GNG 2101 PROJECT REPORT

SELF-LOCKING MANUAL WHEELCHAIR

GROUP C02\_GEN 8

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# ABSTRACT

*Wheelchair injuries can occur when people do not apply the hand brakes to lock the wheels when getting in and out of the wheelchair, or when assuming irregular positions in the chair. Improper use of the wheelchair brakes can be attributed to mental or physical disabilities, forgetfulness, or ignorance. During the winter semester of 2017, Group C02\_Gen 8 in GNG 2101 completed a project in Ottawa with Saint Vincent Hospital which focused on applying design thinking to the creation of an automatic wheel locking mechanism for manual wheelchairs, with the main goal being to prevent accidents by making the task of locking the wheels easier. This report details the process of creating the mechanism, from the initial empathizing phase to the final testing phase of the design process, while taking into account economic, and legal constraints.*

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# **INTRODUCTION**

People who use wheelchairs may have physical and/or mental limitations which requires them to use a wheelchair for mobility assistance, whether temporarily or long term. Remembering to lock the wheels of the wheelchair when getting in and out of it may not be instinctive for those who have memory degeneration or who are just beginning to use a wheelchair. This is dangerous because the wheelchair is be free to move when the wheels are not locked and can move out from under the user; the chance of the wheelchair moving is increased when people grip or rest on the armrests for balance.

All manual wheelchairs have a lever-based wheel locking system which is located in front of the wheels, and approximately two feet above the ground. The aim of this design project is to develop an automatic wheel-locking device for wheelchair users that would lock the brakes when the user is getting in and out of the chair, or when the individual is irregularly positioned in the chair. This system does not require the conscious effort from the user to remember to lock the brakes.

This system would aim to solve a pertinent problem in healthcare and patient safety by preventing a large number of wheelchair related injuries, which would decrease the need for treatment of wheelchair-based injuries by medical professionals. This would be clearly beneficial to the wheelchair users as well as their caretakers and family members.

The team consisted of five University of Ottawa engineering students, under the guidance of a project manager and Professor Anis. The five students are from different engineering departments (Chemical and Biological, Mechanical, Electrical), with a variety of different skills, which allowed each person to contribute to the design project in a unique way.

There have already been wheel locking devices invented, however the current designs rely on mechanical mechanisms to lock the wheels. The solution developed is different from other design solutions which aim to solve the same problem, as it involves electronic components. The system uses a pressure sensor, an arduino microcontroller, and a DC motor. The motor is controlled by the arduino microcontroller which operates a rack and pinion system which rotates to move a pin in and out of a wheel attachment with holes, causing the wheels to be locked and unlocked.

# **PROJECT**

## **CLIENT MEETING**

On January 23rd, the team visited Saint Vincent (SVH) and met with Bocar N’Daiye, the hospital's technologist. He provided the team with relevant information about wheelchair models currently used by patients. He emphasized that wheelchair models can vary drastically in structural design and size. Bocar explained that the placement of the brakes on standard manual wheelchairs cause patients to forget to engage the brakes, which can be hazardous for the following reasons:

* Patient attempts to sits down in an unlocked wheelchair and the wheelchair rolls back, causing the patients to fall on the floor, resulting in an injury.
* Patients attempts to get up from an unlocked wheelchair, the wheelchair rolls back and the patient falls to the floor, causing an injury.
* The patients may also have physical or mental limitations which limits them from the safe use of the wheelchair.
* Patients who sit improperly on the wheelchair have a greater chance of falling off and causing injury

## **NEEDS IDENTIFICATION**

The team devised the following needs identification chart based on the customer needs Bocar expressed. Each need has a weighting system assigned to it with 5 being the most importance and 1 being the least important.

**Table 1: Needs Identification**

|  |  |  |
| --- | --- | --- |
|  | **Needs** | **Importance** |
| 1 | The locking system is safe | 5 |
| 2 | The locking system is easy to use/install | 3 |
| 3 | The locking system meets wheelchair regulations/guidelines | 4 |
| 4 | The locking system is durable | 3 |
| 5 | The locking system is universal | 3 |
| 6 | The locking system is cost effective - within budget | 5 |
| 7 | The locking system is simple to understand/troubleshoot/repair | 3 |
| 8 | The locking system is aesthetically pleasing - not bulky/ugly | 1 |
| 9 | The locking system instills a routine | 4 |
| 10 | The locking system functions indoors | 4 |
| 11 | The locking system functions outdoors | 4 |
| 12 | The locking system functions in precipitation | 4 |
| 13 | The locking system is controlled by the person in the wheelchair | 5 |
| 14 | The locking system is controlled by another person (eg. nurse) | 5 |
| 15 | The locking system is efficient | 5 |
| 16 | Wheelchair retains normal functionality - folding ability, etc. | 3 |

## 

These needs were composed by the team, and were presented to Bocar to make sure that the team understood the requirements for the solution, so that progress could be made in the design process.

## **DESIGN METRICS AND CRITERIA**

From the Needs Specification the design metrics and criteria were created to quantify the needs and set a basis of criteria for the design:

**Table 2: Design Metrics**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Metric #** | **Needs #** | **Metric** | **Importance** | **Units** |
| 1 | 1 | Clean construction, no sharp parts | 5 | N/A |
| 2 | 2 , 7 | Assembly/Disassembly time Time | 2 | s |
| 3 | 6 | Be under budget ($200) to develop | 2 | $ |
| 4 | 15 | locking Time | 5 | s |
| 5 | 3, 4 | Maximum Weight for Operation of System | 4 | kg |
| 6 | 10, 11 | Temperature range | 4 | C |
| 7 | 8 | Size of locking system | 1 | m2 |
| 8 | 4 | Corrosion resistant | 3 | N/A |
| 9 | 11, 12 | Waterproof | 4 | s |
| 10 | 4 | Lifespan of locking system | 3 | yrs |
| 11 | 15 | Sound duration | 5 | s |
| 12 | 15 | Sound amplitude | 5 | dB |
| 13 | 15 | Battery Recharge Time | 5 | s |
| 14 | 15 | Battery capacity | 5 | mAh |
| 15 | 15 | Number of locks | 5 | # |
| 16 | 5 | Number of compatible wheelchairs | 3 | # |
| 17 | 16 | Functionality unhindered | 5 | N/A |

Units were provided to outline which criteria had quantifiable metrics, which was useful in the next part of the design process.

## **PROBLEM STATEMENT**

Based on the user needs and design specifications the team came up with a problem statement: “to develop a mechanism that automatically locks wheelchair brakes when the patient is getting up, about to sit down, or is improperly seated on the chair to prevent falls caused by the wheelchair moving from under them”.

**BENCHMARKING**

The team explored several currently available designs, looking at the metrics provided by the retailers. The relevant designs were evaluated based on the criteria, as shown in the table below. Benchmarking is conducted in order to determine what metrics need to be improved in a new design to make the process of making the new product *worth while*. The product with the highest score is considered the top competitor, and acted as a guide for the team to compare possible designs to.

**Table 3: Benchmarking with Three Competitors**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Metric #** | **Needs #** | **Metric** | **Imp.** | **Units** | **Pratiko Solutions3** | **Safer Wheelchair Locks** | **ADI Stealth Systems2** |
| 1 | 1 | Clean construction, no sharp parts | 5 | N/A | Yes | Yes | Yes |
| 2 | 2 , 7 | Assembly/Disassembly time Time | 2 | min | 90 | 12 | 17 |
| 3 | 6 | Be under budget ($100) to develop | 2 | $ | No | No | No |
| 4 | 15 | locking Time | 5 | s | instantaneous | instantaneous | instantaneous |
| 5 | 3, 4 | Maximum Weight for Operation of System | 4 | kg | 136 | 136 | `136 |
| 6 | 10, 11 | Temperature range | 4 | C | - | - | - |
| 7 | 8 | Size of locking system | 1 | m2 | - | - | - |
| 8 | 4 | Corrosion resistant | 3 | N/A | Yes | Yes | Yes |
| 9 | 11, 12 | Waterproof | 4 | s | Yes | Yes | Yes |
| 10 | 4 | Lifespan of locking system | 3 | yrs | min 1 yr | min 2 yrs | min 2 yrs |
| 11 | 15 | Alarm duration | 5 | s | - | - | - |
| 12 | 15 | Frequency of Alarm | 5 | dB | - | - | - |
| 13 | 15 | Battery Recharge Time | 5 | s | - | - | - |
| 14 | 15 | Battery capacity | 5 | mAh | - | - | - |
| 15 | 15 | Number of locks | 5 | # | 2 | 2 | 2 |
| 16 | 5 | Number of compatible wheelchairs | 3 | # | >25 | >15 | >26 |
| 17 | 16 | Functionality Unhindered | 5 | N/A | Yes | Yes | Yes |

**\*yes is a value of 1, no is a value of 0**

Although limited information was obtainable for the competing products, based on universality, life span, and assembly time, the team decided that ADI stealth systems had the best design. It had a longer life span, higher compatibility count, and relatively short assembly time, as well as being attachable to manual wheelchairs without hindering their functionality.

**DESIGN SPECIFICATIONS**

The team set target specifications that could allow our design to compete with ADI stealth systems. They are realistic expectations of the design to guide the design and manufacturing process, listed in the table below.

**Table 4: Design Specifications**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Metric** | **Units** | **Value** |
| 1 | Clean construction, no sharp parts | N/A | yes |
| 2 | Assembly/Disassembly time Time | min | 60 |
| 3 | Be under budget ($100) to develop | $ | 100 |
| 4 | locking Time | s | instantaneous |
| 5 | Maximum Weight for Operation of System | kg | 200 |
| 6 | Temperature range | oC | -40 to 89 |
| 7 | Size of locking system | m2 | - |
| 8 | Corrosion resistant | N/A | Yes |
| 9 | Waterproof | N/A | Yes |
| 10 | Minimum lifespan of locking system | yrs | 3 |
| 11 | Alarm duration | s | 2 |
| 12 | Frequency of Alarm | Hz | 4000 |
| 13 | Battery Recharge Time | hrs | 4.5 |
| 14 | Battery life | mAh | 2000mAh |
| 15 | Number of locks | # | 2 |
| 16 | Number of compatible wheelchairs | # | all |
| 17 | Functionality Unhindered | N/A | Yes |

An important specification is the locking time of the system. People will rely on the mechanism to automatically lock the chairs for their safety so it must work relatively quickly. The team also noted that the size and weight of the design should be be reasonable enough to avoid difficulty in storage and transportation. In addition, the design is expected to be universal in that it can be fixed to any wheelchair in a wide range of climates.

## **CONCEPT GENERATION AND ANALYSIS**

The team applied several concept generation strategies learned in class which include sketching and using a method called SCAMPER; standing for substitute, combine, adapt, modify, put to another use, eliminate and reverse. The initial process if needs identification and design specifications helped the team during the process of individually coming up with multiple design ideas. The brainstorming process was very general, and all ideas were listed, but the outlined needs of the design helped to guide the team during the brainstorming process. After many ideas had been generated the team compared and discussed the ideas in order to mix, revise and eliminate some of the designs. The process was necessary to move towards a design which satisfies the customer and the team. A few of the individually generated ideas are shown in the figure below.

## 

**Figure 1: Different Concepts Generated**

The most popular ideas among the team members included:

* A mechanical system that would use the pressure from the seat as a trigger to lock the wheels.
* Extra long wheelchair brake handles so that it is easier to lock the manual brakes.
* An electronic system that uses a pressure sensor to trigger the brakes to be locked..
* Devices placed on the arm that would be used to lock the brakes,
* Sensors used on the footrests of the wheelchair that would lock the brakes.

## **DESIGN SOLUTION**

The actual design chosen for development is as follows:

A wheelchair will be fitted with a pressure sensing device that is connected to an Arduino microcontroller, which in turn is connected to two servos. In addition, there will be a fixture on the wheels that enables a pin mechanism to control whether the wheels are locked or not. The brakes will be able to lock/unlock with the press of a button (which is the override system), increasing the reliability of the system. LEDs will be used to indicate when the battery is low and to indicate the status for the locking system.

The microcontroller will be programmed such that when it receives a signal from the pressure sensor indicating that the wheelchair is unoccupied or that the patient is not seated properly (i.e. with their weight balanced at the back of the seat) it will activate the servos. The servos would push the pins into the mechanism on the wheels which would lock the wheelchair. When a force is detected by the pressure sensor (i.e. the patient is properly seated) the microcontroller would send a signal to the servos which would remove the pins from the wheel locking mechanism.

The following diagram illustrated how the mechanism would work:



**Figure 2: Chosen Concept Design**

(1) **Pressure sensor**. The pressure sensor detects the force placed on the seat of the wheelchair. It sends that reading to the microcontroller. This could also be placed on top of the seat.

(2) **Arduino microcontroller**. When less than a prescribed value is detected, the microcontroller would send out a signal to activate the two servos.

(3) **Servos/actuators and pins**. The activated servos/actuators would push a pin into the attachment to the wheel.

(4) **Wheel locking fixture**. When the pins are pushed into the locking mechanism, it would prevent the wheel from moving thus locking it in place.

## **PROTOTYPING AND PROJECT PLAN**

In order to develop a product to satisfy the user’s needs, the team needed to create several prototypes for testing and obtaining user feedback before the end of the semester. A project plan was developed to ensure effective time management by outlining the steps needed to complete the prototypes. A condensed task list is shown below (See Appendix 1 for detailed task list).

* Take measurements of the wheelchair
* Source materials
  + Determine what gauge components would be needed
  + Purchase materials
* Make a computer model of mechanism
* Source cardboard/materials needed to make 1st prototype
* Build first prototype
* Receive feedback from user
* Make changes and construct 2nd prototype

Additionally, the team created a budget to anticipate the cost of creating the conceptual design while satisfying time constraints.

**Table 5: Projected Bill of Materials**

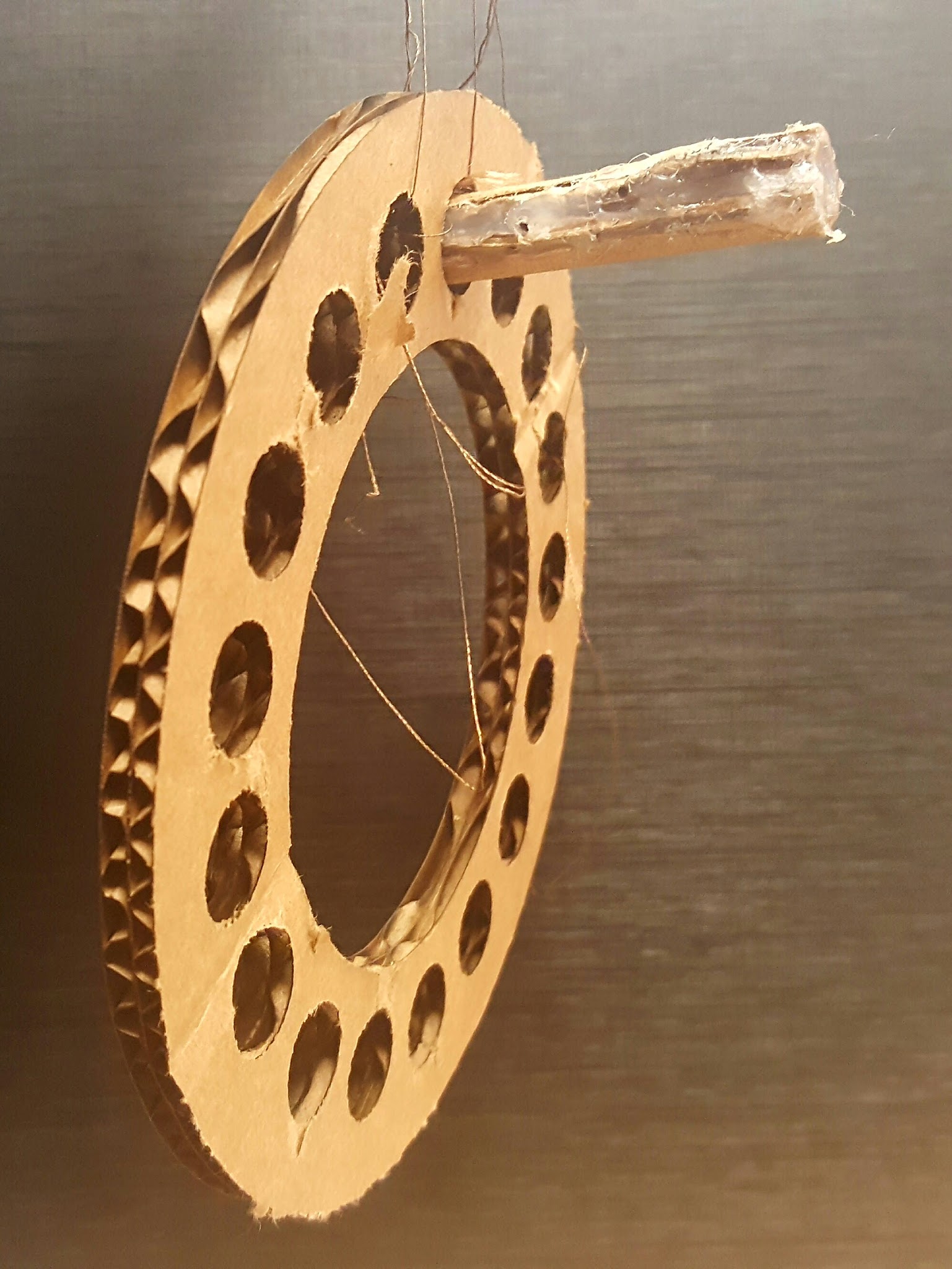
|  |  |  |  |
| --- | --- | --- | --- |
| **Component** | **Price per Unit ($)** | **Number of Units** | **Total Cost ($)** |
| Servo x 2 | 11.00 | 2 | 22.00 |
| Wire kit | 9.00 | 1 | 9.00 |
| Metal sheets/rubber disks | 15.00 - 25.00 | 1 | 25.00 |
| Microcontroller | 25.00 | 1 | 25.00 |
| Pressure sensor x 2 | 9.95 | 2 | 19.90 |
| LED light | free | 1 | 0.00 |
| Button | 0.03 | 50 | 1.58 |
| Speaker | 2.00 | 1 | 2.00 |
| MDF | 10.00 | 1 | 10.00 |
| Total |  |  | ~ $ 114.48 |

In table 5 it can be seen that the total cost for all of the materials is above the allocated budget of $100.00.

PROTOTYPE 1

For Prototype 1, the team used cardboard to develop the pin and Wheel locking fixture. Cardboard was used as the first prototype to lessen the need to spend money but also conceptualize the mechanism physically.

The cardboard prototype allowed the team to explore the design further, as more holes are put onto the wheel, the weaker the fixture will be. It was also difficult to find placement for the components needed to lock the wheelchair.



**Figure 3: Materials used for Prototype 1**

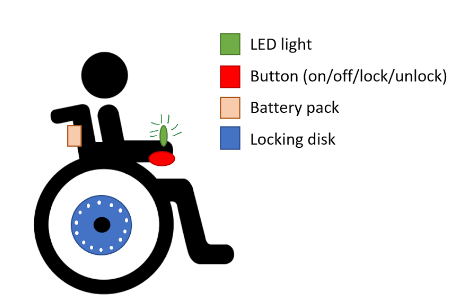
CLIENT FEEDBACK FOR PROTOTYPE 1

The first prototype was shown to the hospital’s technologist, wheelchair technician and occupational therapist to gain their feedback. They showed interest in the concept but also made suggestions on how the design could be improved:

* The battery pack should be in an accessible place so that a caretaker or nurse can change the batteries as needed without any difficulty.
* Any buttons should not be on the top of the armrest because the patients can potentially activate them by mistake when they are maneuvering in and out of the chair.
* Button needs to be easy to use.
* The manual brakes should remain attached to the wheelchair as a precautionary measure.
* The system should include a notification for low battery.
* Any additions should not add too much weight to the wheelchair and should not hamper its ability to fold.

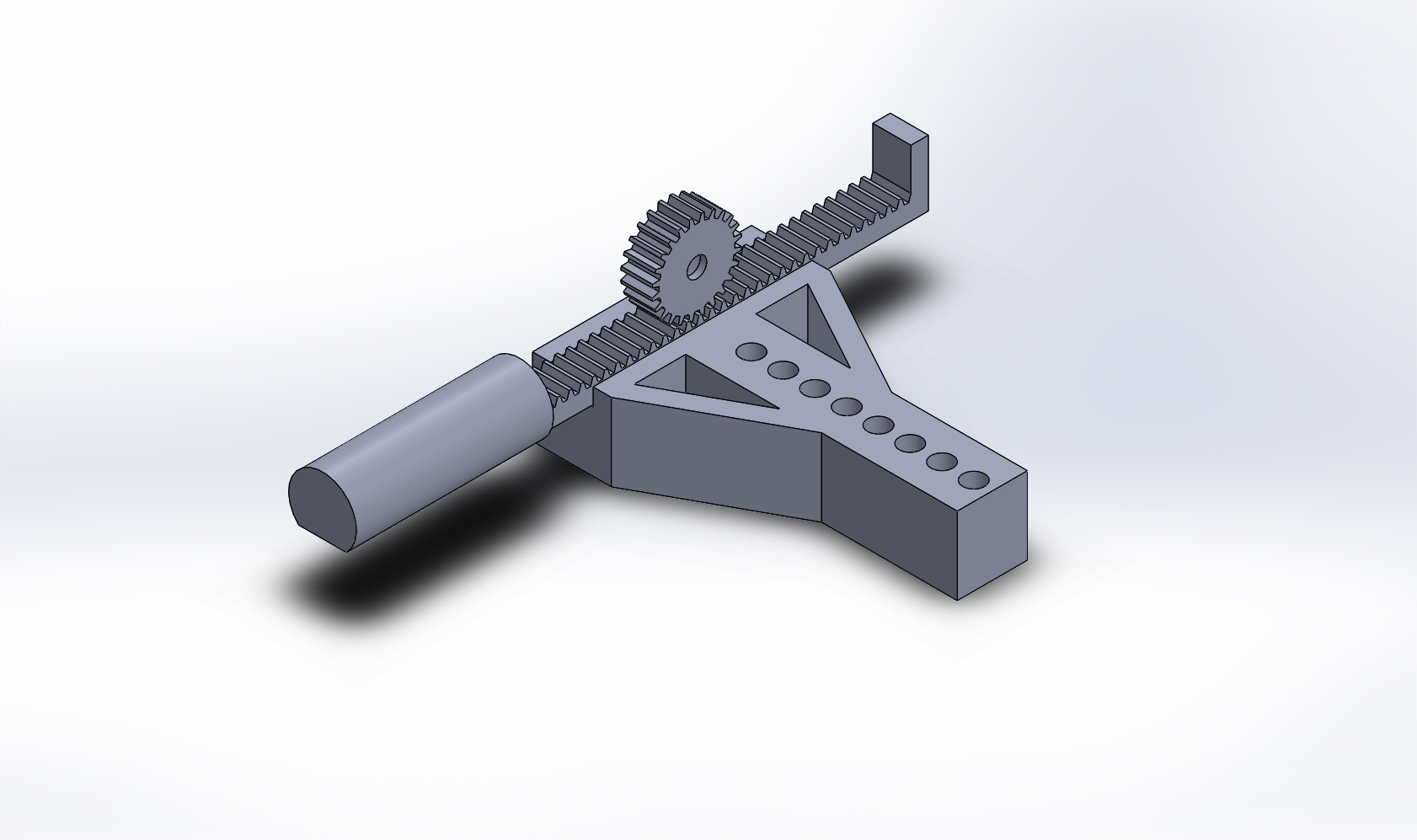
PROTOTYPE 2

The feedback from prototype 1 was used to modify the design of the system:



**Figure 4: Changed Design**

A video presentation was prepared to illustrate the workings of the modified design. It also included a demonstration on how the circular motion provided by the motor would be converted to the linear motion needed to move the pin into the wheel locking attachment. A rack and pinion system was used for the conversion with the pinion attached directly to the motor.



**Figure 5: Computer Design of Rack and Pinion**

CLIENT FEEDBACK FOR PROTOTYPE 2

After viewing the video, the hospital technologist expressed enthusiasm to see the final working prototype on design day.

PROTOTYPE 3

For the final prototype, a pressure sensor was used to detect force placed on the seat of the wheelchair. This would send a high resistance value to the microcontroller. An Arduino microcontroller was used the process the data of the pressure sensor and send information to the DC Motor. The DC Motor turned the gears of the rack and pinion causing the pin to be placed inside the holes of the wheel locking fixture.



**Figure 6: Final Prototype for Design Day**

CLIENT FEEDBACK FOR PROTOTYPE 3

On the design day the judges, which included the hospital's technologist and wheelchair technician, observed how the automatic locking system would work. They were impressed by the working prototype and were interested in the concept. Even though additional features such as the button and the LED light were not incorporated in the design day prototype, they still remain as part of the final design.

## **IMPLEMENTATION AND TESTING**

COST OF PRODUCTION

**Table 6: Actual Bill of Materials**

|  |  |  |  |
| --- | --- | --- | --- |
| **Component** | **Price per Unit ($)** | **Number of Units** | **Total Cost ($)** |
| MDF | 3.00 | 1 | 3.00 |
| Pressure Sensor (incl. shipping) | 41.96 | 1 | 41.96 |
| TOTAL |  |  | 44.96 |

As seen in Table 6 the actual bill of material is much less than the projected bill shown in Table 5. This is because most of the materials were printed using the free materials provided by the Richard L’Abbe MakerSpace. The only things that were purchased were a piece of MDF for the wheel attachment and a force sensitive resistor (pressure sensor), which most of its cost was due to expedited shipping.

PROTOTYPE TESTING OBJECTIVES AND RESULTS

The group constructed prototypes for several reasons. Building the prototypes was used to demonstrate to the customer how the system would work. By doing this we would gain their feedback on the design to make any necessary modifications. Prototyping also served as a learning process for the team. The members were able to incorporate previous knowledge learned in the labs and also gain new knowledge in order to build a successful prototypes. The most important reason for prototyping was to determine if the system was functional. In order to make that determination, tests had to be conducted.

For the first prototype, testing was not feasible since it was intentionally constructed to be a non-functional, concept prototype. The second prototype, however, consisted of a focused, physical prototype of the rack and pinion system used to push the pin in the locking mechanism. The test for this was demonstrated in the video presentation. The pinion was fitted over the motor and placed so that the teeth fit into the grooves of the rack which would be extended to include the pin. Although the system worked, a critical observation was made about the quality of the 3-D printed pieces used: a higher quality design and 3-D print was needed so that the pieces of the system would move and fit together more smoothly.

For the final prototype, which was physical and comprehensive, the pressure sensor was incorporated together with the appropriately coded arduino to run the system. The testing for the sensor simply consisted of pressing it to ensure that it registered a signal which moved the motor. When the whole system was assembled, a test with someone sitting in the wheelchair revealed that the pin was too long, as it had snapped. After the pin was shortened, the design day demonstration of the working prototype also revealed that the battery used to power the system did not have a long enough lifespan as it died after 30 mins of testing. All of the information obtained from prototypes and tests can be used to further the development of this system to be a successfully working product.

## **CONSTRAINTS**

### PATENTS

An intellectual property search was conducted on automatic wheelchair locking systems. Using Google Scholar, patents for self locking wheelchair designs were searched from 1997 to present day (20 years). Three relevant results were found and analysed to examine the impact they may potentially have on further developing our design.

The most relevant results comprised mainly of mechanically operated systems, not electronic like the design outlined above. This means that there are little to no patent restrictions on the electronic aspect of our design.

### SAFETY GUIDELINES AND REGULATIONS

According to the Government of Canada “Justice Laws website”, the device is obligated to perform as intended by the manufacturer. Also, below is a summary of the regulations to be met by the system in order to ensure the safety of users.

* Thorough analysis must be run to identify all risks associated with the operation and functioning of the locking mechanism. If possible, all risks should be eliminated. If not, risks should be reduced as much as possible, information should be provided to alert users of the possible dangers, and protection from the effects should also be provided. The risk alert is a part of the final design concept that could not be implemented due to time constraints. LEDs are to be incorporated to notify the user if the system is locked or not (if the pin has problems going through the openings), and the status of the battery.
* The system would have to be observed to ensure that the materials it interacts with during use are compatible with the materials used to build the system.
* Foreseeable hazards such as electrical, mechanical, thermal hazards, flammability or explosion would need to be identified and minimized in the design, manufacture and packaging of the system. [1]

### PACKAGING REQUIREMENTS

There are certain regulations guiding the marketing and distribution of the system in Canada.

According to the Government of Canada “Justice Laws website”, in order to sell the device to the public, the device should be labelled with certain information, available in English and French.

* The label should include the name of the device, name and address of the manufacturer, directions for safe and effective use, any special storage conditions. The information should be set on the outside of the package (unless there is limited space), and visible under normal conditions of sale. [1]

# **CONCLUSION**

## Further work:

Some other elements are to be added to the design before it is ready for final concept testing, and then possibly manufacturing and distribution. These concepts were not available in the product presented for design day due to time constraints:

* A button to manually engage or disengage the brakes in the event of system failure.
* LEDs in a visible location to display the status of the system: locked, unlocked and battery level
* Waterproofing to ensure the system is functional outdoors without worry and to increase it’s lifespan

Implementing these concepts would create a product that fully solves the identified problem, while satisfying the target metrics and specification of the project. Furthermore, the system would need to be checked to ensure that it complies with the strict policies of insurance companies who specialize in covering medical devices, as well as wheelchair manufacturers. The design may be modified if necessary to prevent users from losing their insurance or warranty for adopting the system. The design was created to be as minimally invasive as possible to the wheelchair frame, meaning all aspects of the locking system are removable and do not affect the integrity of the wheelchair. A finished product would then be licensed according to Canadian laws so that it can be available to the general public.

Specific design file, including the coding files and laser cutting files are avaiable at <http://makerepo.com/khugh011/gng2101c02gen8automaticbrakingwheelchair>

Overall, the team was able to create a working system at the end of the semester, and the project taught the team to apply design thinking to solve real world problems while accounting for constraints.

# **REFERENCES**

[1] Government of Canada, ‘Justice Laws Website’, 2017. [online]. Available: <http://laws-lois.justice.gc.ca/eng/regulations/SOR-98-282/page-2.html#h-5>.

[2] ADI Stealth Products, ‘Disc Brake Systems’, 2016. [online]. Available: <http://adi.stealthproducts.com/disc-brake-systems/>

[3] Pratiko Solutions Supplier, ‘Automatic Braking System’, 2016 [online]. Available: <http://en.pratikopratik.com/our-pratiko-product-lines/medical/automatic-braking-system-for-wheelchair/>

[4] Safer Wheelchairs, ‘Safer Automatic Wheelchair Wheel Locks’, 2016 [online]. Available: <http://www.saferwheelchairs.com/>

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# **APPENDIX**

## Appendix 1: Detailed Task list

|  |  |  |  |
| --- | --- | --- | --- |
| **Due dates** | **Description** | **People involved** | **Plan** |
| 26-Feb | Project plan and feasibility study | everyone | complete the deliverable in a group doc |
| 27-Feb | Prototype 1 | Akif &  Vwede | work on starting to program an arduino to operate two servos upon receiving a signal from a the pressure sensor |
|  | Quinn &  Kara | Take measurements of the wheelchair and order any parts necessary for prototype 1. Put together a cardboard prototype based on the two designs (Proto 0). Then build a prototype from MDF that fits on the wheelchair (Proto 1, to show the user). |
|  | Evan | build a model of the wheelchair on solidworks, and look into the strengths of servos/materials needed for the project |
|  | everyone | go to the hospital and present current ideas and first prototype to Bocar and the wheelchair technician |
| 05-Mar | Business model | everyone | complete the deliverable in a group doc |
| 06-Mar | Customer validation/next steps presentation | everyone | create a google slides presentation, where group members will create slides describing their input/efforts in the project and their next steps. Look put together for the presentation |
| 12-Mar | Economics report | everyone | complete the deliverable in a group doc |
| 19-Mar | 1 min video pitch | everyone | write script for the video, find a location to film the video, edit the video |
| 26-Mar | Prototype 2 | Akif &  Vwede | attach servos to the arduino circuit and mount on wheelchair |
| Quinn,  Kara &  Evan | Help with soldering the circuitry, and 3D printing/cutting/outfitting materials for structural wheelchair parts |
| 27-Mar | Project presentation | everyone | create a google slides presentation, where group members will create slides describing their input/efforts in the project and their next steps. Look put together for the presentation |
| 29-Mar | Design day presentation | everyone | Bring all prototypes and the wheelchair, make a poster to describe the process, and if possible, a video that shows the wheelchair locking system functioning (if unable to demonstrate at venue) |
| 02-Apr | Intellectual property | everyone | complete the deliverable in a group doc |

## Appendix 2: Business Model

After researching different business models, the team decided the best model to further the business plan is the Direct Sales model. This is because it allows a quality product to be delivered to the customer at a competitive price. The model also fosters mutually beneficial relationships between the product developers and the customers. The direct sales model would also enable the product to be technologically developed further due to the input of investors.

This model involves selling the product directly to customers: hospitals, individuals, care centers. Funding for the project would rely on investors, as well as partnership with organizations or hospitals that need the mechanism for their patients. As an incentive, partnering institutions would have the product subsidized for them, or for any of their patients that need the product for individual use. The benefit of partnering with organizations is that they have larger marketing and advertising platforms.

A major risk is that since there are several tested and verified wheel-locking mechanisms for wheelchairs, organizations may decide to purchase those, rather than investing in a start-up product. Hence, finding key partners may be a challenge.

Pricing for the product would be set based on manufacturing cost. One of the objectives was to make the product affordable to users, so the cost of production would be optimized as much as possible without compromising durability and functionality.

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| **Key Partners**  **Users:**  -disabled people  **Buyers:**  -hospitals  -nursing homes  -schools  -wheelchair manufacturers  **Others:**  -insurance/lawyers  -engineer | **Key Activities**  Customer acquisition  Marketing | **Value**  Easy locking system for wheelchairs  Minimizing accidents  Minimizing work for nurses | **Relationship**  Return Policies  Documentations | **Customer**  Caretakers  Hospitals  Clinic Patients |
| **Key Resources**  Manufacturers  Hospitals  Electronic Suppliers  Patents | **Channels**  Website  Visiting Hospitals |
| **Cost Structure**  -shipping  -materials  -manufacturing  -testing  -website | | **Revenue Streams**  Sales  Investors | | |

**Figure : Business Canvas Model for Design**