

GNG2101 Final Report

Wheelchair Assist

Submitted by

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Abstract

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1 Introduction

1.1 Client and Needs

Our group was tasked with creating a mechanical propulsion system that could attach to a wheelchair. Our client lacked motor skills on the left side of her body. Therefore, it was our duty to innovate a propulsion system that could be operated only using one's right hand. It had to be mechanical for an electric solution meant that it could fail due to a lack of battery life. Although this product was created for a particular individual in mind, it's scope is much larger. There are 65 million people around the world who rely on wheelchairs. This product would empower many wheelchair users to travel on their own and alleviate the need for a caretaker.

1.1.1 Benchmarking and Existing Solutions

Current products on the market include a lever system, a pedal system and a double rim system. The pedal system utilizes both feet to propel the chair which wasn't a possible option for our client. The double rim system could work, however is quite difficult to use when attempting to go straight. The lever system used was different from ours, however it was a feasible option for our client. However, the main thing that sets us apart from the competition is our price point. We were able to create a functioning prototype for \$80, whereas the competitions cheapest product is priced at \$400.

2 Engineering Design Process

We used the agile process. We continually redesigned the product through software rendering. After every virtual prototype, we consulted our client to get feedback about the strengths and weaknesses regarding our solution. We also looked up the pricing of the parts required to make said prototype and if it went over the \$100 budget, we redesigned our solution to be more cost efficient.

3 Need Identification and Product Specification Process

Identified Needs:

- Keeps the user in the chair and prevents slipping
- Usable during winter conditions
- Moves straight with only one side of the body being used
- Compact and lightweight
- Mechanical

Ideally the client (who does not have full use of one arm) is able to properly operate a wheelchair and move forward in a straight line. Electric wheelchairs are expensive, require training to use, and have limited battery length. However when the client is unable to use both arms the non-electric wheelchair, turns to one direction or the other and does not go fast enough. The product will be a mechanical mechanism that propels the wheelchair forward from the use of only one side of the client's body.

Benchmarking



Figure 1

Metric	Unit
Weight	Kg
Cost	\$CND
Distance per Rotation or Push	m
Force Required To Move at 5km/h	N

Table 1

Target Specifications

- Width: < 32 inches
- Weight: < 10kg
- Cost: < \$100
- Speed: 4km/h < 5km/h (when performing 1 push or cycle per second)

Problem Statement

Create a mechanical wheelchair assist that propels a wheelchair straight forwards using only one arm, and can move swiftly through snow.

4 Conceptual Designs

The first conceptual design was to combine a lever and pedal system to work in tandem to propel the wheelchair forward. This system was designed to have a rod connect the two outer wheelchair wheels together. On the outside of the left wheel a lever would have been fastened to rotate the wheel, the rod connected to it and therefore the right wheel as well. The second part of this design was the pedal system to work similar to a bicycle. The pedals were pinned to a bike gear which connected through a bike chain up to the freewheel on the rod between the wheels.

The idea behind this dual system was that it would allow the client to have maximum use of their best operating body parts. However, there were many issues with this first proposed idea. First, because the two large wheels on the wheelchair were connected together by a rod, the chair would no longer be able to turn. The wheelchair only needed to go 4km/h so the dual system was excessive even for a client that may not have as much strength as the average person. This design also conflicted heavily with our specific client because of the inability to properly control the right side of their body. This meant that because both feet would be affixed to the pedals, the right foot would constantly be fighting with the left foot. The pedal system and rod connecting the main wheels were completely abandoned.

5 Project Planning and Feasibility Study

Gantt Chart

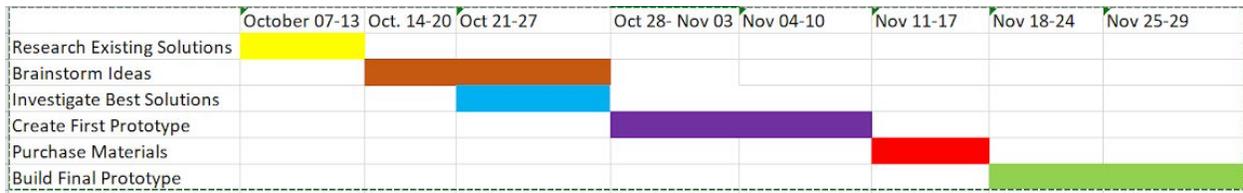


Figure 2

Task List

Task	Duration	Assigned To	Dependency
[1] Brainstorm prototypes	1 day	All members	N/A
[2] Draw out first prototype	1 day	Godwin	1
[3] Show first prototype to client	1 day	Phillip	2
[4] Brainstorm improvements upon first prototype	1 day	All members	3
[5] Create second, physical prototype	4 days	All members	4
[6] Show second prototype to client	1 day	Godwin & Reggie	5
[7] Design third/final prototype	1 day	All members	6
[8] Build final prototype	7 days	All members	7

Table 2

Milestones

- 1) First prototype is created (drawing or model)
- 2) Second prototype is created (rudimentary physical product or part of final product)
- 3) Third prototype or final product is created and presented to client.

Bill of Materials

Item Number	Part Name	Part Definition	Quantity	Unit Cost	Extended Cost	Place of Purchase
1	Ratcheting Wrench	20mm Wrench	1	\$5.41	\$5.41	Amazon
2	Training Wheels	5/16" bolt diameter	1	\$26.95	\$26.95	Amazon
3	JB Weld	Steel epoxy	1	\$10.99	\$10.99	Canadian Tire (1)
4	Carriage Bolt	5/16" diameter 18 tpi 3" long	1	\$0.32	\$0.32	Trudel HomeHardware
5	Carriage Bolt	5/16" diameter 18 tpi 4" long	1	\$0.40	\$0.40	Trudel HomeHardware
6	Flat Washer	5/16" diameter	2	\$0.07	\$0.14	Trudel HomeHardware
7	Lock Nut	5/16" diameter 18 tpi	2	\$0.13	\$0.26	Trudel HomeHardware
8	Hex Nut	5/16" diameter 18 tpi	2	\$0.10	\$0.20	Trudel HomeHardware
9	Pipe Insulation	3/4" X 3'	1	\$0.89	\$0.89	Trudel HomeHardware
10	Braided Nylon Rope	White rope	2ft	\$0.25/ft	\$0.50	Trudel HomeHardware
11	Machine Screws (package)	8-32 2" long	1	\$3.49	\$3.49	Canadian Tire (2)
12	Flat Washers (package)	8-32	1	\$3.49	\$3.49	Canadian Tire (2)
13	Hex Nuts (package)	8-32	1	\$3.49	\$3.49	Canadian Tire (2)
14	Rod	Aluminium 20" X 1"	1	\$12.30	\$12.30	Brunsfeld
15	Tube	Aluminium 5" X 1.5"	1	\$6.80	\$6.80	Brunsfeld
16	Lever	Aluminium 30"	1	\$6.15	\$6.15	Brunsfeld

$\text{Total Tax} = 0.70(\text{amazon}) + 0.35(\text{HomeHardware}) + 1.36(\text{Canadian Tire 2}) + 1.43(\text{Canadian Tire 1}) = \3.84	
$\text{Total Cost (after tax): } \85.62	

Table 3

Uncertainties and Risks

One of the largest uncertainty with this project is how we want to implement our solution. The team has not had much time to think about how we are gonna be able to create a physical product, however we have scheduled meetings during our free time to work out these kinks as well as to work on the development of the product. Another uncertainty is how much the product will cost to make. The biggest risk that our project faces is that our solution may face difficulties with maneuvering in the snow, which is one of the main constraints design criteria.

D.2

1. We have limited expertise when it comes to designing a product; however, we have many technical resources at our disposal including the labs offered at school and the internet. We also have the option of asking our professor, TA or PM for advice.
2. The cost of our product currently costs less than \$100; however, since we are still at the prototype stage we there are many uncertainties which could vary the cost of our product.
3. There are no legal issues with releasing our product to the public.
4. There are no current organizational constraints that will prevent our success; however, our group consists of 3 members so getting all the work done can be challenging at times.
5. Our deadlines are completing the physical prototype in 5 days and having finished product in 14 days. Meeting these deadlines will be challenging due to having 3 members but we are confident we will be able to produce an effective product before the deadline.

6 Analysis:

The following dimensions of the client's wheelchair were taken in order to create a prototype:

Length	31 inches
Width	29 inches
Height between seat and ground	14 inches
Radius of wheel	22 inches

7 3D Model Prototyping and Customer Validation.

First Model

We developed multiple prototypes and consulted with our clients regarding the functionality of the design. Our only physical prototype was made at the end of our design process and we tested it after creating. We used the prototype the way we intended our client to use it. Therefore, we restricted movement on the testers left side of their body and got them to use the propulsion system, measuring movement.



This model was the introduction of an additional wheel placed underneath the middle of the wheelchair. When the lever is pushed, it rotates a rod which has a freewheel cog gear on it. The freewheel system allows the inner cog in which the rod is attached to rotate when the rod is rotating in the wrong direction. When the rod is rotating in the opposite direction, the cog moves the gear that has a chain resting on its teeth. When this chain moves, it turns the second gear that is attached to the wheel. The wheel is attached to a poll reaching up to a metal bar underneath the wheelchair. On the end of this poll there is a spring that press down to keep downwards pressure on the wheel so it keeps in contact with the ground.

Second Model



The previous model had too many parts and took up too much space. This model had much of the same functions as the previous prototype, but was more compact. This prototype also featured a cable that would pull the wheel upwards so that the wheel would not make contact with the ground and the system would be disengaged. For this to work there was a small spring that gets compress when the cabled is pulled tighter. The gear system is now directly beneath the rod and still using the freewheel cog, making actually putting all the mechanics in such a small space very difficult.

The Last Prototype



This prototype no longer used a freewheel gear system. Instead there is a ratcheting system at the base of the lever in which the rod is connected to. The extra wheel still rotates through two gears, but the wheel does not raise. The ratcheting system would be a ratcheting wrench that has a sleeve over it for a uniform shape of the lever. The lever also has the ability to detached and reverse. When the client rotates the lever 180 degrees around the z-axis and reattaches it to the rod, the wheelchair propels in the opposite direction. This attachment system works by cutting the end of the rotating rod that the lever attaches to, to the correct dimensions of the wrench. With about 2 inches of extra space on the end, there would be a clamp that keeps the lever in place. These changes helped solve the issue of going backwards, and simplified the solution.

8 Final Solution

The final solution was a lever and rod system without any gears. First the lever was a 30 inch aluminum plank that was about 1 inch wide and a quarter inch thick, and this aluminum was welded to the 15 inch long 20mm ratcheting wrench using a steel epoxy. The next part was the rod and wheel section. The wheel was a small training wheel that was fastened with two metal plates onto a front poll of the wheelchair on the right side. A plastic about half an inch thick was then shaped into the inner circle of the wheel and 4, 8-32 screw holes were screwed into the plastic. This plastic bracket was then bolted onto the wheel using four 2 inch long 8-32 machine screws. The plastic bracket also had a 5/16' screw hole with an 18 tpi was drilled through the center of it. This wheel and bracket was attached to the rod and lever system. This was done by using a 20 inch aluminum cylinder which had a 1 inch diameter. On one end of the cylinder a 5/16' wide and 2 inch deep screw hole was drilled into the rod. The other end of the cylinder was shaved down using a lathe to the size of the inside of the wrench ratchet. The rod was then pressed into the bottom of the lever, where the ratchet was. To attach this system to the wheel, the rod was screwed onto the 5/16' bolt. To make sure the bolt from the wheel would stay screwed into the rod, the steel epoxy was first put onto the bolt threads. The last part of the solution was keep the lever system connected to the wheelchair during use. A 5 inch long aluminum tube with a 1.5 inch diameter was used for this and slid overtop of the rod. This sleeve was supposed to be clamped to the wheelchair, but instead a string had to be welded to it using the steel epoxy and then knotted to the wheelchair.

This system was extremely simplified compared to the prototypes. Instead of using some sort of system of gears, the lever had its own ratcheting system in the form of a wrench and then was directly secured to a rod which spun the wheel.

9 Business model

1. We would chose a brick and mortar business model. We can develop similar products to assist wheelchairs and create a business selling such products. It's the best business model because free samples can not be given out and it is not possible to turn our customers into free labourers. We could develop a company/store that people come to for wheelchair assistance.
2. How: We would need suppliers that would be able to supply us with aluminium and wheels, so we could produce our product. We would also like to partner with a wheelchair manufacturer to help produce our products.
What: We are assisting individuals in wheelchairs to get around by easier means. Many individuals in wheelchairs have trouble getting around due to their disabilities, our product caters to their strengths and empowers them to get around by themselves or with limited assistance.
Who: We are creating value for people who need extra assistance. This is especially helpful for people with disabilities that make it difficult to use a wheelchair properly. We wish to reach anyone who wants an easier way to use their wheelchair but our most important customer are the people who are one sided in the use of their body or struggle to reach a normal speed(4-5km/h) in their wheelchair. Our customer relation will be the communication we have with our customers in the store. The person interacting will have with the customer will have to be good at dealing with people who have all sorts of disabilities. Much of our customer relation will be person to person and require good people skills. Our customers can pick up the product in person or it can be delivered to them in a box.
How Much: Our fixed costs will be the cost of the rent of the building to sell the material, the salaries for employees, and insurance for everything. Our business will make money purely through sales of the product. We will set the prices to aim for at least a 50% profit margin.

3. We have made the assumptions that our company can not turn our consumers into free labourers. We do not have the ability to give free trials, like a freemium business model. We also made the assumption that we are unable to have a subscription or advertising business model.
4. Our riskiest business assumption is assuming that we do not have the ability to give our free trials. This is because some people may not trust our product's effectiveness or safety without trying the product themselves. This may cause people to settle and look for other solutions rather than making an investment and buying our potentially expensive product. The cheapest way for us to validate this would be by surveying our potential consumers and asking if they would purchase our product without being able to trial it. This would be difficult as we would need to go and find many different people in wheelchairs. The assumption is valid if most people do not care. Another angle would be if we are even capable which should be where we start. We could test it by giving our product to one or multiple consumers and recording if they decide to purchase the same product after use. If most people buy it after the use than the assumption is invalid.

10 Economic Analysis

If we were looking to bring our product to market it would be possible, but it would take a lot of money. We would have to patent our design since it is design that is quite easy to reverse engineer and without a patent could easily be created by another company. In addition, we benchmarked the pricing of other similar products in the market and they started at \$500. We created our product for \$85. With such a large profit margin, we would be able to afford the costs of running a business such as advertising and hiring employees. Our biggest concern with our product is that the market for individuals in wheelchairs is niche which can make it difficult when it comes to selling a sufficient amount.

11 Conclusions and Recommendations for Future Work

There were many lessons learnt throughout the course of this project. The most important lesson learnt for our group was, simplicity is often better. As we improved our design, it continually got more simplistic. In the future it may make more sense to start with trying to come up with the simplest ideas first. In order to help with simplicity, it may help to focus and perfect how to make one function (the most important function) work. When our team started to work on this project there were far too many functions we attempted to put into our design, which were all beyond our abilities. To add to that, we did not focus on the simplest solutions to start. Another benefit to creating simplistic solutions is they are often more cost efficient.

For other teams attempting to work on this project we would suggest to stay away from complicated designs with many moving parts. A lot of moving parts will cause many issues. This includes the system breaking down easy and being very difficult to assemble.

The biggest issue with our final design was the speed. It was unable to reach our desired speeds. This could have been solve by using a larger wheel. Our wheel radius was simply too small which meant that each pump of the lever was moving the chair a very small amount. This is because one pump rotates the rod and in turn the wheel about one quarter of a full rotation. One quarter of a full rotation of our which meant that the wheel was covering about 5 inches of distance per quarter rotation. This was simply not enough. In order to reach 4km/h while pumping the lever at between 1-2 pumps per second, one quarter rotation of the wheel would

need to cover between 20-40 inches. This would mean that the wheel should have a diameter of 25 inches for a quarter rotation to be 20 inches.

12 **Bibliography**

APPENDICES

APPENDIX I: User Manual

Features:

This product is used to propel an individual forward. One must crank the lever continually in order to propel themselves forward.

Installation:

The product must be screwed onto the bottom frame of the wheelchair. When doing this, ensure the wheel is touching the ground and is centered in between the wheelchair's two wheels.

Precaution:

The lever could fall swing straight forward if the user is not being extra alert.

APPENDIX II: Design Files

Include all design files with explanations so the client or other students next term can take your project to the next level. Also provide location on MakerRepo.

APPENDIX III: Other Appendices

You can put important or critical work that you did here. Maybe this work is not central to the structure of your document, but needs to be included).