THOMPSON RIVERS UNIVERSITY

ENGR 1100 - Engineering Design I

Portable Ramp

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1 Introduction

To begin with our ramp design, we came up with many ideas on how to create a reliable, portable, and foldable ramp that complies with the project requirements and constraints. Most of the designs that we built were miniature prototype versions of the product made from cardboard. These prototypes were then tested to see if they were able to remain intact by using small weights. Once we found our final design, we built a 1:1 scale version of it, where we then did all the necessary tests to ensure that they fit the project requirements and constraints.

Among the most important ideas, portable ramps should allow the user to use the product to climb over curbs, access buildings, and to enter vehicles with ease. Users with a range of mobility problems use different types of wheelchairs to be able to move around freely so that they can go anywhere they want. However, when the user comes to a curb or a small obstruction, it blocks the user from accessing places that they need to go. This can be solved in a couple of ways such as having a caretaker, who transfers the user around places by either lifting the user over a curb or by carrying the user into a vehicle. A better option is to have a portable wheelchair ramp. Portable wheelchair ramps are cost-effective solutions where the user will be able to use the ramp by themselves, allowing them to overcome curbs, accessing buildings and many other transportation systems [1].

Throughout this report, we will discuss our problem when designing this ramp and our solution that we came up with to overcome this problem. We will also discuss the other solutions that we did not use, features that are used in all solutions, and the limitations to our designs. Additionally, the environmental, societal, safety and economic considerations are some other key factors that will be discussed in the report.

2 Design Problem

2.1 Problem Definition

We know that one of the leading causes of disability in community-dwelling Canadians is mobility impairments, whether permanent or temporary [5]. We also know that despite the increase of spaces accessible to disabled people, there are plenty of buildings and vehicles old enough not to have any ramp or possibility to implement one. That is the problem we are trying to solve by designing and constructing a portable, lightweight and easy to use ramp.

2.2 Design Requirements

This design has to follow some specifications to offer a durable and quality product for the lowest price. Some of the features, objectives, and constraints are subsequently listed.

2.2.1

2.2.2 Functions

- Adjust height for different situations
- Able to be built easily and very lightweight
- Used by different types of users with different needs

2.2.3 Objectives

- Cheap and accessible for everyone
- Robust design capable of being used outdoors
- Simple and practical design that works for most people

2.2.4 Constraints

- Capable of sustaining at least 10 kg
- Easy to carry weighting less than 1 kg
- Length of less than 100 cm adding to portability
- Total cost of production of less than $15

3 Solution

3.1 Solution 1

Our first approach was to have a simple, lightweight and portable design. We found out that we could just cut open a box, do some extra cuts and put some steps to hold the ramp from different angles since we are making a design with the ability to vary heights.

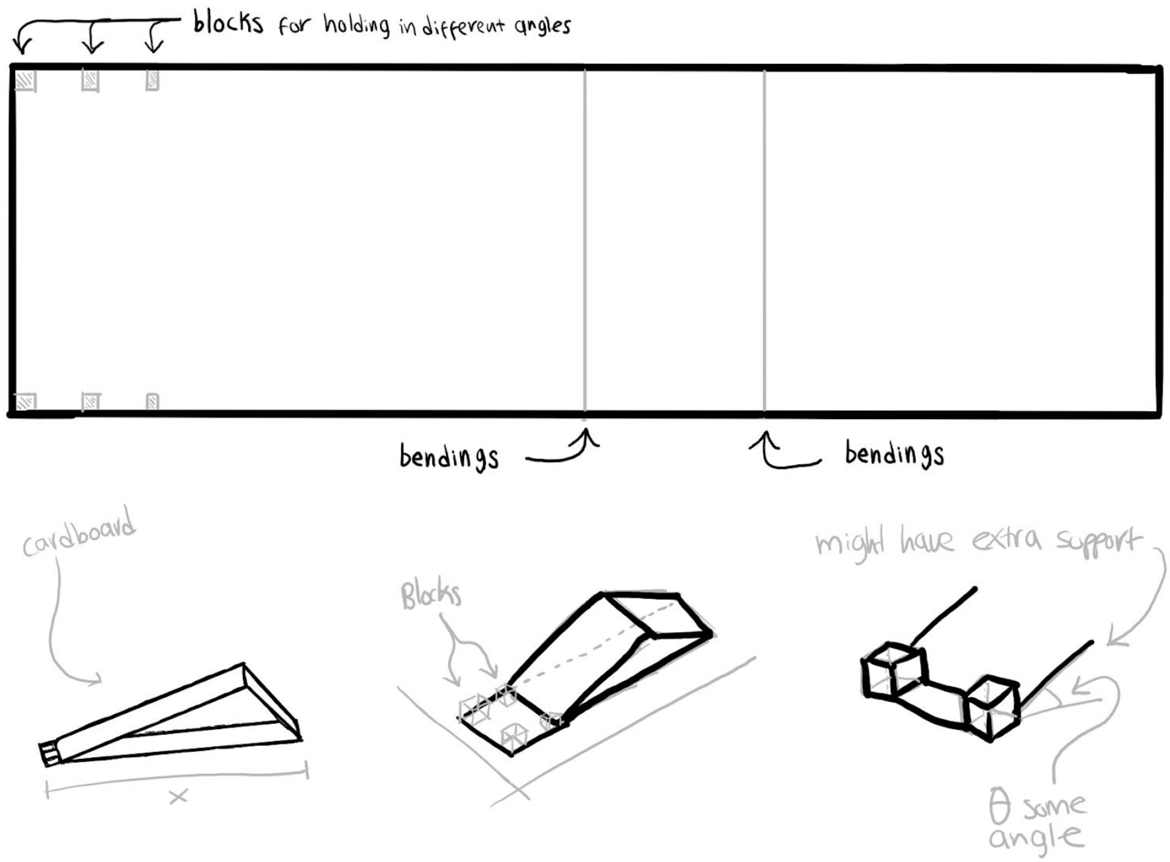


Figure 3.1.1: Rough sketch of our 1st design with components.

We can look at (Figure 3.1.1) and observe the design's overall simplicity. Some of the pros were the minimal effort needed to build the product and the ramp's portability once built since we can fold it very quickly. However, we found that the design had some flaws too.

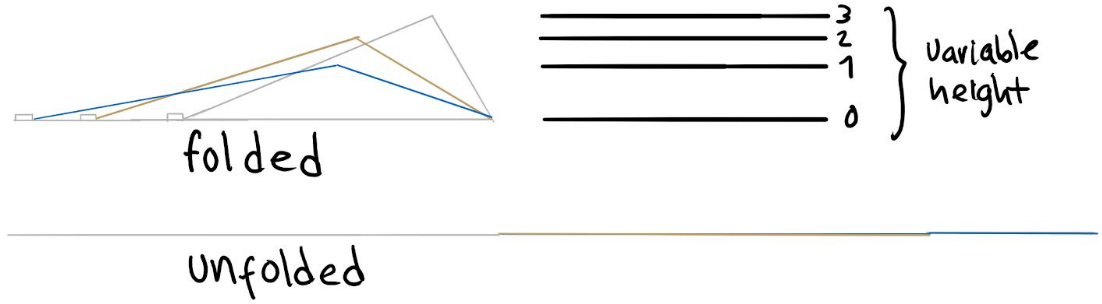


Figure 3.1.2: Lateral view of 1st design, clearly showing the lack of structural support.

We can see in (Figure 3.1.2) that, since it was a simple layout, it lacked structural support, and we determined it would not hold to the requirements. We did a scaled version of it, and we found out that it was caving inwards due to the low contact points. In the end, we decided to discard this design. We decided to sacrifice some of that portability and ease construction, favouring a more robust and durable design.

3.2 Solution 2

With our second approach, we came up with an idea where the ramp could fold toward the base and have 3 medium-sized tabs on each side of the ramp. We would be able to connect these tabs and lock them into slots on the walls of the ramp. These slots on the walls acted as supports and locking mechanisms to keep all the components together. The walls of the ramp had 2 different levels where the ramp could be placed at certain set heights such as 10cm and 20cm as seen in (Figure 3.2.1).

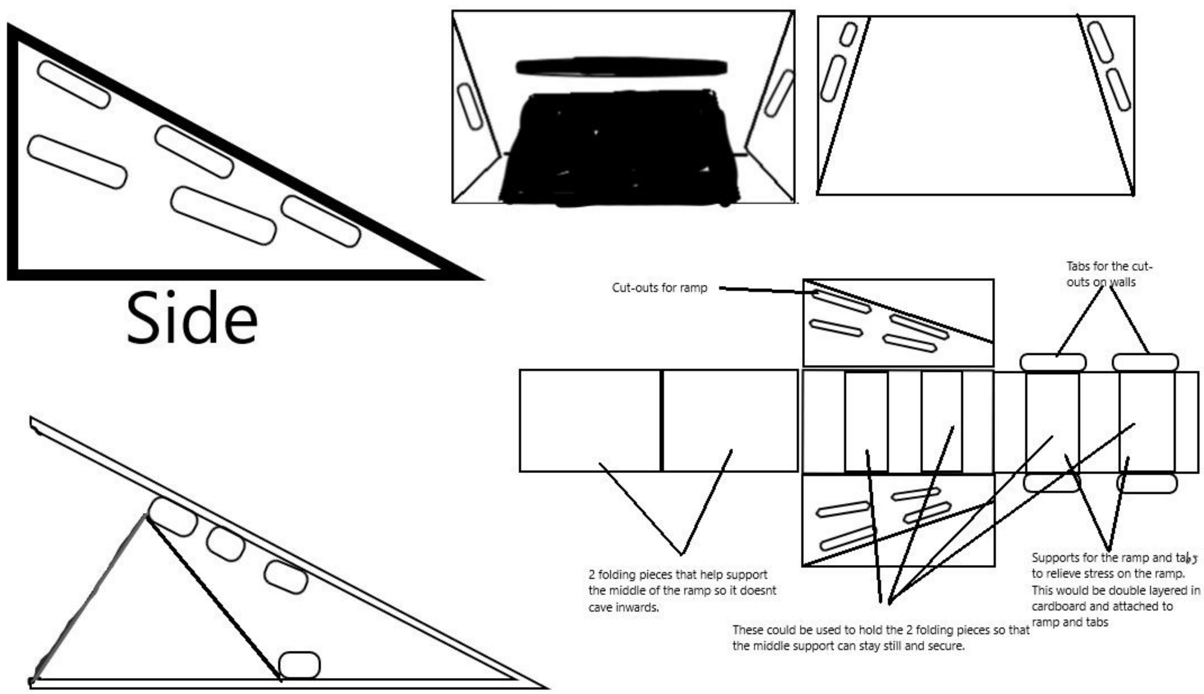
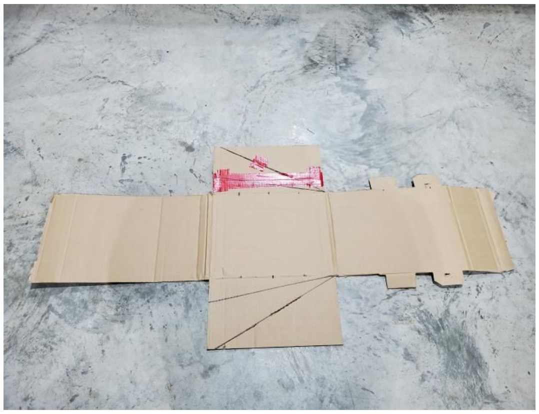


Figure 3.2.1: Rough sketch of our 2nd Design with components.



Flat View

Front View

Back View

Side View

Figure 3.2.2: Miniature version 2nd design (Multiply Views).

The advantage of using this design was that it was all one piece as shown in (Figure 3.2.1 and 3.2.2), meaning that you can cut it out with 1 cardboard box and fold it all together. The disadvantage of this design was that the middle of the ramp had no structural support, and it could only go to certain set heights instead of multiple heights as seen in (Figure 3.2.2). This design was portable, but it seemed large, meaning that it had too much material for a person to carry easily. This design would have worked better if we had a stronger material such as aluminum, where we can then get rid of excess material to reduce the weight, making it easier for the user to carry.

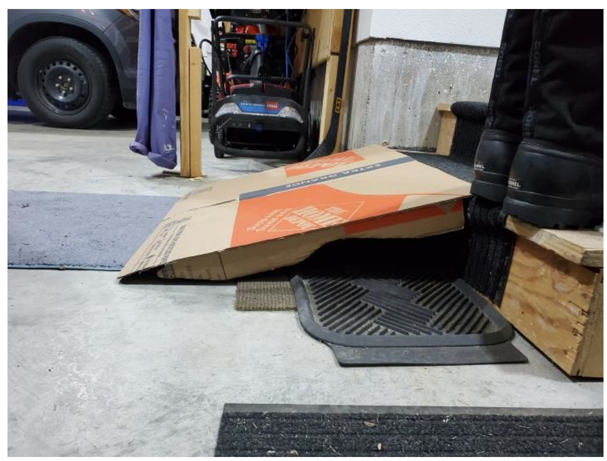
3.3 Final Solution

For the final approach, we came up with a straightforward design which lets the user to effortlessly unfold the ramp longitudinally, making it portable and easy to use for the user as seen in (figure 3.3.1). The reason why we chose this solution over the other solutions is because this design was very portable, easier to use, and able to go multiple heights.

Top View

Bottom View

Folded View



Side View (in-use)

Figure 3.3.1: Images of the final design to scale (Multiply Views).

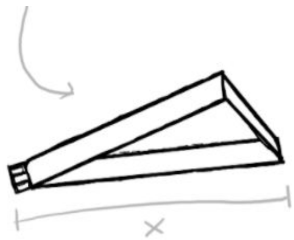
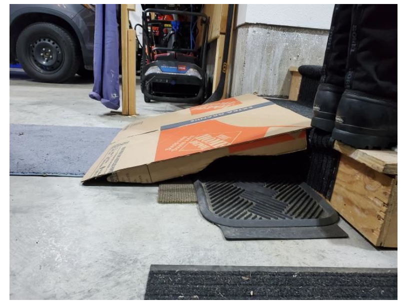
		
<u>Solution 1</u> Uses set heights to adjust to different heights with blocks at the bottom. Lacks support and stability. Easy to fold and to carry.	<u>Solution 2</u> Use set heights by attaching/locking the tabs into the walls of the ramp. Strong support on the walls but lacks middle support. Can fold, but not as easy to carry.	<u>Final Solution</u> Can go to multiple heights, lots of supports all around the base including the middle. Easy to fold and to carry.

Table 3.3.1: Comparing the 3 different solutions.

Additionally, the reason why both old designs didn't work was because they weren't structurally stable in the center of the ramp. Our first designs relied on a single piece of cardboard holding the entire ramp by itself, while our second design relied on tabs to hold the ramp in place, putting all the stress onto the walls of the ramp. Having support towards the center is very crucial to the ramp because when in use, all the forces/stress are applied to the center, which these old designs could not handle. Another minor reason was that the old designs were only set heights, meaning there were only 2 or 3 height possibilities instead of multiple heights.

3.3.1 Components

The components of the final design were 2 faces of an extra-large moving box from Home Depot with the dimensions 22in L x 21.5 in W x 22in D. This cardboard box cost $5.48. The two faces of the cardboard box when cut out, had the dimensions of 27.5in L x 33.5in W (shown in figure 3.32). The left-over pieces were then used to build our main supports for the ramp. We cut out thirty-two pieces of cardboard which measured 16in L x 2.25in W (shown in figure 3.3.6). Eight pieces of these were then glued together creating four strong supports that would be placed at the top and bottom of the ramp. To have more structural strength, we added eight pieces of cardboard measured by 22.25in L x 2.25in W (shown in figure 3.3.4), which were then glued together creating two side supports for the ramp. We also added four pieces of cardboard and created two middle supports for the ramp. The middle supports had the dimensions of 15in L x 2.25in W (shown in figure 3.3.5). At the bottom of the ramp we created four small triangle pieces which would cause the bottom of the ramp to fold down on top of the triangles creating a small slope for the user to have easy access up onto the portable ramp (shown in figure 3.3.7).

<table>
<tr><th colspan="2">Components/Description</th></tr>
<tr>
<td>

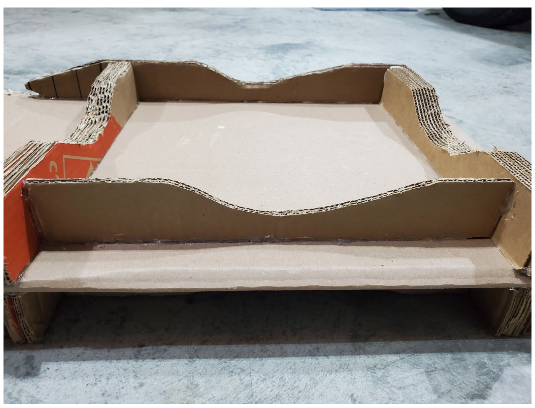
<u>Platform (x1):</u>
This is the main part of the ramp where the user will use to go over a curb.</td>
<td>
<u>Bottom Supports (x4) (at top and bottom):</u>
These supports help support the top and bottom of the ramp. These also act as a stopper when it is unfolded.</td>
</tr>
<tr>
<td>
Middle Support (x2):
These supports help support the middle of the ramp so that it does not cave in on itself.</td>
<td>
Side Supports (x2):
These supports help support the side of the ramp when in use. Also has a built-in handle.</td>
</tr>
<tr>
<td></td>
<td>Triangle Supports (x2):
These triangle supports act as a middle support at the bottom of the ramp when it is on the ground. It allows the folding part at the bottom of the ramp to adjust depending on the slope of the ramp.</td>
</tr>
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Table 3.3.2: List of components and quick descriptions.

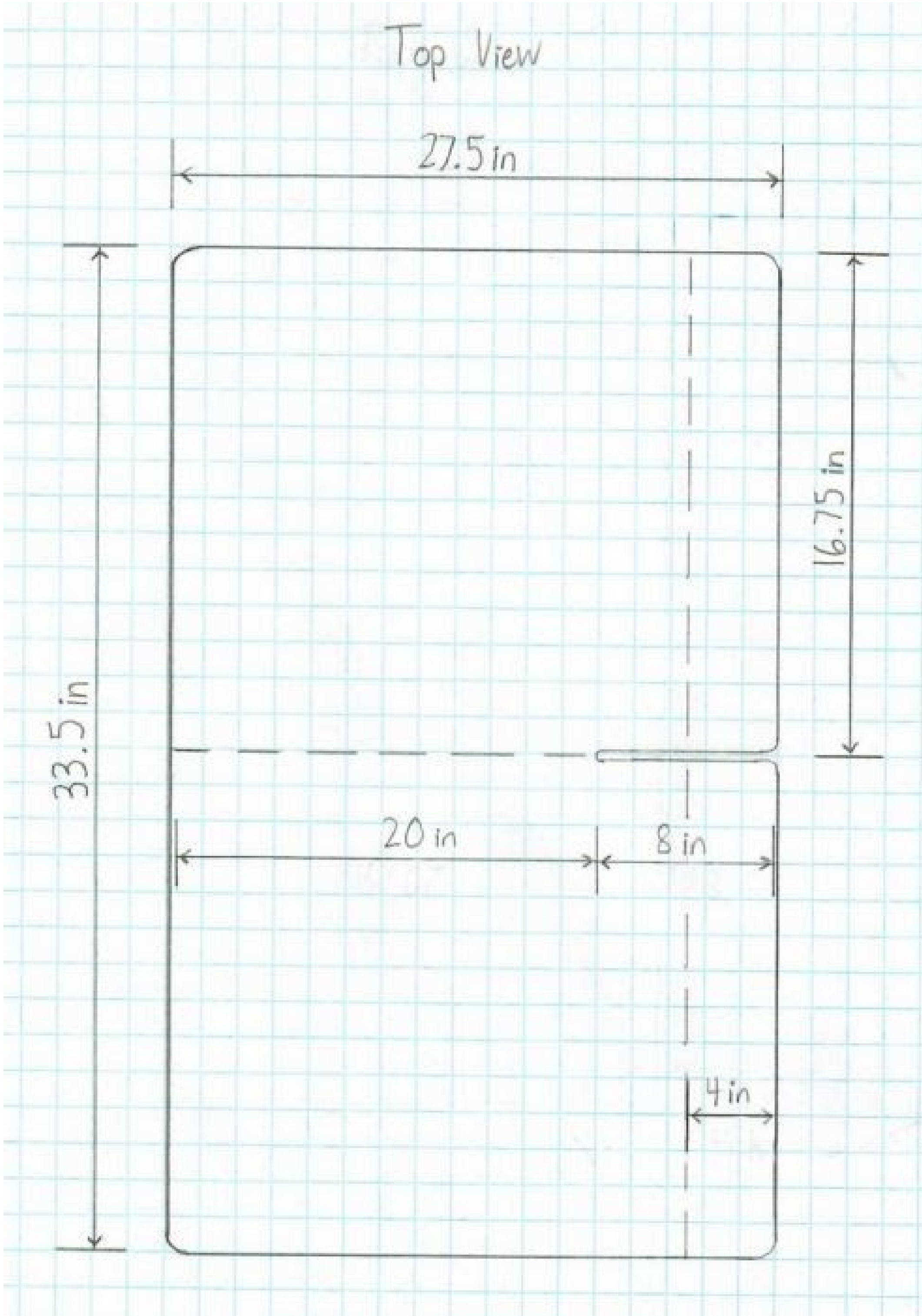


Figure 3.3.2: The sketch and dimensions of the top view of the ramp.

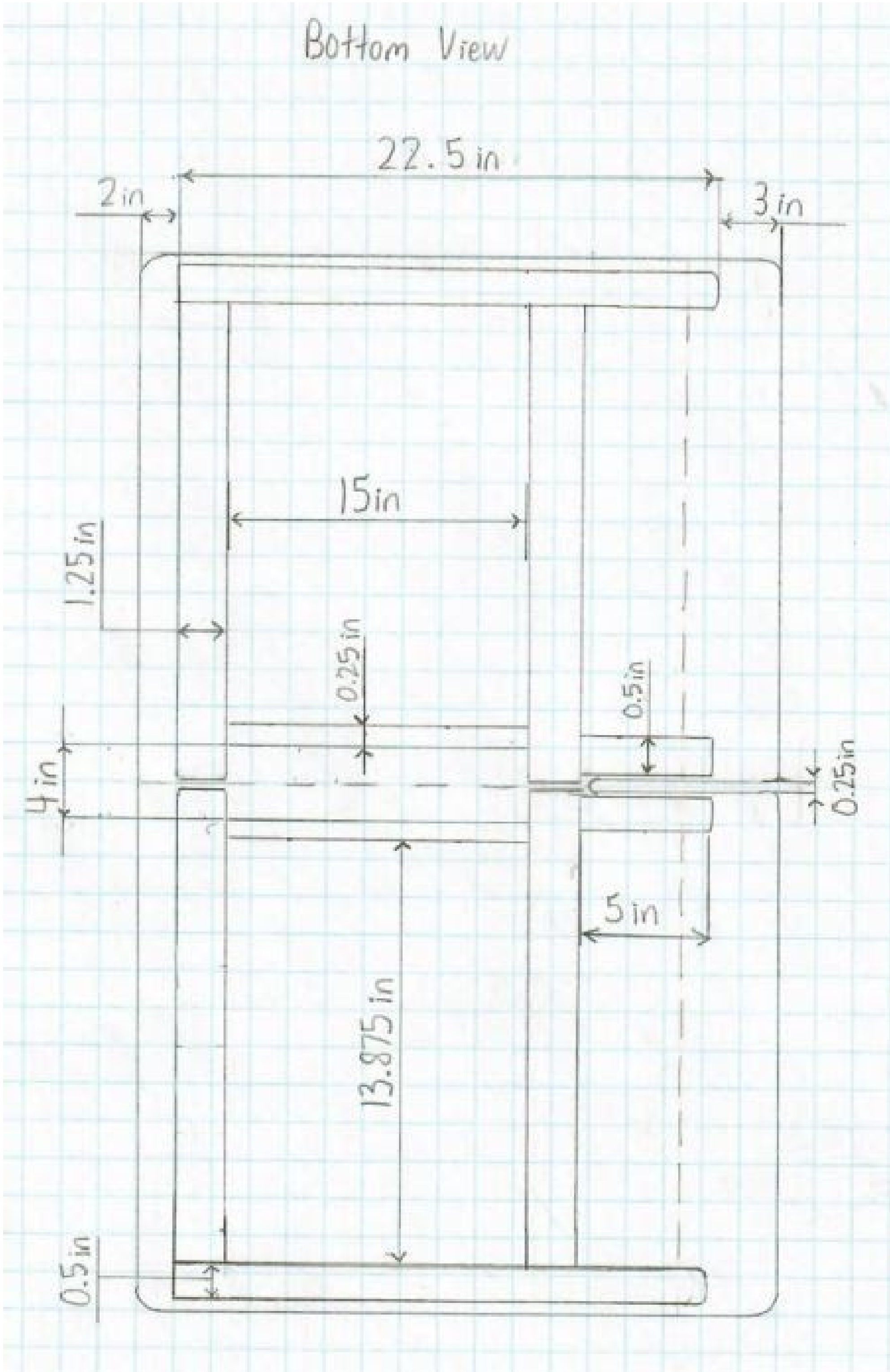


Figure 3.3.3: The sketch and dimensions of the bottom view of the ramp.

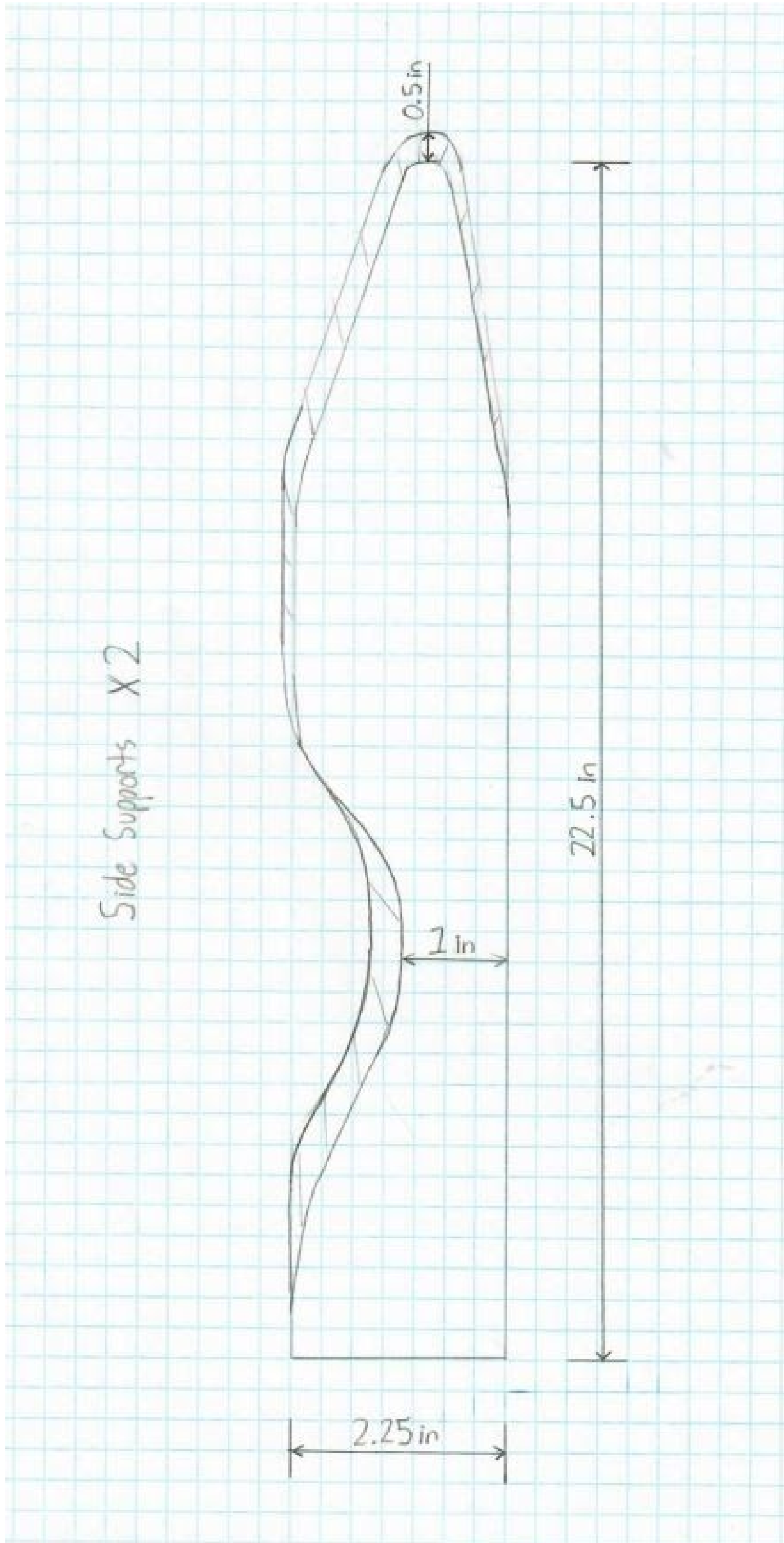


Figure 3.3.4: The sketch and dimensions of the side supports of the ramp.

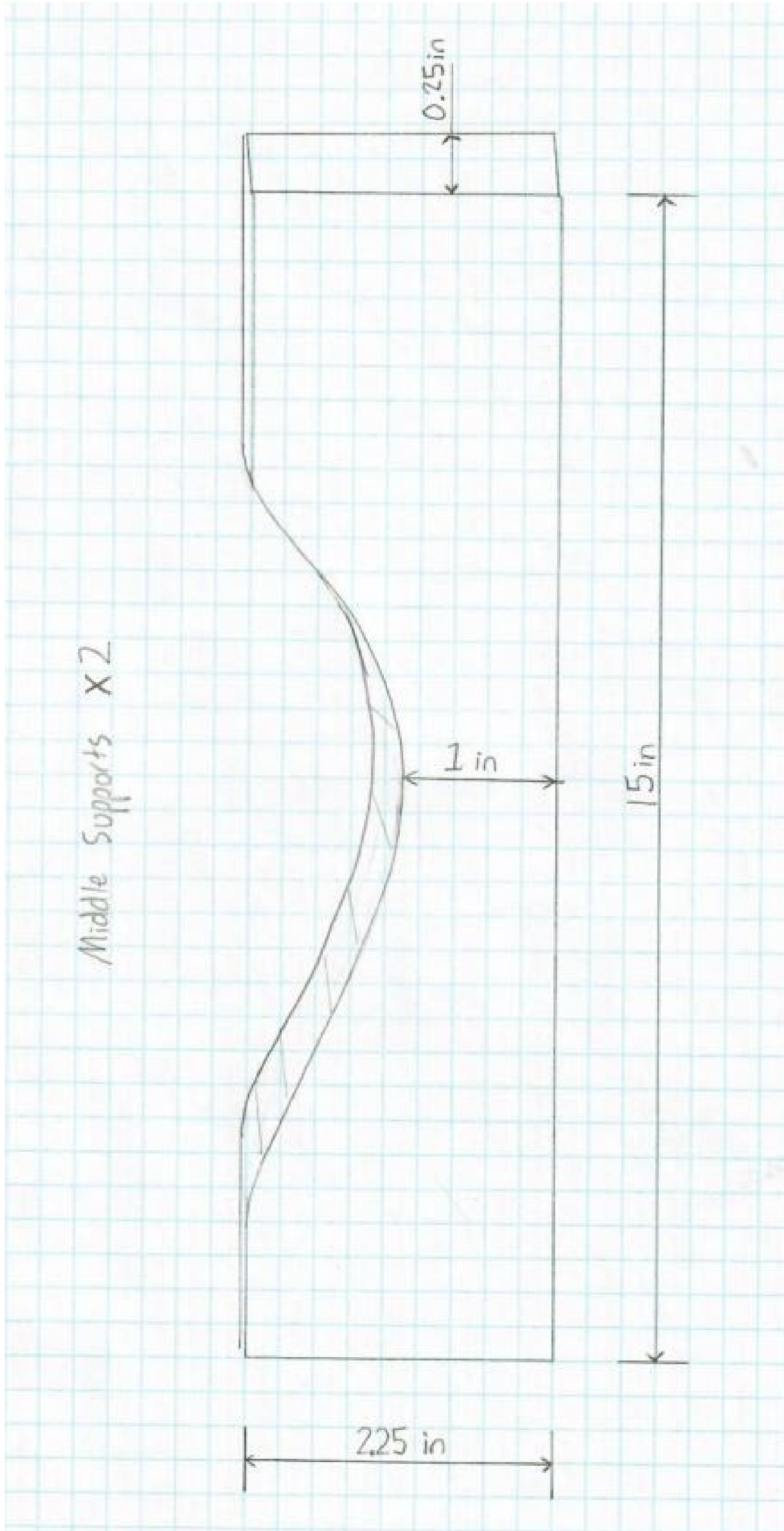


Figure 3.3.5: The sketch and dimensions of the middle supports of the ramp.

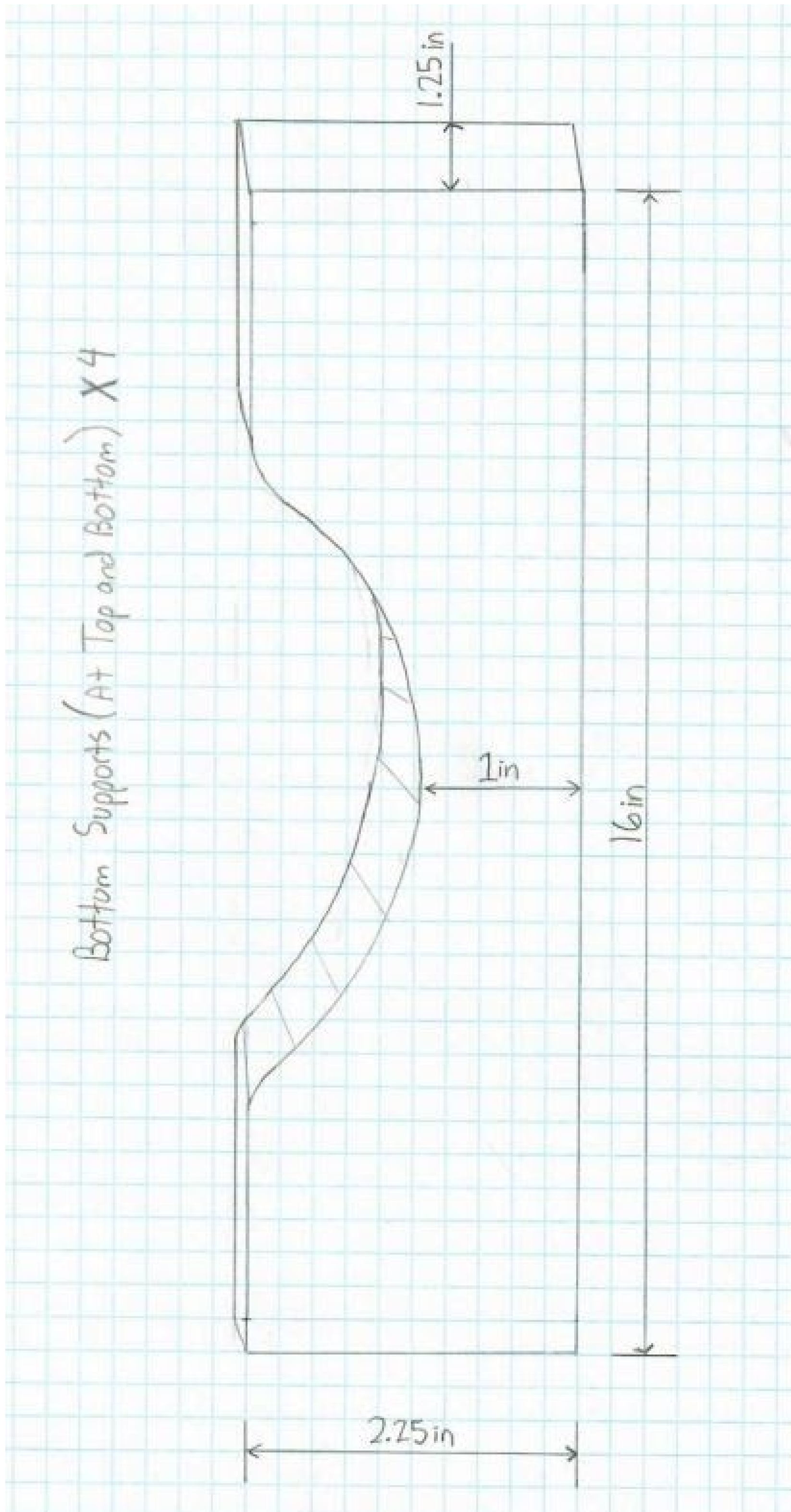


Figure 3.3.6: The sketch and dimensions of the supports at the top and bottom of the ramp.

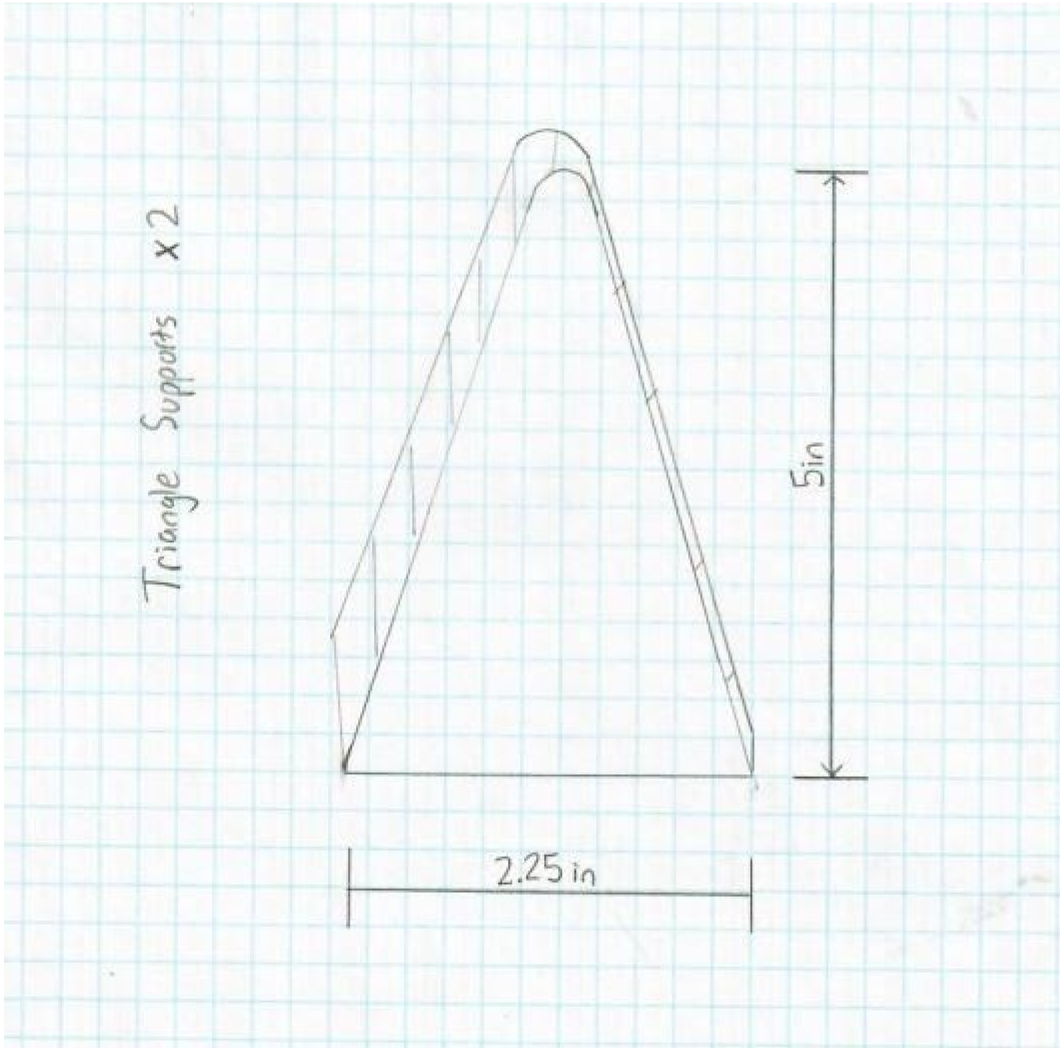


Figure 3.3.7: The sketch and dimensions of the triangle supports at the bottom of the ramp

3.3.2 Features

The features for our final design are that it is foldable, portable, and can access multiple heights. With this design, the ramp can be folded longitudinal allowing the ramp to be stored easily. We also incorporated a built-in handle system which was carved out from the side supports, so when the ramp is folded, you can carry and handle the ramp comfortably making it more portable for the user. Unlike the other solution, this design can go to a wide range of heights from 0cm to 30cm depending on what the user needs as seen in (figure 3.3.8).

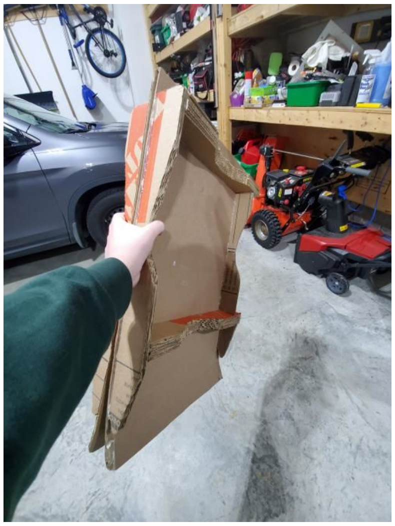
		
Built-in Handle System	Ramp at Doorway	Ramp on Walkway

Figure 3.3.8: Showing the final design features.

3.3.3 Environmental, Societal, Safety, and Economic Considerations

When designing and building the ramp, we took considerations for the ramp to make sure that it was environmentally friendly, safe to use for people, and inexpensive. For environmentally considerations, we built our final design out of cardboard, which can be recycled very easily and can be used for other purposes. We also used a hot glue gun to glue pieces of cardboard together which is also relatively safer for the environment which is discussed in [2], where most hot melt adhesives can be recycled easily compared to some of the solvent based adhesives. The hot glue gun adhesive is 100% solids, containing no VOCs or HAPs, eliminating any kind of environmental and worker exposure reducing hazardous waste [2]. The ramp was very light weight, weighing only 0.975kg. To make our ramp safe for the users, we added structural supports all around the base of the ramp by compiling many strips of cardboard using a hot glue gun to connect the pieces together. We also rounded off the corners to make sure that they are not sharp edges. The ramp is very cheap and affordable as we spent only $5.48 on cardboard and used a hot glue gun which cost $4.99 for a grand total of $10.47.

3.3.4 Limitations

The limitations for the final design was that since we had to build a ramp that weighed 1 kg or less, we had to find a lightweight material that was less than $15. We ultimately chose cardboard as it was cheap and had the structural support while being also environmentally friendly. If we had the ability to spend more than $15 and had access to other materials, building this ramp out of wood or metal like aluminum would add to the overall strength and durability while still being lightweight. Also, by using these other materials, we could cut down some excess material that we would not need unlike the cardboard version to conserve the weight.

4 Team Work

4.1 Meeting 1

Time: September 22, 2020, 1:00pm to 2:00pm

Agenda: Designing Ideas for the Ramp (Sketches)

Team Member	Current Task	Completion State	Next Task
Emiliano Garcia	Coming up with solutions	70%	Design/Build 1st solution
Luka Aitken	Coming up with solutions	70%	Continuing to look for other solutions
Toma Aitken	Coming up with solutions	70%	Starting Report/Research

4.2 Meeting 2

Time: September 29, 2020, 1:00pm to 3:00pm

Agenda: Creating solution 1 and Start Researching for Report

Team Member	Current Task	Completion State	Next Task
Emiliano Garcia	Design/Build 1st solution	100%	Help add to 2nd solution
Luka Aitken	Adding to 1st solution and designing the second solution	70%	Building 2nd solution
Toma Aitken	Researching for Report	65%	Help Building 2nd solution

4.3 Meeting 3

Time: October 2, 2020, 2:00pm to 3:00pm

Agenda: Second Solution and more Research

Team Member	Current Task	Completion State	Next Task
Emiliano Garcia	Building 2nd solution	100%	Researching/adding to report
Luka Aitken	Building 2nd solution/adding to report(intro)	100%	Coming up with final solution/Building
Toma Aitken	Researching for Report(intro)/ Building 2nd solution	100%	Coming up with final solution/Building

4.4 Meeting 4

Time: October 12, 2020, 1:00pm to 3:00pm, 6:00pm to 9:00pm

Agenda: Final Solution and adding to report

Team Member	Current Task	Completion State	Next Task
Emiliano Garcia	Working on Report (Design Problem/1st solution write-up)	60%	Adding to Report
Luka Aitken	Building Final Design and adding to report (2nd solution)	100%	Adding to Report
Toma Aitken	Building Final Design and adding to report (2nd solution)	100%	Adding to Report

4.5 Meeting 5

Time: October 15, 2020, 1:00pm to 3:30pm

Agenda: Working on Report/Asking Question During Office Hours

Team Member	Current Task	Completion State	Next Task
Emiliano Garcia	Asking Questions at Office Hours	10%	Finishing the Report
Luka Aitken	Asking Questions at Office Hours / Adding to all different sub-categories in Final Solution	100%	Finishing the Report
Toma Aitken	Finishing Conclusion and adding to all different sub-categories in Final Solution	65%	Finishing the Report

4.6 Meeting 6

Time: October 17, 2020, 3:00pm to 5:00pm

Agenda: Finishing Report and PowerPoint

Team Member	Current Task	Completion State	Next Task
Emiliano Garcia	Working on PowerPoint and adding to list of figures/tables	60%	Video
Luka Aitken	Finishing Report (Conclusion/figures/ tables/photo)	100%	Video
Toma Aitken	Finishing Report (Conclusion/figures/ turing citations to IEEE	100%	Video

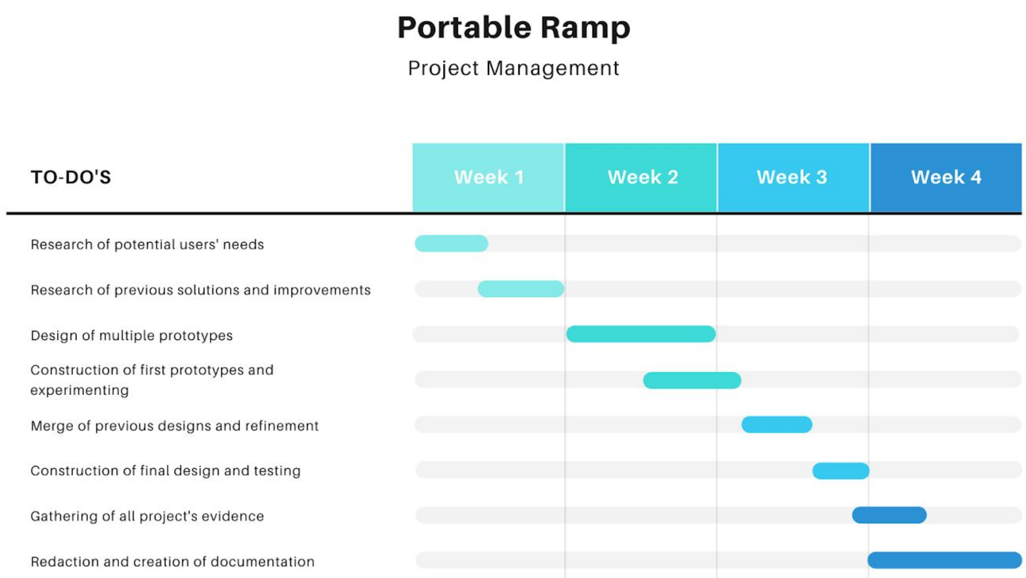
4.7 Meeting 7

Time: October 18, 2020,

Agenda: Video and Powerpoint

Team Member	Current Task	Completion State	Next Task
Emiliano Garcia	Video	100%	N/A
Luka Aitken	Video	100%	N/A
Toma Aitken	Video	100%	N/A

5 Project Management



6 Conclusion and Future Work

In conclusion, we achieved many great ideas on how to make a portable ramp. First, we came up with several designs on how we could make the best portable ramp that followed all the constraints. Our objective was to create a simply robust lightweight ramp that is portable and foldable, while also being cheap and accessible for all users who require a wheelchair.

From our research, we found that many wheelchair users encounter difficulties when traveling around places by climbing over curbs, accessing buildings, and entering vehicles [1]. The importance of accessibility is that wheelchair users need to continually plan on where they are going [3]. Numerous users struggle during all four seasons of the year from slippery/wet surfaces, build-up of snow and ice, and many other obstacles that may be present [3]. Having a dry, portable, and foldable ramp, will help and allow the user to avoid the outside weather conditions that may be present.

From researching the importance and the need for portable wheelchair ramps, we developed 3 different designs with each having its own unique solution. With the first design, it was simple, light, and easy to build, but it could not hold the required weight of 1kg due to the lack of structural support. We found out that it would cave inwards on itself because of low contact points. For the second design, it had a unique concept where the ramp would fold over and could lock into the walls with tabs attached to the ramp. When building and designing the prototype for this, we found that it was too large and bulky for a person to carry easily. We also found that it did not have enough structural support in the middle of the ramp, which would cause the ramp to cave inwards on itself just like the first solution.

In the final design, we achieved all our functions, objectives, and constraints that we listed in our design problem. The final design was easy to build, lightweight, able to adjust to multiple heights unlike the first and second solutions, and can be used by users who require different needs. The ramp can be easily folded in half and is portable with the built-in handle system on the supports. In addition, this design can sustain 10 kg and more, weighs 0.975kg, and does not exceed the length of 100cm making this design the best possible solution when compared to the first and second design. For future improvements for the final ramp design, we would reduce the material used to make the ramp even lighter, but still have lots of structural support. We could add grips to the ramp and make it waterproof so users can use it in the rain or winter. We would also test different types of material to see if we could get better results when comparing it to the cardboard version.

7 References

[1] T. Storr, J. Spicer, P. Frost, S. Attfield, C. D. Ward, L. L. Pinnington, “Design features of portable wheelchair ramps and their implications for curb and vehicle access.” May, 2004. [Online]. Available: https://eds.b.ebscohost.com/eds/detail/detail?vid=3&sid=7b28b407-6343-46d8-b5b2-200f3ee2c269%40pdc-v-sessmgr02&bdata=JnNpdGU9ZWRzLWxpdmUmc2NvcGU9c2l0ZQ%3d%3d#AN=106668178&db=ccm

[2] “Hot Melt Adhesives Technical Issues.” Wayback Machine. https://web.archive.org/web/20100504130114/http://pprc.org/pubs/techreviews/hotmelt/hmtech.html (assessed October 13, 2020)

[3] C. Aamlid, K. Brownfield, “We Are Not Different; We Just Sit: A Case Study of The Lived Experiences of Five College Students in Wheelchairs.” March, 2019. [Online]. Available: https://eds.b.ebscohost.com/eds/detail/detail?vid=11&sid=7b28b407-6343-46d8-b5b2-200f3ee2c269%40pdc-v-sessmgr02&bdata=JnNpdGU9ZWRzLWxpdmUmc2NvcGU9c2l0ZQ%3d%3d#db=a9h&AN=138783811

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[5] E. M. Smith, E. M. Giesbrecht, W. B. Mortenson, and W. C. Miller, " Prevalence of wheelchair and scooter use among community-dwelling Canadians," Physical Therapy, vol. 8, pp. 1135 - 1142, Feb. 2016. [Online]. Available: https://ezproxy.tru.ca/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=ccm&AN=117119082&site=eds-live&scope=site

8 Appendix