conditions.
Include feedback from your faculty mentor, staff, or assigned TA/IAI in this row - *Were curious as to how the add-on will attach to the actual wheel.* - *Concerned that final L shape rod may not be safe for all terrains including floors* - *Try to make the final design the right size according to the actual wheelchair tire and complete it, we may also use a* - *Ensure the material you use for the add-on is ice, water, and salt-resistant* - *Try to make the add-on cleanable* - *Do your research to determine the material choice, and have research to back up any design choices.* - *However, it is not necessary to coat the final design as long as research is done to back up the planned/anticipated design and material decisions.*

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

MILESTONE 5 – COVER PAGE

Team ID: Fri-43

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

Full Name:	MacID:
Aman Minhas	minhaa18
Shadi El-Fares	elfaress
Noor Ahmed	ahmem125
Shajijan Narendran	narends

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MILESTONE 5.1 - FINAL EVALUATION OF THE OBJECTIVES AND CONSTRAINTS

Team ID: Fri-43

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:

Durability	Pounds
Speed/Efficiency	Angular Velocity
Snow removed per rotation	Grams

State your Qualitative Objectives and their Metrics below:

Longevity	Visual scuffing or inefficiency of add-on after a cycle of use
Grip	Ability to stay on track of path – no slipping on ice
Portability	Ease of taking on and off

State your Constraints and their Metrics below:

Cost	Dollars (CAD)
Mass (of tire on)	Kilograms

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

*Insert your **Present Testing Plan** (how you will test your prototype).*
State and justify any changes you made from last week. *For the Quantitative objective of durability: Instead of 15 g blocks, we decided to use 1 kg rice bags. This decision was made as the add-on now has a wooden frame within the inner frame intending to mimic the presence of a wheel, allowing for us to test greater loads on it.*

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MILESTONE 5.2 – TESTING PLAN EXECUTION AND DISCUSSION

Team ID: Fri-43

Execute your testing plan for your Quantitative Objectives:

State and discuss the results of your testing plan in this box.
Durability: The prototype could hold 7kg (7 bags of rice) without breaking or experiencing permanent deformation.

Snow Moved per rotation: Upon testing on snowy surfaces, it was observed that the L-shaped features of the add were consistently pushing back roughly 1-3 grams of snow in its path.

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Execute your testing plan for your Qualitative Objectives:

State and discuss the results of your testing plan in this box.
Longevity: Upon testing on concrete floor, gravel pavement, grass, salt, and snow the prototype did not undergo any visible scuffing or experience any notable inefficiency in its intended function.

Execute your testing plan for your Constraints:

State and discuss the results of your testing plan in this box.
Cost: Ensuring to stay within an overall budget of below $100 CAD, adjustments were made through sourcing materials that were able to efficiently perform their functions while staying within the frame. The following image showcases the original rubber material which would've increased the overall cost of the prototype in comparison to the cost of the L shaped metal rods, costing less than half of the previous material.

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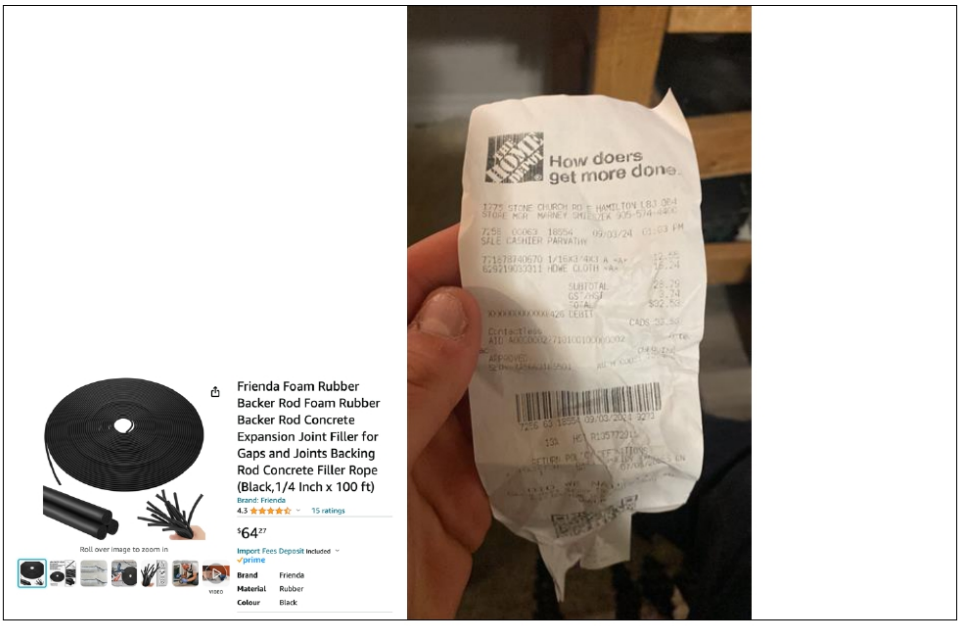

As a team, discuss the results of your testing plan. How did your design do? Did it meet all expectations you had from your design? Did you go through any iteration based on the execution and the results if your test plan? How did the test plan influence your iterative process? Remember, focus on the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

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

- Testing plan was a clear indicator of great durability and strength for material of the wired frame.
  - → Weight test showed no fracture, permanent structural damage, and snow test showed no rusting.
- Structural components of design need to be heavily redesigned as it was unable to hold 1kg with dipping in structure.
  - → Create a component on the wintire which allows for attachment to a wheel through a Velcro-type securement.
  - → With a refined testing plan using a circular tire within the wintire, physical displacement of the tire frame will be prevented.
- Moving Forward:
  - → add a material to cover L shape metal features to prevent damage to surfaces (felt/rough part of dish sponges)
  - → Buy buckles or Velcro strips along with tire replicate to a tire and the attachment of the wintire

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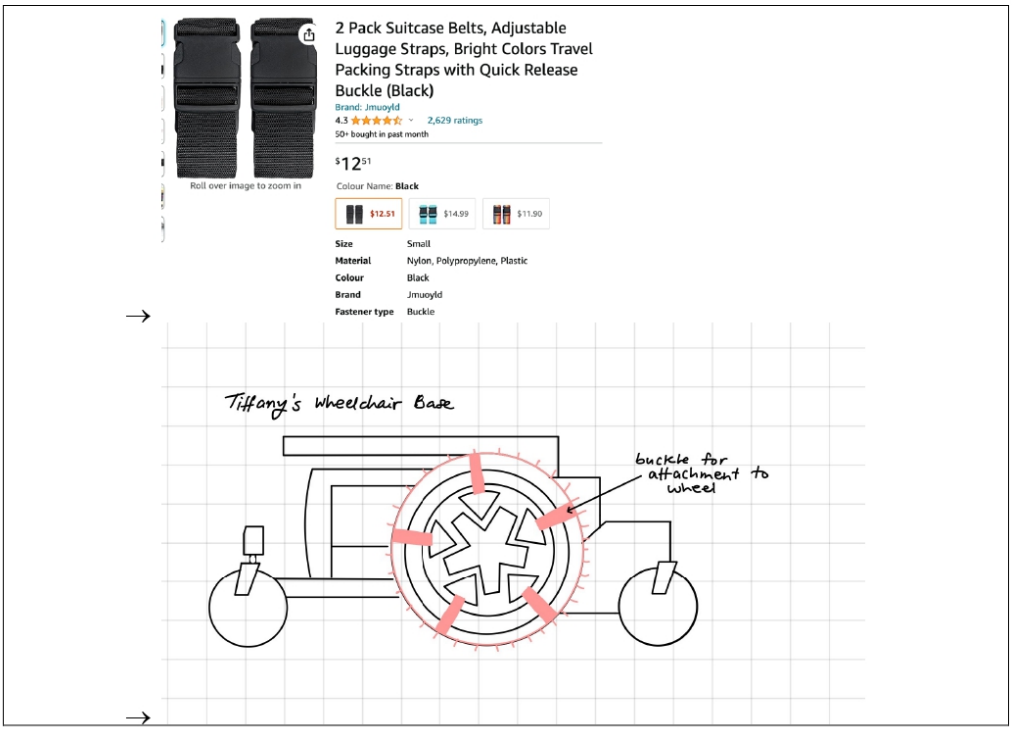

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ENGINEER 1P13:
PROJECT FOUR WORKSHEETS (INDIVIDUAL)

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PROJECT FOUR MILESTONE ONE: PROBLEM FRAMING AND TEST PLAN

MILESTONE 1.1 – CLIENT NOTES

Team ID: Fri-43

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

1. Include your client notes from the introductory client visit

Name: Shajijan Narendran	MacID: narends

- Weather condition affect her mobility.
  - Snow and rain damage her device; can cost millions of dollars to repair.
  - Even road salts can internally corrupt the batteries that power the wheelchair.
- At her job, she is a greeter but she occasionally stocks shelves.
- Battery charger needs outlet, having a portable charger could be useful.
- She has movement from torso up.
- When she opens doors sometimes it damages the wheelchair
- Uses public transportations.
- Temperature affects battery life, cold weather freezes battery.
- Battery life is tracked on her wheelchair.
- She lives in a three-story house.
- Her stove is not torso-level, asks her brother when she wants to cook something for herself.

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

MILESTONE 2.1 – CLIENT NOTES

Team ID: Fri-43

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

Include your client notes from the introductory client visit

Name: Shajijan Narendran	MacID: narends

- Can lift max 20 lbs.
- Has limited mobility in left hand.
- Even exposure to road salts can lead to internal battery corrosion in her wheelchair.
- Her powered wheelchair is an Edge 3 model weighing approximately 250 lbs.
    - Her seat belt is not that strong and sometimes buckles without it she feels like she's going to fall out.
- While her primary role at work is as a greeter, she occasionally engages in shelf stocking duties.
- It is necessary for the battery charger to be connected to an outlet, although a portable charger could prove to be advantageous.
- Difficult to reach battery pack.
- The temperature significantly influences the lifespan of the battery; cold weather conditions can cause the battery to freeze.
- Five batteries on bottom of wheelchair
- 48 hour battery life, 6 month lifespan
- She experiences movement from her torso upwards.
- Opening doors sometimes results in damage to the wheelchair.
- She relies on public transportation for her mobility needs.
- Crosswalk buttons are out of her reach.
- Power outlets are too low.
- Wants to drive.
- The wheelchair includes a feature to track battery life.
- She resides in a three-story house, and her stove is not positioned at torso level, requiring assistance from her brother when cooking for herself.

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MILESTONE 2.2 – RESEARCH ASSIGNMENT

Team ID: Fri-43

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: Shajijan Narendran	MacID: narends

What is your question?

How might some patents already in place conflict/affect our designing process?

What is your answer?

There are some aspects of our ideas that could be deterred by patents currently standing. First and foremost, there is a patent for a mobile app that displays information about the accessibility of any given building or facility [1]. Specifically, this patent restricts our ability to create a system to provide information to Tiffany about the condition of her surroundings. This eliminates the possibility of developing mobile apps or programs in Python that target this specific need. To develop a solution that is beyond the boundaries of this patent, there must be an element that automatically detects Tiffany's position and forewarns about the accessibility of the locations she is near. Since she has only a few locations she cycles between (work, home, grocery store, family's house), there must be some way to save locations that she frequently visits. Furthermore, there is a patent in place for a full-access wheel that adjusts the height of the wheelchair [2]. The patent talks about implementing a feature that allows the user to change the height of the wheelchair depending on the situation and ultimately enhances quality of life. In our design for similar features to improve vertical movement and accessibility, we cannot include something that affects the height of the wheelchair. The primary focus of our design must be the robot arm that attaches to the wheelchair and extends to access objects out of reach, as this would be distinctly separate from the existing patent.

In addition, there are several patents that involve instant communication between a person in a wheelchair and remote assistance. One patent in particular outlines the use of software to dynamically facilitate communications with remote caregivers, depending on the varying situations [3]. These patents present obstacles to our goal of providing efficient communication solutions for

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individuals in wheelchairs seeking remote assistance. Any potential solutions involving communication between the individual and caregivers would have to include a unique element, such as a system to automatically call for help when needed. Additionally, this development would not meet the project goal of making Tiffany's everyday life easier, as this would be something that she would only encounter on occasion. A system involving communication would most likely be between Tiffany and her family or employers, and it must offer something different from the services of her cell phone.

In conclusion, there are many patents that constrict aspects of our design process. Alternatively, elements of the patents could be used in the final design as long as the main focus of the design is not directly taken from the patent. For example, the final system could involve raising and lowering the height of the wheelchair; however, that cannot be the main feature of the system but rather a complimentary aspect toward a larger goal. Existing patents can prove to be both useful and a challenge, depending on the direction the design ends up going, whether it be a software development, a physical part, or a combination of both.

List of sources:

[1] J. Albright. *"Systems and Methods for Providing Information Pertaining to Physical Infrastructure of a Building or Property,"* US 20130205257A, Apr 25, 2017, https://patents.google.com/patent/US20130205257A1/en, Accessed Feb 26, 2024. [Online]

[2] J. E. Beard et al. "*Full Access Wheelchair,"* US 5601302A, Sep 21, 1995, https://patents.google.com/patent/US5601302A/en, Accessed Feb 26, 2024. [Online]

[3] D.E. Tedesco et al. *"Methods for remote assistance of disabled persons having at least two remote individuals which receive different indications,"* US 9202360B1, Feb 11, 2014, https://patents.google.com/patent/US9202360B1/en, Accessed Feb 26, 2024. [Online]

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MILESTONE 2.2 – INITIAL CONCEPT EXPLORATION

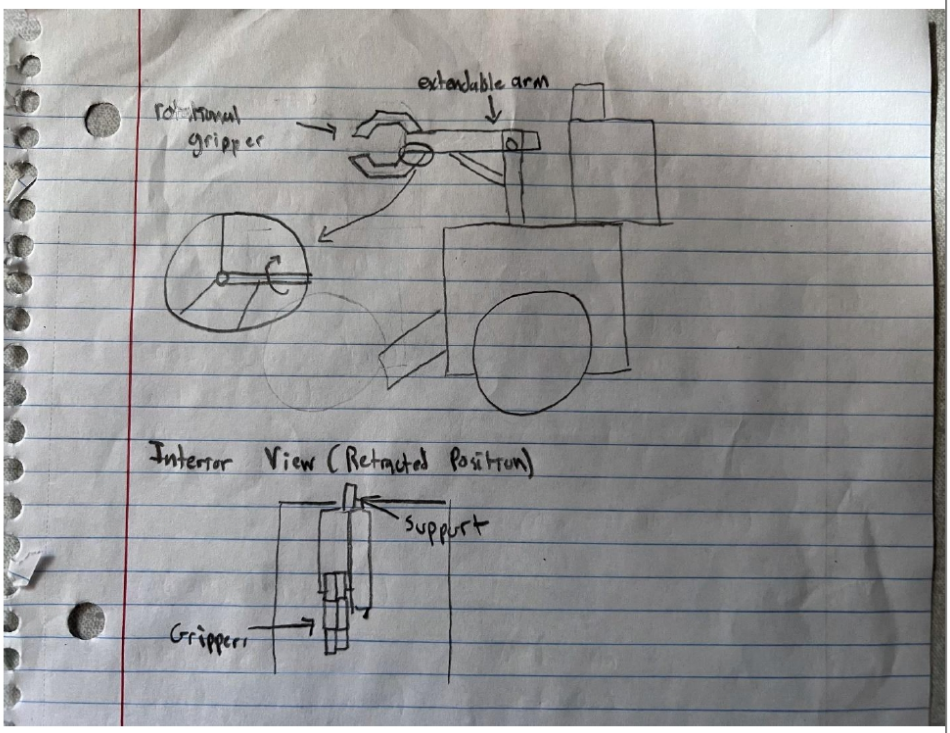
Team ID: Fri-43

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: Shajijan Narendran	MacID: narends

Insert screenshot(s) of your concept below.



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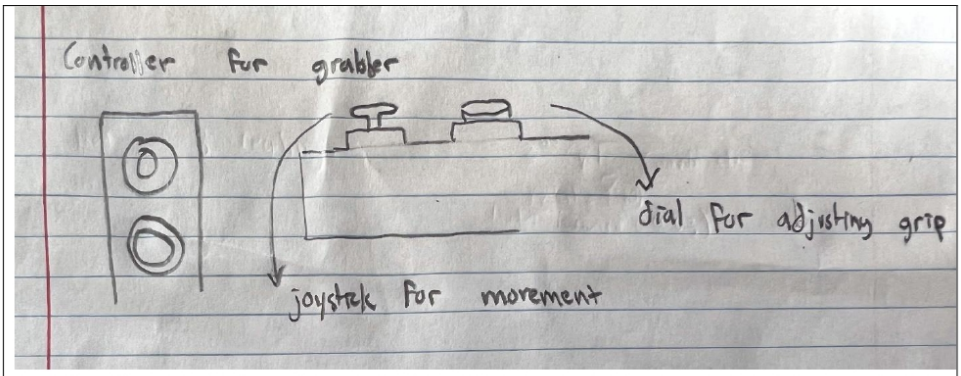

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MILESTONE 2.4 – REFINED CONCEPT EXPLORATION

Team ID: Fri-43

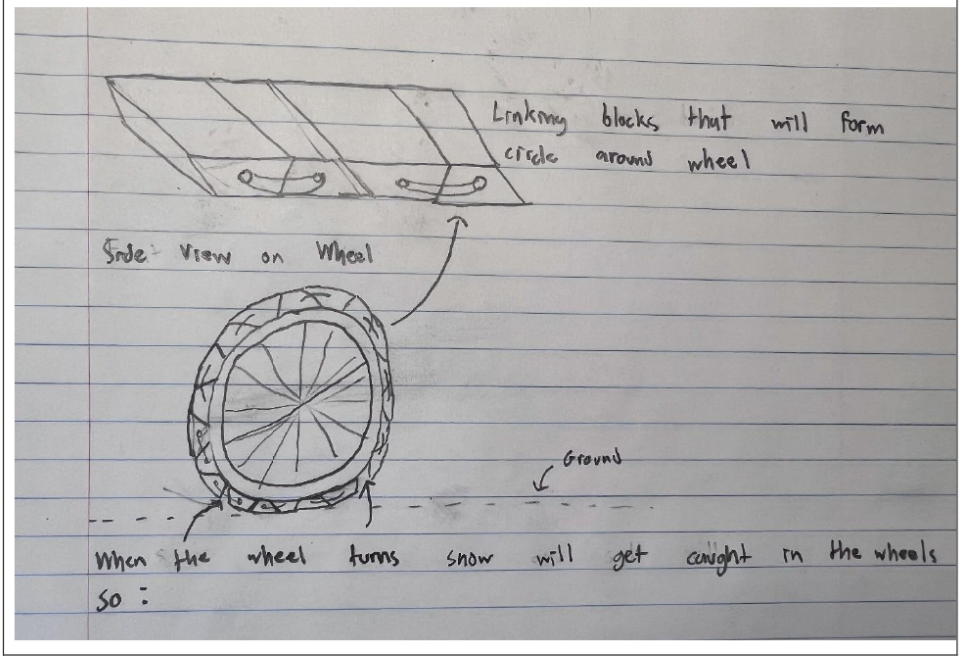
Complete this worksheet during Lab A for Week 7.

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: Shajijan Narendran	MacID: narends

Insert screenshot(s) of your concept below.



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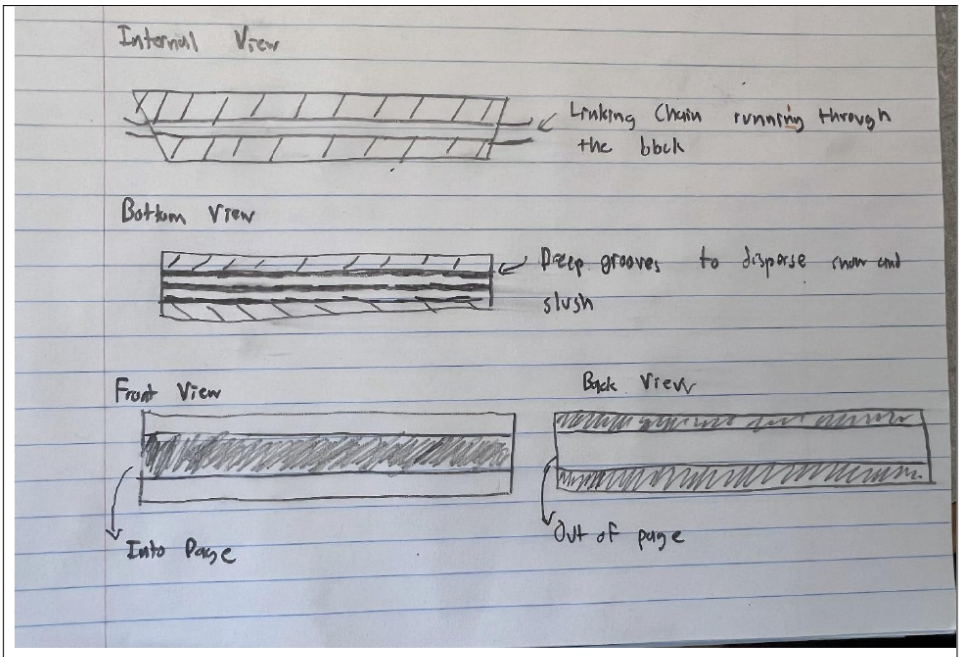

Concept/Means: Chain running through blocks to hold them in place. Blocks come together to form a tread that goes over tires. Grooved wheels to dislodge snow at the bottom and carry snow in-between until it is phased out through the gaps at the end of rotation.

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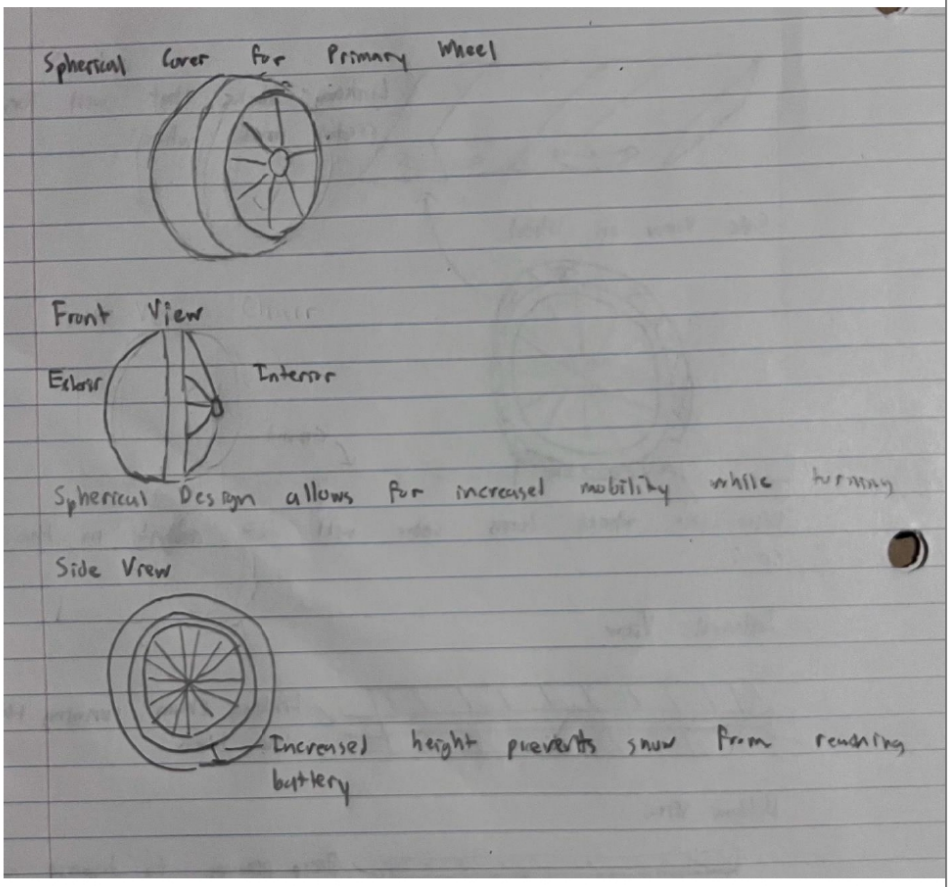
Team ID: Fri-43

Concept 2:

Name: Shajijan Narendran	MacID: narends

Insert screenshot(s) of your concept below.



Concept/Means: Spherical covers to go over top of primary wheels

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

MILESTONE 3.1 – REFINED CONCEPT: INITIAL PROTOTYPE

Team ID: Fri-43

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.).

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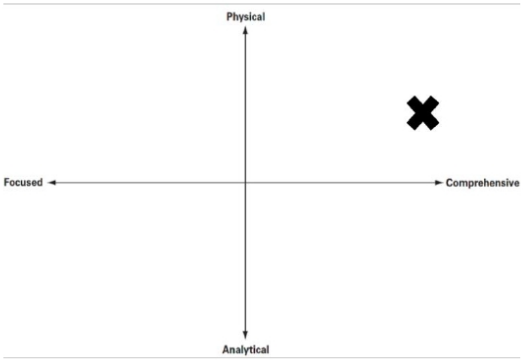
Name: Shajijan Narendran	MacID: narends

Write a short description of your initial prototype below.

Two parts of tread interlinked with tubing to emulate the connection with chains.

Indicate where your prototype falls on the scale below.



Kind of Prototype:

☐ Physical or ☐ Analytical

☐ Focussed or ☐ Comprehensive

Purpose of Prototype:

Demonstrate shape and connective methods between two parts of tread

Level of Fidelity:

Low

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

Objectives	Metrics
• **Flexibility** • **Durable** • **Detachable** • **Smooth Rolling Movements (Wheel Rotations)** •	• **Angular Velocity** • **Weight held in grams.** • •

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

Ensure the trapezoidal shape can support the weight of wheel.

- Run simulation to see the prototype can withstand three times its mass.

Attach wheel, or any circular object to the exterior of the tread, and record observations:

- This includes the smoothness of rotation and whether or not the tread deters the speed of the wheel's angular velocity.

Simulate snow and salt and observe how the prototype deals with it

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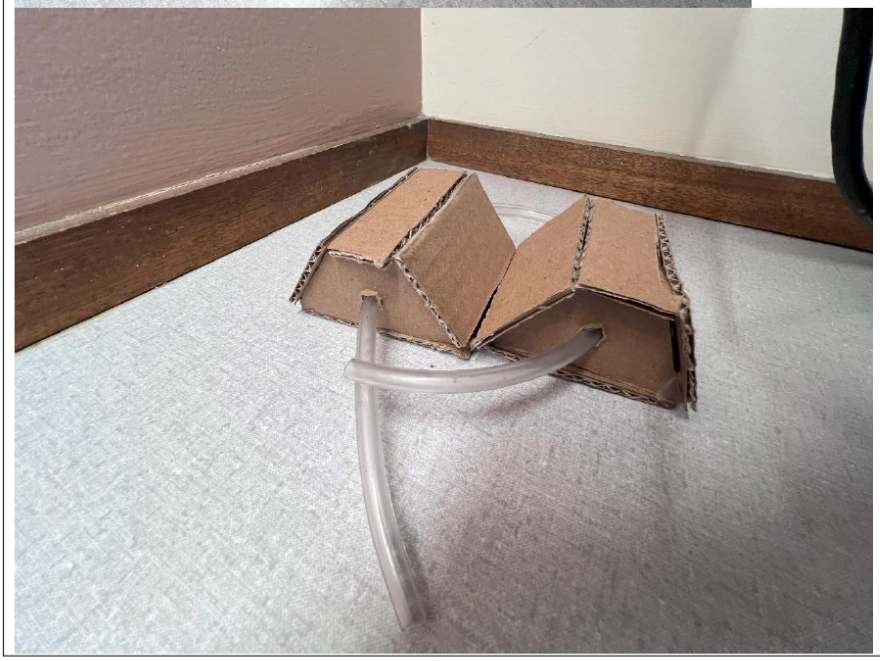
Insert picture(s) of your refined concept (initial prototype) below.



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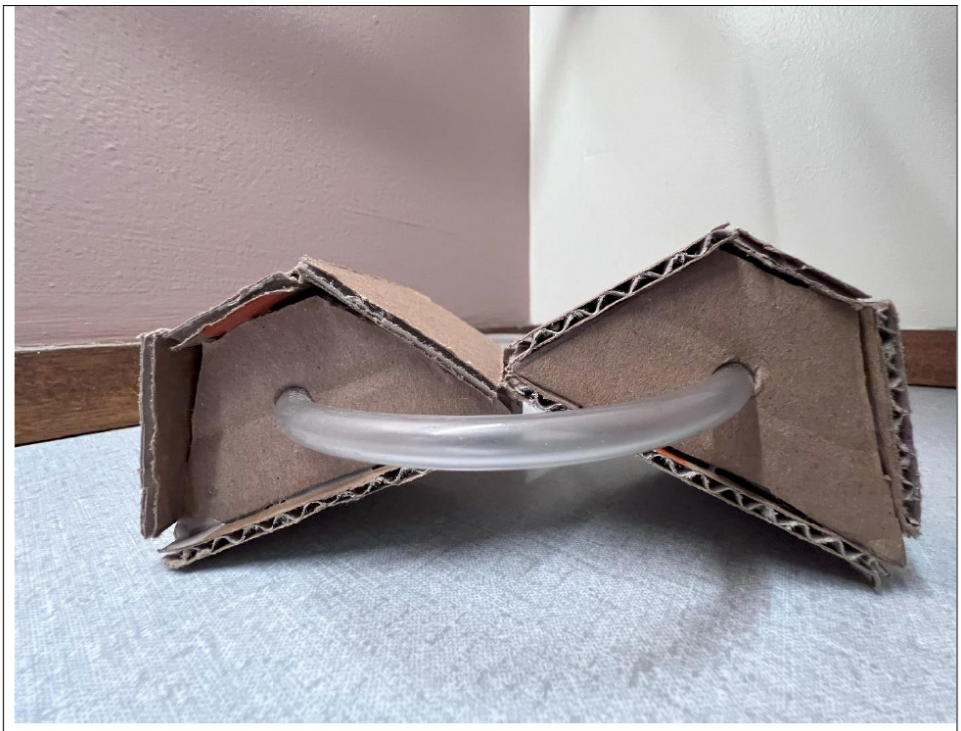

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PROJECT FOUR FINAL DELIVERABLE: PROJECT REFLECTION

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).

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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 part of our final testing plan involved rolling our design through snow and salt and, fortunately for us, it was snowing heavily during our Design Studio time slot which was also the last possible day to test the design. For context, we had created winter tires to help Tiffany deal with the struggles of winter weather like road salt and snow. We ran into a problem however, as during our testing plan, the treads that we designed lost their shape as they rolled. We had created wooden supports, but it did not hold up as well as we had thought; in fact, they broke halfway through the testing phase. Initially, we wanted to use a wheel that was similar in size and shape to the wheels of a wheelchair, but after hours of searching, we could not find one and decided to use the wooden supports instead.

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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:

Around the planning stage of the design process, during the completion of Milestone 3, we decided that we wanted to test durability and how easily the tread could displace snow. When the support broke, we had to decide how we wanted to proceed with our testing plan. We ended up using an incline surface near H.G. Thode Library that was covered in snow to judge the tread's movement downhill. In the end, we found that the design was more than capable of displacing snow.

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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:

By testing our design on the last possible day, I felt as if we limited the value of the testing process. We could not come back another day with a more secure support that actually maintained a circular shape. But at the end of the day, the wheel was not a part of our design; more importantly, the main takeaway was the design's ability to displace snow which it did effectively. Although I was frustrated that our design did not behave like an actual wheel and by the fact we could not test again, there was still value in the information that we gathered.

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

Response

I am not going to dwell on the fact that we could not find a wheel because ultimately, it was not a matter of a lack of effort. Time management is probably an area that we could have planned better, especially if we wanted to test the design multiple times.

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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:

This experience is meaningful because it displays a key aspect of the design process that will be relevant to any kind of engineering project: analysis of information. It would be unresourceful to chalk up every failed test plan to be useless as they will almost always be something to meaningful to takeaway from the experience. In future, I will set aside more time to modify the design in preparation for the testing phase.

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

Response:

Benefits of the plan include a more accurate understanding of the functionality of the design. A downside would be the fact that planning would be more time-consuming and may interfere with other aspects of the project like research.

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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.

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ENGINEER 1P13:
PROJECT FOUR WORKSHEETS (INDIVIDUAL)

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ENGINEER 1P13 – Project Four: *Power in Community*

PROJECT FOUR MILESTONE ONE: PROBLEM FRAMING AND TEST PLAN

MILESTONE 1.1 – CLIENT NOTES

Team ID: Fri-43

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

1. Include your client notes from the introductory client visit

Name: Emilya Hum	MacID: hume3

Client: Tiffany, 33 Condition: Spina Bifida

Job: Greeter but can also stock shelves sometimes Hobbies: Dancing and martial arts

Challenges

- Bus
  - Weather conditions
  - Snow and salt damage her device
- Battery
  - 5 batteries
  - Has to be brought with her everywhere
  - Portable battery might be helpful but there isn't always a wall outlet
  - Battery is uncovered located at the bottom of the chair so prone to damage
  - Is heavy
- Inaccessible doors
  - Video on avenue
- Dancing
  - Was a method of beating isolation
- Finding nurse for catheter

Her Contributions:

- Fixed crosswalk buttons in her area
- Active part of the community
- Got gravel around crosswalk post removed
- Her job installed outlet for short individuals

Society:

- Society doesn't view disabled people as it is
- Lots of stigmatism from society

Mechanism to aid her everyday life

- Grabber
- Back scratcher

Possible ideas

- Seat heater
- Device to protection from weather conditions like rain
- Portable reacher

Q&A

- Do you prefer to try something new or improve current life? Both
- Device to help perform hobbies better? Yes
- Propping doors cause a problem? Yes, damage can cost a lot
- Hidden challenges? Castration, Having to call ahead to see if it is accessible, bathrooms
- Portability of reacher? Can't be brought everywhere, very pointy
- Daily life? HSR lap belts, when parts of his wheelchair break, takes long time to fix
- Going anywhere? Requires lots of planning figuring out transportation
- Battery life of wheelchair? Charger overnight, lasts up to 2 days, always had an extra battery
- Temperature and battery life? Battery needs to be room temp or cold weather could corrupt battery, if too cold have to wait a long time to warm battery up for use
- Battery life indicator? There is something to tell her the charge and can gauge the speed
- Grabber limitations? If object is weirdly shaped it cant really be picked up
- Household? 3 story house, has something to get her up and down the floors
- Cooking? Cooks with her brother, it is a challenge reaching things
- How to charge battery? There is a plug
- Use of technology? Uses Siri often, ipad and laptop can be used without difficulty
- Rain? She ahs to cover herself with a bag or poncho, rain affects the battery and can damage and corrupt
- Salt? Damage to the tires
- Aspirations? Drive, bring awareness that you can dance with dissabilites

Questions

- Challenges at work
- Planes and car rides
- Cost of maintenance

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

MILESTONE 2.1 – CLIENT NOTES

Team ID: Fri-43

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

Include your client notes from the introductory client visit

Name: Emilya Hum	MacID: hume3

Wednesday, February 28, 2024

Screen on console, trouble in weather?, current solutions?

- When screen is smashed whole thing needs to be replaced
- Not waterproof, when it rains a bag is needed to block out the moisture

major problems in the kitchen?

- Height, not being able to reach for things up high
- Turning on the stove and oven

what type of solution does tiffany want?

- Anything we like

does the use of tiffanys phone get in the way of her daily tasks?

- Yes and no, she puts it away so it doesn't get in the way
- Leaves her phone on her footplate but that's not very ideal
- A mount for her phone would be great

are there any routines in your job that you have sometimes have troubles with?

- No

what has been your worst experience going out with your condition

- People stop and stare not knowing the full story
- Stigmatism
- Likes to go by differently abled rather than disability

can you carry more in your left arm than your right arm

- Yes, her right arm is stronger than her left arm due to her condition
- Can you use both arms simultaneously

weight of current gripper?

- One pound or less, very lightweight

current storange on the chair?

- Don't have much, majority of her objects go on her footplate
- Since there are holes on the footplate, the objects fall off sometimes
- Somewhere safe to store them would be nice

how do you store larger things?

- She has a backpack
- Hard to reach for things, so she needs to ask someone to help her to get her stuff so they don't slip

what is the current name or the model of the gripper?

- Unsure, she has two grippers and uses whichever is closer
- She uses her gripper to grab everyday items like her sweaters
- Asks her nurse and PSW for help a lot of the time

weaker in left arm

- Does not have full flexibility in left hand
- Uses stress balls to help strengthen the muscles in her hand

troubles with opening doors?

- For pull doors, she finds that it is a challenge to open
- She uses a dog chew toy around the doorknob to make it easier to reach for the door

wheelchair battery

- Doesn't know the make of the battery
- If the battery can't be charged, you are screwed
- She thinks a portable batter or charger would be really helpful
- If her chair is dying, she calls her family for help
- The five batteries that she needs for the chair get charged all at once

do you use laptops often?

- She uses her phone more often
- She doesn't know what laptop model she has

mobility of arms

- Can move them freely, just gripping in left hand is very weak

what type of items do you carry in your everyday life other than wallet and keys and phone etc.

- Just battery pack and keys and wallet
- Battery pack is the heaviest and is stored in her backpack

issues with mobility?

- Cant twist her arm around to grab things
- She keeps her backpack on the top of her handlebars but if she hits a bump, the bag sometimes slides down which is a problem

layout of the kitchen?

- More details later

when do aesthetics matter you over functionality

- Her friend told her that her chair does not define you and she should make it stand out and more to her tastes (bejewelled)
- Her friend decorated her chair for her and made her feel special
- Tiffany loves anything sparkly, pink, or bright that makes her stand out because it puts a smile on her face

aside from the weather, what makes your chair uncomfortable

- Her back is wide and the chair makes her uncomfortable

do you have any difficulty grabbing anything soft with your grabber?

- Not really, but the shape of certain objects makes it more difficult to pick certain things up

what is the reason for wanting to switch to a new wheelchair?

- Growth
- Very costly to try and get wheelchair fixed (can be anywhere between 10k and 2 million)

what is the maximum weight you can carry with both of your hands

- It depends

how do you store your gripper?

- On her lap or in her bag
- Proper storage and functionaly would be perfect

how do you reach out to things that are wet (soap, etc)

- Family members, PSW, and nurses will help her
- Tiffany feels it would be nice to be independent in that manner

would you benefit from something to help you open doors?

- Something that would be functional for all types of doors would be nice because her dog chew toy solution can't be brought everywhere

what solutions do you have for personal care problems like showering etc

- Has a transfer board to help her transfer from her bed to chair easily
- Harder time transferring from her bed to wheelchair

how do you normally get around town?

- When she goes on trips with her family, they have a special vehicle that has a ramp to help here get in
- She uses DARTS transportation but she has had issues with them in the past, she has been accused of slander when she speaks out against them
- Darts has no communication and their app is always delayed and clients are always upset

how do you get your pants and socks on in the morning

- PSW helps her with these tasks because she has zero function in the lower half of her body

is we attach things on your wheelchair, will the weight affect your chair

- Yes

where are the rods in the her back located?

- They all connect to the middle, they cover her entire spine

do you have the strength in your hand to rotate a gear

- Right hand yes, left hand no

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MILESTONE 2.2 – RESEARCH ASSIGNMENT

Team ID: Fri-43

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: Emilya Hum	MacID: hume3

What is your question?

What is the best material for a portable gripper?

What is your answer?

After research was conducted using the Granta EduPack software, the top materials when sorted by price and density showed to be cast iron (ductile - nodular), low alloy steel, high carbon steel, medium carbon steel, and cast iron (gray). While these options all appeared to be great options because they are much cheaper than alternatives, they are all a lot denser than other materials. The respective materials all have a price of less than 2.00 CAD/kg, but their densities ranged in the 7000 kg/m^3 category [1]. Bambo and wood also come across as ideal options because they are lightweight and affordable. However, they have a lower average yield strength than the alternatives ranging around 35.8 to 62.3 MPa [1]. The metals previous mentioned have a yield strength ranging from 246 to 929 MPa [1]. Additionally, aluminum alloys were an ideal option from analyzing the data on Grant EduPack. It ranked in the middle of the list when the materials were sorted by yield strength, price, and density. While it is more expensive than the previous options at an average cost of 5.81 CAD/kg, its average density is 2725 kg/m^3 which is lower than all the other metals [1]. Aluminium's average yield strength is 274 MPa, and its average tensile strength is 348 MPa [1]. Seeing that aluminium's average yield strength is greater than bamboo and wood, it makes for a good option. After doing some research on current available portable grippers on the market, it was observed that majority of them are made of aluminium alloys. This backs up the idea that aluminium is a good material for the gripper due to its lightweight and durability. To conclude, aluminium alloys are the best material for a portable gripper because it is durable while not being too heavy or expensive when compared to its alternatives.

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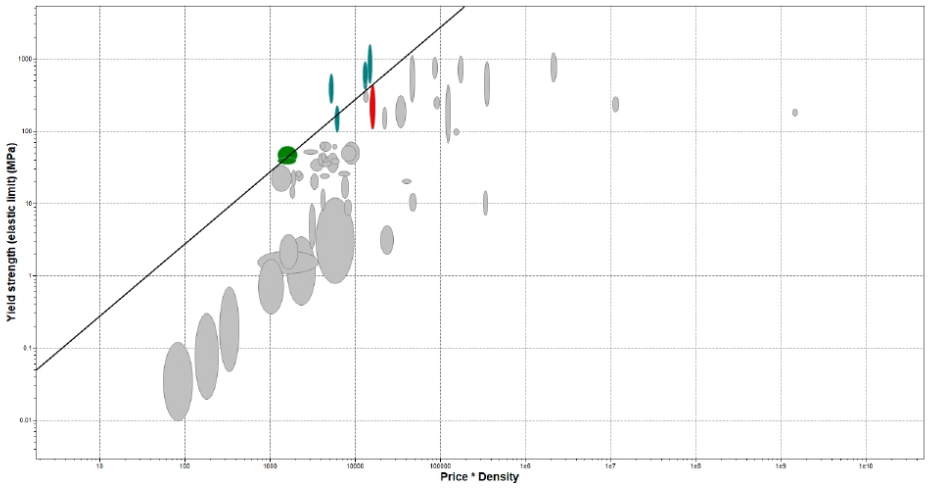

Ashby Chart from Granta EduPack

List of sources:

[1] *Ansys Granta EduPack software*, ANSYS, Inc., Cambridge, UK, 2023 (www.ansys.com/materials)

*** The concept design was fully changed to a new concept during Milestone 2 Lab, but the research assignment was completed prior to the lab for the previous gripper arm concept. ***

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MILESTONE 2.2 – INITIAL CONCEPT EXPLORATION

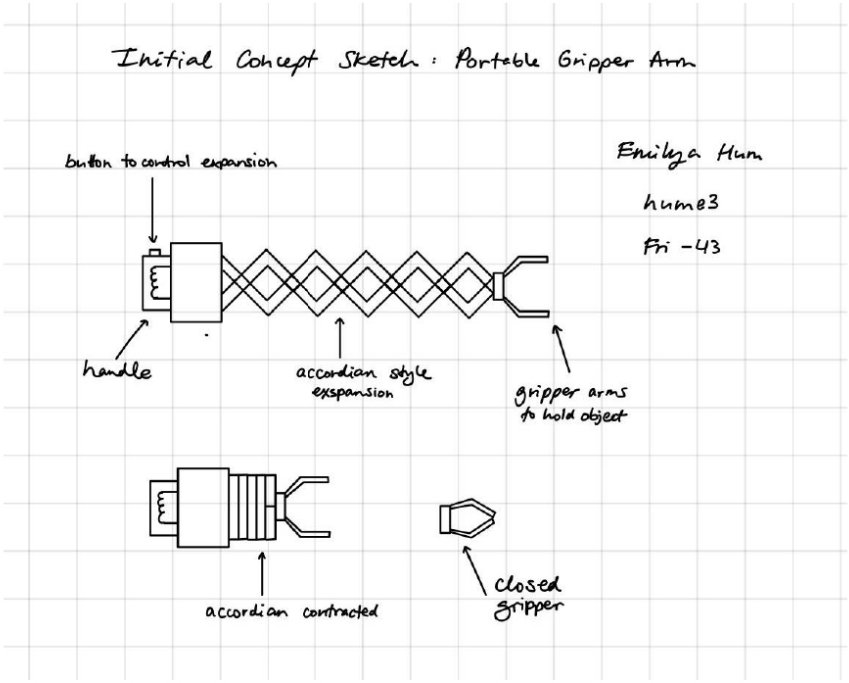
Team ID: Fri-43

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: Emilya Hum	MacID: hume3

Insert screenshot(s) of your concept below.



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MILESTONE 2.4 – REFINED CONCEPT EXPLORATION

Team ID: Fri-43

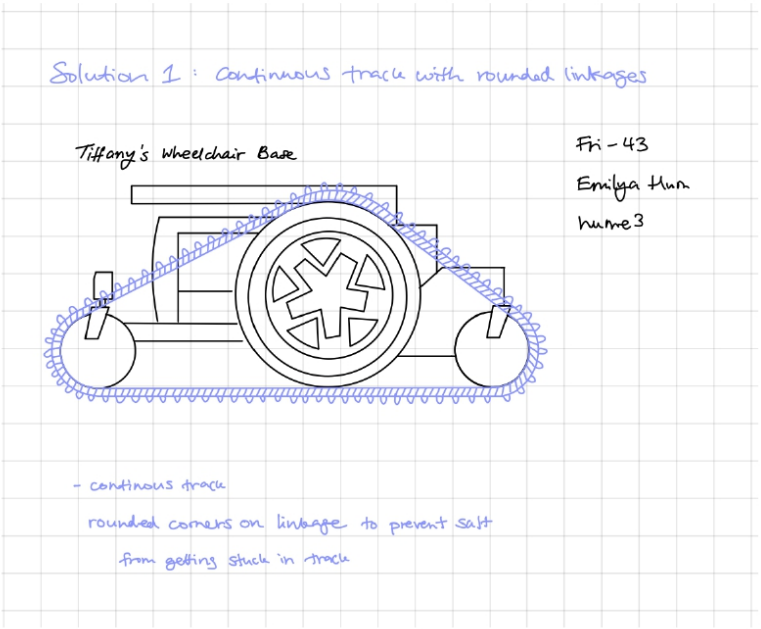
Complete this worksheet during Lab A for Week 7.

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: Emilya Hum	MacID: hume3

Insert screenshot(s) of your concept below.



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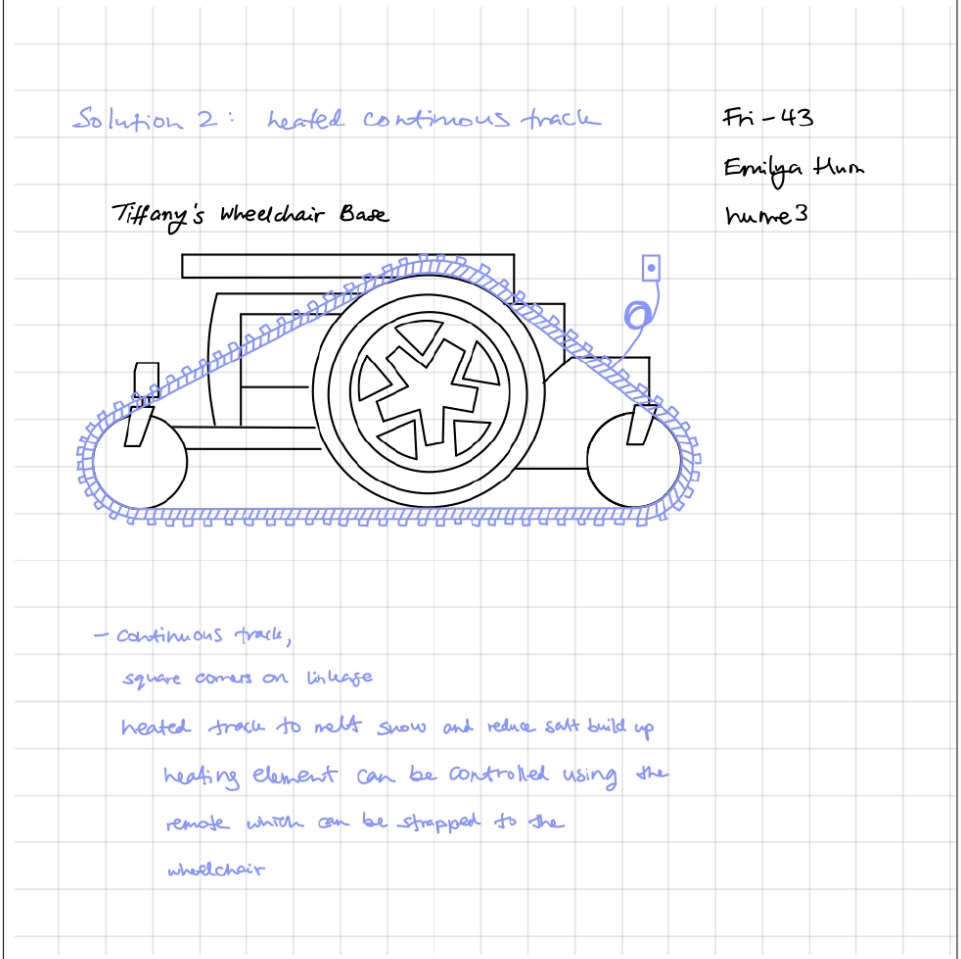
Team ID: Fri-43

Concept 2:

Name: Emilya Hum	MacID: hume3

Insert screenshot(s) of your concept below.



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

MILESTONE 3.1 – REFINED CONCEPT: INITIAL PROTOTYPE

Team ID: Fri-43

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.).

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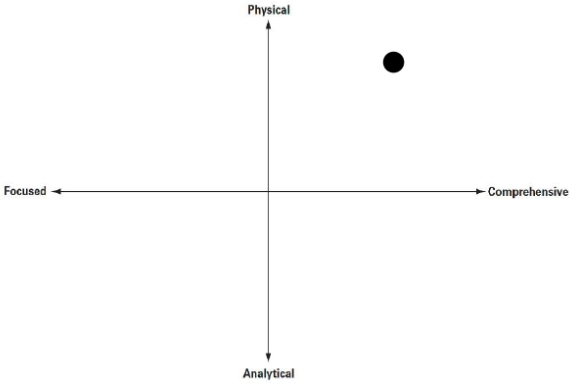
Name: Emilya Hum	MacID: hume3

Write a short description of your initial prototype below.

Tire attachment that has rounded edge treads to reduce the amount of salt and snow that gets stuck in between the treads.

Indicate where your prototype falls on the scale below.



Kind of Prototype:

☐ Physical or ☐ Analytical

☐ Focussed or ☐ Comprehensive

Purpose of Prototype:

To visualize the affects of the attachment for the rotary motion

Level of Fidelity:

Low-fidelity

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

Objectives	Metrics
• **Detachable**	• **Angular Velocity**
• **Flexibility**	• **Weight**
• **Durable**	•
• **Usability**	•
• **Minimize mass**	•

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

- *Apply pressure and weight to test durability*
- *Try rolling the attachment to ensure smooth riding sensation*
- *Weight the prototype to minimize mass*

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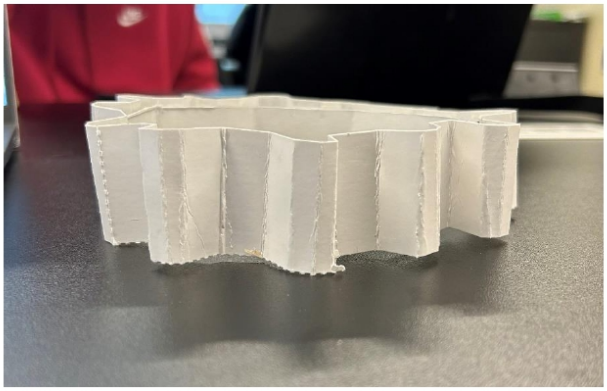
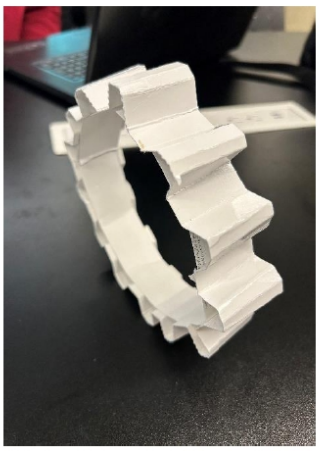
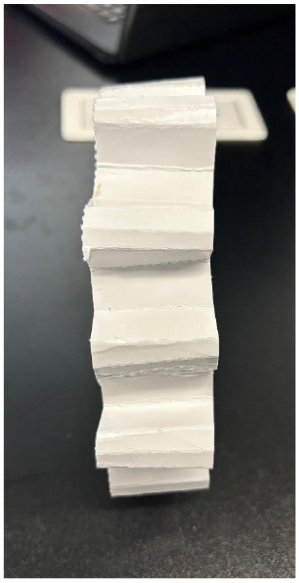
Insert picture(s) of your refined concept (initial prototype) below.







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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).

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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:

To test our design solution, we conducted a series of tests to evaluate its functionality, usability, and durability. Rolling the prototype on the sidewalk demonstrated its functionality and usability at maneuvering through the snow and ice. Applying bags of rice on the design showed the team how durable our design was. From the results of our testing, one change we made to improve our design solution was adding a way to fully secure our design to the wheelchair wheel. This change made our design solution better because the prototype's functionality would not be hindered while making the design safer for the user and surrounding individuals.

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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:

Early in the design process, we had various prototype designs. With all the different design ideas, we had to make decisions on which elements from each design would be used in our final design solution. We accessed each idea using a weighted matrix and it really showed the strengths and weaknesses of each design. We decided that the strengths of each design were going to be combined into the final design solution. I brought up to the group that the prototype with the element to push back snow should be the base of our final design because one of our main objectives was to push back the snow.

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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:

The testing stage really improved my understanding of the design process. Previously when designing, testing was a brief simulation or calculation to prove the design works. Through P4, we did extensive testing which really showed the strengths of our design and some areas that need improvements. I learned how important testing really is in the design process because it is necessary to evaluate the design and make improvements based on the results.

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

Response:

Learning how necessary testing is in the design process is important to me because it will help me improve my designs to produce the best solution. The goal of a design is to satisfy the users and it is important to me that my design is efficient and effective at solving the problem.

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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:

Considering this learning, I will always ensure my future design processes include extensive testing to produce the best possible solution. Specifically, I will use testing in future design projects and during my co-op experiences. As an engineer, it is important to me to solve the problem while designing an innovative creation.

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

Response:

The main benefit from the extensive testing in my plan is receiving the results and feedback to help improve my design. However, extensive testing requires a sufficient time frame. Time may be a challenge in the future because it may limit how much testing can be done.

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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.

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ENGINEER 1P13:
PROJECT FOUR WORKSHEETS (INDIVIDUAL)

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PROJECT FOUR MILESTONE ONE: PROBLEM FRAMING AND TEST PLAN

MILESTONE 1.1 – CLIENT NOTES

Team ID: Fri-43

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

1. Include your client notes from the introductory client visit

Name: Noor Ahmed	MacID: ahmem125

General Info:

- *Client name: Tiffany*
- *Diagnosed with spina bifida, no sensation below the waist, 2 metal rods in her back to straighten her spine*
- *She has a nurse and a personal social worker to assist her with daily tasks*
- *She has a power wheelchair, getting a new one soon (has a lift feature), she likes to accessorize her wheelchair*

Job/Career

- *Works in Walmart*
- *Stocks shelves, requires moving around and greets people*
- *At home she uses a Reacher grabber arm device This device is big, and cannot be brought everywhere. This device does not assist her at work.*

Challenges

- *When it snows, she has difficulty using the sidewalk as they are not plowed properly, there is also the possibility of getting stuck*
- *The salt used on sidewalks in winter can damage the wheelchair battery (very expensive to replace the battery, not insured by her insurance company)*
- *It is difficult to open doors that have handles, and door sizing is sometimes too small to accommodate the width of her wheelchair*
- *Crossing buttons are often not very accessible*
- *She also has rods in her back, the wheelchair is not heated, so the rods can freeze making her feel cold and causing discomfort*
- *She has skin sensitivity, so she cannot use heat pads or warm water bottles*
- *At work she cannot reach higher shelves*

Battery Info

- *Wheelchair battery needs a checkup every 6 months and cannot be kept in a cold environment*
- *Overnight charging*

More Info

- *She participates in martial arts*
- *Wants to be more independent and perform more tasks on her own*
- *Safety is a priority when moving around in her wheelchair*

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

MILESTONE 2.1 – CLIENT NOTES

Team ID: Fri-43

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

Include your client notes from the introductory client visit

Name: Noor Ahmed	MacID: ahmem125

General Info:

- *Client name: Tiffany*
- *Diagnosed with spina bifida, no sensation below the waist, 2 metal rods in her back to straighten her spine*
- *She has a nurse and a personal social worker to assist her with daily tasks*
- *She has a power wheelchair, getting a new one soon (has a lift feature), she likes to accessorize her wheelchair*

Job/Career

- *Works in Walmart*
- *Stocks shelves, requires moving around and greets people*
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- *When it snows, she has difficulty using the sidewalk as they are not plowed properly, there is also the possibility of getting stuck*
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- *She has skin sensitivity, so she cannot use heat pads or warm water bottles*
- *At work she cannot reach higher shelves*

Battery Info

- *Wheelchair battery needs a checkup every 6 months and cannot be kept in a cold environment*
- *Overnight charging*

More Info

- *She participates in martial arts*

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- *Wants to be more independent and perform more tasks on her own*
- *Safety is a priority when moving around in her wheelchair*

Second Client visit notes:

Wheelchair:

- *The foam and plastic armrests are slightly uncomfortable*
- *Her current wheelchair is not foldable, but she has had foldable ones in the past*
- *She charges her wheelchair by plugging it into a regular wall outlet*
- *She stopped charging her phone using her wheelchair as it took too much of the battery power*
- *Her wheelchair was taken away after its castors blew up*
-

Storage:

- *Depending on the weight of an item, it can be attached to her wheelchair*
- *The items would preferably be attached to the armrests on the handle, where they would be easier to reach*
- *As long as an item does not hit the ground, it can hang off the handle*
- *Her backpack is within reachable distance of her if it is on the handlebar*
- *Her backpack carries a plethora of items, including batteries and other daily-use items, but she would like some additional storage*
- *The pockets on each side of the armrests are not functional due to them being fairly small*

Reaching & Grabbing:

- *She requires assistance to reach outlets that are out of reach*
- *The easiest motion for her is pushing, while the hardest motion is grabbing, so picking up oddly shaped things is a struggle*
- *Pulling is more difficult than pushing for her*
- *The side with her toggle is her dominant side, so she can reach it easily, while the other side has some extra space*
- *She cannot reach stovetops and countertops as they are too high up*
- *Her reacher grabber struggles with picking up flat items like paper*
- *Her friend has a magnetic reacher grabber*
- *She uses her reacher grabber to reach her sweaters, which are located on the top of her shelving unit and are too high for her to reach normally*

Doors:

- *Opening door handles is not a struggle for her, but keeping doors open is a struggle*
- *Reaching doors is more difficult than opening them*
- *She moves doors with her footplates*
- *Going through doors is difficult due to the width of her wheelchair*
- *Her bag gets caught on doors or her wheelchair, so she gets stuck and requires assistance to remove the bag*
- *She had a cupholder in the past, which snapped off when it got caught on a door handle*
- *Her home has rectangle door handles, but she encounters all kinds of handles in her daily routine*

Extra Info:

- *She is right-handed*
- *She loves the colors purple and pink*
- *She can only be around non-latex balloons and uses non-latex gloves herself*
- *She uses the HSR along with the HSR and myRide app.*
- *DARTS service requires a relatively long process including interviews and paperwork*
- *She is an iPhone user*

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MILESTONE 2.2 – RESEARCH ASSIGNMENT

Team ID: Fri-43

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: Noor Ahmed	MacID: ahmem125

What is your question?

Pre-existing solutions for Individuals with Mobility Challenges

What is your answer?

To build an inclusive society that ensures accessibility for all individuals regardless of their dis(abilities) several products exist to increase mobility and independence. In order to create a new and unique design solution for Tiffany it is essential to explore the various products that are in store today and also the plethora of ideas that researchers and inventors have been experimenting with.

Like Tiffany, many individuals depend on a wheelchair for mobility. The global wheelchair market size was valued at 4.5 billion U.S. dollars in 2022 and is only expected to rise with the annual growth rate being 7.2 percent from the span of 2023 to 2030 [1]. Due to the commonality of wheelchairs, a plethora of different brands and types exist.

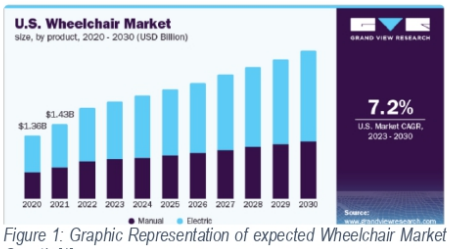

Figure 1: Graphic Representation of expected Wheelchair Market Growth [1].

The two broadest categories of wheelchairs are generally manual and electric. Manual wheelchairs require users to propel themselves by using their hands against the rims of the chair to push or pull the wheels. These types of wheelchairs also have back handles allowing someone to push the wheelchair for the user. Electric wheelchairs, most referred to as powered wheelchairs utilize electric, battery-operated systems that can be controlled using a set of embedded controls [2].

Over the years, technological advancements have unleashed a wide range of possibilities in

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the wheelchair industry which several manufacturers have been quick to implement in their wheelchair designs. Wheelchairs have expanded towards all types of designs and features ranging from simplistic manual designs to complex electrical designs [2]. These advancements have led to specific wheelchair types such as Sports wheelchairs that are designed to help users play specific sports using standard outward wheel designs and Positioning chairs wheelchairs that can recline backward, adjust leg positioning, or completely tilt enabling the user to position themselves however they prefer [2]. Standing wheelchairs allow users to stand as the wheelchair adjusts to a standing position and All-terrain wheelchairs are equipped with special features such as heavy-duty motors, reinforced frames, and balloon tires to handle challenging terrains [3].

For Winter, wheelchairs must be equipped with winter tires to tackle weather conditions associated such as snow, ice, and slush. Some wheelchairs require an entire tire change, while others are specifically designed with features to handle these winter conditions [4].

Another common product designed to increase the accessibility of those with mobility challenges is a Reacher Grabber Tool. This product type can be described as a handheld mechanical tool that increases the extent to which an individual can reach and grab items. Several types of these tools exist with many different features ranging from magnetic mechanisms to suction cups [5].

Several wheelchairs and Reacher Grabber tools exist in the market to aid those with mobility challenges. It can be concluded based on the items offered in the mobility and accessibility product market a user can only equip their wheelchair for winter by installing winter tires to a wheelchair or by purchasing a winter wheelchair. With further research into the specifics of winter tires and wheelchair tires, the knowledge of both can be integrated to develop a winter tire add-on which can directly attach to existing wheelchair wheels. Such an invention can equip users for the winter without the added hassle or cost of switching out their usual tires or purchasing a new wheelchair.

List of sources:

[1] "Wheelchair Market Size, Share & Trends Analysis Report," Grand View Research, 2021. [Online]. Available: https://www.grandviewresearch.com/industry-analysis/wheelchairmarket#:~:text=The%20global%20wheelchair%20market%20size,and%20operations%20in%20different%20regions. [Accessed March. 3, 2024]

[2] "Different Types of Wheelchairs," Redman. [Online]. Available: https://www.redmanpowerchair.com/different-types-of-wheelchairs/. [Accessed March. 3, 2024]

[3] "Types of Wheelchairs, " United Spinal Association. [Online]. Available: https://www.spinalcord.org/disability-products-services/types-of-wheelchairs/. [Accessed March. 3, 2024]

[4] "Wheelchair Winter Tyres," invictus active. [Online]. Available: https://www.invictusactive.com/wheelchair-winter-

tyres/#:~:text=These%20wheelchair%20winter%20tyres%20have%20enlarged%20outer%20lugs%20that%20increase,puncture%20protection%20called%20K%20guard. [Accessed March. 3, 2024]

[5] "The Best Reacher Grabber Tools of 2024," Reviewed USA Today. [Online]. Available: https://reviewed.usatoday.com/lifestyle/best-right-now/the-best-reacher-grabbers. [Accessed March. 3, 2024]

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MILESTONE 2.2 – INITIAL CONCEPT EXPLORATION

Team ID: Fri-43

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: Noor Ahmed	MacID: ahmem125
Insert screenshot(s) of your concept below.	

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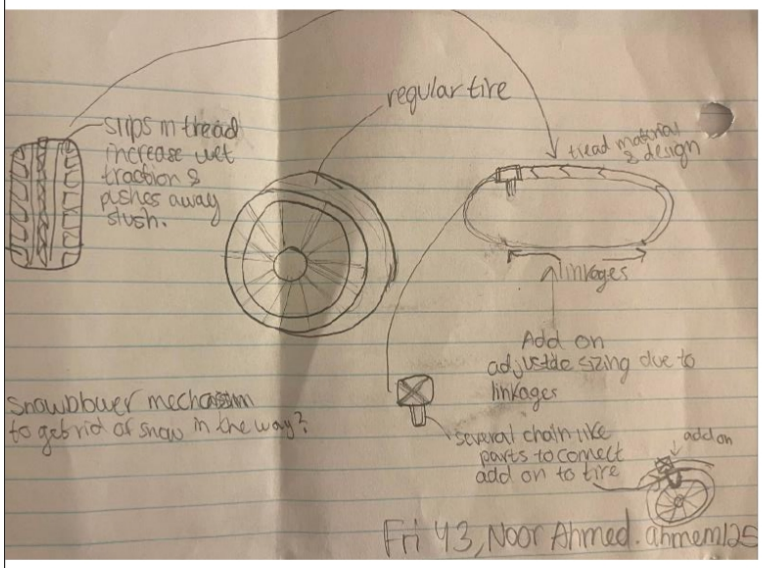

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MILESTONE 2.4 – REFINED CONCEPT EXPLORATION

Team ID: Fri-43

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: Noor Ahmed	MacID: ahmem125
Insert screenshot(s) of your concept below.	

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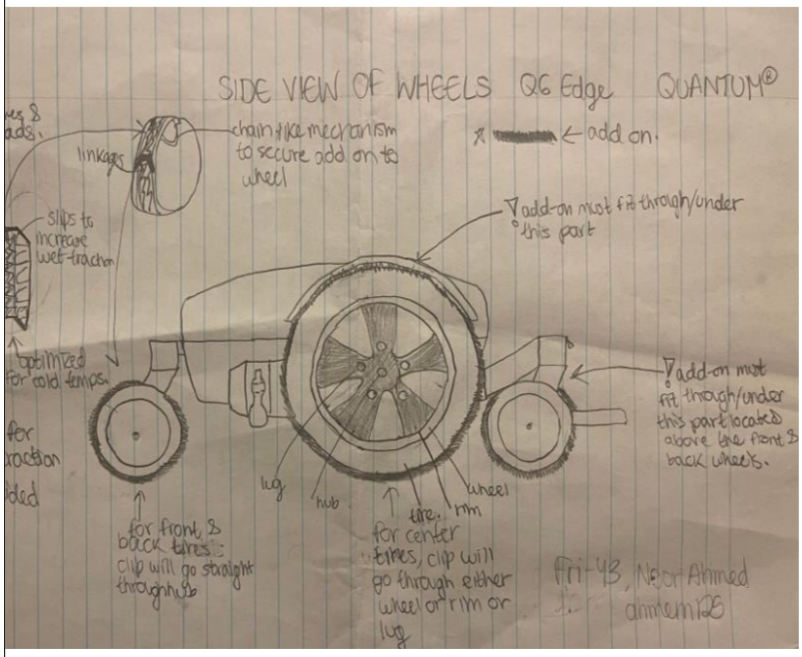

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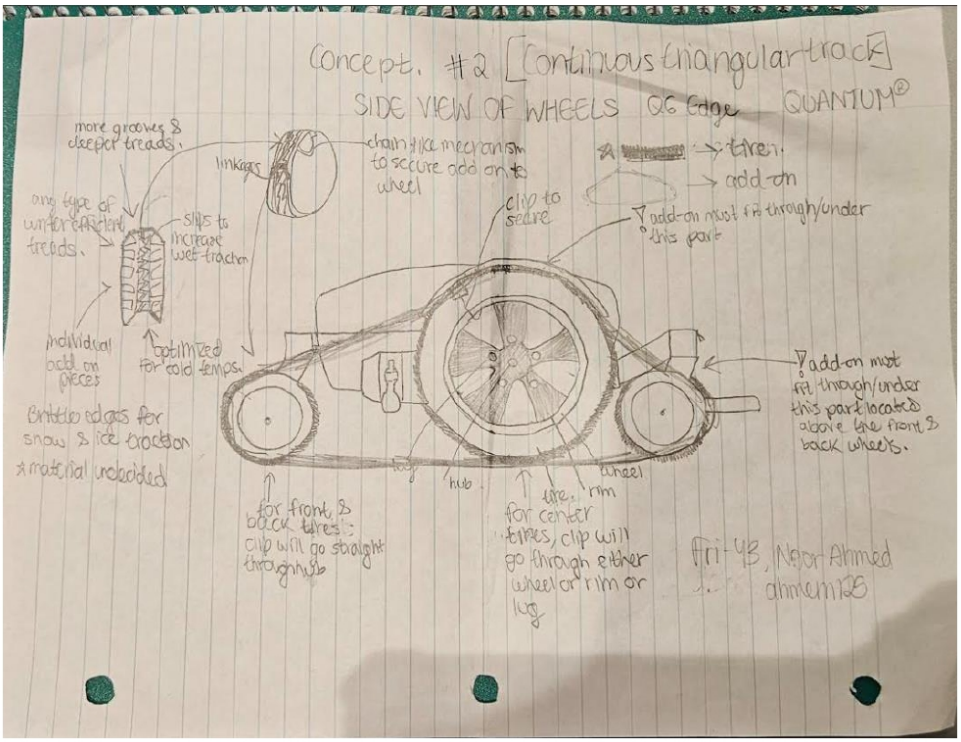
Team ID: Fri-43

Concept 2:

Name: Noor Ahmed	MacID: ahmem125

Insert screenshot(s) of your concept below.



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

MILESTONE 3.1 – REFINED CONCEPT: INITIAL PROTOTYPE

Team ID: Fri-43

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.
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   - → **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.).

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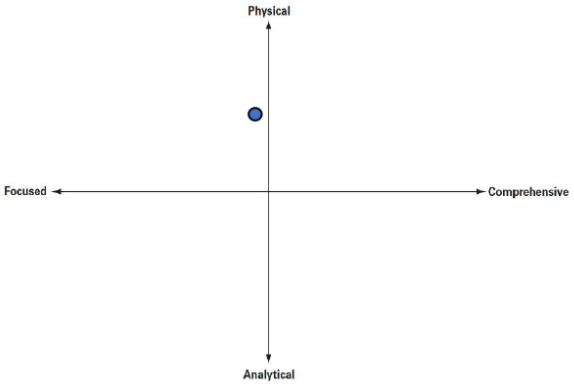
Name: Noor Ahmed	MacID: ahmem125

Write a short description of your initial prototype below.

Large Circular tire add on fabricated with plastic, duct tape, popsicle sticks, and hot glue. The plastic has bumps/bends intending to act like treads as seen on winter tires. Popsicles on the surface of the plastic are used to replicate a feature that helps increase traction in winter conditions. Duct tape was used to secure the inner and outer edges of the wheel.

Indicate where your prototype falls on the scale below.



Kind of Prototype:

✓ Physical or ☐ Analytical

☐ Focussed or ☐ Comprehensive

Purpose of Prototype:

To provide a general physical model of the design for the product and determine areas of improvement and potential features that can enhance the design and function.

Level of Fidelity:

Low

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

Objectives	Metrics
• **Traction** • **Durability/Strength** • **Attachable and Detachable**	• **Level of Grip in various conditions** • **Measure the load it can carry without deforming** • **Physically attaching to the tire, determining attachment feasibility**

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

Check for Grip by rolling the wheel on a gravel road, on a wooden floor, carpet, or low friction surface like ice.

Check for attachability by trying to attach to any tire/wheel that matches the measurements of the prototype.

Place weights on the prototype to determine how much load it can carry without deforming.

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

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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).

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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:

My team initially proposed a reacher grabber design solution but upon further deliberation, we proposed a unique design solution, a winter tire add-on. Upon research, we found that there were only two options when it came to handling winter conditions for wheelchair users. One was to completely swap out their wheelchair tires for winter tires which was a feasible option if the owner has such a wheelchair model that allows for tire switching. The other was, the owner having to buy a completely new wheelchair equipped for winter, one could say, this option is pricy, and often such a wheelchair is not equipped for all-year-round conditions. This design solution demonstrated some biomimicry as the add-on has features for traction, similar to the fundamental purpose of the feet of animals that reside in snowy winter climates. After completing a physical prototype, it was tested for durability, snow moved per rotation, longevity, grip, and portability. In the span of 2 hours, all these objectives were tested for the single prototype. Some challenges we faced in the testing process achieving the snowy condition we required for our testing plan along with keeping the tire straight up as we tested it. We walked outside to a specific corner on campus that had some snow piled up. To keep the tire straight up and prevent it from falling, we inserted a wooden x-shaped block to mimic the presence of a tire allowing the add-on to stay straight as we rolled it on various terrains. From the overall results of the testing plan, two changes we made to improve our design solution were to add a circular tire inside our add-on so it could better mimic the add-on in action with the added support of a tire, along with adding Velcro buckles to attach the add-on with the tire better

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demonstrating the attachability of the add-on to pre-existing wheelchair tires. Both changes made our design solution better as they helped it carry out its function more readily while better showcasing both its structural and attachability features. This entire experience showed me that my ideas are valid and I should always strive to think outside the box to generate new and unique ideas. Below of an image of our wooden solution during the testing process.

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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?

;;p;p;p;p;p;p;p;;;p[[Response:

At the very start of the project, my entire team was set on a Reacher grabber-centered design solution. However, I was opposed to the idea because it was far too common, and I wanted to explore and propose a fairly unique design solution. Upon further brainstorming, my team agreed on a winter-tire add-on design solution, which I later named the "WinTire". During milestone 3, each team member had created their initial prototype, each of which we weighed using a decision matrix to decide which two initial prototypes our prototype for testing would be based on. The matrix had criteria including Ice and snow traction, ability to push snow back, durability, attachability to the wheel, and smooth driving sensation. The criterion was tested based on both the features of the tangible prototypes along the potential these features had to evolve/improve to meet the criteria. One team member's prototype stood out to me, as it incorporated several features that demonstrated the objectives we had set for the design solution, including sponge pads for traction, indents in the add-on frame for flexibility and grip, along with a clip-on mechanism for attachability. I faced a few challenges during the decision prototype, including combatting this overwhelming feeling of how this design solution would be executed to achieve its function and objectives. However, after creating a refined project timeline, I realized our design solution was attainable if we adhered to our responsibilities along with the timeline.

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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:

I've always had the misconception that generating an idea is the most challenging part, and executing an idea is much harder. Through prototyping and testing processes it became very apparent to me that bringing our ideas to life is very difficult. The design solution idea of a winter-tire add-on came to me instantly, however, I did not know where to start when it came to executing it, luckily this is where the collective skills and support of my team played a big role. We were all able to put or heads together and brainstorm which gradually led to the execution of our design solution. I also learned two very important things, one being that testing is a vital part of the design process, and the other being the significance of having a team with multiple skill sets and backgrounds. Both these things help an idea grow and improve into an invention. Our decision-making process was repeated at a few stages which was beneficial to the project as it helped us explore alternatives that could be used for our solution, along with combatting any weaknesses we observed our design to have. Delaying some decision-making may have improved our design, however this was not feasible as we had to adhere to a strict deadline and our ongoing decision-making throughout the project already gave us several opportunities for design improvement.

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

Response:

These insights are important to me as they demonstrate the factors needed to execute a design. I learned the vitality of a team and the importance of flexibility in terms of always being open to feedback, criticism, and opportunities for improvement in the design process. Making changes, decisions, and improvements to a design solution are ongoing tasks that require the most consideration and a hefty amount of time, however, without them the design process is incomplete and it hinders the execution of a design to reach it fullest potential.

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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:

I learned that improvements are necessary for the successful execution of an idea which is valuable to me as an engineer because it teaches me the openness I require when presenting my ideas to others, and how I can beneficially take other's input for the betterment of my ideas. Moving forward, I will always have a greater openness and appreciation for feedback, criticism, and embody the entire idea of stepping back and analyzing an idea for areas of weakness and improvement.

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

Response:

There are several challenges involved with adhering to my new set goal of using both feedback and criticism to implement improvements in my ideas and designs. When it comes to my own ideas, sometimes I can get defensive about initial aspects of the idea which make it difficult to remain open to criticism and act on it. It is also challenging to implement certain improvements, they can be time-consuming, costly, and both mntally and physically rigorous. However, several benefits are associated with my goal such as adjusting my idea to be suitable for conditions or objectives I had not accounted for initially and allowing for ongoing progress with simultaneously

making refinements.

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.

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ENGINEER 1P13:
PROJECT FOUR WORKSHEETS (INDIVIDUAL)

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PROJECT FOUR MILESTONE ONE: PROBLEM FRAMING AND TEST PLAN

MILESTONE 1.1 – CLIENT NOTES

Team ID: Fri-43

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

1. Include your client notes from the introductory client visit

Name: Shadi El-Fares	MacID: elfaress
Client Notes: *Name: Tiffany* *Age: 33* *Condition: Spina Bifida* *Mobility: Relies on power wheelchair for mobility* *Assistance: Supported by a nurse and PSW for daily activities* *Occupation: Walmart employee, responsibilities include shelf stocking and customer assistance* *Challenges:* *- Limited lower body mobility* *- Requires aid for everyday tasks* *- Encounters difficulties with inaccessible doors* *- Wheelchair constraints on uneven surfaces* *- Challenges in reaching high shelves at work* *- Experiences cold sensitivity due to presence of metal rods in back* *Goals:* *- Enhance independence in daily activities* *- Improve wheelchair accessibility and safety measures* *- Seek solutions for reaching high shelves at workplace* - *- Address cold sensitivity, especially during winter months*	

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

MILESTONE 2.1 – CLIENT NOTES

Team ID: Fri-43

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

Include your client notes from the introductory client visit

Name: Shadi El-Fares	MacID: elfaress
Client Notes: *Name: Tiffany* *Age: 33* *Condition: Spina Bifida* *Mobility: Relies on power wheelchair for mobility* *Assistance: Supported by a nurse and PSW for daily activities* *Occupation: Walmart employee, responsibilities include shelf stocking and customer assistance* *Challenges:* *- Limited lower body mobility* *- Requires aid for everyday tasks* *- Encounters difficulties with inaccessible doors* *- Wheelchair constraints on uneven surfaces* *- Challenges in reaching high shelves at work* *- Experiences cold sensitivity due to presence of metal rods in back* *Goals:* *- Enhance independence in daily activities* *- Improve wheelchair accessibility and safety measures* *- Seek solutions for reaching high shelves at workplace* *- Address cold sensitivity, especially during winter months*	

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MILESTONE 2.2 – RESEARCH ASSIGNMENT

Team ID: Fri-43

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: Shadi El-Fares	MacID: elfaress
What is your question? *How will we use Motor Control in this our design solution?*	
What is your answer? Controlling Multiple Motors Simultaneously with Arduino Controlling multiple motors simultaneously using an Arduino microcontroller offers a wide range of applications, for our design solution. This capability allows for precise coordination of movements, synchronization of operations, and the ability to create complex, multi-degree-of-freedom mechanisms. One common scenario where this is crucial is in systems that involve expansion and retraction mechanisms, such as robotic arms, CNC machines, 3D printers, and more. Why Control Multiple Motors? 1. Complex Movements: Many applications require multiple motors to work in tandem to achieve complex movements. For instance, a robotic arm might need several motors to control different joints, each contributing to the overall motion. 2. Balancing and Stability: In systems like self-balancing robots or drones, multiple motors are used to control different parts of the system to maintain stability and balance.	

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3. Increased Load Capacity: When a single motor cannot handle the load requirements, multiple motors can be used together to distribute the load and prevent strain on any single motor.
4. Redundancy and Reliability: Having multiple motors for critical applications provides redundancy. If one motor fails, others can continue to operate, ensuring the system's reliability.
5. Speed and Efficiency: By distributing tasks among multiple motors, the system can operate more efficiently and achieve higher speeds.
We have to:
1. Motor Selection:
- Choose the appropriate motors based on your application requirements (e.g., DC motors, stepper motors, servo motors).
- Consider factors such as torque, speed, power requirements, and control precision.
2. Motor Drivers:
- Since Arduino pins are not designed to provide enough current or voltage for motors, motor drivers are used as intermediary devices.
- Common motor drivers include L298N, L293D, A4988 for stepper motors, and dedicated servo motor controllers.
3. Power Supply:
- Motors often require more power than the Arduino can provide. A separate power supply should be used for the motors.
- Be sure to properly connect the grounds of the Arduino and the motor power supply to avoid noise and interference.
4. Arduino Programming:
- Use Arduino's programming language, which is based on C/C++, to write the code for motor control.
- Libraries such as `AccelStepper` for stepper motors or `Servo` for servo motors can simplify the code.

Controlling multiple motors simultaneously with Arduino opens up a world of possibilities for robotics, automation, and other projects. By selecting the right motors, using appropriate motor drivers, providing adequate power, and writing efficient code, you can create intricate systems

capable of precise and synchronized movements. Whether it's expanding and retracting mechanisms or any other complex motion, Arduino offers a versatile platform for realizing your designs.

List of sources:

[1] A guide to designing robust robot arms - technical - chief delphi, https://www.chiefdelphi.com/t/a-guide-to-designing-robust-robot-arms/425684 (accessed Feb. 26, 2024).

[2] "Controlling a DC motor with Motor Shield REV3," docs.arduino.cc, https://docs.arduino.cc/tutorials/motor-shield-rev3/msr3-controlling-dc-motor (accessed Feb. 26, 2024).

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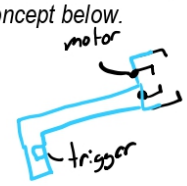
MILESTONE 2.2 – INITIAL CONCEPT EXPLORATION

Team ID: Fri-43

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: Shadi El-Fares	MacID: elfaress
Insert screenshot(s) of your concept below. 	

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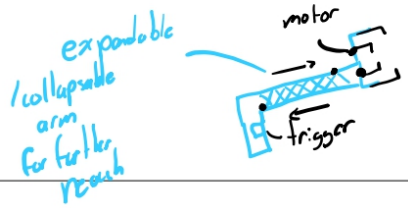
MILESTONE 2.4 – REFINED CONCEPT EXPLORATION

Team ID: Fri-43

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: Shadi El-Fares	MacID: elfaress
Insert screenshot(s) of your concept below. 	

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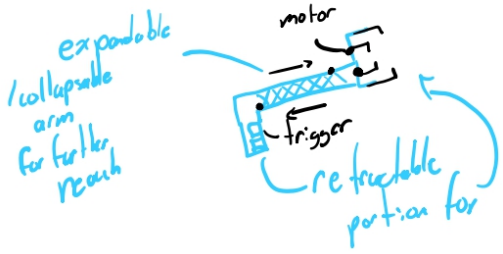
Team ID: Fri-43

Concept 2:

Name: Shadi El-Fares	MacID: elfaress

Insert screenshot(s) of your concept below.



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

MILESTONE 3.1 – REFINED CONCEPT: INITIAL PROTOTYPE

Team ID: Fri-43

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.).

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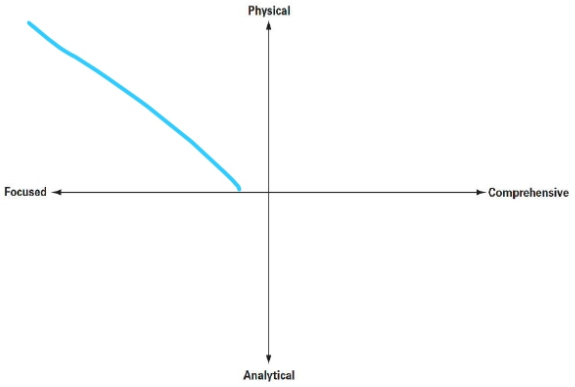
Name: Shadi	MacID: elfaress

Write a short description of your initial prototype below.

My initial prototype is a miniature version of the snow remover add-on to Tiffany's wheels.

Indicate where your prototype falls on the scale below.



Kind of Prototype:

☐ Physical or ☐ Analytical

☐ Focussed or ☐ Comprehensive

Purpose of Prototype:

The purpose of this prototype is to test the snow-plowing ability and mechanical feasibility of the product.

Level of Fidelity:

Extremely low

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

Objectives	Metrics
• **Roll**	• **Stiffness**
• **Structurally strong**	• **kg**
• **Move snow back**	• **Pieces of snow**
•	•
•	•

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

Scrunching paper up in small pieces and have it roll-over to see if the small pieces fly backwards to mimic snow.

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

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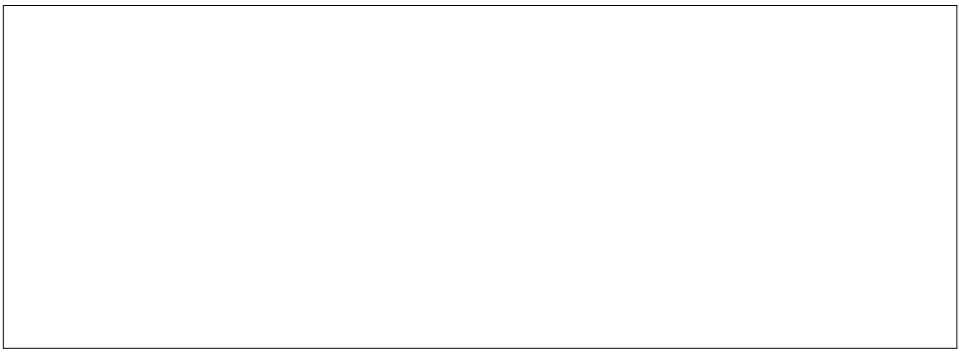

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PROJECT FOUR FINAL DELIVERABLE: PROJECT REFLECTION

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).

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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 our team project on developing the WinTire, a pivotal moment arose when we realized the necessity of a costly yet durable material to support the tire's functionality. This realization, involving Noor, Shajijan, Aman, Emilya, and myself, significantly impacted our approach, as it not only highlighted potential cost savings but also shed light on material complexities explained in detail within our Design report. This realization occurred during the phase where we were planning to test the prototype's feasibility.

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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:

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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:

This incident challenged our assumptions about the feasibility of the WinTire design and our testing plan. It forced us to confront the misconception that our prototype could accurately represent the final product without the necessary materials. Learning about the requirement for silicon rubber, which we found to be costly, was an eye-opener. Understanding the importance of integrating all essential design aspects into the prototype for accurate testing outcomes surprised us.

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

Response:

During our team project on developing the WinTire, a pivotal moment arose when we realized the necessity of a costly yet durable material to support the tire's functionality. This realization, involving Noor, Shajijan, Aman, Emilya, and myself, significantly impacted our approach, as it not only highlighted potential cost savings but also shed light on material complexities explained in detail within our Design report. This realization occurred during the phase where we were planning to test the prototype's feasibility.

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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:

This incident challenged our assumptions about the feasibility of the WinTire design and our testing plan. It forced us to confront the misconception that our prototype could accurately represent the final product without the necessary materials. Learning about the requirement for silicon rubber, which we found to be costly, was an eye-opener. Understanding the importance of integrating all essential design aspects into the prototype for accurate testing outcomes surprised us.

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

Response:

These new insights are crucial because they reshaped our understanding of idea generation, testing, and decision-making in the design process. We now comprehend the necessity of thorough planning, ensuring that prototypes represent final designs realistically. This understanding enhances our ability to anticipate challenges, manage costs, and improve project efficiency.

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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.

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ENGINEER 1P13:
PROJECT FOUR WORKSHEETS (INDIVIDUAL)

1

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ENGINEER 1P13 – Project Four: *Power in Community*

PROJECT FOUR MILESTONE ONE: PROBLEM FRAMING AND TEST PLAN

MILESTONE 1.1 – CLIENT NOTES

Team ID: Fri-43

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

1. Include your client notes from the introductory client visit

Name: Aman Minhas	MacID: minhaa18

- inspires young individuals with spina bifida

Overview. Spina bifida is a condition that occurs when the spine and spinal cord don't form properly. It's a type of neural tube defect. The neural tube is the structure in a developing embryo that later becomes the baby's brain and spinal cord and the tissues that enclose them. Dec 19, 2023

Mayo Clinic
https://www.mayoclinic.org › ... › Diseases & Conditions

Spina bifida - Symptoms and causes - Mayo Clinic

-
  - metal rods placed within back as a cross to aid in spine curvature.
- restricted from daily tasks.
  - driving, walking, providing or family
  - society sees disability for something it's not.
    - be treated like normal.
- **challenges**
  - weather
    - snow, rain etc. interrupts her movement with mobile device.
    - cost effective & efficiency effective.
    - ALWAYS wear sweaters due to metal rods
    - solution for getting caught in rain.
      - bag to cover console.
      - make waterproof?
  - battery
    - battery too big!
    - functions
      - colour indication for battery life
      - salts for snow damages battery & further inhibits transportation.
      - having to carry an extra battery.
        - unable to charge battery —> curate a portable solution to keep battery charged.
        - SOLUTION AT WORK: outlet within reach
      - battery placed under seat → no cover = dangerous
    - battery life → can last up to 2 days but keep it safe for one day.
      - battery life tracker IS AVALIABLE
      - battery runs out → mobility stops → no other alternative within reach
      - replacement times come within a week to 2 weeks.

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- forgetting to charge it overnight causes complications.
- temperature & affects.
- in cold weather → corrupts battery
- doors
- not big enough and open LONG enough to be moved into spaces.
- crosswalk buttons
- 2016 - July 2023
- 6 done - 2 within the works.
- not within reach!
- city councillor gave her placement on committee.
- technology
- voice assistant

- **hobby**: martial arts
  - entering competitive martial arts → for self defence
  - dance → helps improve mental state.
  - TIME INTERFERENCE → to do regular activities such as travelling outside of Hamilton takes months of preparation.
- **work**: greeter
  - assisted in stocking shelves.
    - getting to higher places and shelves is difficult.
- household tasks
  - three story houses (basements, main, second floor w 3 rooms)
  - elevator within house to make easier to move.
  - cooking limitations → aid from others to reach stoves, counter tops, etc.
- new wheelchair
  - wheelchair that lifts and down
    - COST FOR FEATURE: 1-3000$ not covered.
- daily fixes
  - Reacher Graber → grab off the wall
    - long rob with a claw machine clasp on it
      - abstract shapes and larger objects not able to grab.
  - wooden back scratcher
- Q & A
  - improve something new or continue current life?
    - Open to trying something new
    - a bit of both → integrate more accessibility
  - propping open door
    - damages wheelchair → cost effective
    - time to repair/approval from ODSP can take weeks/months.
    - cost: $500/battery replacement
  - hidden challenges
    - in & out cauterization: going to the bathroom happens through a tube.
    - making sure every place is accessible BEFOREHAND.
  - pointiness of “Reacher grabber” interferes with moving around safely.
    - have stores carry them.
    - make collapsible

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

MILESTONE 2.1 – CLIENT NOTES

Team ID: Fri-43

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

Include your client notes from the introductory client visit

Name: Aman Minhas	MacID: minhaa18

- *Remove stigma around disability and being "different:*
- *Strengthened right side*
- *Emphasis on standing out*
  - *pink & sparkle.*
- *Difficulty with reaching "wet" and "slippery" objects*
- *Rod right now is estimated around 5 pounds.*
- *Nurse & personal support worker's present for assistance*
  - *Personal support workers assist with everyday tasks*
- *Wheelchair Model*
  - 

  Edge 3
  - *Three wheels on each side*
  - *Larger wheel in middle carries must support of weight on top of base*

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MILESTONE 2.2 – RESEARCH ASSIGNMENT

Team ID: Fri-43

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: Aman Minhas	MacID: minhaa18

What is your question?

Through what improvements can the mobility, challenges, everyday lives of individuals with spina bifida be enhanced? What are the possible drawbacks of these solutions?

What is your answer?

Spina Bifida transforms the lives of individuals from the day they were born, leading to limits within their potential in today's world [1]. Without the extensive research and technology going into accessibility towards those with disabilities, navigating their everyday lives would become an extensive obstacle. Tiffany mentioned the challenges she faces particularly with the weather.

Tiffany had expressed the hidden challenges of her disability that are further than what meet the eyes, specifically weather complications. As spina bifida is the incomplete development of the spine [1], there are rods to be put in place to straighten and replicate what the spinal structure should be. These metal rods are conductors and therefore carry heat away at a fast rate, leaving individuals with spina bifida colder than the average human [2].

Navigating the cold winter months becomes a challenge for Tiffany due to the wheels on her mobility device. With snow and ice on the ground, especially through the intense winters in Canada, Tiffany loses all ability to go outdoors on her own due to the smoothness of her tires being unable to combat the complicated surface. Tiffany's current wheelchair model, the *Edge 3*, has three wheels on each side, where the front and back ones are mainly responsible for the rotation and the large middle wheel supports the weight with the main translational motion [4]. The ice makes the surface too slippery, where the friction is so minimal and the risk of gliding off is extremely common. On the other hand, snow builds up on the surface making movement through the compact medium practically impossible. While cities use salt to boost traction and friction to

reduce slipping on icy roads in the winter, the salt also contributes to the wear and tear on Tiffany's tires, leading to extra unnecessary expenses [5].

Due to the disability, Tiffany has lost all mobility from her waist down and uses a wheelchair for mobility. Despite the great advancements within technology, wheelchairs lack many mobility features and merely are unattainable for individuals due to cost, being out of region, or the time for shipment [3]. Tiffany expressed her concerns with her current wheelchair's battery, being heavy weight, without a cover, and the possibility of running out of charge to be extra factors she must consider before going out for the day.

While Tiffany faces multiple obstacles, she was sure to express the advocacy her disability gives her and how she can now live as an inspiration to individuals all over the world. Through extensive involvement throughout her community and featuring as a solution for the inaccessibility around her town, Tiffany and other likewise individuals can propose a future accessible for all.

List of sources:

[1] "Spina Bifida," *National Institute of Neurological Disorders and Stroke*, 2024. https://www.ninds.nih.gov/health-information/disorders/spina-bifida (accessed Feb. 26, 2024).

[2] "Does Body Metal Cause Pain in Cold Weather?," *Direct Orthopedic Care*, 2019. https://www.directorthocare.com/does-body-metal-cause-pain-in-cold-weather/ (accessed Feb. 26, 2024).

[3] A. Pulrang, "Why Is Accessibility Still A Problem? What Can We Do About It?," *Forbes*, Oct. 12, 2022. Accessed: Feb. 26, 2024. [Online]. Available: https://www.forbes.com/sites/andrewpulrang/2019/11/21/why-is-accessibility-still-a-problem-what-can-we-do-about-it/?sh=7920b727f23a

[4] Quantum Rehab, "Edge® 3 Wheelchair Base | Quantum Rehab® :: Electric Wheelchairs," *Quantum - The Rehab Power Chair Solutions Company*, 2024. https://www.quantumrehab.com/quantum-power-bases/edge-3.asp (accessed Mar. 03, 2024).

[5] J. Ripat *et al.*, "Winter Mobility and Community Participation Among People Who Use Mobility Devices: A Scoping Review," *Archives of Rehabilitation Research and Clinical Translation*, vol. 2, no. 1, pp. 100018–100018, Mar. 2020, doi: https://doi.org/10.1016/j.arrct.2019.100018.

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MILESTONE 2.2 – INITIAL CONCEPT EXPLORATION

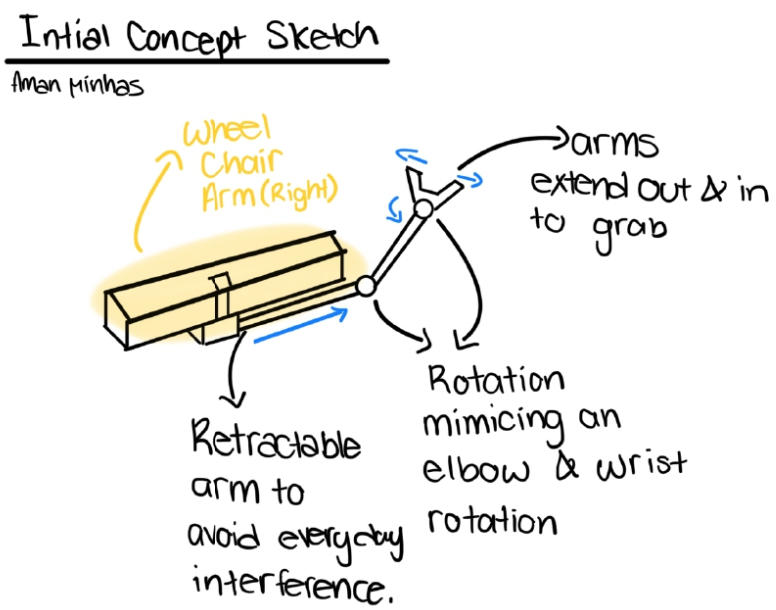
Team ID: Fri-43

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: Aman Minhas	MacID: minhaa18

Insert screenshot(s) of your concept below.



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MILESTONE 2.4 – REFINED CONCEPT EXPLORATION

Team ID: Fri-43

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: Aman Minhas	MacID: minhaa18

Insert screenshot(s) of your concept below.

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Team ID: Fri-43

Concept 2:

Name: Aman Minhas	MacID: minhaa18

Insert screenshot(s) of your concept below.

used along side chains
↳ chains roll over snow
↳ studs prevent ice slipping

Elevated studs dig into snow & ice – increasing traction

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

MILESTONE 3.1 – REFINED CONCEPT: INITIAL PROTOTYPE

Team ID: Fri-43

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.).

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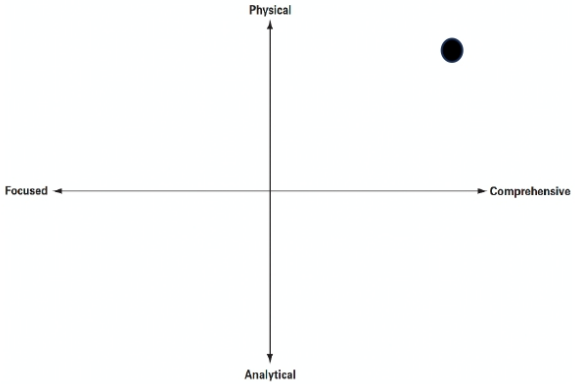
Name: Aman Minhas	MacID: Minhaa18

Write a short description of your initial prototype below.

A circular cap, representing the tire, has a thin rope material along the circumference, replicating the belt being attached to the physical design. Three sponges, cut diagonally are taped to the circumference, showcasing the effects a frictional material would have on different materials.

Indicate where your prototype falls on the scale below.



Kind of Prototype:

☐ Physical or ☐ Analytical

☐ Focussed or ☐ Comprehensive

Purpose of Prototype:

To visualize the effects of the physical traction methods on the belt around the wheel.

Level of Fidelity: Low fidelity – scaled down general idea

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

Objectives	Metrics
☐ **Flexibility**	☐ **Weight (Grams or Kilograms)**
☐ **Durability**	☐ **Angular Velocity**
☐ **Portability**	
☐ **Longevity**	
☐ **Grip**	

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

- Apply weight in increments of 2g to test the maximum withstand of weight applicable.
- Create simulations of different floor conditions for wheel to test angular velocity and traction through various mediums.
    - Ice, grass, etc.

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

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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).

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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:

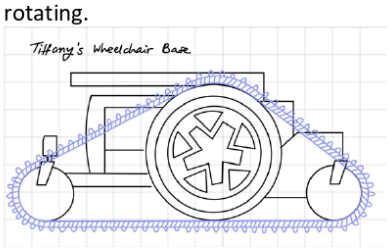
Generating & Testing Ideas:

- 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:

Our initial design to improve Tiffany's transportation over unideal circumstances, such as snow and ice, was combatted through our winter tire add on. The current wheelchair model has three wheels on both sides, two smaller ones utilized mainly for rotation and a larger middle one responsible for her main mobility, certain conditions had to be considered before prototyping. Through the research of her wheels, and understanding the functions each wheel was considered for, it was evident having all three wheels connected through a

conveyer belt design was impractical as it would limit her movement, specifically when rotating.



That interference was then questioned with having the tire add on for all three wheels, as it would protect her wheelchair in all aspects. While the extra protection would be great, we came to an agreement to curate a single tire add-on that can be circumference-customized, to allow a cost efficient along wheelchair specific option rather than having a design that will only fit her current wheelchair.

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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:

Prior to creating a physical prototype, decision matrices and sketches to visualize the concept were essential aids in curating the final product. These tools were the main parts of the decision-making process as we collectively as a team reviewed the sketches, referenced back to the objectives, and made changes as needed. Specifically with the decision to move away from our initial idea of a reacher grabber to a winter tire attachment, there were factors to consider such as originality, conceptualizing a product that would effectively improve Tiffany's everyday life, and the given timeline for the project. As our decision to switch happened a week into the timeline, utilizing a refined timeline was essential for our group as we had to ensure our previously done research was compatible to the new design and reconstruct our problem statement and other essential portions. While the rest of the team was focused upon the overall product, I identified the smaller technical details such as ensuring the material chosen is flexible to ensure her transportation is as smooth as possible along with bringing the groups attention towards how the add on will fit onto the tire and any interference it may bring through the size of the flexible rods.

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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:

Our team having a change in decisions earlier on within the project was much less detrimental for our project completion timeline as we had ample time to curate a new problem statement, objective, constraints, and general sketches to stay on track with the rest of the project. Had we delayed our decision by another week, our group would have been far more behind and the overall prototype creating process would have created a far larger dent into our personal time. While the decision making process occurred various times throughout the project through switching our design, switching the materials, or reconstructing the prototype, I maintained flexibility and adaptability, resulting in a stronger final design.

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

Your response:

These highlights made the process of essentially restarting within a project a far less intimidating process than it seemed to be beforehand. While we had restarted earlier on and were in luck in terms of not having to immensely interfere with our personal time, had that decision been done later, a refined timeline will always be a great tool to fall back on and avoid feeling overwhelmed.

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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:

This project introduced me to all setbacks that are essentially inevitable within a project. Having to restart and critically think of a new solution seems as a daring process but through the techniques such as refined project timelines and various annotated sketches, projects can be easily adapted towards a conclusive final product.

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

Your response:

While the refined project time presented the benefit of having a reliable plan for what the following project time would look like, there are challenges of the "what if's" that are unavoidable. When combatting those unexpected setbacks, while refined project timelines are no longer a viable option, such as when I curated quick sketches to generalize and communicate ideas and changes allow for a final conclusive product that reflects all factors of the project.

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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.