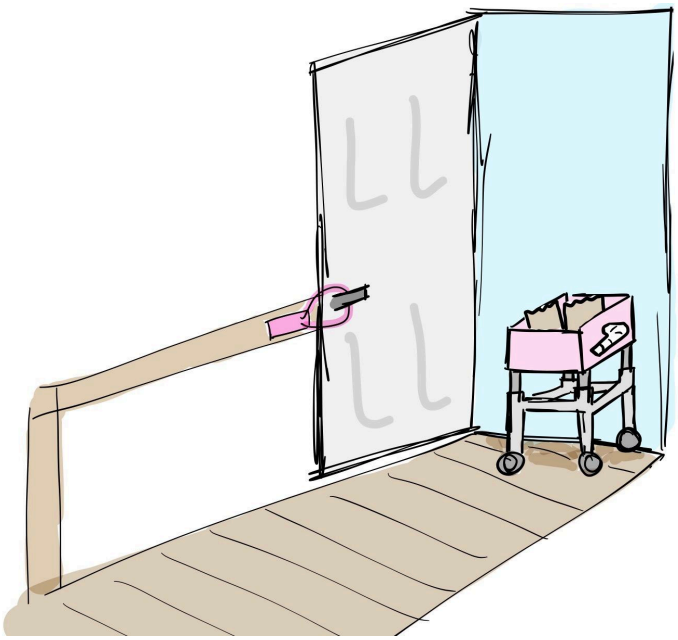
THE GO-GETTER



Prepared for:

Mrs. Judy Geigner

Date:

February 21, 2023

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EXECUTIVE SUMMARY

Design Challenge
Our project partner, former schoolteacher Judy Geigner, has osteoarthritis and Parkinson's disease, which impact her ability to perform everyday tasks. One such task is getting groceries, as lifting the heavy bags and moving them from her car to the house proves difficult and painful.

Our Solution
Our design, The Go-Getter, consists of two components: a cart and a door latch.

The door latch is a simple prototype constructed of a resistance band and duct tape intended to be screwed into a wall near a door. The door into Judy's house from her garage self-closes, so the door latch will keep the door in place when stretched over the handle. This will allow her to get her groceries into the house without worrying about keeping the door open.

The cart is the more complex component and consists of the following parts:

- A battery-powered linear actuator allows the cart to be height adjustable.
- Lockable swivel wheels for ease of movement.
- A mesh basket to keep the groceries in.
- A basket side that can come undone at the top and fold down to form a ramp. This ramp can be used to easily slide groceries in and out of the basket without having to lift them.
- Horizontal handles made of 1 inch PVC to easily maneuver the cart.

The door consists of two parts:

- Two screws that help attach the door latch to the rail.
- A resistance band that extends to wrap around the screen door's handle and thus keeping it in place.

BACKGROUND AND INTRODUCTION

In a world where millions of people have limited mobility, it is surprising that there aren't more solutions aimed at helping them transport groceries. Going to the supermarket is an essential part of most people's routines, but this can be very difficult when they're limited by how far they can reach or how much they can carry.

Judy Geigner, a retired school teacher living in Normal, IL, was diagnosed with both Parkinson's disease and osteoarthritis, a combination that makes it very difficult for her to bend over to grab her grocery bags and carry them into her house. As a result, she finds herself dependent upon her family members to help her do everyday tasks such as carrying groceries (See Appendix A.1.1: Project Partner Interview for detailed information about how Judy describes the obstacles she faces while transporting the grocerries). Although Judy already has a ramp connecting her garage and kitchen, she still has to lift the groceries and transport them all the way from the trunk to the kitchen by herself. Specifically, she has to bend down to get the items out of the trunk and lift her arms to place the items onto the kitchen counter (See Appendix A.1.2: Observation Summary for detailed description of Judy finishing the whole transportation process). Such a process has become increasingly harder for Judy and she is in need of a solution to help her get the task done independently.

Several solutions already exist to help people with mobility issues deal with their groceries. One of them is a cart designed by two students at SF State. It is collapsible and has adjustable handles, grippy wheels, and brakes (See Appendix A.2: Secondary Research Summary). The cart has grips, which allows the user to feel more stable, and has ample storage space so that they don't need to change their shopping habits. Motorized walkers are another solution, as they're easy to maneuver, but they have very limited storage space. Laser light canes are also useful in some cases, as they help reduce hesitation in Parkinson's patients when they're walking. (See Appendix A.2: Secondary Research Summary to learn more about Parkinson's and osteoarthritis.) However, these solutions don't fit Judy's specific needs, and most people in the same situation as her continue to rely on someone else to bend over or lift heavy objects for them. We have studied Parkinson's and osteoarthritis closely and interviewed Judy to understand exactly how she is affected by these disabilities.We need a cool, stylish, and modern solution to help a one-of-a-kind lady.

The goal of our project is to make it easier for Judy to unload her groceries so that she can gain independence. However, finding a solution to Judy's problem has the potential of helping more than just Judy. Other people with disabilities struggle with lifting and moving objects by themselves, so our solution could be helpful to them as well. These individuals' families could also benefit from a solution as they would no longer have to worry about their loved ones hurting themselves by lifting heavy objects.

We do have a few restrictions that we have to keep in mind when devising our solution. For instance, we have a budget of $100, we need to work with a steep step, and our solution needs to be

- Lightweight
- Fit Through Doors and work with steep ramp
- Safe and Easy for the User to Use. The cart should not tip over given a certain amount of force
- Preferably mechanical and not electrical
- Accommodate Different Surfaces
- Height must be high enough to reach countertop and fit in trunk of car

(For a more detailed description of the project, users, and constraints, see Appendix B: Project Definition.)

Join us as we embark on a journey to help Judy, and all people affected by osteoarthritis and Parkinson's, get their independence back.

DESIGN CONCEPT AND RATIONALE

Our system solution is called The Go-Getter. This design, shown in Figure 1, will provide her with two solutions to address three of her most pressing issues.

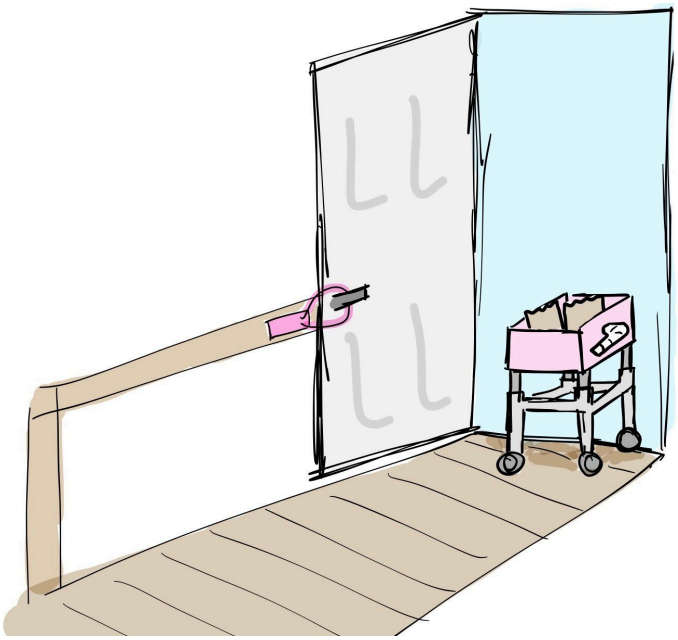


Figure 1: The Go-Getter, as a system of solutions

Part 1: The Lifty Cart

The first part of our multi-step solution is a height-adjustable and user-friendly cart shown in Figure 2.

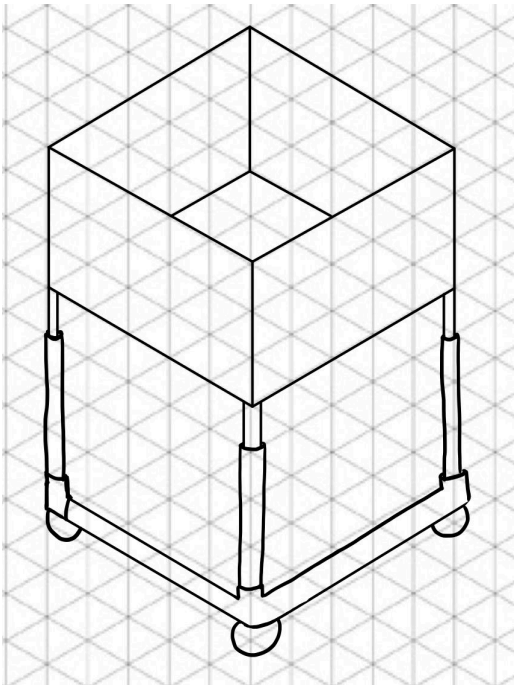


Figure 2: Mock-Up Diagram of the Lifty Cart

The aspect of unloading her groceries that Judy struggles with the most is not being able to lift her bags from her trunk and get them onto her kitchen counter. That's where the height-adjustable part of the cart comes into play. Judy's trunk has a height of 28 inches while her kitchen counter is higher, at 36 inches (Appendix B). Her bags are often heavy and sometimes overloaded. It is both difficult and unsafe for her to lift them and place them on her counter. For more information about Judy's limitations, see Appendix A.1: Primary Research Summary.

To address this issue, we decided to install a linear actuator (shown in Figure 3) in the center of the cart, which will push it up 8 inches, corresponding to the height difference between the car trunk and the kitchen counter.

Figure 3: Linear actuator that can extend in length

The actual storage part of the cart is an 18x18-inch box made up of a plastic frame with mesh sides, similar to the material in Figure 4. The mesh sides will help Judy fit as many groceries into her cart as possible, while also making it as lightweight as possible, and that the plastic frame will make it sturdy.

Figure 4: Example of a mesh basket

One side of the basket is reinforced with hard plastic and separable from the other sides, like in Figures 5 and 6. The side is attached to the basket with velcro which the user can peel to open the side. This will allow Judy to simply slide her groceries into the basket without having to lift them over the side of a tall basket.

Figure 5: The side latch when closed and velcroed.

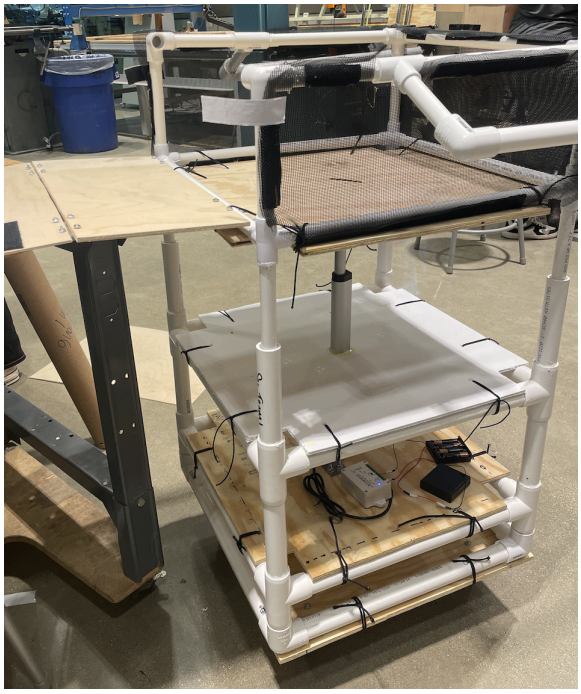


Figure 6: The side latch when open

Part 2: The Door Latch

As for the final part of our design, the door latch, is a rectangular shaped piece of duct tape, which can be screwed onto the railing of the ramp. The resistance band is attached to the door latch because half of it is covered with duct tape, and leaving the other half out so it can attach to the door.

The door latch is made of a resistance band and duct tape like in Figure 7. The first part is a thick layer made of duct tape, and the second part would be the resistance band so that it could extend long enough to attach to the door. Photos showing how to use the door latch are in Figure 8.

Figure 7: The door latch mock-up

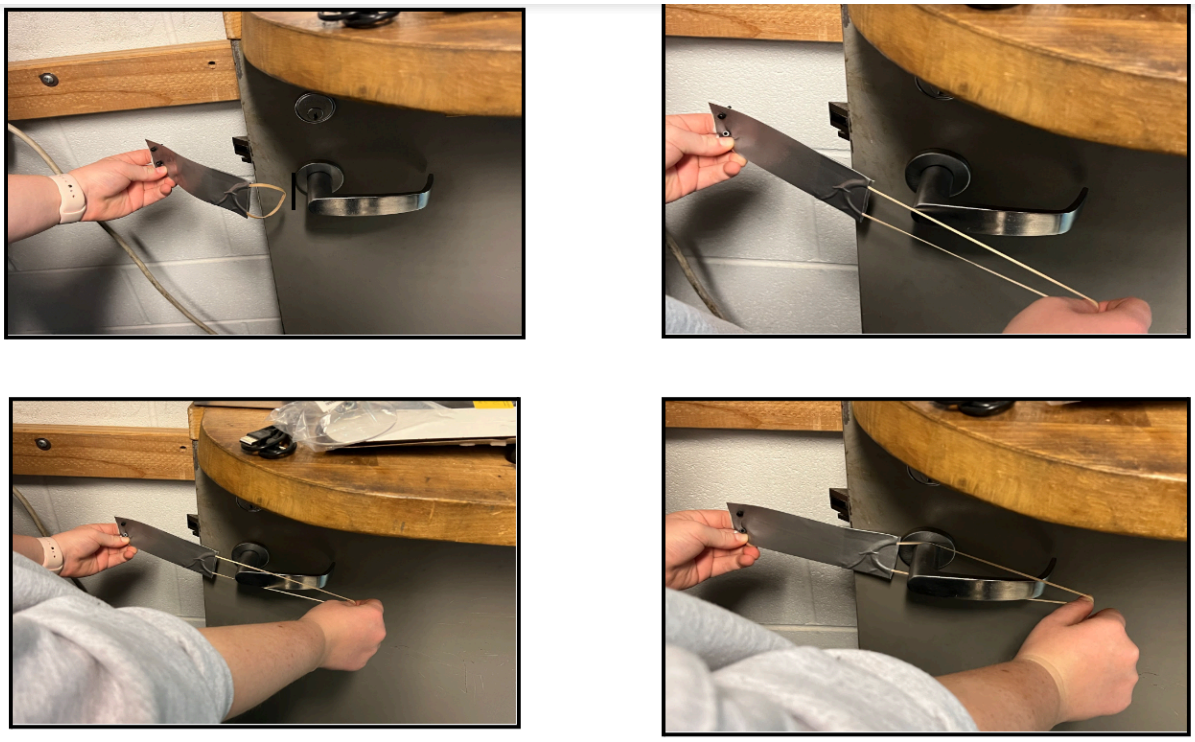


Figure 8: A series of photos showing how the door latch mockup works

Rationale

As a group of professional Wildcat engineers, we employ special, human-centered design principles as well as cutting-edge materials on our cart. Our Go-Getter with its two features meets our set of project requirements listed in detail below.

Lightweight: To meet the ideal value of 15 lbs, we plan to use hollow PVC pipes for the frame of our cart. We use thick canvas for our basket and light wood board for the base of our cart.

Fit through the doors: As mentioned above, the width of Judy's door is 32 inches, but we defined the ideal value of our cart to be 18 inches. As Judy may not want to use an 80-inch cart for giants, we would not really take the height as a constraint. Our basket would be 16x16 inches, while the two handles would be approximately 3 inches at each site. Therefore, the width of the cart would be 22 inches and perfectly fit Judy's door while leaving enough room for her to operate the cart.

Safe and easy to use: To meet this requirement, we first make the wheels wide enough so Judy won't lose balance when operating the cart, and it could be used as a support when Judy slips on the ramp. The linear actuator is not made by brilliant DTC students, and the extended piston rod might fall unexpectedly (it won't be in usual cases because it is a screw-like structure and the rod would stay in its position if it is out of power.) Therefore, we would make part of the four PVC rods wider than those holding the basket so that the basket won't fall down. Finally, we would make sure our prototype has no sharp corners or glitches.

Must be high enough to reach the countertop and fit in the trunk of the car: As mentioned above, our cart has a linear actuator with a remote controller, so Judy could change the height of the cart simply by pressing a button (maybe two). Therefore, the height of the cart could meet the height of the trunk and the counter.

Accommodate different surfaces: We would use wide wheels that could go smoothly on concrete, wood, and ceramic tiles.

Can prevent overloading bags: The depth of our basket is designed to be shallow, so Judy could not overfill the basket. Plus, the canvas would have sunken if the items in the basket are too heavy, thus preventing the user from overfilling.

For more information about our design process, see Appendix C: User Feedback and Testing and Appendix D: Design Review.

DIRECTIONS FOR USE

To help our project partner use our product, we have compiled a list of instructions on how to use the lifty cart and door latch. The two solutions work together to create a seamless experience for the user to move groceries from the trunk to the kitchen counter inside.

Step 1: Once the car is parked and fully off, open the garage door and the trunk of the vehicle. At this point, the groceries should be visible from the trunk, like figure 9.

Figure 9: Open Trunk with groceries

Step 2: Walk to the screen door and extend the door latch, as seen in figure (##). Open the screen door and loop the latch around the handle of the screen door. The screen door should now be held in an open position that won't automatically shut. Refer to figure ## for a better reference. Open the other door wide enough for the cart to fit through.

Figure 10: Door Latch to Door

Step 3: Grab the lifty cart from the garage or kitchen and roll it to the trunk of the car. It is not necessary to lift the cart as it has wheels on the bottom of the cart.

Step 3(a) Optional Step: There are locks on the wheels of the cart. Although not necessary, it is possible to lock the wheels by pushing down on the flat metal portion of the wheel with the imprint “lock” downward. Refer to Figure ## for the location of the lock. When the cart is new, it may be a little difficult to lock and you may have to put a little more force on the wheel in order to lock. You can apply the lock on as many wheels as you’d like. The more wheels locked, the greater chance that the cart will not move.

Figure 11: Wheel in Locked Position

Step 4: Using the remote controller, lower/raise the height of the cart to the height of the trunk. To do this, extend the antenna of the remote controller and refer to figure ##.

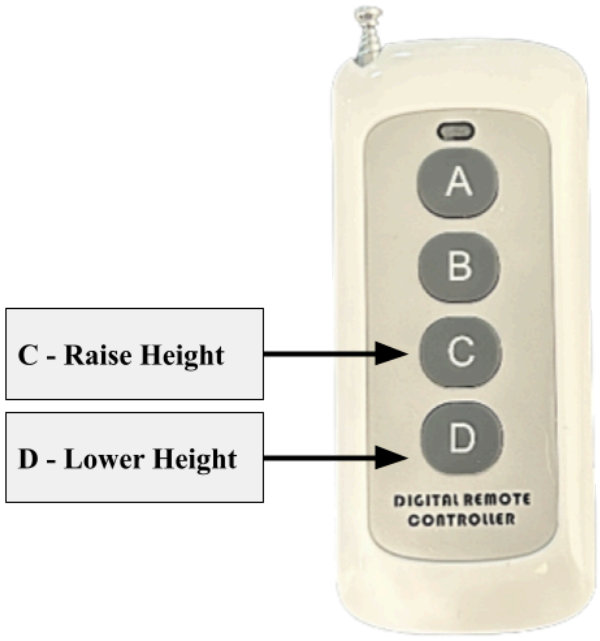


Figure 12: Remote Controller Manual

Step 5: Once the ideal height has been reached, open the extender by pulling on the velcro straps on the side of the cart basket. Refer to figure ## for a visual representation of the extender. Once the velcro has been pulled, the flap should extend out automatically if you pull it open. It is now convenient to drag the groceries to the basket from the trunk.

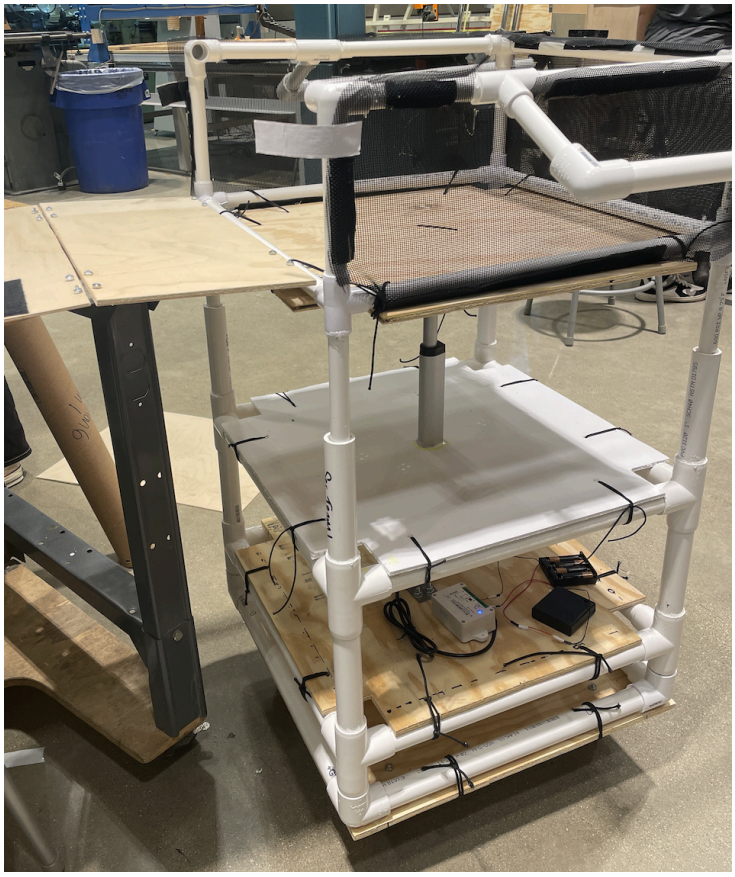


Figure 13: Lifty cart with extender out

WARNING: Overloading the grocery cart may result in the cart malfunctioning, which could lead to minor injuries. Please do not place excessive weight on lifty cart.

Step 6: Once all groceries have been placed in the cart, pull the extender back into the original position (upright) and secure the extender by attaching the velcro from both sides of the cart again. If step 3A was done, unlock the wheels by kicking the bottom of the metal plate upward. This should create a click noise and the wheel lock should be flat. Apply this to all the wheels locked.

Step 7: Using the handles on the sides of the carts, roll the cart up the ramp and into the kitchen. For safety reasons, if you feel like you are unable to reach the top of the ramp, lock 2 wheels using step 3A and take a break.

WARNING: In the case that the brakes on the wheels fail, the cart will roll backward. Do not stand behind the cart or its line of action if you decide to stop in the middle of the ramp.

Step 8: Once you have reached the kitchen counter, use the remote controller to raise the height of the cart. Refer to figure 12 for the remote controller instructions.

Step 8(a) Optional Step: Locking the wheels can help keep the cart in its place. To lock the wheels, refer to step 3A.

Step 9: Follow step 5 in regards to opening the extender. After the extender has been opened, push the groceries out onto the kitchen counter.

Step 10: Close the extender and place the cart wherever you feel would be most convenient for the next time you will use lifty cart. If you have more groceries that did not fit inside the lifty cart, repeat steps 3-9 until all groceries have been taken out of the trunk.

Step 11: Retract the door latch by pulling on the door latch and release it from the screen door handle. Once the latch has been removed from the door, let go of the latch gently. It should retract to its original position.

WARNING: Letting go of the latch too quickly may result in minor injuries on the hand. Release the latch slowly and calmly to prevent injuries.

WARNING: Depending on the screen door, the door may try to shut immediately after removing the latch from the door handle. If this is the case, apply some force to the door and do not let go of that force until the latch is fully retracted into its original position.

Step 12: Close the trunk of the car and the garage door. This concludes the directions of using the lifty cart and door latch as a system of solutions.

Warning: The Lifty Cart may use lithium ion, alkaline, or lead-acid batteries to provide a power supply to the height-adjustable component of the lifty cart. Lithium and lead-acid batteries are dangerous goods and, as such, require special packaging for transportation. All domestic and international shipments containing lithium or lead-acid batteries are subject to transport regulations on hazardous goods according to ADR RID, ADN, IMDG, ICAO / IATA Regulations.

FUTURE DEVELOPMENT

Sturdiness

If we were to revisit our design and improve it, one component we would focus on is the cart's sturdiness.

1. By carefully choosing the height of the wheels and the height of the linear actuator, we could place the actuator directly on the base of our cart instead of having another platform to support it in order to match up the height of the trunk, which would make the cart more stable while having lighter weight.
2. We could also buy a linear actuator that has a plate on its tip so the top of it could be attached to the wood plate by screw, which would stabilize the cart while it is lifting.
3. Given more budget, we could have bought telescoping PVC pipes that interconnect with each other perfectly. They would stop the cart from moving wobbly while adjusting the height and enhance the stability of the cart's whole structure.
4. Given more time, we would connect the handle to the frame of the basket in a more stable way. We only use one screw and a nut to connect them right now and they move wobbly while we apply much force on it. Thus, it would be optimal if we use more screws and hot glue to connect them.

Weight

Weight is one of the most important factors we defined in our project definition (See Appendix B: Project Definition), and we would like to improve it given more time and budget.

1. We could work on making the cart lighter by changing different materials and finding other ways to assemble the whole piece. We ended up using a lot of PVC pipes and several layers of plywood, which resulted in our cart being heavier than we would have wanted. In the future, we could think about minimizing our use of PVC pipes and plywood by adjusting the position of the linear actuator and the way we connect different parts of the cart.

Aesthetically Pleasing

The third way to improve our design would be making it more aesthetically pleasing.

1. Given that we had limited time and budget, while building our prototype, our primary focus wasn't to make it pretty. We didn't line the basket with mesh in the most tidy way, so it would be optimal for us to wrap the basket in a whole piece of mesh and do more careful cuttings to make it look nicer.
2. We used thin nylon ropes to connect different parts, which is convenient and sturdy, but not pretty. We could use screws and other connecting pieces to connect plywoods with PVC pipes instead of using ropes and hot glue.

Eco-Friendly

Being a group of engineers that care about the future of our planet, we should take actions to use eco-friendly materials for construction.

1. As we've mentioned above, most of our prototype is made up of PVC pipes. As engineers, a big part of our role is to weigh the costs and benefits of the materials we use for our design instead of only pursuing low-coet. Thus, we should use other eco-friendly materials to replace the PVC pipes given more budget.

APPENDIX A: BACKGROUND RESEARCH SUMMARY

Mrs. Geigner has osteoarthritis and Parkinson's disease. The latter is a neurodegenerative disease that affects the right side of her brain. Due to her health issues, Mrs. Geigner has undergone brain surgery, back surgery, and replacements of both her shoulders and knees. Her current health condition makes it difficult for her to carry her groceries from the trunk of her car to her kitchen counter. She needs a way to transport her groceries from the trunk of her car to her kitchen counter given that she has limited mobility. A solution to this problem would not only alleviate her pain but also allow her to be more independent.

A.1: Primary Research Summary:

We conducted two forms of primary research: an interview with the project partner and an observation study with Judy.

A.1.1: Project Partner Interview

Introduction:

We conducted the interview with our partner in person at the Ford Motor Company Engineering Design Center Room G-205 on January 15, 2023. The purpose of our interview was to gain a further understanding of Mrs. Geigner's health conditions and to learn more about the housing conditions she lives in. The class conducted the interview together, even though there are 3 other groups working on the same project.

Methodology:

To prepare for this interview, the class collaborated on questions to ask her. We combined all of our questions into one Google Doc, categorized each question by health and physical conditions, grocery shopping routines, location, car, and housing. We then further deleted redundant questions and assigned each section to one or two people to ask during the interview. During the interview, 3 classmates volunteered to take notes and write a transcript. Below is a summary of our findings from the interview.

Results

Certain actions, such as turning her head, cause Judy to lose her balance. This is a direct consequence of Parkinson's disease. To help with her balance, Judy relies on a cane everywhere except for inside her condo. As for her osteoarthritis, it mainly affects her shoulders, back, and hands, and causes her a lot of pain, especially when carrying her grocery bags. It is also present in her knees, ankles, and toes.

There are three main facilities involved in the task of Judy transporting items: the trunk, the garage, and the kitchen. The trunk is 24 inches high, and she has no trouble getting shopping bags out of the trunk.

For the garage, Judy had a wooden ramp installed in it. The distance from her car to the ramp is 10 feet. The ramp — which isn't ADA certified — helps her get from the garage to her door. It isn't that convenient though, because not only is it fairly steep, but Judy also needs to step onto it since it doesn't start from the ground. There are also two rugs in her garage, one on the ground and the other on the ramp. Her garage's floor and the ramp are both compatible with wheels.

After getting up onto the ramp, there are two doors separating the garage from the kitchen. The first one is a screen door that closes quickly — often on Judy — and the second one is a regular door that she can keep open. Judy mentioned adding a latch to the screen door to keep it open would be a feasible solution. Her doorway is between 32 and 36 inches wide and the distance from her door to her kitchen counter is 8 feet. Once she is in her kitchen, she puts her groceries on shelves that are 36 inches above the counter and in cabinets that are 5.5 feet. She said that putting her groceries away wasn't that big of an issue for her.

Judy has to do multiple trips to and from her car in order to get all of her items in her kitchen. She follows a specific process to carry her groceries: she begins by moving her bags from her trunk to the bottom of the ramp, and then picks them up two at a time to get them into her kitchen. The items she buys are more or less the same every week: meat, frozen vegetables, bread, eggs, butter, milk, and cream. She doesn't like the fact that the baggers at the supermarket put all the meat in the same bag, and says that carrying the heavy milk jugs really hurts her shoulders. She uses plastic bags for her groceries because according to her, baggers tend to overfill paper bags.

Judy has certain aesthetic preferences she'd like to see applied to the device. Her favorite colors are blue and purple. She expressed a preference for a mechanical design as opposed to an electrical one. She also made it clear that she wants her device to be as light as possible, otherwise, she won't be able to push it up the ramp.

A.1.2: Observation Summary

Introduction

On Tuesday, January 17, we watched a video of Judy getting groceries out of her car and into her house. We discussed our observations amongst ourselves and with our classmates. This observation summary goes into detail about Judy's process of transporting her groceries from her car to her kitchen.

Methodology:

We observed that the process of Judy getting her groceries can be divided into three parts: getting them out of her car, going up the ramp and through the door into the house, and walking through the kitchen and putting the groceries on the counter.

The observation took place in Room G.205 in the Ford Design Building on the Northwestern University campus between 12:30-2:30 PM. The video of Judy moving her groceries was played many times with frequent stops for discussion among team members and the class. Two students in the group used the AEIOU method of observation while the others used the POEMS method. Both methods are outlined below:

AEIOU stands for activities, environment, objects, interactions, and users. There is also a section to elaborate on the user experience, which is divided into five sections: physical, cognitive, social, cultural, and emotional. Someone observing an event should fill out each section in intense detail to ensure that there are no missing pieces of information when they use the observations for designing a solution.

POEMS stands for people, objects, environment, messages, and services. Similar to the AEIOU format, this format also has a section to elaborate on the observations and write general comments about the situation. POEMS also needs to be filled out in incredible detail to ensure every piece of information has been extracted from the event.

Results:

Part 1: Getting groceries out of the car.

In this particular scenario, Judy only had one grocery bag to carry. She opens the trunk and then leans back slightly before leaning forward to grab the grocery bag. Using her right hand, she picks up the groceries and then switches the bag to the left hand and uses her right hand to close the trunk. Using the environment portion of AEIOU, the height of the trunk door appears to be too high for Judy to easily reach as she struggles to lift her arm and press the button. She then switches the grocery bag back into her right hand.

Part 2: Going onto the ramp.

After grabbing one bag of groceries, Judy takes 8 steps onto the ramp. The ramp has a step which she climbs with some difficulty on her right foot. She uses her left hand to hold the left rail and slowly walks up the ramp. She switched groceries to her left hand again so she could use her right hand to open the screen door. Here, Judy stumbles as the action of opening the screen door disrupts her balance. This is because she holds the door open with her entire body as she opens the other door and goes into the house. The services part of POEMS is the primary focus of this part because the ramp is intended to be a service to help Judy get into her house, but with the step and steep angle of the ramp, it appears to still cause Judy some difficulty.

Part 3: Putting the groceries on the counter.

After getting into the kitchen, Judy carries her groceries to the counter, lifts her arms and places the items onto the counter. Judy uses the counter by the door to steady herself with her right hand. The AEIOU method works well for this part because it allows the team to further observe that the height of the kitchen counter makes Judy strain her shoulder to lift the bag. The weight of the bag is also a factor in her difficulty to lift the bag onto the counter because it, too, puts strain on her shoulder.

After observing Judy move her grocery bags from the trunk of her car to the kitchen counter, our group discussed each step thoroughly. We realized that each part of Judy's grocery-getting process presents its own unique problems.

In part one, the act of moving the grocery bag out of the trunk seemed to cause her difficulties with balance and reaching, as can be inferred from her leaning back to reach forward to grab the bag. Judy had to orient herself in such a way that she would not fall from grabbing a bag of decent weight.

Part two also presented balance issues in the way Judy opened the screen door; having to put her entire body into keeping the door open while carrying extra weight (the grocery bag) seemed hard for her to do. Balance is a key issue in people with Parkinson's and osteoarthritis so carrying anything that offsets a person's center of mass is not easy to do. Also in part two, the five-inch step onto the ramp appears to hurt her more than it helps her because it again challenges her balance. A ramp is supposed to help people who cannot go upstairs, so having a step up to a ramp is not a good solution to Judy's problems.

Finally, the act of lifting the grocery bags and putting them on the kitchen counter showed how Parkinson's and osteoarthritis can weaken muscles and place strain on joints. From secondary research, the team knows that these conditions are the result of eroded cartilage around joints that make it painful to move. Judy mentioned earlier in an interview that her conditions specifically affected her shoulders which is clearly seen in part three.

A solution to these problems needs to account for Judy's difficulty balancing and the strain getting groceries puts on her joints.

A.2: Secondary Research Summary:

In the early stages of our design process, our team carried out extensive research about our topic prior to and after our interview with our project partner to further gain a better understanding of our project. Below is a summary of our findings.

1. Osteoarthritis:

Osteoarthritis is a condition in which the cartilage on the ends of the bones breaks down, causing the rough surfaces of the bones to rub together. When this happens, people with osteoarthritis often experience pain and discomfort in their joints [1]. Osteoarthritis mainly affects three parts of the hand: the use of the thumb, the middle joint of a finger, and the joint closest to the fingertip [1]. A visual representation of osteoarthritis can be seen in Figure 9 below. Over 32 million people have osteoarthritis, and it mainly affects people over the age of 60. Other factors such as constant injury and obesity play a factor in a higher chance of having osteoarthritis [2].

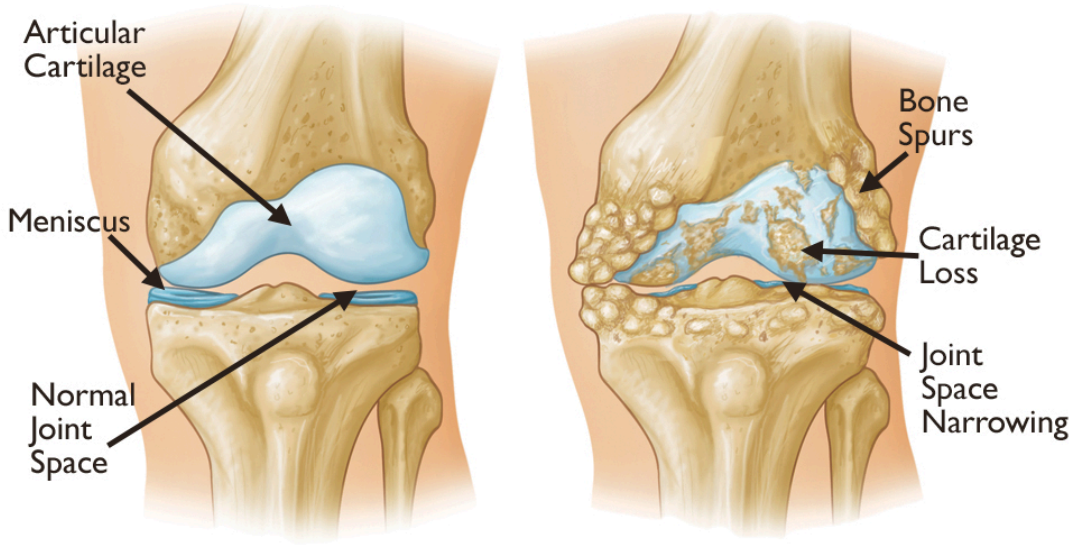


Figure 14: Visualization of Osteoarthritis

As of January 26, 2023, there is no permanent cure for osteoarthritis. However, treatments to help alleviate some of the pain include physical therapy, consistent exercise routines, weight loss, and medication such as pain relievers [2]. If these treatments do not work, surgery is an option but is a last resort. Self-management skills have also been shown to boost confidence and manage arthritis. Self-management is becoming educated about the effects of osteoarthritis and ways to manage the symptoms individually. It involves developing relaxation and coping skills along with exploring lifestyle changes that may reduce pain. [3]

2. Parkinson's

Parkinson's disease is a brain condition that primarily affects people above age 60. The disease is caused by nerve cells in the brain's basal ganglia dying, which then decreases the amount of dopamine that part of the brain produces. Refer to Figure 10 for a visual representation of the brain and the location of the basal ganglia.

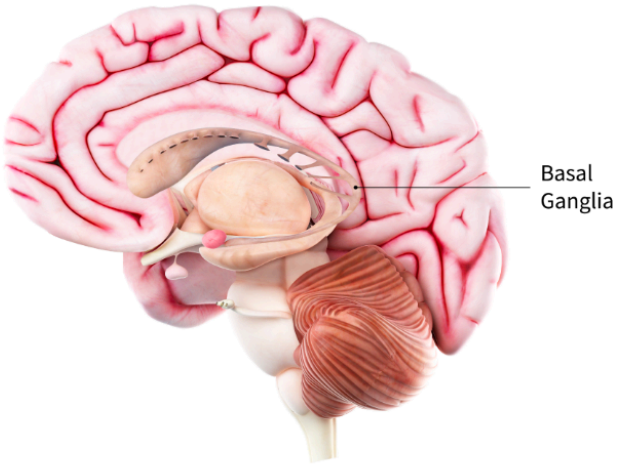


Figure 15: Basal ganglia

Dopamine is a chemical that regulates the fluidity and control of movements, so when there is less dopamine in the brain, movements can become slow and uncoordinated [4]. The four major symptoms of Parkinson's are tremors in the extremities and the head, muscle stiffness and prolonged muscle contraction, slowness of movement, and impaired balance and coordination which can lead to falls [5]. There are also some less common symptoms, such as depression, difficulty swallowing and speaking, urinary problems, and skin problems [5].

As of January 26, 2023, the primary treatment method is a drug called levodopa which increases dopamine levels in the brain and allows patients to return to their normal lifestyle. [5] Other treatment methods work to reduce the symptoms of Parkinson's that aren't movement-based, such as occupational and speech therapies that help patients speak as they did before Parkinson's.

3. Existing Ideas

3.1. Scissor Lift

The scissor mechanism gets its name because the components made of steel under the work platform are hinged with pivot points to produce a system that looks like several sets of connected scissor blades. To operate the system, the power source would retract or extend the scissor lift mechanism to raise or lower the load-bearing platform up and down. The power source can either be mechanical as in Figure 11 or electrical as in Figure 12. Mechanical scissor lifts require energy input from a person, which could be an issue when designing a solution for someone with disabilities.

The whole system is geometrically stable. The configuration consists of a set of connected parallelograms with pivot connections that enable the operator to extend or retract the system without causing shape changes. [6]

Figure 16: The configuration of the scissor lift system

Platform

The platform on the top of the scissor system can be of various sizes, shapes, and material. It is the working space to bear the loads. In the case of a liftable shopping cart, the platform's size depends on the amount of items Judy takes each time.

Scissor Legs

The scissor legs are the crisscross array or parallelogram-like configuration made of fabricated metal. They bridge the gap between the base and the platform and are the most important part of the whole system. The maximum working height of the scissor lift mechanism depends on the length of each scissor leg, the number of scissor legs, and the general strength of the system.

Base

This foundational part of the scissor lift mechanism is a sturdy footing made up of strong, rigid brackets. Commonly, the base is engineered with tracks to guide the rollers at the bottom of the scissor legs. In this case, there would be wheels attached to the bottom of the base just as the normal shopping cart. The size and configuration of the scissor lift base will depend on the model and its application. [6]

Figure 17: An electric scissor lift cart

3.3. Foldable shopping cart

Given the cost and complexity of the traditional scissor lift, a lightweight, foldable shopping cart also came into our scope. Instead of using a scissor lift system to change the height of the basket, the top of the cart would be able to rotate for easy placement into a car or counter. This makes for a simple design that is easy to use but could potentially be unreliable in its ability to stay in place both because of the moving wheels and rotating basket. The specifics of how the foldable shopping cart works is shown in Figures 13 and 14.

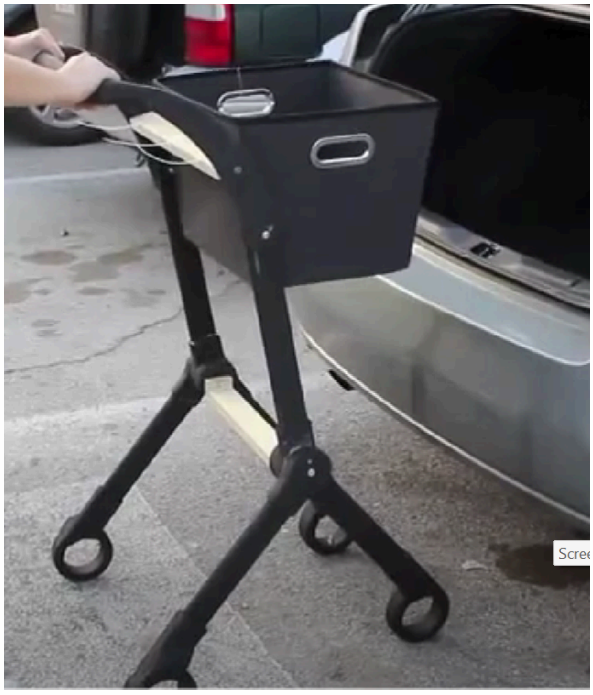


Figure 18: The upright position of the foldable shopping cart.

Figure 19: The foldable shopping cart rotated so the basket goes into the car trunk

One issue associated with the foldable shopping cart can be clearly seen in Figure 14 where only the basket fits into the trunk of the car, not the entire cart. This would require

the user to attach and detach the basket from the cart base every time they want to use it, which could be difficult for someone with Parkinson's disease and osteoarthritis due to their issues gripping objects. [7]

3.4 ADA Ramps

The American Disabilities Act of 1990, also known as ADA, is a federal civil rights law that prohibits discrimination against people with disabilities in everyday activities. In order to comply with these rules, most areas need ramps or a gradually elevated surface to prevent avoidable injuries. Stairs and curbs can be a hazard to those with disabilities because they have a higher chance of falling or injuring themselves. Section §405 of the ADA curb ramp requirements for 2021 covers the following ADA curb ramp design standards:

- Clear Width: A ramp run must be at least 36 inches wide between the ramp's handrails.
- Rise: A maximum of 30 inches per run, with no limit on the number of runs.
- Running Slope: 1:12 maximum slope, or one foot in elevation change for every 12 feet.
- Cross Slope: The ADA permits a maximum ratio of 1:48.
- Alterations: Are permitted on running slopes with limited space, such as:
- 1:10 maximum with 6 inches maximum rise
- 1:8 maximum with 3 inches maximum rise
- A slope of no greater than 1:12 [8]

All of these specifications are shown in Figure 15.

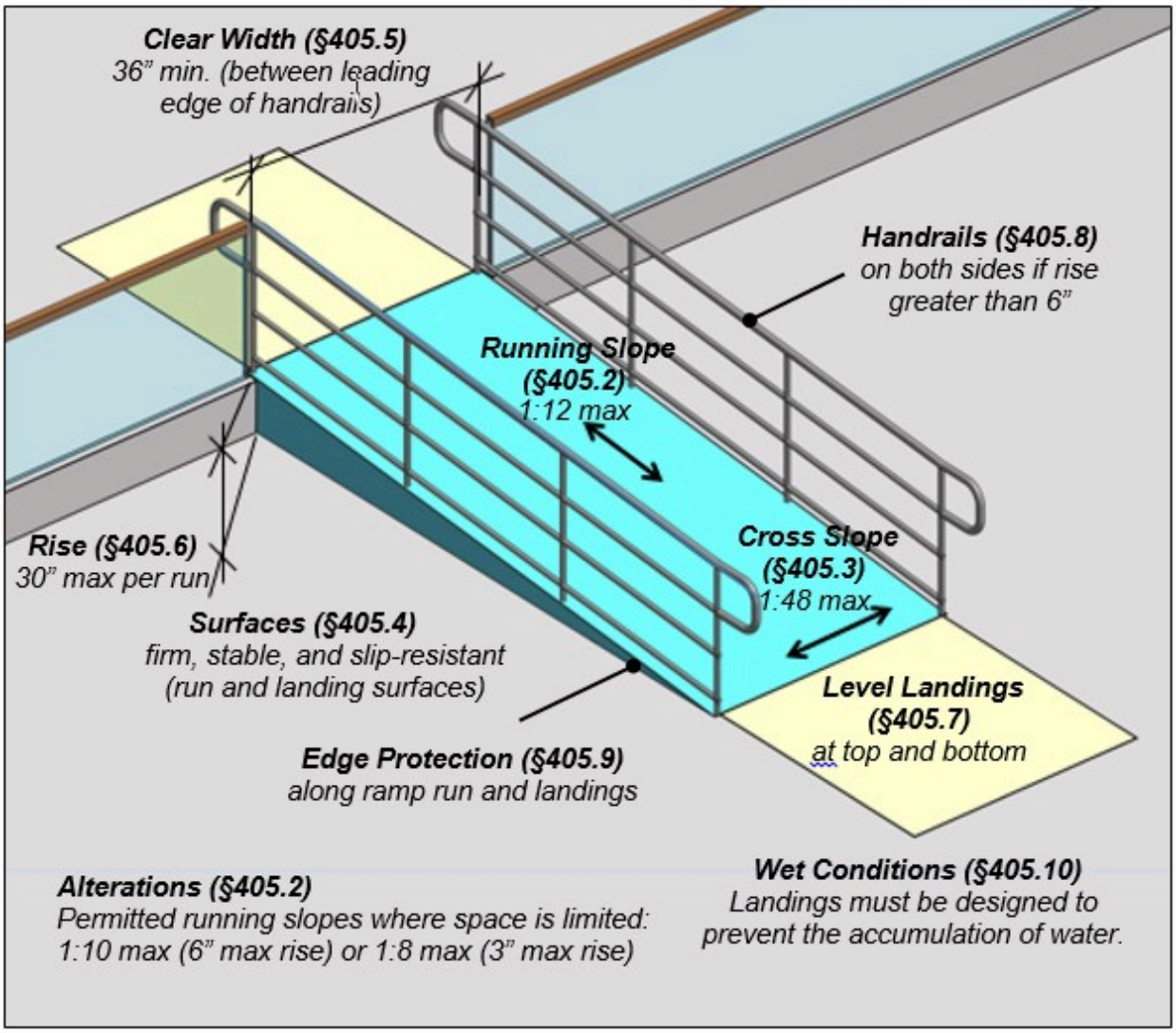


Figure 20: ADA Ramp Guidelines

Alternatives for a curb ramp that adheres to ADA standards include having an elevator or platform chair lift. These rules apply to multifamily housing and the majority of public and private facilities [9]. Penalties for non-compliance to ADA standards for ramps can cost millions of tax dollars, as seen in a $1.3 billion Los Angeles lawsuit and $15 million Cedar Rapids, IO lawsuit [10].

APPENDIX B: PROJECT DEFINITION

Problem Statement	Mrs. Judy Geigner needs a way to transport her groceries from the trunk of her car to her kitchen counter because osteoarthritis and Parkinson's make it difficult for her to do so. A solution to this problem would alleviate the pain she feels and allow her to be more independent.
Constraints	● Our prototype needs to be ready to be presented by March 11th, 2023. ● We have a budget of $100 that we need to keep in mind when thinking about the materials we want to use to build our prototype.
Users and stakeholders	● Judy: The project partner whose needs we are formulating the solution around. ● Judy's family: Those who worry about Judy's well-being and often help her in lifting groceries and getting them into her house. ● Other people with Judy's conditions: The solution could potentially be modified for others with osteoarthritis and/or Parkinson's who struggle with lifting groceries or objects in general. ● Other families with loved ones who struggle with Parkinson's and osteoarthritis: Similar to Judy's family, people with family members could benefit from the solution because they have to worry less about the independence and well-being of their struggling family members.
Illustrative User Scenario	The user in this illustrative scenario is our project partner Judy, who has Parkinson's and osteoarthritis. Our observations are based on our interview with Judy, and on a video showing her process carrying her groceries from her car to her kitchen counter. Judy lives alone and goes grocery shopping once a week. She stores her bags in her car's trunk, and has trouble carrying them into her kitchen once she makes it back home. She finds herself having to carry her groceries one or two bags at a time because her osteoarthritis weakened her shoulders. Judy's procedure for getting her groceries to her kitchen is divided into three parts: getting the bags out of the trunk, carrying them into her house by walking up the ramp, and opening the two doors that separate her garage from her condo. Getting onto the ramp and walking on it isn't an issue for Judy. However, opening the screen door makes it difficult for her to get into her kitchen, as it quickly closes on her. Once she's in her kitchen, she also needs to lift her items high enough to put them onto her counter, which is another difficult task for her. Our design will make it easier for people who have Parkinson's and/or osteoarthritis to transport their groceries from the trunk of their car to their house. Users will no longer need to carry heavy bags, but instead will have an easy way to roll their items inside of their kitchen.[11]

<table>
<tr><td>User Profile</td><td>Mrs Judy is a woman in her seventies living alone. She has difficulty lifting items up and carrying heavy items due to her Parkinson’s and osteoarthritis. She also has mobility issues that she has to use a ramp to connect her garage and the kitchen.
[11]</td></tr>
<tr><td>Project Requirements</td><td>
<table>
<tr><th>Requirement</th><th>Metrics</th><th>Units</th><th>Ideal Value</th><th>Maximum Value</th></tr>
<tr><td>Lightweight</td><td>Weight</td><td>lbs.</td><td>15 lbs.
Based on Project Partner Interview</td><td>20 lbs.</td></tr>
<tr><td rowspan="2">Fit Through Doors and work with steep ramp</td><td>Height</td><td>in.</td><td>25 in.
Based on height of Judy’s trunk and kitchen counter</td><td>80 in.
Size of Door</td></tr>
<tr><td>Width</td><td>in.</td><td>18 in.
Based on User Testing</td><td>32 in.
Size of Door</td></tr>
<tr><td>Safe and Easy for the User to Use. The cart should not tip over given a certain amount of force</td><td>Weight</td><td>lb.</td><td>30 lbs.
Based on User Testing</td><td>50 lbs.
Testing</td></tr>
<tr><td>Preferably mechanical and not electrical</td><td>Voltage</td><td>V</td><td>0V
Based on Project Partner Interview</td><td>12V</td></tr>
<tr><td>Accommodate Different Surfaces</td><td>Number of Surfaces</td><td>N/A</td><td>1
Based on User Observation Report</td><td>3
Based on User Observation Report</td></tr>
<tr><td>Height must be high enough to reach countertop and fit in trunk of car</td><td>Height</td><td>in.</td><td>28 in.
Based on Project Partner Resources</td><td>36 in.
Based on Height of Countertop</td></tr>
</table>
</td></tr>
</table>

Table 1: Project Definition

APPENDIX C: USER TESTING AND FEEDBACK

Methodology

We brought the physical mockups as seen in the following figures to the project partner on February 2, 2023 in Ford Design and Engineering Center Room G.205. We came in with specific questions pertaining to each idea and mockup but also let Judy voice any concerns she had about the mockup.

For each round of testing for each mockup, we asked her how she felt when using it. This helped us understand exactly how our solution could help or hurt her even when she was not vocal about her struggles. Our goal in mockup testing was to see how we can further improve our solution to make it more applicable to her situation, so careful observation of Judy's interactions with the mockups was essential.

Design Idea 1: Lifty Cart

Figure 21: Lifty Cart Mock-Up

The Lifty Cart shown in Figure 16 has three key parts: the handles, the side latch, and the scissor lift platform. All three parts are described in detail below.

Part 1: The Side Latch

The Side Latch is a way to get items out of the cart without lifting them. A velcro strap attached to the box portion of the cart holds one side of the box together so it can act as a true box or bin. However, the velcro can be pulled back and the side folded down to allow groceries or other items to be slid into the box instead of lifted. Figures 22-24 below show a mock-up of the velcro strap.

Figure 22: The velcro strap when closed.

Figure 23: The velcro strap when opened but the box side kept up.

After the velcro straps are unlatched, the latched side of the box can fold down, as shown in Figure 24.

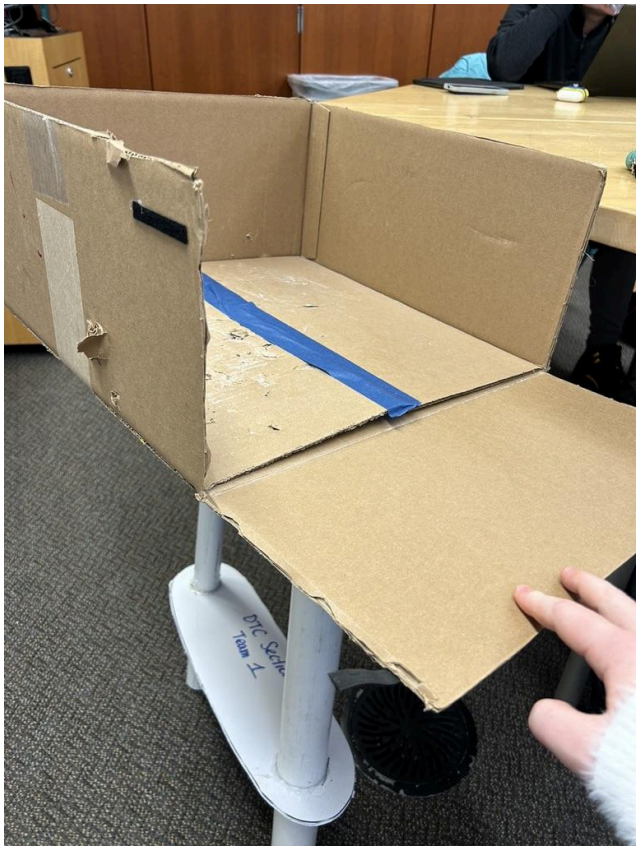


Figure 24: The unlatched side of the box folded down.

With the side folded down, a user can simply slide groceries into the box without having to lift them up and into the box.

The Side Latch meets the needs of the design in the following ways:

- Allows the user to protect shoulder joints by avoiding lifting heavy objects.
- Safe and easy to use.
- Mechanical solution with no electrical elements.

Questions for the project partner:

- Ask her about the aesthetics of the strap. Is the width of the velcro too small?
- Have her peel the velcro herself. Is it hard to peel the velcro off?
    - Should we implement something on top of the velcro strap to make it easier to peel?
    - Should we use other solutions like a
- Have her think about her grocery shopping experience and the dimensions of her car. Does the side of the box need to be longer to reach the trunk or counter when folded down?

Results and Observations:

- Judy prefers the velcro to be much wider for her in order to unlatch the side easily
    - Maybe ½ inch or 1 inch velcro
- She prefers the 8 inch depth of the cart, as it makes it a lot easier for her to grab her groceries from the cart
- The cart was too tall in her opinion and she suggests we make the poles shorter as she likes the depth of the cart
- Judy likes the idea of having the extra flap on the end of the latchable side to move her groceries easily
- She wanted to confirm that the cart will be on 4 poles, as the mockup only has two
- Adding a weight sensor idea to the cart is a great suggestion, but don't worry about it too much if it's not there in the final prototype
- Discussed whether or not she would like the cart to be height adjustable
    - Potential solution: mechanism similar to a laundry rack
    - Judy said she would not like a scissor lift because she wouldn't be able to lift it
- User would prefer a mesh-type material (like ones found on office chairs) or canvas fabric material for the cart because it is lightweight and somewhat sturdy
    - Canvas fabric material makes it washable - which is a good plus!

<u>Part 2: The Handles</u>

The handles provide an easy solution to pushing a potentially heavy cart. Designed after a traditional walker, it features two rigid handles connected to opposite sides of the box on the cart. The user can hold the handles and push the cart forwards with both hands or one. A mock-up of the rigid handles is shown in Figure 20.

Figure 25: Mock-up of the rigid handles created with PVC pipe.

A more general mock-up of the handles is shown in Figure 26 below. This also includes a smaller fabric handle on the side opposite the latch that allows the user to pull the cart instead of pushing it with the large rigid handles.

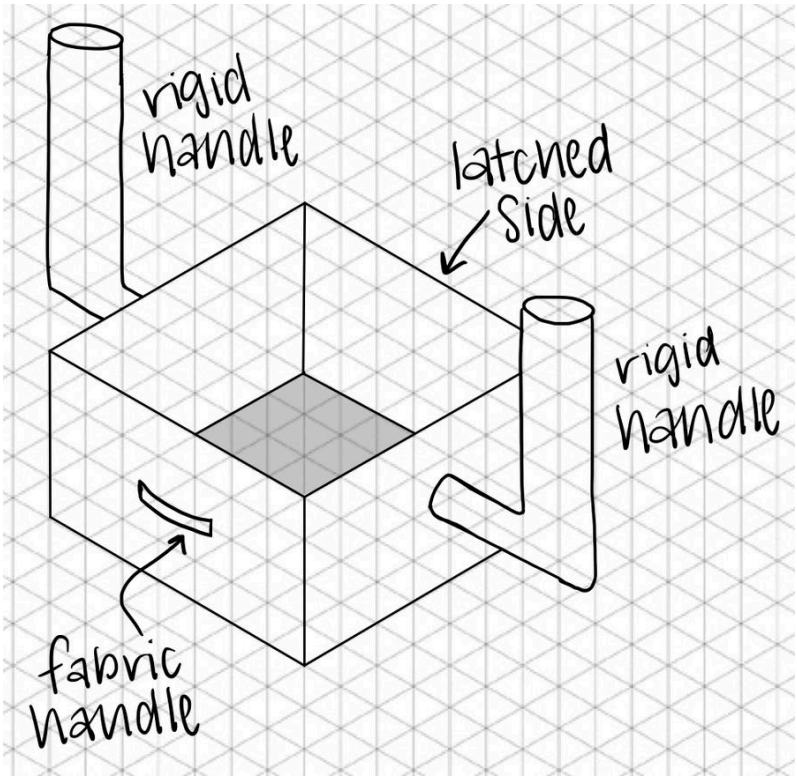


Figure 26: Drawing of the box with all three handles: two rigid and one fabric/soft.

The user can easily use both types of handles to move the cart without significant strain on the body.
The handles meet the needs of the design in the following ways:

- Safe and easy to use.
- Lightweight.
- Allows for easy movement of the cart.

Conditions and Testing:

- The handles were not connected to the cart at that time, but we still asked her questions about the thickness of the handles and their placement on the cart.
- To have her test the thickness, we asked her to grab the handles and tell us how the grip felt.
- We had her test the placement of the handles by asking her to act like she was pushing the cart and tell us which placement and orientation felt most comfortable.

Questions for the project partner:

- What material does she prefer for each type of the handle?
- Is the handle too big for you to handle?
- Do the rigid handles provide enough stability while moving the cart?
- Is the addition of a fabric handle on one side of the box beneficial for cart usage?

- Where on the cart is the placement of the rigid handles most comfortable for her?
- Which direction should the handles point to that better meets your needs: vertical or horizontal?

Results and Observations

- The project partner would prefer handles that can move up and down, but if that is not possible, she prefers the horizontal orientation.
- The project partner found the current thickness of the handles (2.25 inches) to be too wide and would prefer a 1.75-2 inch diameter. She likes the sturdiness of PVC pipe.
- She doesn't think she would use a fabric handle if placed on the side of the cart.

Part 3: The Scissor Lift Platform

The scissor lift platform is what makes the Lifty Cart go up and down. The box with the handles and side latch is put on a scissor lift platform that can only change height by 8-10 inches. The limited mobility is desired because the height difference between the project partner's car trunk and kitchen counter is 8 inches. A mock-up of the scissor lift with the box on top is shown in Figure 22 below.

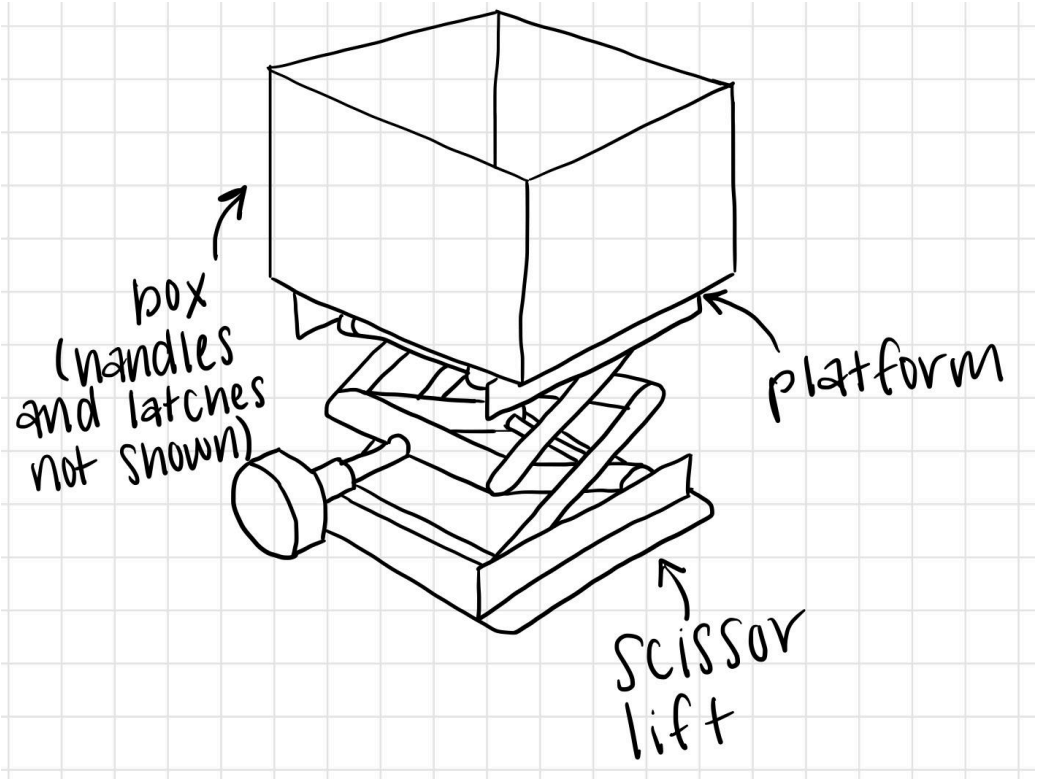


Figure 27: Scissor lift platform with box. Handles and latches on the box not shown.

The round crank on the left is turned by the user and the box is then raised to the desired height. The scissor lift platform meets the needs of the design in the following ways:

- Keeps Judy from bending over and losing her balance to pick up her groceries.
- Is a mechanical solution.
- Lightweight compared to other carts and raising platforms.

Conditions and Testing:

- We had no physics mock-up to show her for testing, but did show her Figure 21 and explained how a scissor lift could be useful when handling the cart.
- We asked her about her ability to lift something as she would with a mechanical scissor lift.
- Finally, we had her describe why the scissor lift would be a good or bad addition to the design.

Questions for the project partner:

- Does the scissor lift being mechanical hurt her in any way? Should it be electrical so she can avoid exerting herself while cranking?
- Does the cart need to change height at all? Is this a necessary part of the solution?

Observations:

- She mentioned that if the cart was full of groceries she would not be able to lift the scissor lift to raise it to a taller height.
- She also mentioned that having a height-adjustable cart would be very helpful if we can make it electrical.

Design Idea 2: Door Latch

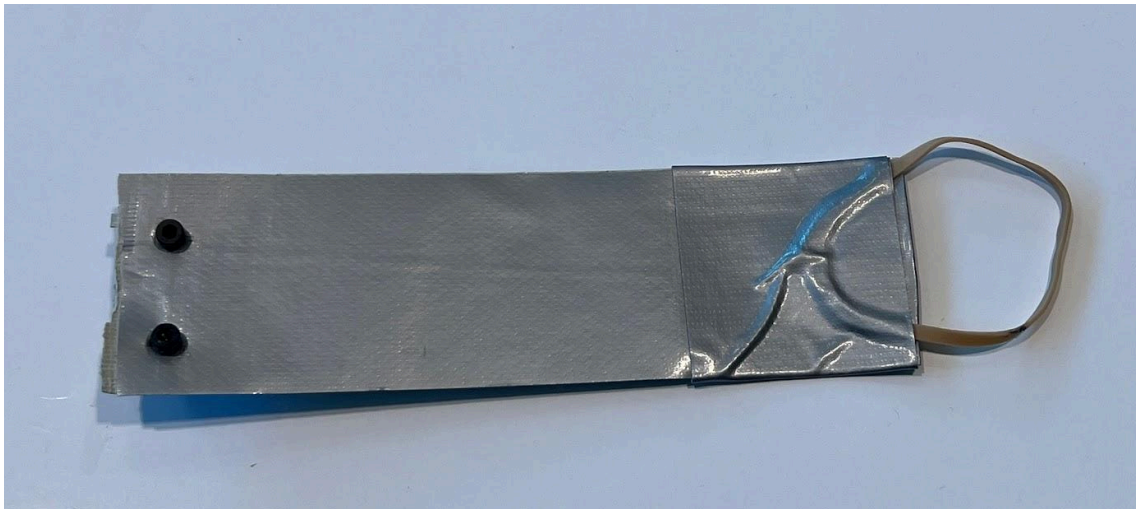


Figure 28: Door latch mock-up

The project partner has a screen door in her garage that self-closes which makes it hard for her to bring groceries into her house easily. The door latch screws into a wall or any other sturdy surface next to the screen door. When the screen door is opened, the user can place the rubber band around the door handle and release the door, which keeps the door in place and open. The user can then go into and out of the house without having to continually open the screen door with the door latch, as seen in Figure 28. A step-by-step diagram is shown in Figures 29-31 that walks through how to use the door latch.

Figure 29: The door latch placed by a door near the door handle when opened

Figure 30: The rubber band is stretched over the door handle

Figure 31: The rubber band keeps the door open

The door latch meets the needs of the design in the following ways:

- Easy to use.
- Completely mechanical design.
- Keeps the user from losing balance and potentially falling when opening the door while carrying objects.

Conditions and Testing:

- We brought the physical mock-up shown in Figures 24-26 to the project partner and had her test her ability to grip the rubber band and move it.
- We also asked her about how the door latch could be attached to nearby walls or banisters.

Questions for the project partner:

- Is she able to screw something like the door latch into a nearby wall or another surface?
- Is she able to grip the rubber band to easily move it on and off the door handle?
- What are her aesthetic preferences? What color and/or material should it be made of?

Observations:

- She mentioned that she would prefer a thicker rubber band to avoid potential breakage.
- Incorporating the door latch into her home would not pose a problem.

Design Idea 3: Ramp Extender

* As of February 2nd, we were notified by the project partner that she will be installing a complete full ramp. *

The current ramp installed in the project partner's house has a non-ADA-compliant steep ramp that has a 4.5-inch step at the bottom of the ramp. In addition, there is no flat surface area at the top of the inclined ramp, which makes it difficult to open the door. Our mockup is to build a new ramp that extends further into her driveway, has a flat surface area at the top of the incline, and has a lower angle of inclination. An alternative solution is to build upon the existing ramp and make an extension on the bottom of the ramp. This way, there is no steep step at the bottom and it can help the project partner move onto the ramp safely. A drawing of the current ramp and the new ramp concept can be seen in Figure 32.

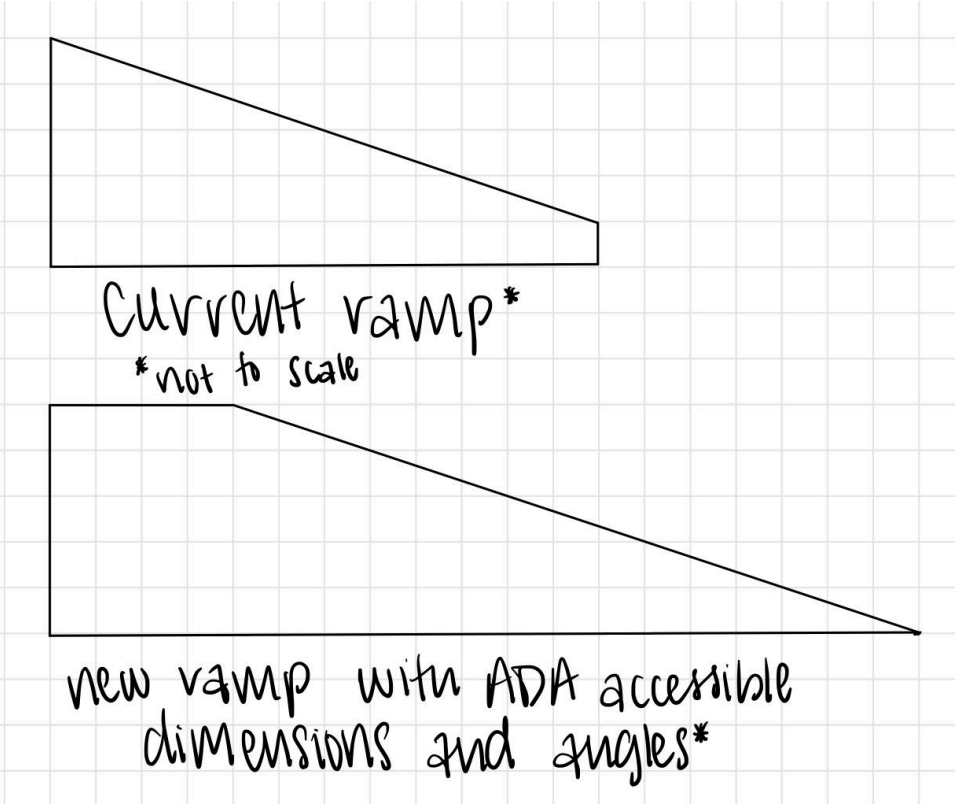


Figure 32: The current ramp and new ramp concept. Neither drawing is to scale.

The redesigned ramp and ramp extension meet the needs of the design in the following ways:

- Easy to use and much safer
- There is no electrical component to any part of the ramp
- Weight is negligible as the project partner will not be carrying the ramp

Questions for the project partner:

- Would she prefer a new ramp with a lower angle incline or a tiny extension of the existing ramp?

- Would she be okay if the ramp was extended further out?
    - How far out would she like the ramp to extend?
- What are her aesthetic preferences? What color and/or material should it be made of?

We did not ask her about the ramp extender because a plan to fix the ramp is already in action by outside parties.

Iteration

We basically agree on the project definition we have right now, but there are some modifications based on the interview with our project partner.

First, we should add a section “making the height of the cart adjustable”, and the specifications along with it. As our project partner mentioned, having a cart with static height would still make her lift stuff out of the basket, so it would be ideal for us to add that point to our project definition.

Second, we should add a section about the handles we want to build. We presented our designs for the handle to our project partner and she eventually agreed on one of them. We should add this part as it is one of the most important parts of our device.

Third, we should modify the part “Preferable all mechanical and no electrical” in our project definition. As mentioned by our project partner, she could not operate the mechanical handle used for lifting the basket, so it would be better for the lifting mechanism to be electrical and powered by batteries. The priority stays the same, but the content would be changed.

Fourth, we should prioritize the part saying “Height must be high enough to reach countertop and fit in the trunk of car” before “electrical powered with battery”, as it is one of the most important points our project partner elaborated on during the interview.

Some insights we gained from feedback and testing are as follows:

- The project partner is only opposed to an electrical solution because she is unsure where she would plug it in. However, if the solution was battery-powered, she would prefer that over a mechanical system.
- In order for the solution to be completely effective, it needs to be able to change height so the project partner is not bending down regularly.
- The project partner didn’t think it would be necessary to have a fabric handle on the side of the basket as there are no occasions she would have to pull the cart.
- The ramp does not need to be extended by our team because she has already hired someone to fix it for her.
- Any solution we create needs to be designed such that it protects against the project partner losing her balance and/or falling.

After discussing our discoveries from the user testing, we have revised our plan in the following ways:

1. If we are to make the cart height adjustable, it must be battery-powered and after talking to the shop about how to do that, we landed on using a linear actuator. A large linear actuator can hold around 330 pounds and extend 10 or more inches. If we attach a square platform to the top of the actuator, then it could support a box and all the groceries within while bringing the box up and down. It can be controlled by a controller that comes with the actuator for easy height adjustment. To stabilize the platform as it goes up and down, we can incorporate smaller poles into the PVC pipe base that restrict the box from wobbling no matter the height the actuator extends to.

2. Based on our design plan, one side of our basket could lay down (as shown in Figure 33) so that Judy could have an extra platform to put her items when moving them out of the basket to the counter. We discussed that part with our project partner and she liked our idea, and she would like the platform to be extended, longer than its original length (which is the height of the basket). We would attach another foldable sheet onto the side, and it falls down as the side lays down.

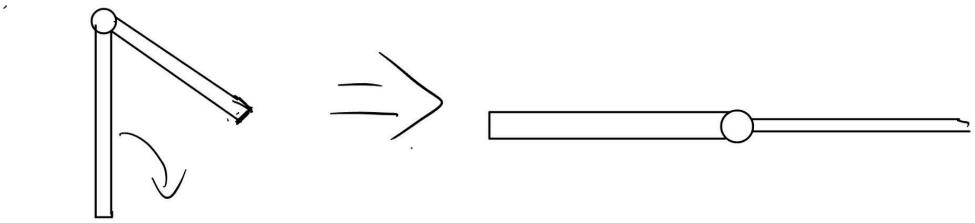


Figure 33: A drawing of how the cart side would extend

Discussion

Some insights we gained from iteration testing are as follows:

1. We should always iterate after making a critical decision in our design process, it is a good way to attain a deeper understanding of our project partner's needs and our current solution. It also provides an opportunity for each of the team members to share ideas and incorporate them into a whole.
2. If we run into a constraint that impacts our design, we should ask the project partner how they feel about the design before scrapping it. Sometimes there are factors we are not taking into account when discussing constraints that can be clarified by simply talking to the project partner. This happened to us when the project partner said she did not want an electrical solution when she actually did not want a solution that had to be plugged into an outlet.
3. Having a group consensus on all items and our objective of the project is an essential part of working towards our final goal of helping our project partner. By consistently reviewing our

project definition and refining it based on primary research and experimentation, we will keep ourselves on track toward the completion and success of our project.

APPENDIX D: DESIGN REVIEW

Introduction

We conducted a design review on February 9, 2023 in the Ford Design and Engineering Center Room G.205 at 1:15 PM. The purpose of this design review is to get feedback from colleagues so that we can eliminate problems before we give the project client a design with faults. In a five-minute presentation and ten-minute Q&A session, we presented our components of the Lifty Cart and the door latch as a system of solutions for our project partner.

Methodology

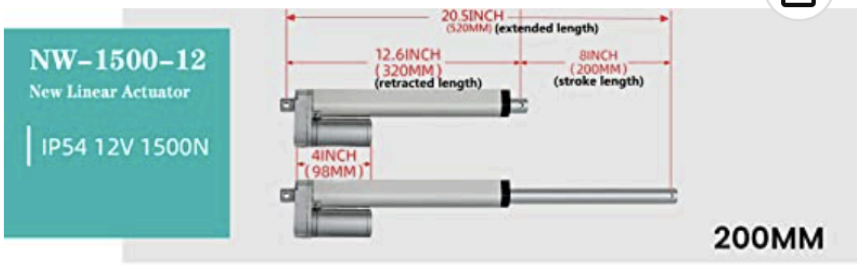
To prepare for this design review, the team worked on a PowerPoint presentation to present to the class. During the presentation, each team member presented one section of the slides and we all answered the questions asked by the audience at the end. Throughout the presentation, one member of our team took notes from our audience providing feedback to our ideas.

Results

The audience provided insightful feedback on our design ideas and asked valuable questions to highlight certain aspects of our design that we originally did not consider. Each subheading below highlights the feedback from each component of our design.

Linear Actuator on Cart

Most of the questions were about the linear actuator. Because the project partner has indicated that she does not prefer to have an electric-powered device (due to an issue with power outlets), many questions were asked about the battery power. Questions regarding how often the battery would have to be replaced, the size of the battery, and being rechargeable were asked. Because the battery can be placed anywhere on the cart, we still need to discuss an ideal location to switch the battery.



RATED LOADS (LBS) N	STROKE LENGTH (MM)	TYPE	VOLT	RETRACTED LENGTH (MM)	EXTENDED LENGTH (MM)
330 lbs (1500N)	50	NW-1500-12	12V	155	205
	100	NW-1500-12	12V	205	305
	150	NW-1500-12	12V	260	410
	200	NW-1500-12	12V	320	520
	250	NW-1500-12	12V	370	620
	300	NW-1500-12	12V	420	720
	350	NW-1500-12	12V	470	820
	400	NW-1500-12	12V	550	950
	450	NW-1500-12	12V	600	1050

Figure 34: Product dimension of Linear actuator

As seen in Figure 29, a 12V battery will be used to power the linear actuator. Because the battery is not included in the linear actuator product, we have the flexibility to choose a battery that is rechargeable. Figure 30 shows a sample product of the 12V battery.

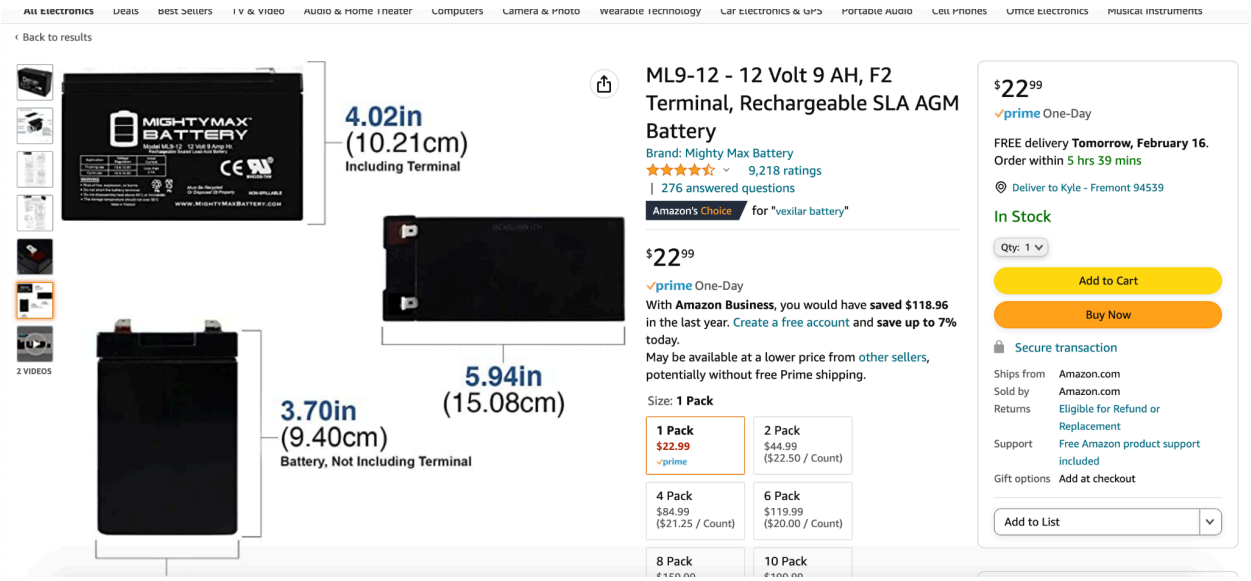


Figure 35: Sample 12V battery on Amazon

The figure includes the dimensions of the 12V battery and it weighs about 4.5 pounds. With its size and weight, it is possible to place the battery anywhere on the cart, preferably at a place where it is accessible. It's also rechargeable so the project partner does not have to purchase a new battery every time the battery dies. The product description of the battery states that it can resist shocks and vibration, which makes it much safer for the project partner to use.

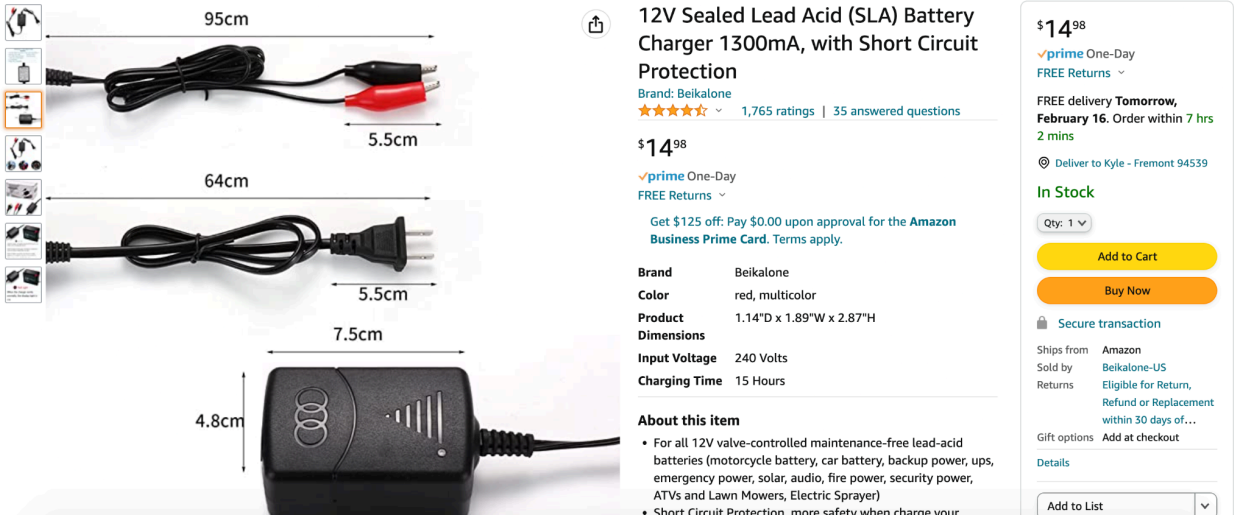


Figure 36: Sample 12V Battery Recharger

A sample battery recharger that connects to the standard electrical outlet is shown in Figure 31. Although the project partner prefers not to have any electrical components, the battery would only have to charge once every several weeks. In the case that the battery runs out of

power, our project partner will still be able to use the grocery cart, just without the adjustable height feature.

One other aspect is the safety of the linear actuator. In the case that the linear actuator fails, one big concern is if the groceries will fall. As seen in Figure 32, the four supporting poles (one is hidden in the figure) will hold the cart and keep most groceries in the basket. In the case that the linear actuator fails and the basket is no longer supported mid-air, the basket should only fall vertically and therefore the support bases will keep it in place.

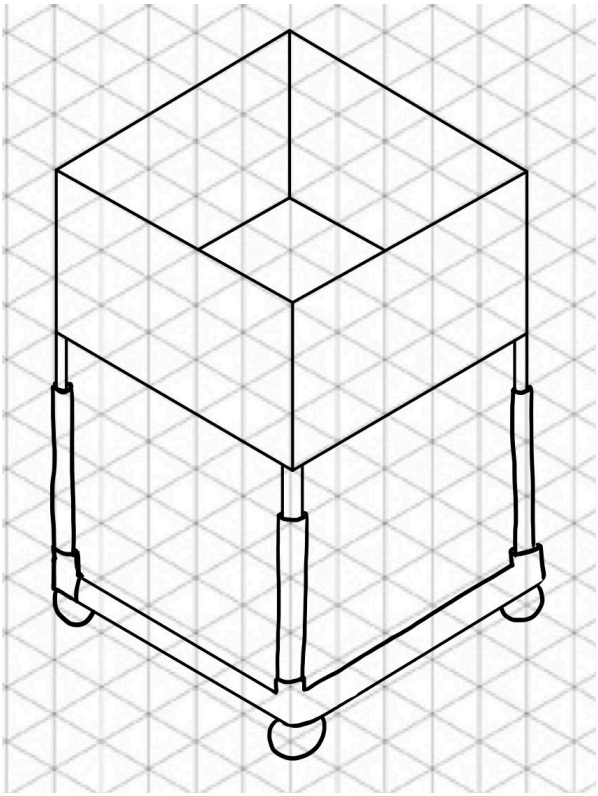


Figure 37: Visual Representation of supporting poles

Joe Kuechel, operations director of the Ford Prototyping Center, suggested for safety reasons to build a locking mechanism in case the linear actuator fails. After discussing with the team, we were unable to find a solution to the locking mechanism, and look forward to discussing this component with Joel in our future shop consultation.

One component of the linear actuator that our team realized during the review was that we weren't familiar with how the project partner would be able to use the linear actuator. There is actually a controller component of the linear actuator not included with the product that we need to purchase in order for the project partner to use the linear actuator, as seen in the visual diagram Figure 33.

Figure 38: Sample Wiring Plan with the controller.

The manufacturer of the linear actuator has their own controller, as shown in Figure 34.

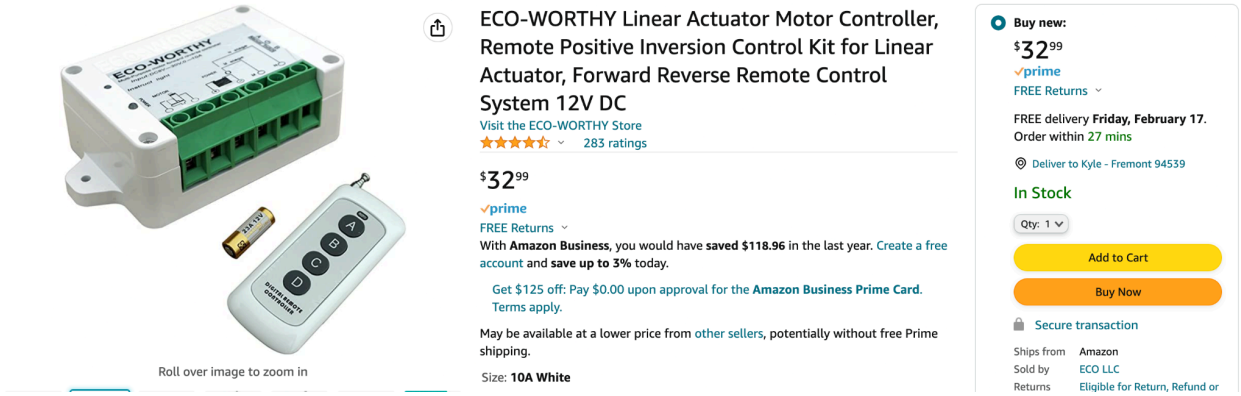


Figure 39: Linear actuator controller on Amazon

With the linear actuator product, a 12V battery, and the controller with a remote, we are able to create a safe and user-friendly height-adjustable cart.

Door Latch

We asked the audience for suggestions regarding material for an elastic and sturdy component so the project partner could place the door latch on the door without much resistance. One of the audience members suggested we use resistance bands because of their elasticity. An example of the resistance bands is shown in Figure 35.

Figure 40: Resistance band fabric to be used for the door latch

The resistance band is affordable and is an accessible option for our project partner. It is 12x3 inches and has five different levels of resistance. Our team could easily test its durability and lightness, and consult Judy about which one she would prefer. If each resistance band has the same amount of durability, it would be best to use the x-light band for convenience.

Handles

With the extra addition of handles, one of the concerns was if the cart will still fit through the doors. Because the cart box dimensions were about half of the size of the door, we concluded that there was plenty of space for our project partner to move and for the cart to be in place. As long as the handles do not exceed 8 inches in width each, there will be no issues. We expect to have the handles at approximately 2 inches in width each. A mock-up of the design is shown in Figure 36.

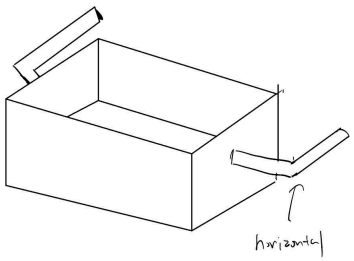


Figure 41: Mock-up of the basket with handles.

Box Material

There were also some questions about the box material since we had expressed that we wanted to use canvas fabric, as shown in Figure 37.

Figure 42: Canvas fabric used for the cart basket

However, because Judy had previously stated that she wanted the fabric to be washable, we had to think of a way to remove the fabric basket while still keeping it in place while on the cart. We thought of using a zipper, but then decided to use a solution taken from some laundry bags as shown in Figure 38.

Figure 43: Laundry bags held in place using velcro straps

The laundry bags in Figure 38 are held in place using thick velcro straps that are then tied around rigid poles. We can implement this idea by attaching the velcro straps to the canvas

basket and using a PVC pipe frame to hold the basket up. This would allow the project partner to take the basket off the cart for washing if she were to spill something on it but also allow the basket to stay in place while in use.

Discussion

Participating in the design review allowed us to ask questions to the class and gain valuable feedback for our design. It also gave us an opportunity to see what other groups are doing and possibly incorporate similar ideas into our own project. Presenting our PowerPoint allowed us to practice our public speaking and interpersonal skills with a group of similar-minded people.

In addition, it highlights how important it is that all team members understand all components of our project well. When an audience member asks us a question and we don't have an answer, it's an eye-awakening experience and allows us to discover a major component of our project that we didn't realize during the planning process. For example, we didn't think about where to place our 12V battery until someone asked us about it. There are many instances similar to this and after our presentation, we were able to reflect on these components carefully.

Overall, we had a positive experience with the design review and look forward to collaborating with other teams in other activities.

APPENDIX E: DIRECTIONS FOR CONSTRUCTION

Materials

Table 2: Materials Used for Construction of Lifty Cart

Material	Specifications	Quantity
Linear Actuator	NW-1500-12 330 lbs, 12V 12 inch, 10mm/s	1
Remote Controller	ECO-WORTHY, white, universal controller	1
Battery Set	Two parallel battery sets, each of 4 batteries.	1
Battery	AA	8
1’’ PVC pipes	40’’	3
0.5’’ PVC pipes	40’’	2
Plate wood	16’’ * 16’’	3
0.5’’ 4-way PVC connector		4
1.0’’ 3-way PVC connector		4
1.0’’ 4-way PVC connector		8
0.5’’ 3-way PVC connector		2
0.5’’ 2-way PVC connector		2
Wheels	4 inch, 1200 lbs Duty, with lock	4
Resistance band	5.91’’ * 3.15’’ * 0.59’’	2
Polyester Mesh	35" * 86" * 1/32"	1

Detailed instructions

1. The Frame of The Cart

1.1 Cut 1-inch PVC pipes into four 18-inch sections.

1.2 Connect the four pipes to form a square using four 1-inch PVC 3-way connectors.

1.3 Repeat these two steps three more times to form three other PVC square frames.

1.4 Cut four X-inch sections out of a 1-inch PVC pipe: these will serve as the pillars of the cart.

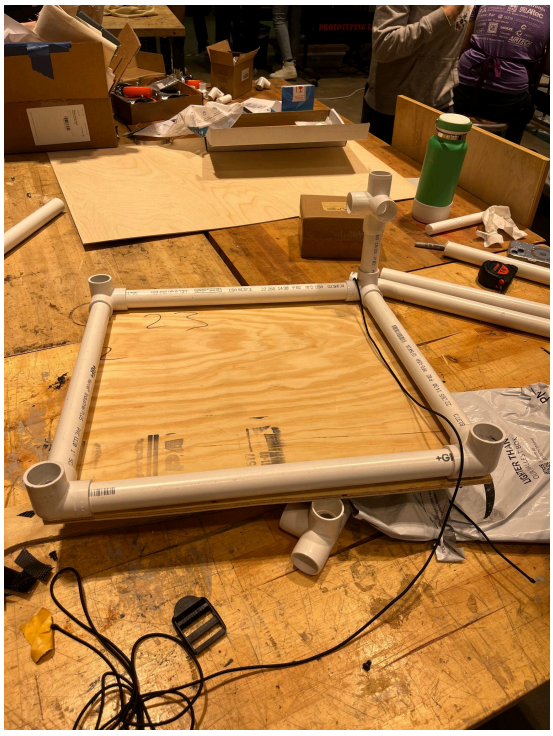


Figure 44: Assembling the frame of the cart

1.5 Build three wooden platforms by cutting a piece of plywood into three 21-inch squares.

1.6 Cut out squares that match the lengths of the connectors at the edges of two of the three wooden platforms. Leave the third platform intact — it will serve as a base for the wheels to be attached to.

1.7 Set one of the cut-out wooden frames above the top PVC frame — this will serve as the base of the basket.

1.8 Set the second cut-out wooden frame above the second-to-last PVC frame.

1.9 Drill holes into a few random spots of these wooden platforms and fit the nylon ropes into them. This will allow you to attach the platforms to the PVC pipes.

1.10 Drill holes into the last wooden platform — the one whose edges weren't cut out that correspond to the holes in each of the four wheels.

1.11 Once these holes are drilled, attach the wheels to the platform using four screws and four washers for each of the four wheels.

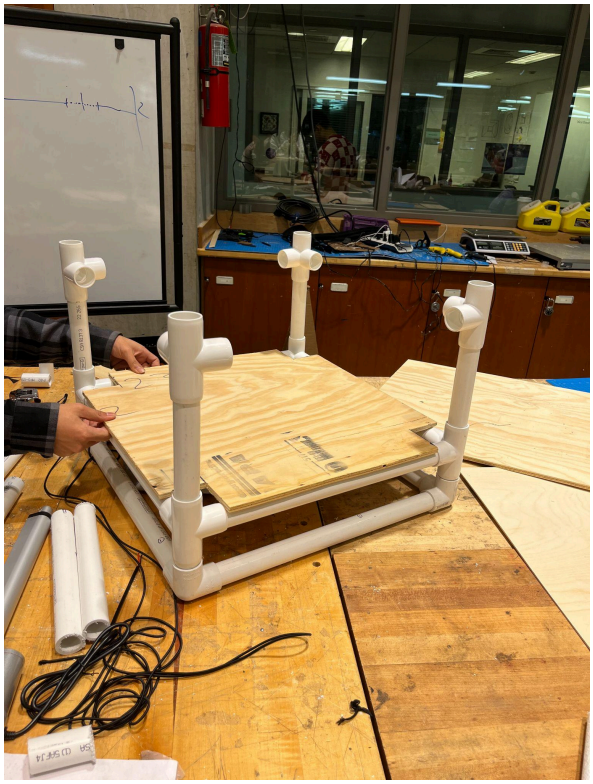


Figure 45: Assembling the frame of the cart pt.2

Figure 46: Assembling the frame of the cart pt.3

Figure 47: Connecting the plywoods with the PVC pipes using nylon ropes

Figure 47: Detailed illustration of the knots

2. The Linear Actuator

2.1 After finishing building the frame of the cart, we go ahead and work on assembling the linear actuator.

2.2
2.3

Figure 48: Placing the linear actuator

3. The Basket

Figure 4x: Placing the latchable plywood

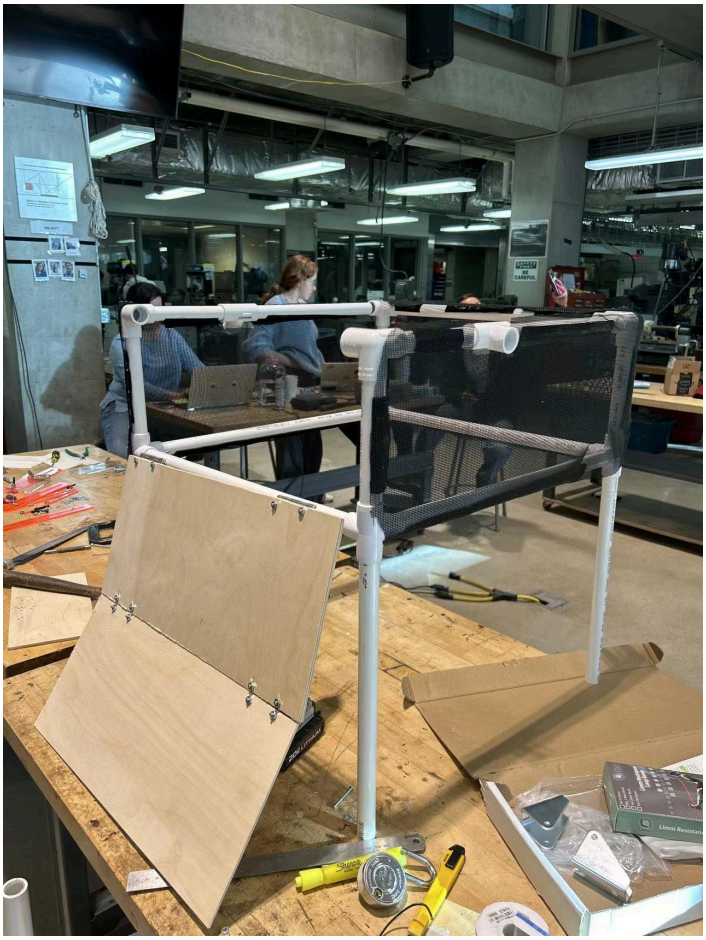


Figure 4x: Finishing the basket

REFERENCE APPENDIX

[1] “Osteoarthritis of the hands: Arthritis foundation,” *Osteoarthritis of the Hands | Arthritis Foundation*. [Online]. Available: https://www.arthritis.org/diseases/more-about/osteoarthritis-of-the-hands. [Accessed: 23-Jan-2023].

[2] “Osteoarthritis (OA),” Centers for Disease Control and Prevention, 27-Jul-2020. [Online]. Available: https://www.cdc.gov/arthritis/basics/osteoarthritis.htm#:~:text=Osteoarthritis%20(OA)%20is%20the%20most,underlying%20bone%20begins%20to%20change. [Accessed: 27-Jan-2023].

[3] S. E. Ward, “Osteoarthritis Self-Management,” Arthritis Society Canada, Feb-2021. [Online]. Available: https://arthritis.ca/about-arthritis/arthritis-types-(a-z)/types/osteoarthritis/osteoarthritis-self-management. [Accessed: 29-Jan-2023].

[4] A. Mandal, “Dopamine Functions,” News Medical, 09-Apr-2019. [Online]. Available: https://www.news-medical.net/health/Dopamine-Functions.aspx#:~:text=Dopamine%20in%20movement&text=Dopamine%20reduces%20the%20influence%20of,may%20become%20delayed%20and%20uncoordinated. [Accessed: 27-Jan-2023].

[5] “Parkinson's disease: Causes, Symptoms, and Treatments,” National Institute on Aging, 14-Apr-2022. [Online]. Available: https://www.nia.nih.gov/health/parkinsons-disease#:~:text=Parkinson's%20disease%20is%20a%20brain,have%20difficulty%20walking%20and%20talking. [Accessed: 27-Jan-2023].

[6]“What is the mechanism of a scissor lift used for?,” *Handling Specialty*. [Online]. Available: https://www.handling.com/scissor-lift-mechanism#:~:text=The%20scissor%20lift%20control%20system [Accessed Jan. 26, 2023].

[7]“Uplift Prototype Testing,” www.youtube.com. https://www.youtube.com/watch?v=4uSca43L5AI (accessed Jan. 26, 2023).

[8] “All You Need to Know About Ada Ramp Requirements in 2021,” ADA Solutions, 2021. [Online]. Available: https://adatile.com/all-you-need-to-know-about-ada-curb-ramp-requirements/#:~:text=Clear%20Width%3A%20A%20ramp%20run,maximum%20ratio%20of%201%3A48. [Accessed: 29-Jan-2023].

[9] “Guide to the ADA Accessibility Standards,” U.S. Access Board. [Online]. Available: https://www.access-board.gov/ada/guides/chapter-1-using-the-ada-standards/#:~:text=The%2n.d.

A%20Standards%20apply%20nationwide,are%20covered%20by%20the%20ADA. [Accessed: 29-Jan-2023].

[10] “ADA NON-COMPLIANCE: WHAT HAPPENS WHEN CITIES OR BUSINESSES DO NOT COMPLY?,” ADA Solutions. [Online]. Available: https://adatile.com/ada-non-compliance-what-happens-when-cities-or-businesses-do-not-comply/. [Accessed: 29-Jan-2023].

[11] Judy Geigner, private communication, January, 2023.