GNG 2101 - FINAL REPORT

Submitted to
Prof. Hanan Anis
GNG 2101

By

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This report includes the results and process of our product development project. It will include documentation of our design process and solution.

Abstract

This report examines the process of constructing a portable ramp for our client at the LIFE Program. Included will be our design process and solutions to our specific problem. This report will discuss our business model and how our team plans on bringing our solution to market. Also discussed are the components of our ramp and will provide a user manual for our client with detailed instruction on how to use our product.

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Introduction

This problem is relevant because there are many people that suffer from disabilities and mobility issues. We have connected with people who have experienced the struggles of traversing an inaccessible world while in a wheelchair, and understand that many public places do not provide adequate support to those with limited mobility. We hope to provide solutions that can solve universal problems regarding limited mobility. Our mission is to provide a portable ramp that is lightweight, strong, and easily portable. Our lightweight ramp features a high strength to weight ratio, easy portability, and numerous safety features to ensure that our product is safe, reliable and easy to use.

First Client Meeting

During the first client meeting at LIFE, our group focused on empathizing with our client/user. This allowed us to understand their needs and wants. In order to properly identify the real problem and ideate solutions for this project, meeting the client was essential to the success of this project. The information presented to us by the client allowed our team to start the creative, analytic process of designing a solution.

For example, the client was able to provide us with a specific location (Walkley Bowling Alley) to base many of our metrics (ie. ramp length) on. The client was very helpful and informative which was key to starting the design and creation process.

In future meetings, we hope to gain more information by digging deeper and asking the client about all the information required, as some information was only presented to us after the initial client meeting (provided by TA's). This will prevent us from the situation that happened during our first client meeting (prepared questions for the client without knowing it was also the user).

[refer to appendix "A" for raw observations from the interview]

- Walkley bowl was the main venue for their trips (Once a month)
- The current solution was very heavy and ineffective (large gap so the caretakers needed to "pop a wheelie")
- User felt scared when going up or down steep slopes
- 60-90 lbs on the back of the wheelchairs (user necessities are in the bag *mandatory*)
- Ideally stored on the wheelchair
- Most users are in wheelchairs
- Year-round, once a month use
- Durability, portability and adjustability
- Ramp will be taken to various terrain (uneven surfaces, muddy and sticky steps)
- 3 stair max

From these notes a table was made ranking the customer's needs (1 being important and 5 being not as important).

Table 1 - Identified Needs

Identified Needs (There is a need for…)	Priority
The ramp is lightweight	1
The ramp is durable and strong	1
The ramp operates properly in all weather conditions	3
The ramp is versatile (can be used for individuals with a variety of disabilities)	4
The ramp can be used up to 3 steps	3
The ramp prevents a gap between the stairs and the end of the ramp	2
The ramp is compact	2
The ramp is stable and secure when in use	1

Product Specification Process

Once the clients needs were prioritized, our group to developed a **Problem Statement**: Participants of the LIFE program are in need of a portable, durable, compact, and lightweight ramp in order to access areas that are otherwise not accessible to people with mobility issues.

After the Problem Statement was developed, our group looked into the market to see what products were currently available. A benchmark was done with three different products.

Figure 1 - Product 1: Silver Spring Single-Fold Wheelchair Ramp

This product seem too short and the weight was not available, however it provided 2’ guard rails, was compact, strong, and even cost effective.
https://www.discountramps.com/handicap_ramp/p/SCG-X/

Figure 2 - Product 2: EZ Access Suitcase Ramp - Signature Series

This next product was longer and held more weight than the first product, however the ramp weight and collapsable size were not available. In addition, the ramp was far more expensive. http://www.adaptivespecialties.com/EZ-Access-suitcase-ramp-signature-series.aspx

Figure 3 - Product 3: Roll-A-Ramp

Finally, the last product was the longest, held the most weight, however, it was 40 pounds in weight and extremely costly https://www.rollaramp.com/wheelchair-scooter-ramps/

All of the products were put into a table and compared. From the metrics available our group determined which attributes of each product satisfied our clients needs and created **Target Specifications** in the figure below.

Table 2: Benchmarking and Target Specification Table

Metric #	Description	Unit	Silver Spring	EZ Access	Roll-A-Ramp	Marginal Values	Ideal Values
1	Length	ft	3′	6′	8′	Min- 4′ Max - 10′	8′
2	Width	in	30″	30.5	30″	Min - 36" Max - 48"	42′
3	Collapsed DImensions	in	Height - 3″ Width - 15"	N/A	N/A	Height 2′ Width 20" Depth 6"	1′x10″x3″
4	Load Capacity	lbs	600 lbs.	800	1000	Min - 800	1000
5	Material(s)	-	Aluminum	Aluminum	Aluminium		
6	Ramp Weight	lbs	N/A	N/A	40	Max - 60	30
7	Stability Features	-	2″ side rails	Un-breakable handles, extruded non-skid tread for superior traction	1 ½″ side rails	Min 1 in side rails	31
8	Adjustable Length	ft	N/A - Accesories can be purchased	N/A	Can remove/add 1ft. panels	Adjustable	Adjusts from 1′-8′
9	Gap between ramp and landing?	-	no	no (self-adjusting bottom transition plate for easy conversion from ramp to ground)	no	no	no
10	Cost	$	79.99	274.98	877.99	100.00	80.00

Initial Conceptual Designs

The **Design Criteria** was determined from Table 1 and the **Target Specifications** finalized our metrics as shown in Figure 4. It was determined that the safety and security of our user should be prioritized (stability, side rails to prevent falling, etc.), followed by portability/use and finally cost.

Mandatory Criteria:

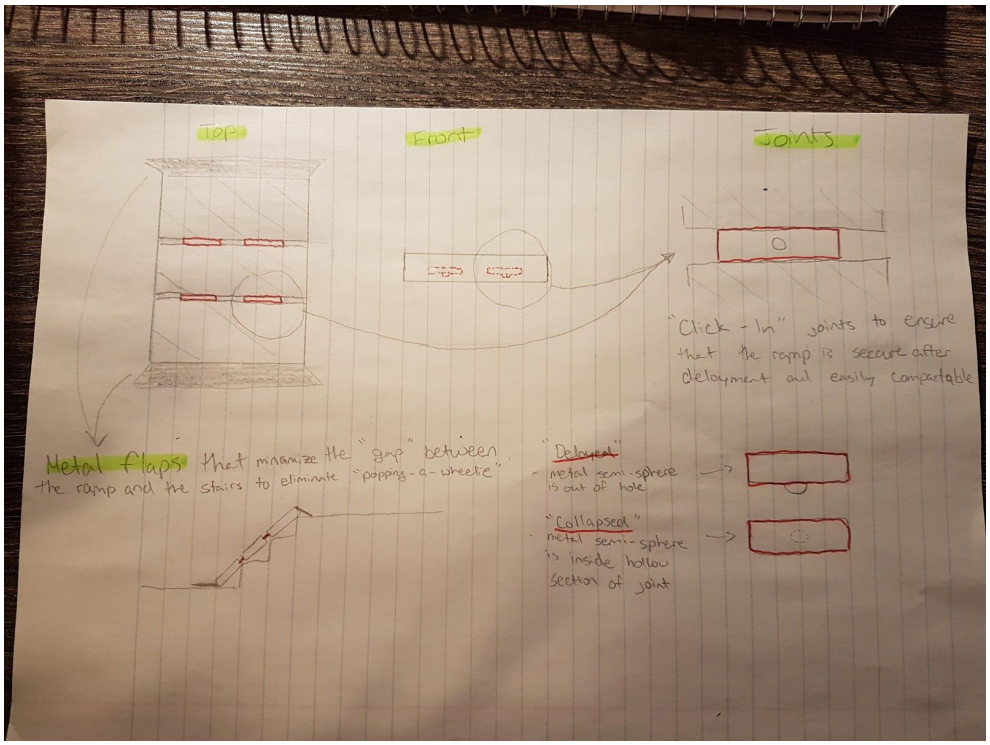
1. The portable ramp must be secure and safe (not shift/slide when in use, 1” side rails, etc.).
2. The portable ramp must support a load of 800 lbs.
3. The portable ramp must not leave a gap between the ramp itself and the landings of the stairs.
4. The portable ramp must be able to function properly in all weather conditions (durable).
5. The portable ramp must weigh a maximum of 60 lbs.
6. The portable ramp must clear at least 3 steps with dimensions;
   (125mm (4-7/8”) to 200mm (7-7/8”) Rise per step)
   (210mm (8-1/4”) to 355mm (14”) Run per step)
7. The portable ramp must collapse to a maximum size of 2’ x 20” x 6”.
8. The portable ramp must not cost more than $100.00.

Optional Criteria:

9. The portable ramp should be between 4’ and 10’ long and 36” and 48” wide when fully extended.
10. The portable ramp should be able to be stored on the back of a wheelchair.
11. The portable ramp should have grip tape

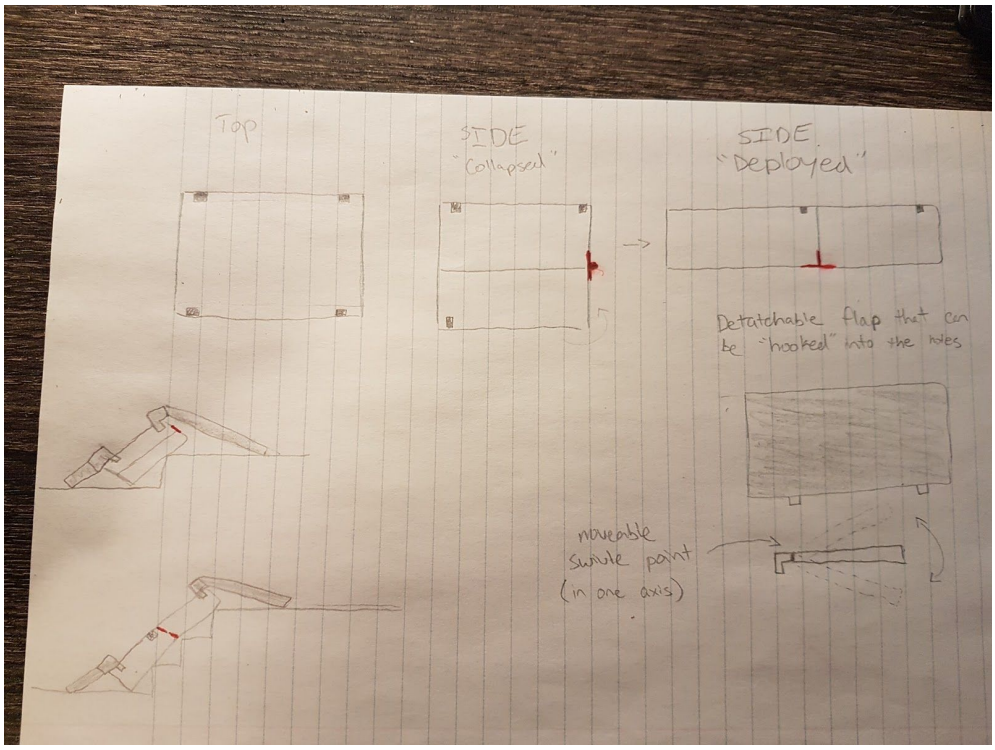
Please Assume All Shown Designs were made with 1’ detachable side rails

Figure 4: Clicking hinges concept design



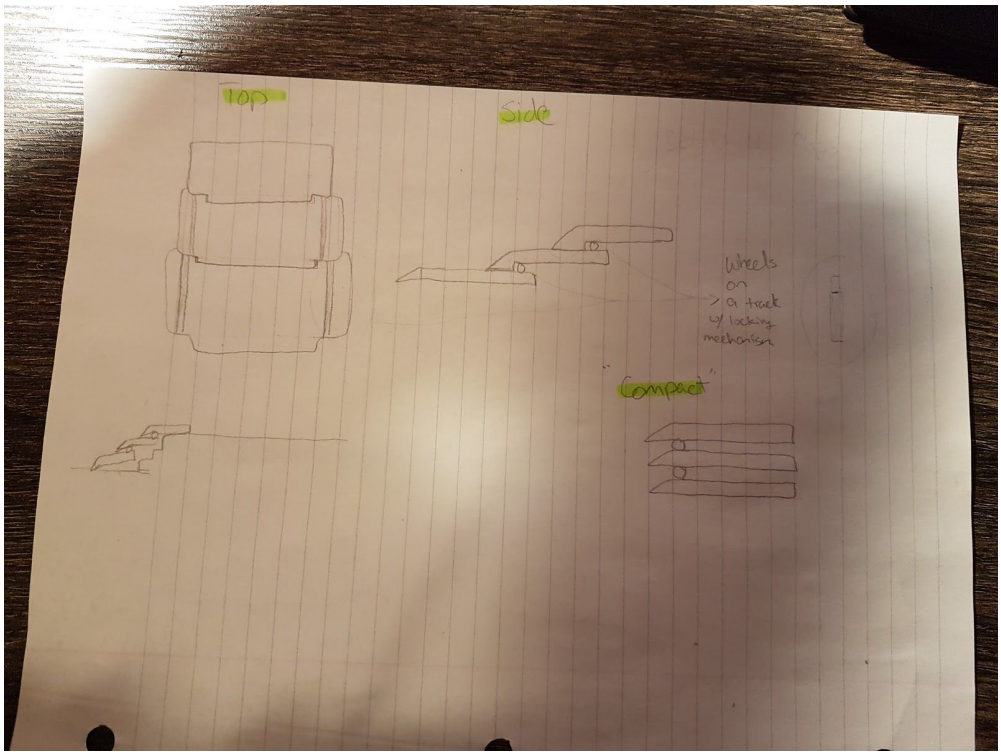
These types of joints allow the ramp to be deployed and collapsed in an efficient time. The joints also provide the ramp with security and stability. The metal flaps would allow the ramp to still be effective despite being too long/steep.

Figure 5: Removable flaps and clicking components concept



This design allows the ramp to be used when not fully deployed. Holes are created so that the detachable flaps can be “hooked” onto the ramp to allow for easy mounting and demounting of the ramp.

Figure 6: Wheel sliding mechanism concept (1)



This final ramp introduced wheels along a track in the ramp with a locking system to prevent the wheels from moving. This allows the ramp to be modified whenever it is being used. In this design, the ramp decreases in width with each section of the ramp to minimize the overall weight of the ramp.

Figure 7: Wheel sliding mechanism concept (2)

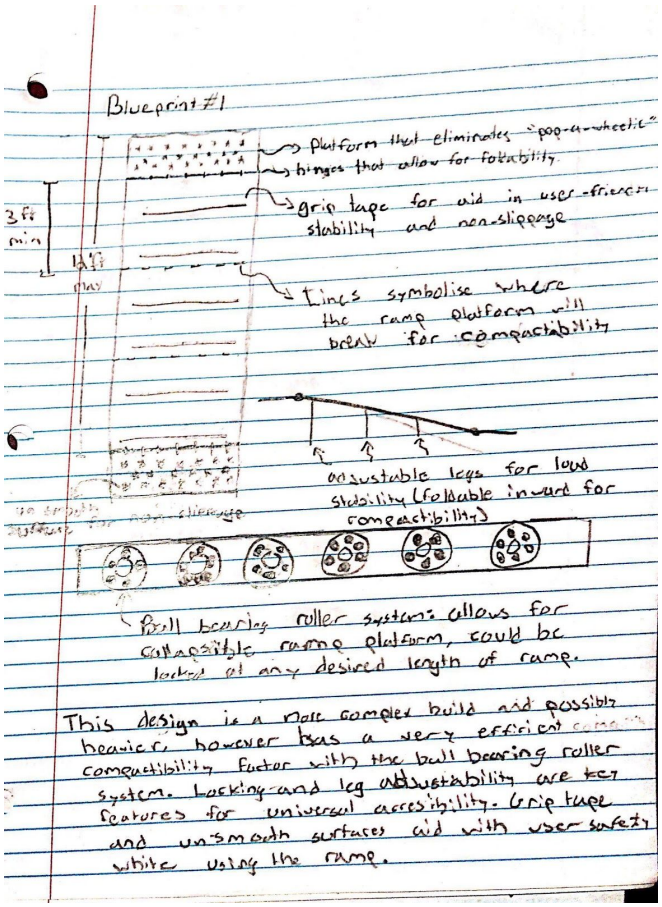


Figure 8: Fold out extension and hinges concept

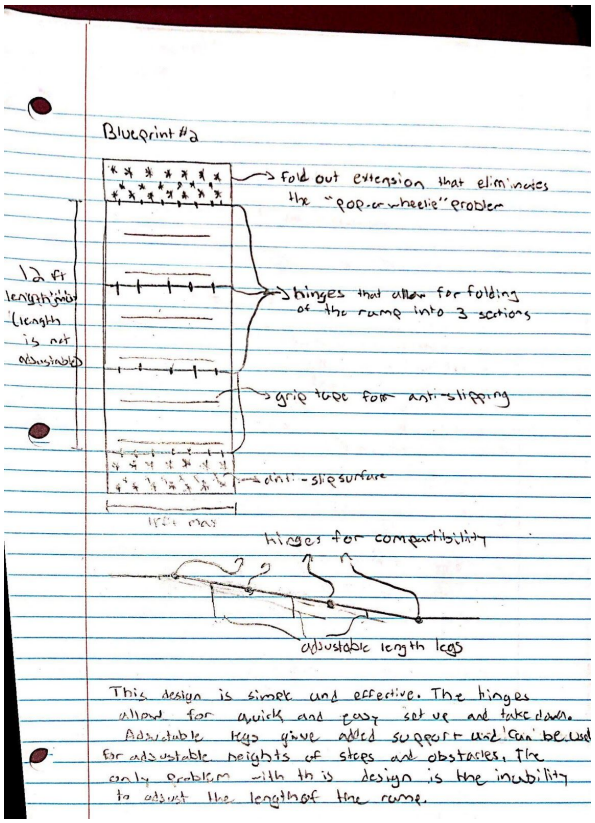
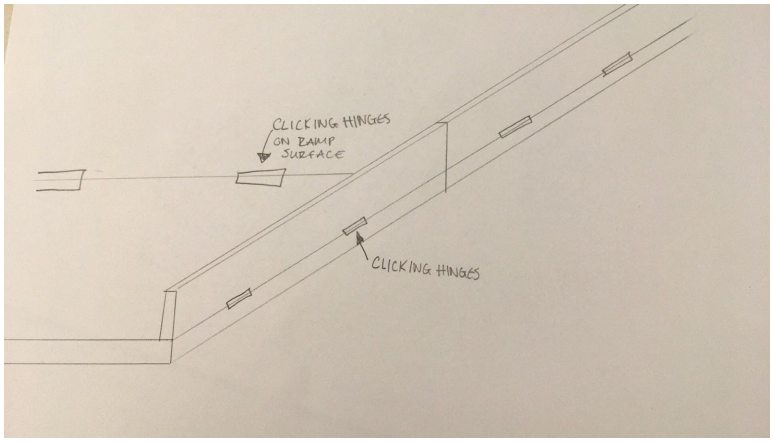
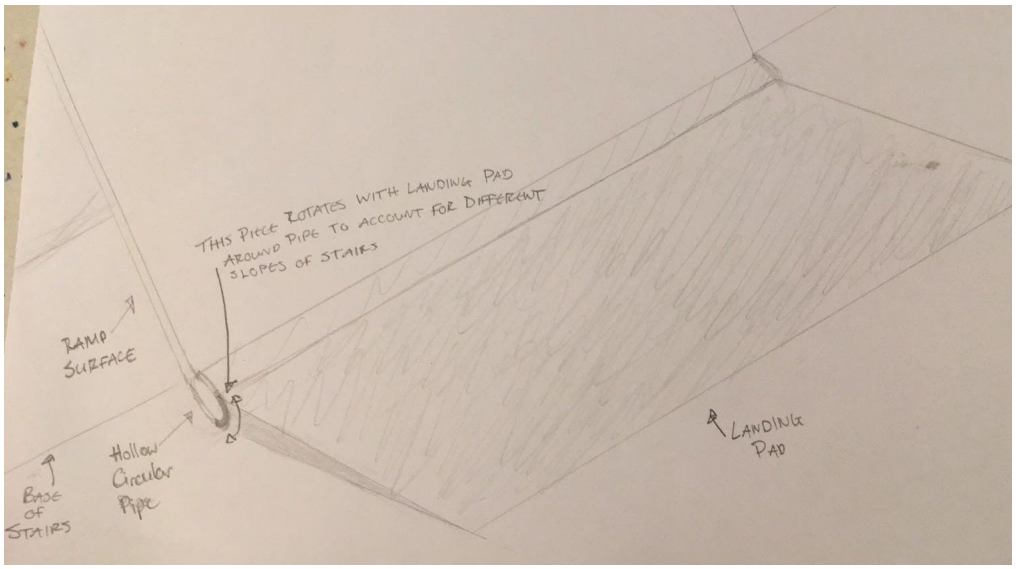


Figure 9: Clicking hinges and side rails



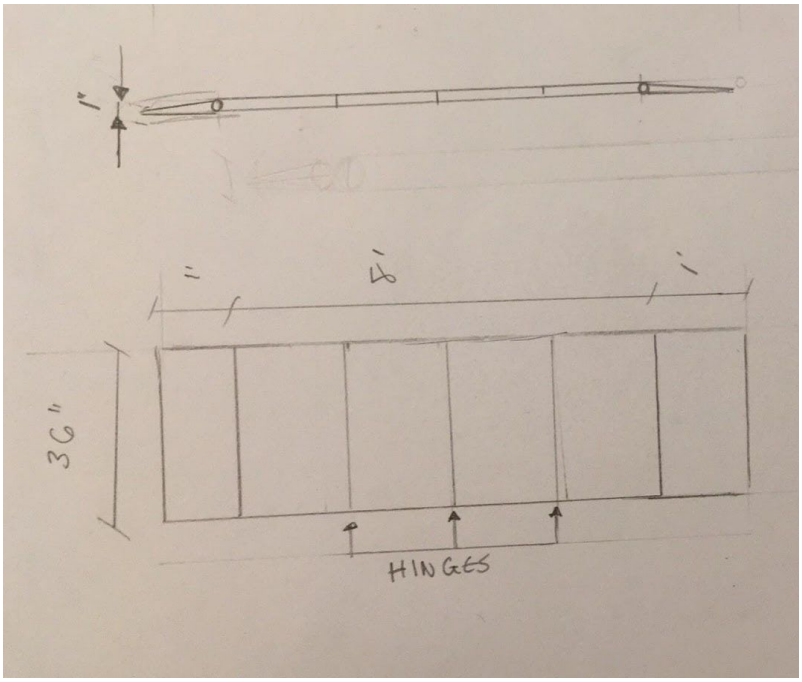
The hinges will separate the main portion of the ramp into 4 sections, which will fold accordion-style into each other. Because the depth of the ramp will be less than 1.5”, this will allow the ramp to fit our side constraints for all dimensions.

Figure 10: Hollow pipe landing pad system concept



To eliminate the wheelchair having to “pop a wheelie” to get onto/off of the ramp, the main portion of the ramp will be locked in place via attachment to a pipe. The landing pad will also be attached, but by a clip. This will allow it to rotate approximately 180 degrees, accounting for a variety of slopes one might need to ascend.

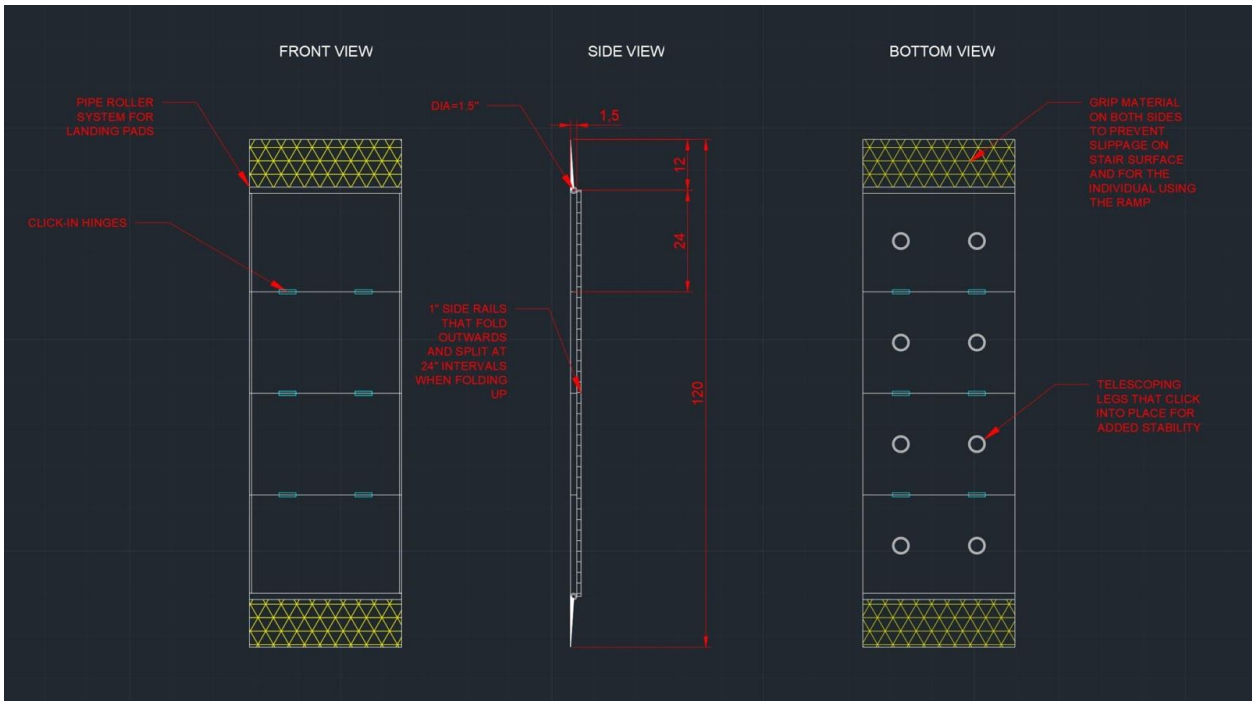
Figure 11: Accordion fold design with dimensions concept



When the ramp folds to compact, the railings will need a way to move out of the way as well, so as not to impede the collapsing. The side rails will be on clicking hinges, which will allow them to

rotate outwards. The rails will also be split at 24” increments, which is the same as the main portion of the ramp.

Figure 12: Initial group concept design



Our initial group design was created by taking the most effective ideas during the individual concept generation and putting them together in a seamless and practical group concept. The major concepts included in our ramp are in relation with our design criteria.

Landing pads are attached to a pipe roller system and can rotate 180 degrees which allows the ramp to be on various angles depending on the dimensions of the steps (Mandatory Criteria #3). Click-in hinges allow the ramp and side rails to collapse accordion style into a light, compact rectangle. They also elongate the ramp to its maximum length (Mandatory Criteria #10 & Optional Criteria #10). Grips on both sides of the landing pads provide stability once the ramp has been deployed (Mandatory Criteria #1 and #11). Telescoping legs at the bottom of the ramp are used for added stability, for bypassing obstacles and adjusting the height of the ramp at various spots (Mandatory Criteria #3, #6, #2 and #1). Finally, side rails that fold during the compaction phase are used so that the user doesn’t roll off the side of the ramp during use (Mandatory Criteria #1 and #7).

Table 3 - Decision Matrix

Criteria	Accordian	Ball bearing	Track
Weight	1	3	2
Strength	1	2	3
Compactable	3	1	2
Functional	1	3	1
Overall	6	9	8

In this figure, the lowest score determines our best design, according to our decision matrix. 1 is the best score in class, 3 is the lowest score.

Project Planning and Feasibility Study

Our team has decided to implement a hybrid Plan-and-Execute and SCRUM method. Because of the specific time constraints on the project (certain parts of the project are due each week), we thought that a linear approach to project task due dates would be necessary, while still being able to maintain an iterative, customer-needs-driven process. Thus, each portion of the project will have a specific due date (as outlined in the Gantt chart and task list below), but the tasks will be organized into sub-sprints. These sub-sprints will allow the process for each phase to be iterative, while the specific timeline for each of the sprints to be completed will be respected.

Figure 13: Project Schedule

	Task Name	Start Date	End Date	Duration	Prede…	% Com…	Status	Assigned To	At Risk	Comments
1	Develop Project Schedule	10/06/18	10/06/18	1d	none	100%	Completed	Mackenzie		
2	Generate Concept Designs	09/28/18	10/08/18	7d	none	80%	In Progress	all		Want to make 4 concept designs
3	Develop CAD drawings of all concept designs	09/30/18	10/08/18	7d	none	50%	In Progress	Mackenzie		
4	Develop budget for concept design	10/05/18	10/08/18	2d	none	20%	In Progress	Ben, Ryan		Can be altered after each re-design
5	Review Concept Designs with Client	10/09/18	10/09/18	1d	2, 3	0%	Not Started	all		Client meeting set for Tuesday
6	Make adjustments to selected concept des	10/10/18	10/10/18	1d	5	0%	Not Started	all		Based on client's comments
7	Order materials for final prototype	10/10/18	10/30/18	15d		0%	Not Started	B Ben		Estimated 2 week delivery
8	Develop CAD drawing and determine functionality of concept design	10/11/18	10/12/18	2d	6	0%	Not Started	Mackenzie		
9	Make first prototype out of basic materials to present to client	10/11/18	10/12/18	2d	6	0%	Not Started	R Ryan		
10	Get feedback on first prototype from client	10/15/18	10/15/18	1d	4, 8, 9	0%	Not Started	all		Meeting date not yet scheduled
11	Make adjustments to concept design	10/16/18	10/17/18	2d	10	0%	Not Started	all		Based on client feedback
12	Conduct numerical modeling on new concept design	10/18/18	10/24/18	5d	11	0%	Not Started	all		
13	Evaluate performance of concept design based on modeling results	10/25/18	10/29/18	3d	12	0%	Not Started	all		
14	Get feedback on modeling from client	10/30/18	10/30/18	1d	13	0%	Not Started	all		Can be via electronic communication
15	Make final adjustments to concept design	10/31/18	11/01/18	2d	14	0%	Not Started	all		Based on client feedback and legal stanc
16	Construct final functional prototype	11/02/18	11/12/18	7d	7, 15	0%	Not Started	all		
17	Test final prototype	11/13/18	11/21/18	7d	16	0%	Not Started	all		
18	Prepare report for design process	09/19/18	11/27/18	50d		25%	In Progress	all		Add findings throughout project duration

Table 4 - Sprint 1

Sprints

Prototype 1		
Task	Role	Responsibilities
8	Mackenzie	Create a technical, visual representation of the product that will provide the client with enough information for the client to visualize the technical aspects of the final product
9	Ryan	Create a tangible representation of the product for the client to determine the functionality of the product
10	Team	Determine whether the porduct meets the client's needs and make adjustments to the design as necessary

Table 5 - Sprint 2

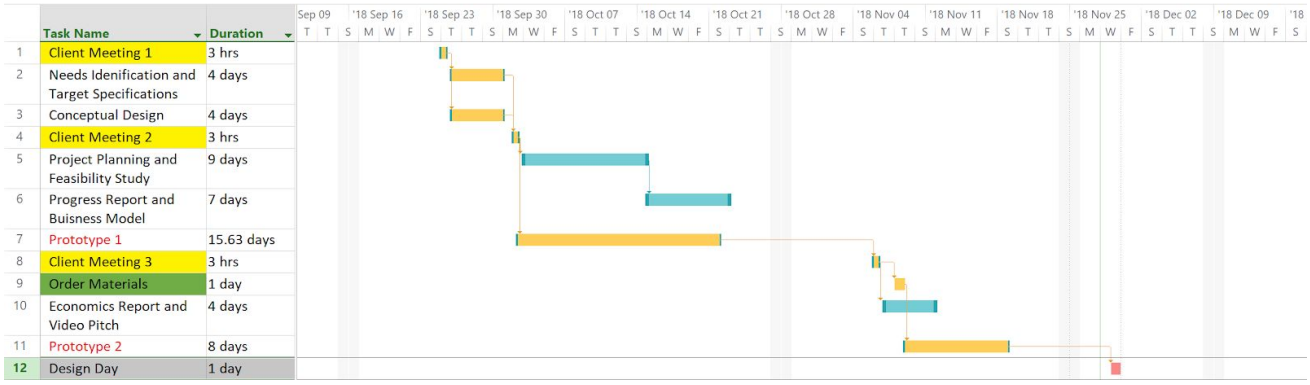
Prototype 2		
Task	Role	Responsibilities
12,13	Team	Create a virtual model of the product that can be tested to determine the safety and practicality of the design
14	Team	Revise the initial concept design to create a revised concept design that fits the design criteria (specified in deliverable C) and is compliant to any regulations/standards.

Table 6 - Sprint 3

Prototype 3		
Task	Role	Responsibilities
15	Team	Build a fully functional physical model that matches the concept design
16	Team	Test the model and make any possible adjustments so that the physical model matches the concept design and design criteria
17	Team	Evaluate the effectiveness of the final design in terms of reaching the design criteria and using the client's feedback. Make suggestions and reccomendations for future attempts at creating a solution

Gantt Chart

Figure 14: Gantt Chart



	Task Name	Duration
1	Client Meeting 1	3 hrs
2	Needs Idenification and Target Specifications	4 days
3	Conceptual Design	4 days
4	Client Meeting 2	3 hrs
5	Project Planning and Feasibility Study	9 days
6	Progress Report and Buisness Model	7 days
7	Prototype 1	15.63 days
8	Client Meeting 3	3 hrs
9	Order Materials	1 day
10	Economics Report and Video Pitch	4 days
11	Prototype 2	8 days
12	Design Day	1 day

Technical Feasibility:

Our team has enough expertise and technical resources, but can still be further developed. Skills learned in the Manufacturing Training Centre, Makerspace lab, and general engineering courses will be implemented to build a tangible product. Resources include all University creative spaces, such as the ones listed above, and these spaces will prove to be more than accommodating for what our group needs to do.

Economic Feasibility:

The cost of the project is within reason. The only overhead are group will experience is cost of materials. With a $100 budget, the materials necessary could be found at many home improvement stores or metal/lumber yards. A quote for actual cost of materials will be made available closer to build time, however our group is certain the budget will be enough to fulfill our needs and make a product that fulfills the clients needs.

Legal Feasibility:

There are no legal issues with releasing our solution to the public. Every idea/iteration of our product was our own and no copyrights or patents are found that restrict us from completing our build.

Operational Feasibility:

Our group organization is very good. We have a detailed and structured project plan that ensures our success. There is no lack of organization or any problems that may have been

looked over in our plan. Our group has curated and developed every necessary measure in order to complete this project in an efficient way.

Scheduling Feasibility:

Our deadlines are developed in such a way that are constantly iterating and improving in between deadlines. With that being said our only deadlines are ones we have imposed regarding presentations of or prototype builds, and official time restraints provided to us from our Project Manager. This system allows for greater innovative design process, but also encourages the idea of having a deadline in order to keep things moving efficiently and not letting the group get sidetracked by staying too focused on one process. Our deadlines for prototypes (Oct. 7, Oct. 14, Nov. 11) are well within reason and picked according to our skills and schedule capabilities. These deadlines will promote an efficient working environment and prove to help us complete a well working and well designed product.

Prototyping and Testing

Testing is done to avoid critical problems down the line, ensure proper functionality, ensure that the user can operate the product and save time and money. The prototypes tested will be low fidelity because it is the first of three prototypes and cost effective materials are being used. There is going to be a qualitative, selective and functional test for the comprehensive design of the ramp (flaps, joints and collapsibility). This will be the first time various attributes of the ramp will be integrated physically. Additionally, the design for supporting the ramp will be tested through a quantitative, selective, functional and focused test.

Test 1 - Comprehensive

Figure 15: Comprehensive prototype - folded

Figure 16: Comprehensive prototype - unfolded

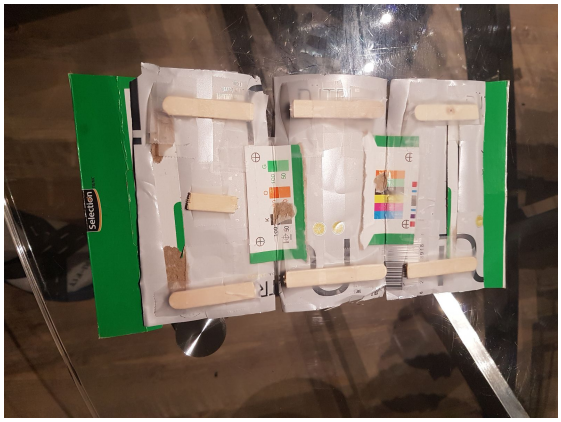
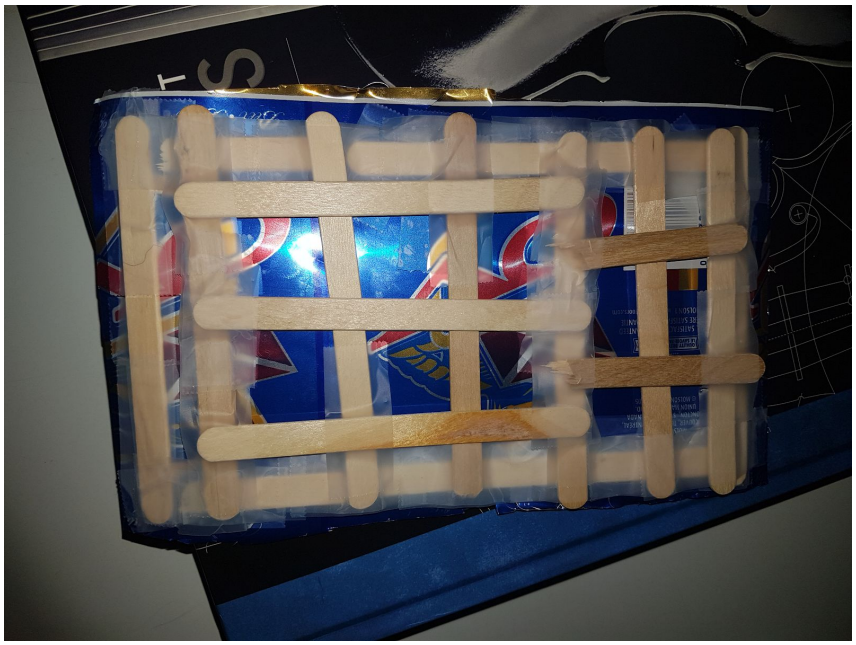


Figure 17: Comprehensive prototype - top view

The context of the images above are as follows: Deployed ramp design with hinges, supports and detachable flaps (top left), front face of that ramp (bottom left), and collapsed ramp with flaps detached (top right).

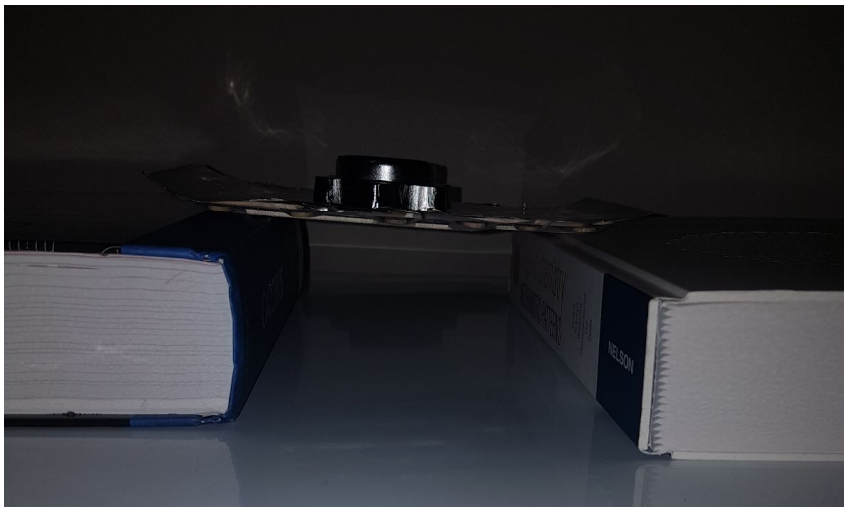
Test 2 - Focused

Figure 18: Ladder pattern prototype



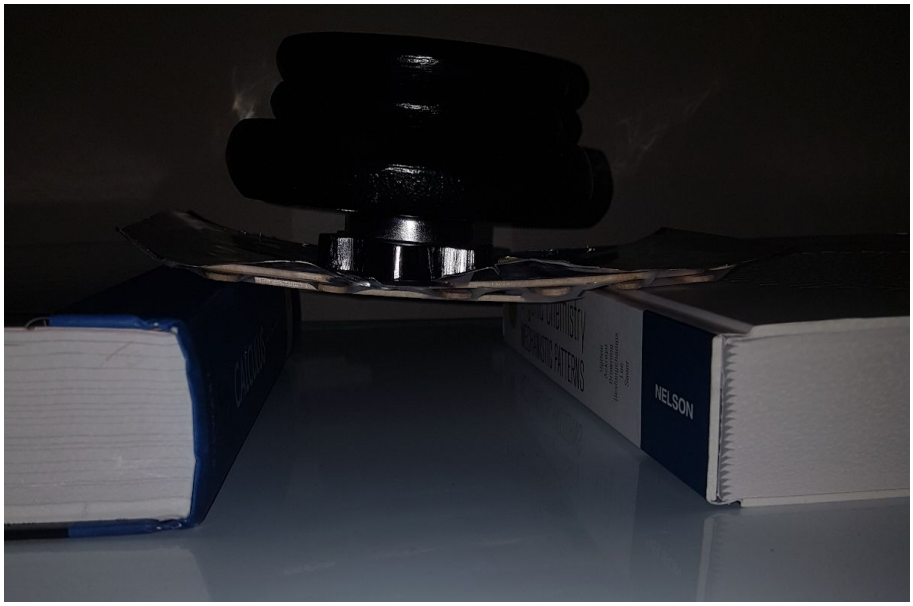
This is the ladder design with a minor hatching pattern for support (before loads are applied).

Figure 19: Ladder - 1.1 lbs load applied



1.1 lbs applied.

Figure 20: Ladder - 6.7 lbs applied



6.7 lbs applied.

Figure 21: Ladder - failure at 12.9 lbs

Failure after 12.9 lbs applied.

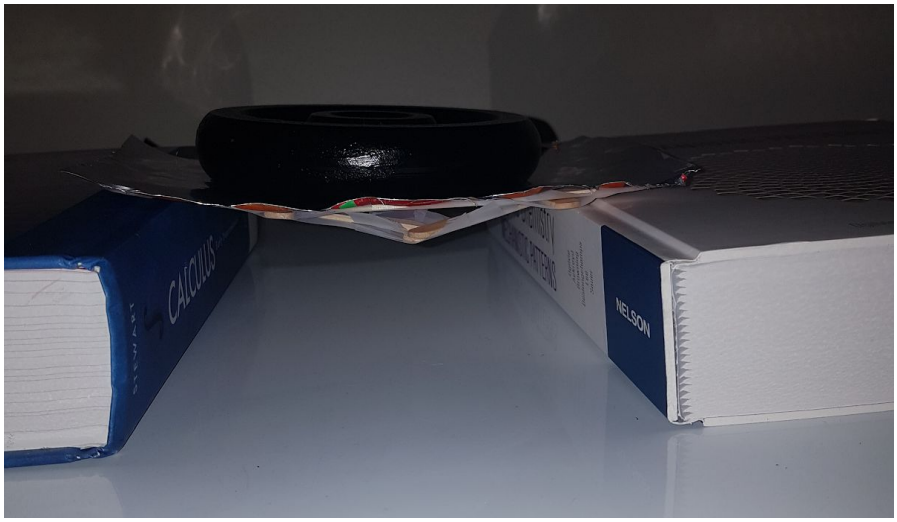
Table 7: Failure mechanisms for each load applied for ladder pattern

Loads Applied (lbs)	**1.1**	**6.7**	**8.9**	**11.2**
Description	No bending occurring	Slight bending	Exaggerated bending with supports fraying	Failure

Figure 22: Diamond - bottom view

Diamond pattern load distribution design, no load applied.

Figure 23: Diamond - 3.4 lbs applied



3.4 lbs applied.

Figure 24: Diamond - 10.1 lbs applied

10.1 lbs applied.

Figure 25

Failure after 13.4 lbs was applied.

Table 8: Failure mechanism after each load applied

Loads Applied (lbs)	**3.4**	**9.7**	**10.1**	**13.4**
Description	Slight bending + frayed support	Further bending but same amount of fraying (supports)	Exaggerated bending with supports fraying further	Failure

Analysis for Initial Concepts

The initial hypotheses for this design were as follows:
Advantages:

- The ramp has any adjustability factors that will allow the user to feel safe when trying to access areas that would otherwise not be accessible.
- The ramp will fit the size constraints desired by the user

Disadvantages:

- The ramp has no immediate solution that withstands ALL weather conditions. The ramp also focuses on adjustability rather than practicality
- The telescoping legs on the bottom of the ramp would only be able to extend in 1” increments and therefore may not provide the desired stability
- A lot of moving parts which could cause failure
- All of the adjustable segments of the ramp could become time consuming for the user

After completing our low fidelity prototypes, it was determined that the initial design was ineffective at solving the problem. Overall the design was non-cohesive, too complex, and very expensive.
In test one, the deploying and collapsing mechanisms were evaluated. To do this, first the prototype was constructed and then folded at the location of the hinges. This folding mechanism was deemed ineffective because instead of folding so that the ramp pieces were flush, the edges of each ramp section butted up against each other. From this test, it was determined that the accordion fold method would not be effective. Also using this prototype, the removable flap system was tested. It was designed with the purpose of eliminating the gap between the ramp and the stair landing. This system worked well as the gap was eliminated, but it was hypothesized that by making the flaps detachable, the slots they attach to could become clogged by mud, salt, and snow. Thus, this method would only be slightly effective.
In test two, several reinforcing mechanisms for the ramp face were tested. After applying loads to two designs, the ladder design with hatched supports was the most effective. Next, the RPN for this pattern, and for the diamond hatch pattern, were calculated to determine how safe each design was:

rpn=s*o*d

RPN (design 2.1) = 9 * 4 * 9 = 324

RPN (design 2.2) = 8 * 3 * 9 = 216

The values for the RPN of design 2.1 were given as follows:

Severity of Failure: A 9 was given in this category because if a failure were to occur while the design was being utilized the user would be put in an unsafe situation immediately. With failure, this design also does not function properly. However, the design gives brief warning before total failure because of slight cracking in certain support areas. This would allow the user to stop utilizing the device before safety becomes a concern.

Occurrence of Failure: A 4 was given in this category because the design is commonly used in many platform scenarios with relatively low failures at heavy loads.

Detection of Failure: A 9 was given in this category because our design falls in the type 1 control umbrella. The only thing preventing failure or reducing the rate of failure is the way that our design was built and ideated.

The values for the RPN of design 2.2 were given as follows:

Severity of Failure: An 8 was given in this category because our design places the user in an unsafe scenario is failure were to occur. The design loses much of its primary function but can still work to some degree. The design has minimal warnings, but minor cracks can be heard before total failure occurs and the user can remove themselves before and unsafe scenario happens.

Occurrence of Failure: A 3 was given in this category because our design used a method that is made to support heavy loads for a long period of time. The design evenly distributed weights allowing for relatively low failure rates.

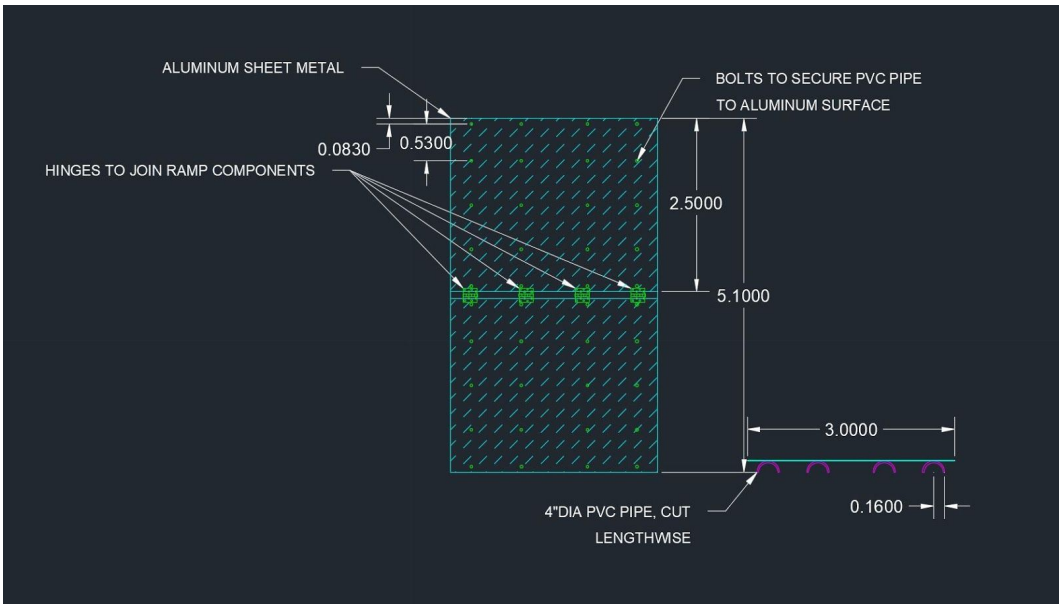
Detection of Failure: A 9 was given in this category because our design again falls in the type 1 control detection umbrella. The only thing preventing or reducing the rate of failure is how the design is ideated and built.

Another issue with this concept design was the associated cost. Many materials were researched for the ramp face, such as aluminum, that would be strong enough to support the target load of 700 lbs, be light enough to make the total weight of the ramp less than 20 lbs, and be within a $100 budget.

For all of the above reasons, it was decided that a new design would need to be conceptualized.

Revised Conceptual Design

Figure 26 - Revised conceptual design



After the analysis of our initial design, it was determined that there were too many moving parts and we needed to change our concept design. The figure above shows our revised concept design. Since this was the first time the client was seeing the revised design they had a lot of feedback for us.

First, they thought the new design would be too big to put on the back of the wheelchair, and should have a carrying strap for the individual accompanying the individual in the wheelchair. Additionally, the client noted that we should prioritize the weight of the ramp more now than before, as a person would have to carry it, potentially for long distances.

Despite these hesitations, the client loved the new idea and are very excited going forward. We weighed out the pros and cons of our new design to them. Our client really liked the fact that our new design would be lighter weight and more durable. Using PVC piping instead of wood, the weight drastically decreases, and durability of materials increase. The new design is also more convenient for our client in universal temperatures and environments; PVC can be exposed to more environments than wood can. With the weight of the ramp being of utmost priority, the client was especially pleased to hear that a solution to the heaviness of wood and lumber can be decrease

Analysis for Revised Conceptual Design

Prototype 2

Our second prototype is used to gather data. We are creating a functional prototype in order to test different aspects of our design such as functionality, mobility, deployment times, weight it can withstand, etc. This prototype should ideally be an accurate representation of our final product in order to properly illustrate how the tested values on our prototype 2 translate to the final product. We are going to create a working prototype and test it.

Table 9: New Estimated Bill of Materials

Item Number	**Materials Required**	**Part Name**	**Description**	**Purpose**	**Estimated Cost (Cost*Quantity)**	**Reference**
1	Metal	Face of Ramp	Sheet of metal that will be attached to the PVC pipe base	To connect the base of the ramp together and provide a surface to maneuver on	$0	Scavenged
2	PVC Pipe	Ramp face supports	Schedule 40 PVC 4 Inch Diameter	To provide stability and strength to the face of the ramp.	2 pieces *($16/ea)= $32	https://www.homedepot.ca/en/home/p.pvc-12-inches-x-10-ft-schedule-40-plain-end-pipe.1000100828.html
3	Misc.	Binding elements	16 Gauge metal Industry grade zinc coated	To connect the face of the ramp and the PVC supports.	$37	Home hardware, no website link.

Prototype II

The prototype was built with diamond sheet metal, nuts, bolts and (4-inch diameter) PVC pipes (2.5 ft long). The PVC pipes were cut vertically, down the center of the pipe, using a bandsaw. Then, with a ¼ inch drill bit, our team used a hand drill and a drill press to drill holes into the PVC pipes and the diamond sheets. Finally, the pipes were attached the bottom of the diamond sheets with the nuts and bolts.

Upon completion of assembly, our ramp looked exactly like we intended it to look like, and followed our design goal effectively. For this prototype, a big concern for us was whether or not our design would hold up to the strength test. Our design needed to hold approximately 400 pounds. After building and testing, our prototype was comfortably able to hold up to 735 pounds without any sign of design failure. The prototype was further tested under a wheelchair, and again with a person sitting in a wheelchair. This ensures that our design will work with exact specifications that were given to us by our client. The ramp is portable, and it will have solutions in place that will ensure that transportation is simple and effective. Our ramp boasts a simple design that can be easily put together, which is exactly what our client needs.

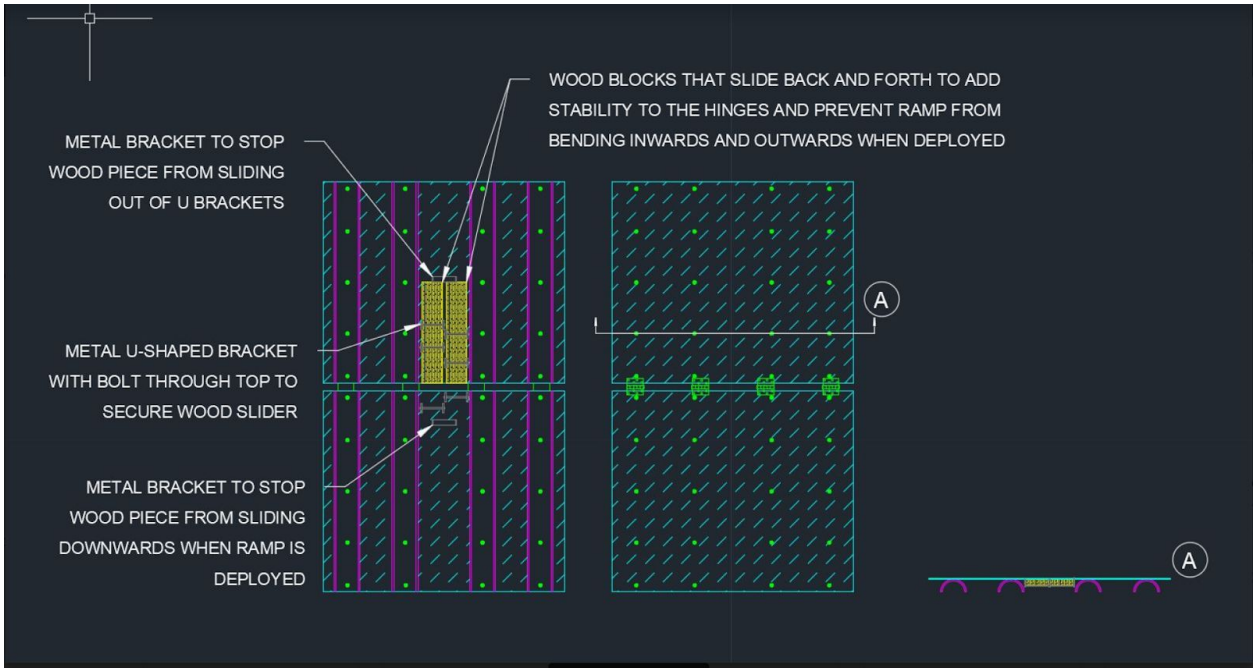
We are under budget for this project. The PVC necessary for the build cost $40, and the hardware (ie. nuts and bolts) cost $37. This leaves us with $23 remaining, which will be used in final details for the ramp such as grip tape for extra safety factors. Our diamond plate was obtained from the university, and therefore free for our budget. However, the diamond plate that we received was estimated at approximately $46. This is of course an approximate value, since the university did not place a monetary value on the piece of metal that they gave us, but the estimate was evaluated using prices found on the Home Depot website.

Figure 27 - Prototype 2 Tested (1 of 2)

Figure 28 - Prototype 2 Tested (2 of 2)

Final Product + Analysis

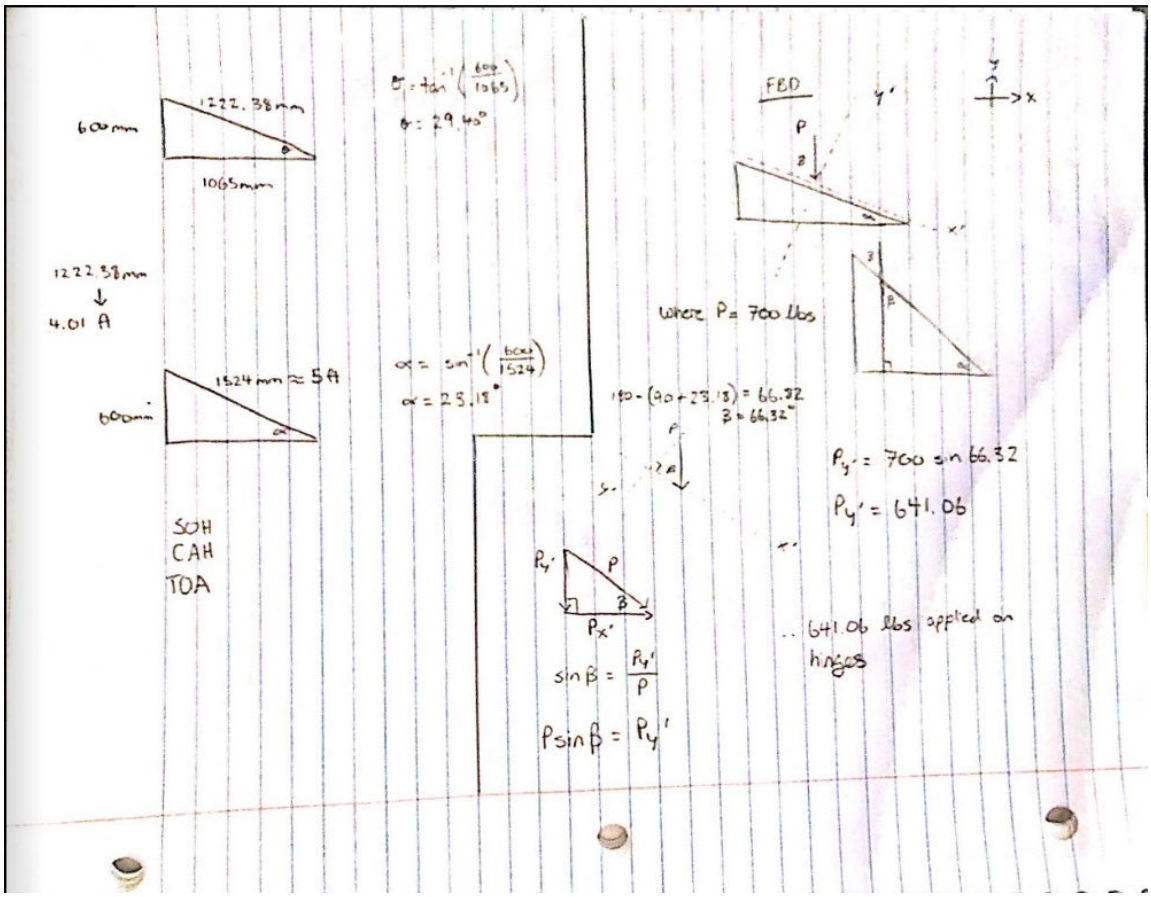
Figure 29 - Final concept design



Figureadawdda shows our groups final design. After the analysis of Prototype 2, there was a flaw in our design when connecting the two ramp faces via hinge. To determine how much load would be applied to the hinges, a calculation was done using pythagorean theorem and a Free body diagram as shown in figure 30

It shows the minimum angle (30 degrees) and ramp length (4 ft) required when the maximum step dimensions are used (from the design criteria). Then using the maximum stair rise and our determined ramp length of 5 ft, the new angle on incline (23 degrees) was calculated and the applied load on the hinges

Figure 30 - Angle and Load bearing Calculation



After the calculation determined the load on the hinges were 641 lbs, it was obvious that hinges alone could not withstand such a lot. Thus a wood-block sliding system needed to be implemented in order to support the hinges. Figures 31 and 32 shows our final product with the newly implemented wood-block sliding design. This was then tested by two of our group members and a wheelchair being pushed up 3 steps.

Figure 31: Final product deployed

Figure 32 - Final Product undeployed

Below is our final bill of materials

Table 10: Final Bill of Materials

Item Number	**Materials Required**	**Part Name**	**Description**	**Purpose**	**Estimated Cost (Cost*Quantity)**	**Reference**
1	Metal	Face of Ramp	Sheet of metal that will be attached to the PVC pipe base	To connect the base of the ramp together and provide a	$0	Scavenged

				surface to maneuver on		
2	Metal	Metal Brackets	U - Shaped metal brackets that attach to the bottom of the platform	Create a rail system that allow for wood blocks to slide into desired positions for increased platform strength	8 * $4.56= $36	Home Depot
3	Wood	Hinge Reinforcement	Wood blocks to increase strength	Added support under the hinges to resist bowing	$0	Scavenged
4	PVC Pipe	Ramp face supports	Schedule 40 PVC 4 Inch Diameter	To provide stability and strength to the face of the ramp.	2 pieces *($16/ea) =$32	https://www.homedepot.ca/en/home/p.pvc-12-inches-x-10-ft-schedule-40-plain-end-pipe.1000100828.html
5	Misc.	Binding elements	16 Gauge metal Industry grade zinc coated	To connect the face of the ramp and the PVC supports.	$37	Home hardware, no website link.

Business Model

Business Model Selection

Our group has elected to use a “bricks and clicks” business model to make a profit off of our portable wheelchair ramp. In this customer-driven business model, the product is sold by both virtual (online) and physical locations. This gives customers the freedom to choose how they want to learn about and purchase our ramp. We have identified older members of the population, for example the baby boomers, as one of our largest target markets, since this population is growing older and has a growing need for products that solve accessibility issues. Members of this generation tend to prefer a face-to-face approach to sales, and really value personal connections. However, younger generations tend to favour the convenience of online shopping. In selecting a business model that accommodates all generations, we will be significantly increasing our potential market, theoretically increasing our revenue.

Business Model Canvas

Value Proposition

- Our company will address mobility/accessibility issues by providing individuals with a way of traversing uneven ground, stairs, and other otherwise inaccessible terrains.
- Our products will be portable and durable, and have low weight-to-length ratios.
- A low-cost solution is a high priority.
- Our customers will love us because we provide solutions that will solve problems that our customers face on a daily basis.
- By providing solutions for our customers, we establish a connection of trust and kinship, and that is what is needed to make our customers love us and trust us.

Customer Segments

- We wish to reach and serve:
    - Clients with mobility issues
    - Employers that may have employees and substituents with mobility issues working for them.
    - Establishments that help people with mobility issues. ie. LIFE Program.
- We wish to create value for:
    - Clients with mobility issues
    - Companies that aid people who have mobility issues.
    - Establishments that have relations of any sorts with people who may have mobility issues.

Customer Relationships

- Individuals with mobility issues
    - Contact them about products, provide them with a way to buy/ask questions about the products, give them access to support staff to troubleshoot problems with our products
    - Clients with mobility issues are essential to the success of the business - they are the ones who will ultimately be using the ramps so it is important to impress them
    - They will be reached through the channels outlined below
- LIFE Program (and other similar programs)
    - Contact them about products, provide them with a way to buy/ask questions about the products, give them access to support staff to troubleshoot problems with our products, provide staff at these programs with a product that is easy to work with/assemble and transport
    - These programs are very important as they will not only purchase this product for their own use, but they can also help us network to other potential customers (individuals with mobility issues)
    - They will be reached through the channels outlined below as well
- Owners of businesses with physical locations
    - Contact them about products, provide them with a way to buy/ask questions about the products, give them access to support staff to troubleshoot problems with our products, provide them with a product that is easily stored and maneuvered
    - This is a much less critical customer, as this product is not a necessity for them. However, many inaccessible locations would benefit from having this product.
    - They will be reached through the channels

Channels

- Virtual Location (website)
    - Easily accessible
    - Preferable to a physical location for many members of younger generations
    - Gives potential customers a way to view and access information about our ramps
    - Cheaper than a physical location
    - Can be accessed at any time at any location (where there is internet service)
- Physical Location (store)
    - Provides clients with a more personal way of learning about or purchasing the ramp
    - Preferable to a website to many members or aging generations
    - Allows customers to ask complex questions about our products that could not otherwise be answered by a website
    - This is a more expensive means of selling the product because of the cost to rent a building, use electricity, hire staff, and more
- Advertisements
    - Get our company values and product features across to customers

    - Could be perceived as an annoyance if not well thought-out
    - Depending on the medium this could be very expensive
    - This would reach customers on a daily basis, while they are going about their daily routines
- Shipping companies
    - Necessary if we are to have a web domain
    - More convenient for customers than in-store pickup, but is more expensive (for either us or the customer)

Revenue Streams

- Customers are currently looking for a durable, effective, and cost-efficient solution to a variety of accessibility issues
- Current solutions are between $60 and $300, but do not meet all of the criteria outlined by potential customers
- We will make money by selling customers our product to individuals or companies through virtual and physical locations, and we will set the pricing based on the cost of the materials used to make it and the time and outside resources, with a marginal profit

Key Partners

- Key supporters
    - Companies that work with individuals with accessibility issues - can network with their own clients to let them know about our product
    - Could partner with companies that make/design wheelchairs to make our products compatible
- Key suppliers
    - Building supply stores - provide materials to make the ramps
    - Shipping companies - provide us with a service to deliver the ramps from our warehouses to customers and our stores
    - Marketing specialists/companies - provide us with strategies to reach our customers and execute these strategies
    - Manufacturing companies - produce our product
    - Lawyers - help certify our product, get patents, help with other legal issues

Key Activities

- Users will be able to access locations that would otherwise be inaccessible
- Suppliers will help us create our physical product and deliver it to the users, as well as making the users aware of our product
- Our key supporters will help us further improve the design of our product and connect us with those that may also be helpful

Key Resources

- We will need a strong customer base to back our product and network to others
- Strong connections and communication with partners and suppliers will be a critical component of the function of our business, as we will be relying on them to advise, produce, and deliver our product

Cost Structure

- The most important cost associated with our product will be the materials required to make the ramp
    - The most expensive material will be the metal (most likely aluminium), and this price could also fluctuate for the worse in the early stages of the startup as metal prices are not the most stable
- Another critical cost would be wages for employees
    - IT staff (ie. website maintenance)
    - Salespeople
    - Support staff (ie. customer help line)
- The cost of our suppliers' services will also be important to consider
    - If the business was to encounter legal issues, a lawyer would need to be hired, which would be quite expensive

Economic Analysis

Figure 33 - Economic Analysis

#	Description	Fixed/Variable	Direct/Indirect	Cost	Unit	Quantity per Year (est)	Total			First Year	Second Year	Third Year
1	Raw Materials	V	D	$75	per ramp	19000	$1,425,000			$75,000	$375,000	$1,875,000
2	Ramp Building Labour	F	D	$16	per hour	19000	$304,000			$16,000	$80,000	$1,875,000
3	Factory Space	F	I?	$80,000	per factory	0.1	$8,000			$80,000	0	0
4	Product Shipping	V	I?	$20	per ramp shipped	10000	$200,000			$20,000	100000	$500,000
5	Product Storage Warehouse	F	I	$20,000	per 100m^2	0.1	$2,000			20000	0	0
6	Retail Location	F	I	$36,000	per store per year	5	$180,000			0	36000	0
7	Salespeople	F	I	$16	per hour	26000	$416,000			$0	$332,800	$665,600
8	Advertisement	V	I	$70,000	per year	1	$70,000			$70,000	$70,000	$70,000
9	Web Domain	F	I	$15	per year	1	$15			$15	$15	$15
10	Website Maintenance	F	I	$600	per year	1	$600			$600	$600	$600
11	Administrative Staff	V	I	$20	per hour	41600	$832,000			$832,000	$832,000	$832,000
						Cost per Year*	$3,437,615		Total Cost	$1,113,615	$1,826,415	$5,818,215
						Income	$3,800,000		Income	$250,000	1250000	6250000
						Revenue	$362,385		Revenue	-$863,615	-$576,415	$431,785
									Net Revenue	-$863,615	-$1,440,030	-$1,008,245
						*assume year 5, 10 year payment plan for buildings						

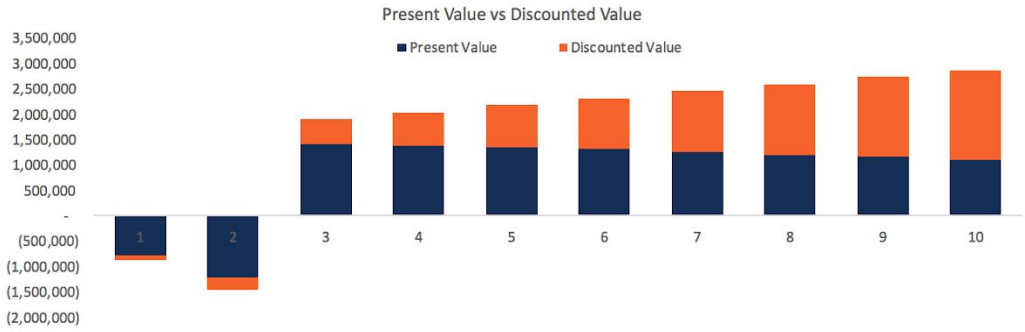
Pictured is a table of associated cost and a three year business outlook if we were to bring our product to market.

Figure 34: Final Budget

This is our product's budget analysis, as shown we did go over budget, but only because we chose high quality materials for our build.

Figure 35: Future value

Net Present Value										
Discount Rate	**10.0%**									
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Discount Factor	0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39
Undiscounted Cash Flow	(863,615)	(1,440,030)	1,906,785	2,045,785	2,184,785	2,323,785	2,462,785	2,601,785	2,740,785	2,879,785
Present Value	(785,105)	(1,190,107)	1,432,596	1,397,299	1,356,580	1,311,716	1,263,798	1,213,752	1,162,360	1,110,282
Net Present Value	**8,273,170**									
Discounted Value	(78,510)	(249,923)	474,189	648,486	828,205	1,012,069	1,198,987	1,388,033	1,578,425	1,769,503



$$\text{Break Even Point in Units} = \frac{\text{Fixed Costs}}{\text{Sales Price per Unit - Variable Cost per Unit}}$$

Break Even Point (Units) = $910,605 / ($250 - $75) = 5204

$$\text{Break Even Point in Dollars} = \text{Sales Price per Unit x Break Even Point in Units}$$

Break Even Point ($) = $250 * 5204 = $1,300,879

Pictured above is our projected net present value and a 10 year evaluation. Also pictured above is our break-even points calculated using our “sales” price.

User Manual

Let this section provide as a user manual outlining every detail of our project that is relevant to the users health, safety, and general utilization of the product.

Key Features:

The ELEVATE portable ramp can hold up to 750 lbs across its platform. It features a hinge system that allows for collapsibility, storability, and portability. In order to increase strength across the hinges, a sliding block system creates a bridge on the underside of the top face of the platform that supports the load that the hinges must take. The ramp is constructed of high strength PVC piping, Aluminum diamond plate alloy, and 16 gauge fastening nuts and bolts.

Functions and capabilities:

As previously stated, the ELEVATE portable ramp can hold 750 lbs. It is 5 feet in length, 3 inches thick, and 3 feet wide. It is capable of folding into a rectangle half of its length (2.5 feet long x 3 feet wide). The ramp is able to traverse 3 steps, or 21 inches in rise. At that rise, the ramp functions at a comfortable 20 degree incline, however a greater rise can be traversed at the cost of a less comfortable angle of incline.

Installation:

The ELEVATE portable ramp can be implemented and installed anywhere.

1. Ensure environment in well suited for ramp use. Ie. place on even surface and incline of no more than 21 inches for best effect.
2. Deploy ramp from collapsed position.
3. Slide wood blocks in place, forming the bridge under the hinges and connecting the two pieces.
4. Position ramp in such way that the “Up” panel is elevated, and the “Down” panel is touching even ground.
5. Use ramp in safe way and as directed. Proceed in straight line in swift motion up the platform up the platform. Using the ramp in an unsafe way (ie. jumping, swerving) could result in injury.

Collapsing:

1. Slide the wood blocks into “stow-away” position.
2. Fold ramp into collapsed position.

Maintenance:

The ramp is low maintenance. If used in wet conditions, dry the ramp to ensure no rust gets built up between the alloy and the fasteners. If used in muddy conditions, wash ramp to remove mud from platform with a moist cloth. If a piece of PVC breaks, stop use. Obtain a new piece of PVC from the spares provided, unfasten the bolts connecting the platform and the broken PVC, refasten the new piece of PVC and continue use as directed. If a wood block breaks, stop use immediately. Unfasten the stopper put in place behind the wood, slide out the broken pieces and put a new piece of wood in its place, refasten the stopper and continue use.

Safety Guidelines and Precautions:

If any mechanism on ramp breaks, stop use immediately and refer to maintenance section for troubleshooting directions. Do not use the ramp in an unsafe manner. This means any jumping, swerving or any other unsafe use could result in injury to the user or people around the device. Only use the ramp as directed (ie. in a swift fashion up the platform of the ramp). The ramp can hold 750 lbs, any load greater than that could result in the ramp's failure and/or injury to the user. If failure and injury occurs, seek first aid help.

Troubleshooting:

Refer to maintenance section. If there are any questions, call 289-686-2794 or email elevaterampgroup@gmail.com.

Conclusions and Recommendations for Future Work

In conclusion, our build was a success and we completed a tangible product that could be marketed and produced for consumer retail. We learned that time management is the key to success. Unfortunately we learned this too late, and our build was very stressful near the end of the deadline. We also learned to gather and research on all of the information that our client provided us. Walkley bowl was, in reality, not at all like the client described and we built a product that was too universal for the problem described to us. This means that our ramp was ideated with a three step incline in mind, however the client only needs this solution to a problem that does not require such a large and versatile build. With that being said, there are further developments that could be made to improve our teams design. These developments include: side rails for added safety, grip tape for added traction, a flap that eliminates the gap from the platform to the environment, and a lighter way to support the necessary load. If these can be done in the future, then this ramp can truly be iterated to an outstanding product that can be possibly turned into a profit.

References

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