Second Nature Solutions

T02 Group 10

As a future member of the engineering profession, we, Second Nature Solutions, are responsible for performing the required work in an honest manner, without plagiarism and cheating. Submitting this work with our names and signatures is a statement of understanding that this work is our own and adheres to the Academic Integrity Policy of McMaster University and the Code of Conduct of the Professional Engineers of Ontario.

Names and Signatures of Team Members

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Abstract

Our client, Elissa, has the condition of general dystonia which has resulted in her inability to perform certain fine motor functions, trouble with balance, and in the case of our project, not being able to move heavy loads reliably and efficiently. Due to Elissa's surgery, whenever Elissa would attempt to move around heavy loads such as laundry, groceries, etc., she would experience straining on the wires in her neck area placed there to help with her tremors. As such, performing such a task has proven to be very difficult for her. Medical documentation is provided in Appendix A. Our product/design aims to aid Elissa in this problem of moving heavy loads. The product has been modelled off of a traditional dolly, with various modifications like stair climbing wheels and a raisable platform. All of the functions of the design have been carefully thought through in order for the design to be easy for Elissa to operate. As for benefits, Stair climbing wheels allow for Elissa to transport heavy loads up and down the stairs with relative ease. Furthermore, the electric jack lifting system reduces the amount of awkward lifting motions she would have to do. This benefits her due to her impaired ability to perform fine motor tasks with her hands such as grip related activities, making manually lifting objects or manually cranking a jack difficult. A dolly system would be particularly advantageous for Elissa as she has stated that pushing things is not as hard of a task as pulling or picking things up. If given more time, our group would have implemented the features suggested to us that we were unable to implement due to time and resource constraints. This includes the ability to apply an emergency braking system to prevent loss of control of the device in certain situations, the implementation of more cost-efficient alternatives, as well as weight reduction of the overall design.

1.0 Introduction

1.1 Background

Our client, Elissa, suffers from a condition that causes the muscles in her body to move uncontrollably and involuntarily, known as general dystonia. Because of this, Elissa experiences difficulty performing a handful of everyday tasks, such as speaking, writing, using a keyboard, using the stairs, etc. as mentioned in her medical documentation found in Appendix A [2]. In the case of our design, we aim to improve her ability to carry and transport heavy loads from one location to another. Elissa has claimed in numerous in-lecture interviews that when moving heavy objects around, she would often experience pain in the scar tissue near the wiring in her neck (placed there by the surgery she underwent years ago due to her condition) (Figure 2 & 3, Appendix A). As such, it is especially difficult for Elissa to move things like laundry baskets full of clothes, groceries, book bags, and other common items.

1.2 Refined problem statement

To design a dolly system that aids Elissa, our client who suffers from general dystonia, in the displacement of relatively heavy objects. The purpose of this solution is to prevent discomfort in the areas surrounding the wiring in the client's body. The device is to be safe to use, suited to her specific needs, portable, and able to support loads of approximately 10 kg. The solution will be used for Elissa's day-to-day activities (in her home, running errands, etc.) in an environment that sees weather including rain and snow/ice, and common obstacles like stairs, curbs, bumps, etc.

1.3 Design objectives and constraints

Prior to the design conceptualization itself, we laid out a number of design objectives and constraints to provide us with a foundation on what we wanted the design to look like and how it would function. Much of this conceptualization started with the objective tree consisting of objectives and constraints of our design, which can be found in Figure 1, Appendix A. Beginning with the objectives, we laid out three main objectives the design would have to have. These objectives include being ergonomic, lightweight, and supportive. Selection of the three main objectives stem entirely from Elissa's condition. The device must be ergonomic as the device is designed to be useful in any work environment that requires any form of heavy lifting. The design being lightweight is a necessary objective of the design as Elissa's condition prevents her from maneuvering any sort of heavy objects, and so if the design was too heavy the design itself would be counterintuitive. Furthermore, the objective of being supportive is a must as the main objective of the design is for Elissa to be able to transport heavy loads from one place to another, so if the design fails to support relatively heavy objects then the whole design fails to meet its main objective. Moving onto the constraints, stemming from the objective of being ergonomic, we found it absolutely necessary to avoid any feature that would result in the use of fine motor skills, as Elissa has mentioned before in several lectures that such actions were difficult for her to perform. Furthermore, given that it is difficult for Elissa to perform tasks that require extensive use of her muscles, we added another constraint to the design to minimize input strength as much as possible, which directly ties into the objective of the design to be lightweight.

1.4 Existing ideas and solutions

Parts of our final design have been inspired by several already existing ideas, all combined into one design thats purpose is to improve Elissa's ability to transport heavy loads from one place to another. One of which includes the dolly, which is a two wheel cart with a flat platform that is used to transport items from place to place. Our design's main chassis consists of a modified dolly for its ease of transportation and its relative compactness proves to be beneficial for Elissa with regards to her condition. To improve the functionality and usefulness of the design, we took the liberty of replacing the dolly's wheels with stair climbing ones. This stems from an already existing idea of a device called the "Climb cart". This device possesses "wheels that is able to climb stairs effortlessly. It has a 6 wheel system that allows it to pivot up stairs[1]."This idea was used as it is able to perform a function that would be very beneficial to Elissa and improve our design. The combination of an easy to move dolly and the ability to climb stairs enables Elissa to move a variety of objects all around her house and in many other environments, such as the stairs of an apartment complex, curbs, grocery stores, etc. with relative ease. Furthermore, the use of existing ideas and concepts allowed our group to focus on other functions of the design in the limited time given, such as the raising and lowering of the platform -- one of the main functions of the overall design.

2.0 Conceptual Design

2.1 Ideation

At first, we came up with the basic idea of using a dolly system to help Elissa move the specified heavy loads (large or cumbersome loads, particularly weighing over 20lbs). Also, we wanted to find a means for raising those loads on the platform of the dolly so that she did not need to bend her body, reducing the pain from movements that would pull on the scar tissue around her wires.

With these ideas, the group developed some functions and means using a morph chart, pictured in appendix B figure 1. For instance, we wanted our design to lift loads off the ground, and we also wanted the design to enable easy transport of the loads across various types of terrain. Some of the means we came up with, for example, were pulley systems, hydraulic jacks, or winches. For handling movement we thought of triangle-oriented wheels, a hook for navigating stair railings, or a belt which is attached to the client for more support of the dolley.

2.2 Design Alternatives

We developed three designs which we believed fulfilled all the functions in our morph chart. The first design is a dolly with a platform that can be raised (as seen in appendix B, figure 2). It is built by the base of dolly car with the stair climbing triangle-oriented wheels, a solid platform on the bottom, and a pulley system on the top which connected to the platform to lift it. She does not need to bend her body with this design, meaning the product can reduce the amount of pain Elissa may have to endure in a day.

The second design is called “Winch Box”. The design sketch can be found in appendix B figure 3. It is composed of the milk-crate-like box on the bottom, two large wheels, an electric winch system, and a luggage-style collapsible handle. It has the same principle as the first design, except we opted to replace the platform with a box (which would be more effective at carrying many small loose objects. With the raising platform or box makes her feel less pain or stress from the wire on her back when she wants to do something by bending her body.

Finally, we decided to use the third design to expand our creative reach. The components of this design consist of a high-power fan, that would push air down and effectively lift the dolly's base like a hovercraft. When the dolley is stationary, a scissor jack powered by the same battery that the fan uses could be used to lift and lower weights to a more convenient height. A handle is attached with an interface on near the handles for control of the fans and the jack. This design idea is represented in figure 4 of appendix B. Even though this design is hard to accomplish, this design still fulfills most functions in the morph chart and it allowed the team to see the full potential of each others' imagination.

2.3 Decision Matrices

With the three designs, we use various objectives and constraints to mark the best design for Elissa**.** Our best-of-class chart can be found in appendix B figure 5. The first design is called "Dolly with the lifting platform". For portability, the base of design is a dolly and Elissa can carry it easily. Also, for supportive, it has a solid platform which is connected to a jack on the bottom. The jack is able to raise any loads from the ground and the platform can hold the loads steadily.

The second is the "Winch box" which is similar to the first design in that both of them are supportive and easy to transport. However, an electric winch system is used in the second design which would reduce the amount of manual input required, but there is no definite place to attach the hook of the winch in every scenario it may be used in.

The third design "hover dolly", is creative, but it does not sufficiently meet most of the objectives. For example, the giant fan system is not portable and the platform can only be raised when it is completely stationary. It also would not be able to climb stairs/curbs at all, unlike the other two designs. Although design one and two were tied in points, a major deciding factor for choosing design one was that design two did not accomplish the objective of safety as well as design one did, since the design was clunky and large. Thus, our group decided to use the first design as the one to base our prototype upon.

2.4 Design Evaluation

In the first interview with the science students, we were offered some useful suggestions for the operation of the lifting system embedded in the dolly's construction (refer to Appendix B figure 6). Referring to the Impact Review notes in Appendix B, figure 8, they mentioned that it would be hard for Elissa to operate some of the manual apparatuses (such as the crank of a winch system). Instead, we were suggested with the concept of using feet to operate the lift rather than hands. Furthermore, the reviewers inquired about the materials we were looking into using for the construction of the final prototype- to which we had no real answer. It was clear at that point that material choice was crucial for making our design portable for Elissa to transport and easy to use, among other things.

Referring to the peer review notes in Appendix B, figure 9, the group we met with said the design is good but were not quite sure when Elissa would use it. They suggested we make the design more simple so that it is more accommodating for Elissa's day-to-day activities, while also noting that can Elissa may actually find it difficult to bring a dolley up and down stairs, even with the stair climbing wheels in prototype two. Near the end of the review, the reviewing group members tried to brainstorm another way to lift the platform up rather than raising up through pulley system. There seemed to be a general consensus that lifting the platform from the bottom of the base might be a more realistic approach.

At the second interview with science students, we brought a medium fidelity example of our second prototype (shown in Appendix B figure 7). We presented the dolly we would be using as the basis for our design, inserted the triangle-shaped wheels at the bottom, and attached a bungee on the base. Although we did not have the lifting platform on the dolley, we told the reviewers that we would insert a pedal on to a crank which would operate a scissor jack (this being the new solution to raising the platform up). After we finished talking about our design, the science students were very impressed, to our surprise, but still had useful feedback to give. For example, they said we should focus on the shape of dolley's handle due to Elissa's dystonia (Appendix B, Figure 10). Instead of the existing handle which was narrow and rather unsupportive, they thought we could change it into separate handle and make it more wider for Elissa.

When we did our presentation with fellow engineering students, most of the discussion stemmed from the foot-operated scissor jack system. There were concerns regarding how Elissa would connect the bike pedal crank to the scissor jack, and if that would entail a bending over motion that we sought to eliminate in the first place (Appendix B, Figure 11). With this concern, we were made aware that we would have to do some deep thinking about the process of assembling the device we create.

3.0 Final Design

3.1 Description

Our purpose in this design was helping her to reduce the pain from wires on her back when she bent her body, like she did the laundry and bent her body too much, the wire would shock her body. For instance, Elissa wants to do her laundry, she can use the dolly to transport her laundry bag. She uses the drill to rotate the axle and operate the scissor jack and let it raise up the platform to a proper height, so she will not bend her body and carry all loads. If she wants to move the dolly upstairs, the triangle-oriented wheels come in handy

The design was based on a dolly, a pair of stair climbing triangle-oriented wheels, a platform, and a scissor jack on the bottom. The dolly was the basis of our design and the normal circular wheels were replaced by the triangle-oriented wheels with fixed axles. Scissor jack was connected between the bottom of dolly and the platform, and there was an axle which passed through the center of scissor jack. When a drill twirled the axle, it operated the scissor jack to raise the platform up.

3.2 Objectives, Constraints, Metrics

Our final design met several objectives which the group set out to achieve in the ideation phase of development. One of the objectives was portability, and the metric we used to measure this was total device weight (to be less than 20lbs). The device ended up being 13lbs, which is heavier than we would have liked it, but still met our objective nonetheless. The final design also met the objective of being ergonomic. Since the device was configured based on a dolly, it required little to no fine motor skills, and the device was proven to be easy to use even when grip strength was intentionally reduced by users to simulate the client. Lastly, our design partially met the objective durability. Every component used to make up the device is industrial, making *them* durable. However, since the device is rather heavy, if it were dropped down a set of stairs for example, it is very likely that components would become detached. That being said, the design can easily withstand extreme weather and can sustain blows (objects hitting the device or being slammed on the lifting platform. So, out of the three objectives the group chose to be the most paramount, our prototype met all of them (to some extent, of course).

In terms of constraints, one of the constraints we set from the beginning was to have no sharp edges. This was to reduce the damage that the dolley could do to Elissa or her surrounding environment (house walls, for example). Though the lifting platform was sanded at the edges to round the corners, we still believe that the edges are still sharp enough to do damage if it was hit against a wall, so in that respect we did not meet the constraint. However, the edges are not sharp enough to cut our client, meaning that part of the constraint (the more important part, we believe) was met. Another constraint we set was the overall weight of the device had to be less than 20lbs. The method for testing how well this constraint was met was done using metrics (refer to the next paragraph). Finally the last constraint we set was that the device had to be able to support at least 20lbs of load. This was set because that was the specified amount of weight that Elissa had difficulty carrying. Our device met this constraint very well, as will be shown in the metrics below as well as in our testing (section 3.4).

In the metrics chart (appendix C, figure 6), we made our own units and metrics of three objectives respectively. Our goal was meeting all the best standard in the marking part. For the objective of being lightweight, our goal was reaching 4 to 6 kg of the overall mass of the device. In the end, our design was 13lbs (5.9kg) which was consistent with our goal. Then, we measured the compactness of our design, with our goal being to make the total folded height below 50cm. To meet this goal, we used the luggage-style handle we had on the device to close the handle, leading the device to shrink to about 50cm in the end. The last objective we used for our metric analysis was supporting loads. We chose to simply measure how much weight the dolly/jack platform could withstand in its fully raised position. As noted in our testing methods section, our design was able to hold over 30 pounds which exceeded our previous goal. To sum up, our device reached all the best standards in our metric chart and achieved the highest possible score (12/12 points).

3.3 Construction Methods

The team really took on the objective of durability for the construction of the prototype, and it was executed almost too well in some cases. The original metal dolley was purchased as the base of the prototype, and the Climb Cart [1] wheels were mated to that chassis as a replacement for the traditional dolly wheels. This was done by removing the axle of the climb cart and replacing the old axle/wheels to avoid welding/cutting. The raisable platform was made by cutting a 14”x20” piece of plywood, cutting a 4”x16” piece out of that to hinge and create a ramp. The hinge feature was accomplished simply by screwing two garage door hinges to the bottom of the two lengths of plywood. To mount the scissor jack to the base of the dolly, a hockey puck was cut in half and placed in between the mounting plate of the scissor jack and the underside of the dolley. The spacing allowed the raisable platform to achieve the lowest possible resting position. The pucks/jack were fastened by wrapping metal strapping around one of the metal pipes of the dolley on each side of the jack, then the pucks were fastened to the dolly by screwing the metal strapping on the top and bottom of each puck. Afterwards, the jack was then screwed to the pucks. The jack was then raised to drill in screws to fasten the plywood platform to the scissor jack. A bill of materials can be located in appendix C figure 1.

Now for the breakdown of how to use the device. To unfold the jack from its folded position (appendix C, figure 4), simply push down the platform so it lies flat on the ground, then extend the handle upward into its operating position. The electric system that we currently have in place (a drill) gets attached to the scissor jack and will lift up and down based on the direction of rotation of the drill. When operating the device, it is used just like a regular dolley, and when escalating stairs or curbs, lead with the cart trailing behind when ascending, and let the cart lead when descending for the stair climbing wheels to work optimally.

These materials were chosen because they were readily available at the time of construction. In fact, most of these items were used because they were found in group members' garages. In hindsight, the materials we used were far more industrial than they needed to be, which lead to issues with total weight of the device. For example, the scissor jack can handle up to 5000lbs of load, where we only needed it for approx. 20lbs. Given this, the materials were once again readily available for the prototype but would likely have been changed if the group had more time and resources (see conclusion for further reflection on this matter).

3.4 Testing Methods

The first thing we tested was the load capacity of the dolley. This was done by lifting the jack up and down while increasing the amount of weight on the raisable platform. The metric we used for this assessment was weight (in lbs), where the goal was to withstand at least 20lbs. As shown in appendix C figure 2, the prototype was able to withstand 40lbs of load. No extra load was added because the group simply ran out of weights to use to test the device.

The second testing method we applied was to use the device to climb a flight of stairs. This, quite obviously, was done to test how easy it would be to use the device in its intended environment. After testing ourselves as well as asking random individuals to test the product, the ease of use of the device over stairs, as well as in the everyday world, was apparent. The device count mount and dismount stairs with ease, and could negotiate outdoor terrain without issues as well.

The final thing we did to test the effectiveness of our product was walk with it (in its closed position, seen in appendix C figure 4) from one end of the McMaster campus to another. The path travelled can be found in Appendix C figure 3. Though the device is not intended to be carried for such a long distance in the closed position, it made it clear to the group that weight reduction would be a priority if further changes were to be made to the device. Oppositely, the device was then taken through the same route in its operating position (fully opened and extended) with a 15lb duffel bag, and the device travelled across the path with almost no difficulty (overcoming stairs, curbs, cracks, etc.

4.0 Conclusions

To conclude, this project presented itself as an unforgettable learning experience that certainly did not come without its challenges.

Having finished the project, there were a few things the group would have liked to change if further development of the prototype was done.If more time had been given, we would have tried to look at different ways we could have reduced the cost of materials. We would have tried to find cheaper alternatives to the materials we used (example- find special wheels alone, rather than buying an entire cart). Additionally, we would also consider making the device more lightweight. The final design is a little heavier than what we wanted it to be for Elissa. The largest weight contributor of the device was the jack used to raise and lower the platform- weighing about 8 pounds. If more time had been given, we would have looked into trying to design an alternative way to lift the platform that does not require something so heavy. If our product were to go into full production, for example, we would likely look into making a scissor jack in house that is scaled down for the intended use. We also think an aspect of our device we would have wanted to improve is the force/positioning required for taking the cart up/down stairs. Although the triangular wheels helps the device go up the stairs, it may still be a bit difficult for Elissa to apply enough force to pull up and control the cart on the stairs. One of the concerns that were voiced in our peer review was the lack of an emergency braking system on the device, in case Elissa felt as though the cart was going to slip out of her hands.The group chose not to implement this feature in the prototype, but we would certainly look into this if more time and resources had been given.

Looking back at the experience and the building process, we believe there were some things we would have done differently. We feel that we should have came up with more design alternatives. Throughout the process we only had 2 solid design alternatives. The limited technical knowledge of the group members, coupled with the simplicity of the problem we set out to solve, were partly responsible for this. Spending more time on developing design alternatives would have opened up more options and ideas for the group to consider when producing an innovative and perfectly ergonomical device. As a group, we should have also tried to come up with a better schedule. During the entire design process, we failed to properly decide on a concrete schedule to base our meetings off of. Though the meetings we held were effective, additional face-to-face meetings would have likely contributed to producing more innovative results.

When it came to team chemistry though, we were stellar. A way to communicate online was established immediately, and all team members made an effort to personally connect with everyone to ensure an efficient and fun process. If a group member was unsure of something, they would not hesitate to ask teammates, and in return those teammates would not hesitate to help them in any way they could. In short, we could not imagine how much more difficult this process would have been had we not created the kind of bonds we did right from the beginning of the year.

All in all, the group learned some very valuable skills and lessons. Time management, communication and brainstorming were three of the greatest skills that each group member developed during the project. We also learned that having a concrete schedule to follow and trying to get input from other people is a very valuable tool that should not be overlooked. Overall, as long as you have a group of individuals who are dedicated to achieve a common goal, anything is possible- and this project is an example of this.

5.0 References

[1] BulbHead, “Climb Cart Stair Climbing Folding Cart,” *BulbHead,* US20070075509A1. [Online]. Available: https://bulbheadinternational.com/products/climb-cart-stair-climbing-folding-cart. [Accessed: Sept. 18, 2019].

[2] “Avenue to Learn”, *avenue.mcmaster.ca*. [Online]. Available: https://avenue.mcmaster.ca/. [Accessed: Sept. 22, 2019]

Appendix A- Introduction

Figure 1: Objective Tree (any chamfered edge box is a constraint)

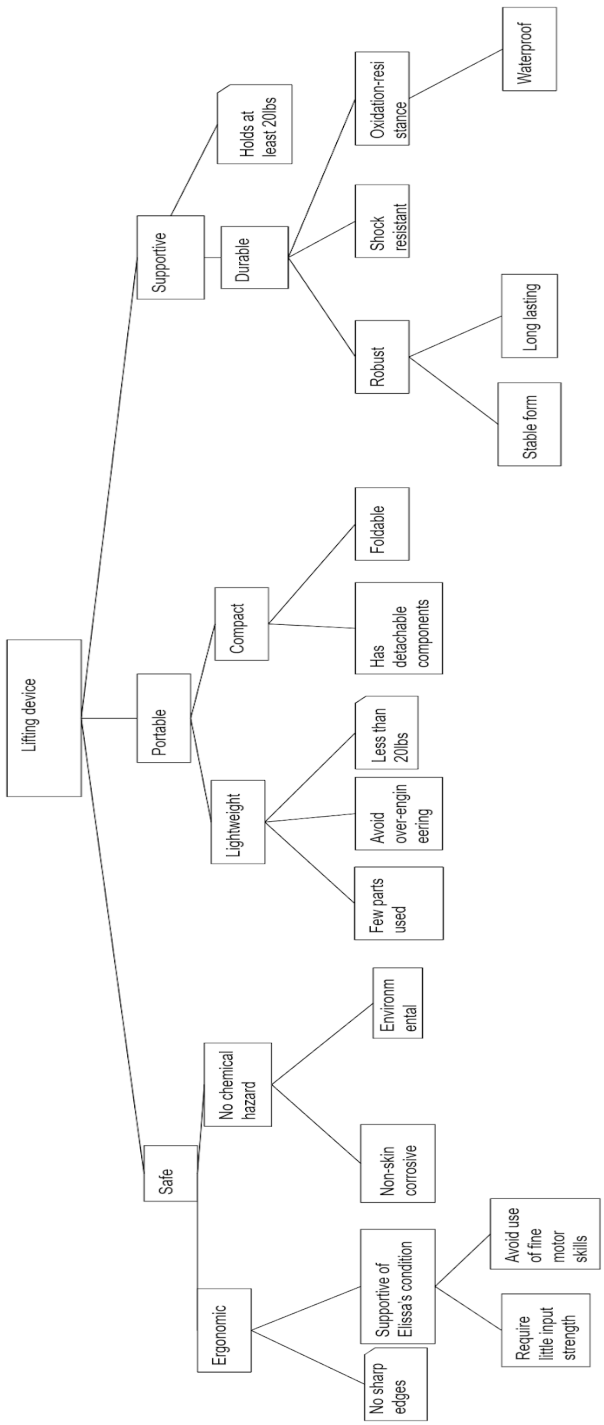

Figure 2: Client Meeting Notes

Client name: Elissa

- Condition: Primary Generalized Dystonia (right handed)
    - **Before surgery:**
        - Speech is affected
        - Affects how her muscle works
        - Hard to control her muscles
        - Hard to write
            - Couldn't take notes in class, work, etc
        - Speaking became difficult (before surgery)
        - Had battery placed in chest to control the electrical impulses from electrodes in her brain placed by the surgery
    - **After surgery:**
        - Surgery helped for the most part but she still has a couple of problems:
            - Speech is still a little bit slurred
                - Can't project her voice that well
                    - Gets muffled whenever she yells or projects her voice
            - Her hands make it hard to write
                - Shakes a lot, hurts
                - Tries to avoid it at all costs
            - Off balance sometimes
                - Sometimes using the stairs is hard
            - Can't do intense activities (bungee jumping, etc) in fear of the battery being pulled
            - Hard to lift >30 pounds
                - More so what she does with it (lifting up putting down, etc)
                    - Holding laundry
                    - Shoveling snow
            - Trouble typing
            - In the morning its hard to grasp things
                - As if her hand isn't awake
            - Her index finger on right hand curls randomly making her wrist hurt
                - Hardest thing for her is using her right hand
                - The finer activities like writing is her biggest challenge
                    - Things like driving is fine
                - Using her smartphone is fine
            - When typing, beginning is ok but as she continues to type it gets harder and harder
            - Experiences small tremors in right hand (usually comes from using her right hand a lot)
            - Turns the battery off when in an airport for example

Figure 3: Client Q&A Notes (bolded questions are relevant to our problem statement)

<u>**Question**</u>	<u>**Answer**</u>
“Do you have stairs in your home?”	She does, and she has a lot.
“How do you feel holding your smartphone?”	It feels fine, typing is usually okay but sometimes it gets harder to type over time.
“How long do your fingers curl for?”	Until she changes what she is doing. Not her hand that hurts more, more like her wrist that hurts.
“What weight are you comfortable holding?”	Harder to hold things more with her right hand (like a coffee mug) for long periods of time.
“Does it hurt when you restrict your hand from curling?”	It doesn’t hurt at all.
“What do you think about using a prosthetic?”	She would be fine with that.
“How do gloves cause irritation?”	The wool gloves causes a “rug” type of burn on her hands due to the way her hands rub together.
“What objects do you struggle carrying with and why?”	It depends on the object. The movement of the object is not the problem. It’s more of what she does with it.
“Any trouble rotating your hand?”	It’s uncomfortable for her to rotate her hand.
“Is it easier for you to move your entire arm than it is to move your wrist?”	Yes.
“What shapes are easy for you to hold?”	Round shapes.
“Do you have any problems carrying laundry or groceries?”	The movement is what creates the problem. She can carry it fine, but moving it around, turning around, etc. is too much.
“Difficulty doing laundry?”	Going up and down the stairs with the laundry basket is difficult for her.
"Does carrying large objects like laundry affect your balance?"	Yes. Picking up the basket is fine, but moving it around pulls on the scar tissues around the wire.

Appendix B- Conceptual Design

Figure 1: Morph Chart

Functions	**Means**				
Lift heavy loads off the ground	Pulley with manual crank	Hydraulic jack	Electric winch	Sturdy material to hold heavy loads	
Move heavy loads around	Wheels on the machine	Handles to control steering and movement	Wheels that move 360 degrees to allow turning	Steering wheel to somehow control the turning of the wheels	Strap onto person
Move stuff up and down stairs	Three wheels fastened to common axle (refer to design #1)	Attaches to railing	Slides up/down stairs using smooth bottom	Belt connection to the person's waist	
Prevent stuff from falling out	Barrier in front of objects	incline back to prevent slipping off	Adhesive material	Clamps to hold objects in place	Straps keeping objects inside
Holds Multiple objects at once	Multiple platforms	Multiple compartment s	Platforms with large surface areas	Places to hang things	

Figure 2: Design alternative 1

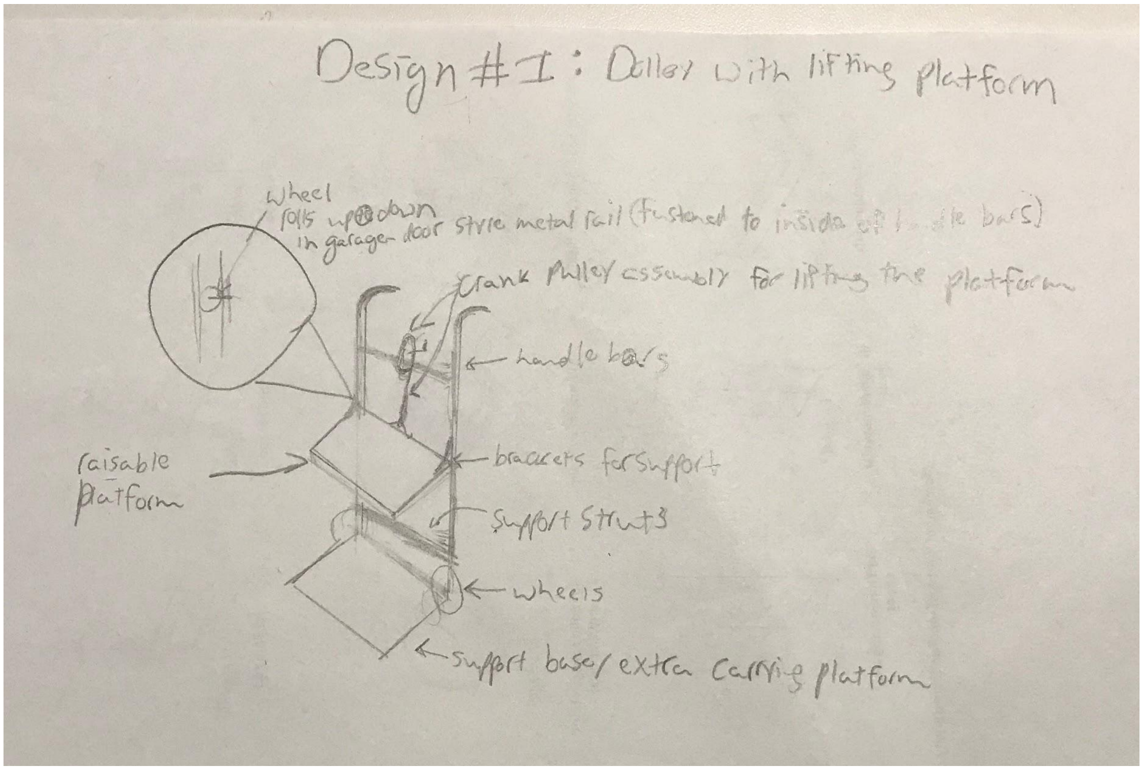

Figure 3: Design Alternative 2

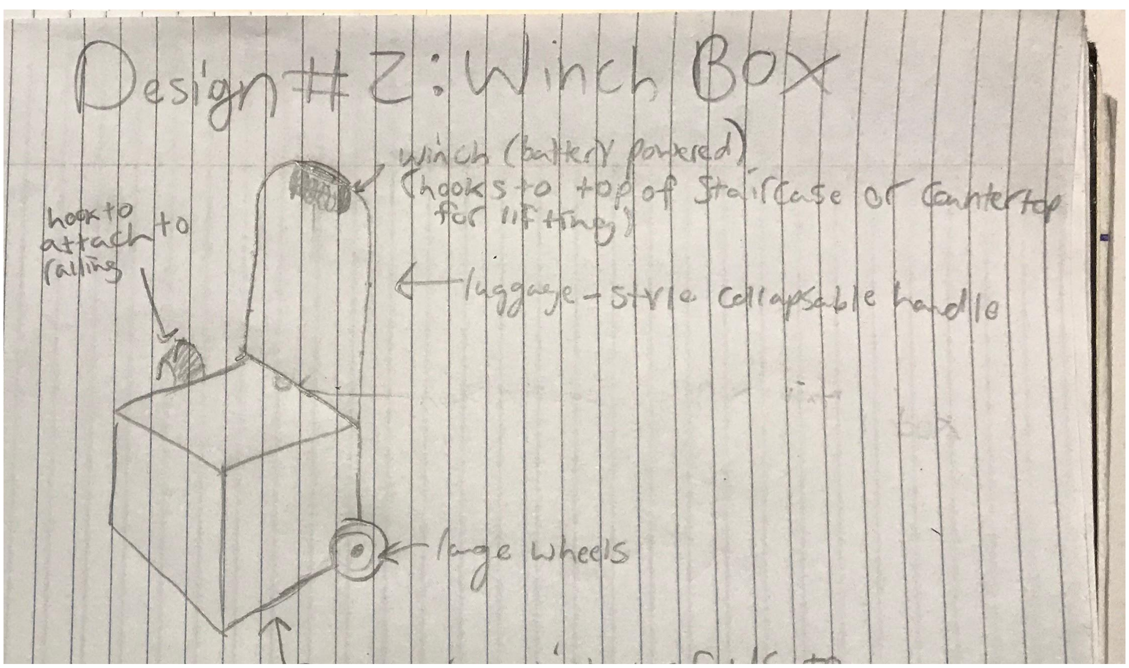

Figure 4: Design alternative 3

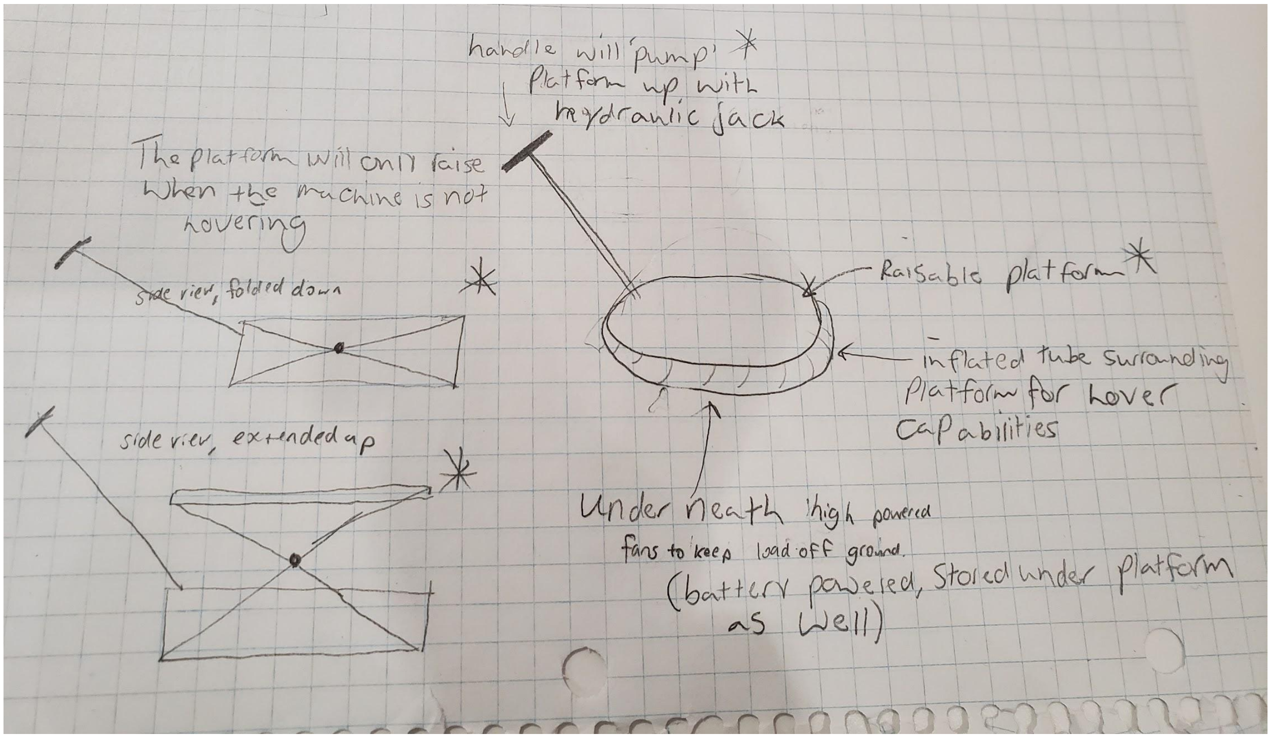

Figure 5: Best-of-Class Chart

Design Constraints (C) and Objectives (O)	Design #1 - “Dolly with lifting platform”	Design #2 - “Winch Box”	Design #3 “Hover Dolley”
Portable (O)	2	3	1
Supportive (O)	3	2	1
Safe (O)	3	1	2
Durable(O)	1	3	2
No sharp edges (C)			
Total:	9	9	6

The two highest scored designs are the “Dolly with lifting platform” and the “Winch Box”.

Figure 6: First prototype construction

Figure 7: Second prototype construction

Figure 8: Impact Review Notes (Low Fidelity)

- One concern is how Elissa's condition might hinder her ability to turn the crank on prototype 1
    - One suggestion is to instead have Elissa use her feet instead of her hands to raise the load up
- How are we going to design the machine (in terms of what materials to use) that might make it easy for Elissa to transport the design from place to place (i.e. from her house to her car, etc.)

Figure 9: Peer Review Notes (Low Fidelity)

- Main concern of both prototypes is how Elissa will bring the machine down the stairs without her dropping it
- How are we going to go about using electricity to pull the load up in prototype 2?
- Turning while maneuvering with heavy loads has been proven to be difficult, as noted by Elissa. How do these designs deal with this fact?
- What materials will we be using to make the design as lightweight as possible?

Figure 10: Impact Review Notes (Medium Fidelity)

- One suggestion was to add brakes onto the wheels so the dolly doesn't move when she tries to raise the load
- Additionally, the handle should accommodate for Elissa's hand condition and have it be easy for her to use for long periods of time.

Figure 11: Peer Review Notes (Medium Fidelity)

- Bike pedal idea could interfere with the wheels if placed at the bottom
- The pedal could also get stuck on the stairs, even if the handle were to be removable there would still be a problem with her bending down to remove the handle to replace the handle
- We could use a lever at the top of the dolly, so it's easy to raise and also won't get caught on the stairs, etc.
- Have something that retracts the bungee cord so it doesn't get tangled up on things.

Appendix C- Final Design

Figure 1: Bill of Materials

Component	Description	Quantity	Cost per	Total Cost
Metal Dolly	4ft tall, base of 1ft by 1ft	1	$30	$20
Climb Cart	Purchased for wheels only, which are rubber/plastic	1	$42.98	$42.98
Lifting platform	½” Plywood, 4’x8’ sheet	20”x16” piece was used	$27 per sheet	$1.74
Scissor Jack	Metal, 20” maxmimum lift height	1	$39.78	$39.78
Hockey puck	Rubber, for fastening scissor jack to dolley	1	$1.45	$1.45
Steel Strapping	For fastening scissor jack to dolley	Metal strapping with holes for mounting fasteners. A 1ft length was used	$0.62 per foot	$0.62
Screws	½”, metal, Phillips head, used for fastening	20	$0.13	$2.60
Garage door hinges	Metal, 5” long	2	$8.35	$16.70
Labour	Four university students	20hrs per student	$0.00	$0.00
				$125.87

Figure 2: Testing Method with weights (40lbs, approx. 18 kg)

Figure 3: Walking Route for portability/compactness test

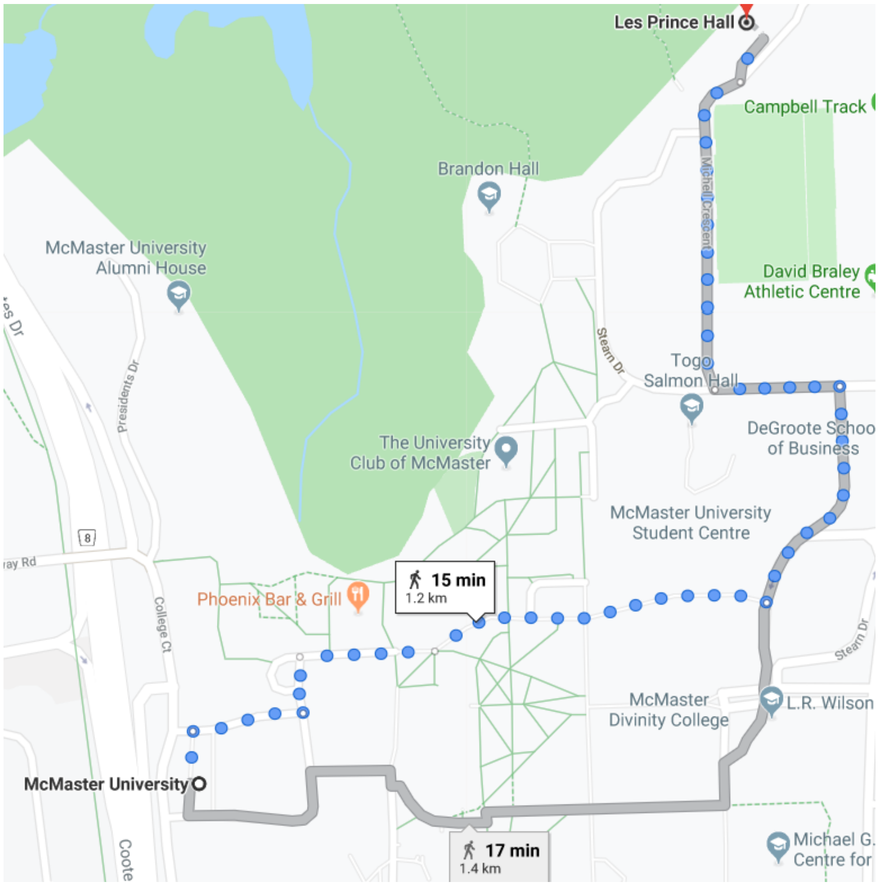

Figure 4: folded position of device

Figure 6: Metric Charts

Objective:	Lightweight
Unit/Metric	Units: The overall mass of the device (in kg) - 0 points: worst - 2 points: best Metric: 7 - 9 kg: 0 points 6 - 7 kg: 1 point 4 - 6 kg: 2 points 2 - 3 kg: 1 point 0 - 2 kg: 0 points

Objective:	Compact
Unit/Metric:	Units: Minimum dimensions (if folded) of device in centimeters - 0 points: worst - 5 points: best Metric: Height: - >130 cm: 0 points - 110 - 130 cm: 1 point - 90 - 110 cm: 2 points - 70 - 90 cm: 3 points - 50 - 70 cm: 4 points - <50 cm: 5 points

Objective:	Support load
Unit/Metric:	Units: Maximum carrying weight in kilograms - 0 points: worst - 5 points: best Metric: <3 kg: 0 points 3 - 5 kg: 1 point 5 - 7 kg: 2 points 7 - 9 kg: 3 points 9 - 11 kg: 4 points >11 kg: 5 points