Optimal Design Team 10

Project for Carolyn Martin

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Team 10

Project 14 – Sponsor Dr. Enderle

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1. Optimal Design Report 10

1.1 Introduction:

Two projects were designed and specialized so Carolyn Martin, a 42 year old female who has Multiple Sclerosis, could further her physical therapy treatment and be able to use her own kitchen. Two separate projects have been designed, with the first project being a dual exercise machine and the second being a power stander. Each of the machines are specialized to fit our client’s specific needs.

The first project focuses on the necessity for Carolyn to further her physical therapy. Exercise is our client’s first priority and will be the major theme of the first project. The machine design incorporates the ability to both stretch and do resistive peddling without having to leave or move the clients’ wheelchair. The design consists of three major components, the frame, microcontroller/engine/push button system, and rotating a plate. The frame is comprised of an aluminum base which is used to support the exercise apparatus and the motor. Aluminum rods are used to fasten and secure the peddling system and the stretching mechanism to the frame and the rotating plate. The pedaling and stretching systems will be mounted on opposite ends of the machine. With the use of a switch, potentiometer, and a programmed microcontroller the motor will rotate the plate 180 degrees, each time the button is pressed, allowing the user the ability to exercise using the equipment.

The second project focuses on the desire Carolyn had for cooking and using all of her kitchen appliances. Our design of the power stander has the ability to hoist the client from her wheelchair onto the stander as well as securing her by supporting her weight with a harness. The hoist bar is made up of steel and is controlled by a linear actuator, making the hoisting mechanism an automated feature. Once she has reached the standing position, the stander can be controlled via joystick control. The joystick gives inputs to the PIC microcontroller and is directly responsible for moving and directing the wheels. By making the stander automatic, Carolyn will be able to navigate around her kitchen as she pleases. The stander frame and base are both made from steel due to compensate for the high load stress placed on the system. Unlike normal standers, the design allows the user to interact with the surroundings around them by eliminating front supports and countering the weight with a longer base in the back.

1.2 Subunits:
1.2.1 2-in-1 Exercise Machine for Carolyn Martin:

1.2.1.1. Base: (Put pic of base)

The base needs to sturdy enough to support the full weight of the custom exercise machine for Carolyn Martin. Aluminum will be the primary material used to layout the foundation. All in all, as seen on figure 1, 10 distinct aluminum rods will be used to design the base.

Figure 1: Aluminum Base

Six of these structures need to be constructed to lay down the foundation for the exercise machine. Two of the rods will be curved to make the incline in the base design. The other two rods will connect the two curved pipes creating place to attach the rest of the structure of the overall machine. Anti-scratch pads will be places on the bottom the lower tubes so the floor doesn’t get damaged when the machine is in use. Welding the pipes together is the best method for ensuring stability in the base. With these pipes laid out and welded together a .5 inch thick aluminum plate (220 GA) will be welded the two pipes that connect the curved pipes. In the middle of the steel plate we will create a circular cut that will approximately be .5 inches thick and have a diameter of 10 inches. With this circular chunk of the steel cut out from the overall sheet another small circular cut that is .5 inches thick with a diameter of 4 inches needs to be made at the center of the initial cut. Overall in the steel plate there will be two circular cuts which make a hole all the through the steel plate.
1.2.1.2. Rotating Structure:

The base will be the foundation for the rest of the machine to be constructed from. Four aluminum rods (Aluminum Structural Pipe 1-1/2 SCH 80 (1.90 OD X .200 wall)) will be attached to the base in a vertical manner. The rotating mechanism will be transferring energy to these rods and they will do all the rotating. This will be done by laying a circular piece of aluminum (9.75 inches in diameter and .25 inches thick) into the circular cut made on the plate of the base. This plate will have free movement within the circular molding made on the base, but it will stay within the confines of the mold. The plate will have 4 holes cut in it, as seen on figure 2, which will be the exact area of the ends aluminum pipes so they can be inserted into the circular plate.

![Figure 2: SolidWorks aluminum plate with four holes](image)

The four aluminum pipes need to be inserted into each of the corresponding holes and welded together to create the upper structure of the exercise machine.

1.2.1.3. Rotation System:

Our intention is to give our client a choice between two exercises, both of which are essential in her rehabilitation process. One involves a pedaling mechanism which will help strengthen our client’s lower extremities. The other exercise is passive and involves stretching, but will also aide our client in her rehabilitation process. These two exercises need to be implemented on the same machine without taking up each other space; so we decided to place them on opposite sides of each other. A rotation mechanism will be installed so when a particular exercise wants to be done the client can press a button to rotate the machine.
First and foremost a motor will be used to make the rotation in our machine possible. We will be using a brushed dc motor, as depicted on figure 3.

![Brushed DC Motor](image)

**Figure 3: SolidWorks design of a brushed dc motor**

This provides torque directly from DC power supply to the motor by using internal commutation, stationary magnets, and rotating electrical magnets. The brushed DC motor will provide all the energy needed to make this machine spin with a proper control system. It will be located in a caged compartment directly underneath the base of the machine. This location is ideal because all the components above the motor will be rotating.

To control the spinning of the device a microcontroller and a push button needs to be installed. A stand will be created off of the upper structure of the machine where the button for rotation will be mounted. The button will have a simple push design and the reliability will be upwards to 10,000,000 cycles. A simple design will make using the machine easy for our client. Once this button is pressed the system will rotate a complete 180 degrees. This process will happen every time the button it pressed. With this being the base each of the exercise mechanism needs to mounted on opposite ends so that when our client presses the button one of the machines will be directly in front of her to use. The microcontroller will be the bridge between the switch and the motor. An 8-bit digital microcontroller, as seen on figure 4, is preferred.
The major system that will be controlled in the rotation is the speed and torque. The mechanism for which the microcontroller executes these commands can be viewed on a flow chart on figure 5.

![Flow chart diagram](image)

**Figure 5: Mechanism of that links the microcontroller, engine and button**

With the inputs of speed, torque and direction set upon pressing the button the step which the flow char depicts will be carried out.

The mechanical design of the rotation system will involve using a drive shaft and aluminum plate. The drive shaft will piece the motor and the rotating steel plate (refer to figure...
2) together. The steel plate can’t be placed directly on the motor due to the design so a drive shaft is needed to bridge the gap. The energy generated by the engine will transfer to the drive shaft and will be visible when the steel plate spins. The steel plates will be located right above the motor and drive shaft. Most the energy expunged by the motor will be released through this particular plate. It will provide the rotating mechanism necessary to create this machine to our specifications. The plate must also be attached to the four support rods that extend from the base of the machine.

1.2.1.4. Pedal and Stretching Mechanisms:

The most important aspect of this machine design is the exercise mechanisms. The first exercise method requires the user to place his/her feet on a pedal system and bike with built in resistance. This builds strength and stamina which our client desires in her rehabilitation process. The other form of exercise is far less physical, but equally as important in effectiveness. It involves stretching me that requires the user to insert his/her feet in foot rest. Then the user will grab vinyl pulleys, which are attached to the nose of the foot rests, and pull so the ankles, calves, and hamstrings will be stretched.

The pedal system that will be implemented can be seen on figure 6

Figure 6: Instridy Cycle XL Pedal Exerciser
This model was chosen for its low cost and space saving design. Also the net weight of the product is only 9 lbs. which is ideal for mounting to the overall structure of the machine. It also has a built resistance feature which our client can adjust to her preference. Looking back at the structure of the four steel rods they will be sticking vertically up from the circular disk. With this setting in mind we will build a layer in between the rods where the pedal system can be mounted to, ass seen on figure 7. This layer will involve connecting two of the rods, horizontally, will a piece of aluminum. Welding this piece to the overall structure is ideal. This will ensure the pedals are in place and will not fall off at any point. Making this attachment halfway up the machine allows for the user to keep their feet on a parallel plane. This is necessary because our client will be using this device from her wheelchair and raising her feet is definitely an issue.

The stretching mechanism, as previously mentioned, will be located on the opposite end of the pedal system. The design allows for the user to place his/her feet into the foot rests and stretch significant legs muscles by pulling on the vinyl coated steel fiber ropes. This allows for the user to choose which exercise he/her wants to perform at any given time. On the opposite end of the pedal attachment two free rods will be available for mount the stretch mechanism. We will be inserting two large screws on the sides of the rod about halfway up the system. These screws will be the attachment points for the stretching attachments. With the stretching attachments installed to the two steel rods the user now has two exercises to choose from.

1.2.2. Mobile Automated Stander:

The second project being designed for Carolyn Martin is an automatic stabilized stander that will allow her to move freely around in a natural standing position. The design contains several subunits, but as a whole, the unit will lift her out of her wheelchair, safely secure her in the erect position, and allow maximum reach so she can perform her desired actions in the kitchen. Once she is in the device, Carolyn will be able to move around with the use of a joystick, PIC, and microcontroller.
1.2.2.1. Base:

The base shown in figure 8 is made of steel in which the load of the device and Carolyn will be supported. The base is constructed with the attachment point of the frame located near the front of the device. The base is comprised of two halves with the frame attachment point being used as the reference bisecting point. Each of the halves resembles horseshoes with the back piece being longer than the front piece. At the bottom of the four ends of the base are wheels with the front wheel being larger than the back.

The function of the steel base is to provide strength and stability to the device. The base is comprised of steel which provides needed weight and strength in order to support the constant load on the device. It’s designed as two horseshoes for further stability of the device, as well as minimizing the size of the machine to allow the largest range of movement. The back half of the base is extended in order to allow Carolyn to pull her wheelchair as close as possible to the frame. The back of the frame also will have to counterweight the load that will be applied to the front of the device. The front wheels and support also feature a short design in order to allow Carolyn to move as close as possible to her countertop while providing her with maximum reach. With the weight being mostly located towards the front of the device larger wheels are used on
the front of the base for load bearing purposes. The back of the base is furnished with smaller wheels in order to maximize mobility and allowing for controlled and more precise movements.

The base will undergo stress tests after the welds have been set and before the frame is attached. The base is an essential in supporting the entire system as well as supporting an individual. The base must therefore be able to handle loads twice as much as the expected load in order to ensure safety of the device and the user.

1.2.2.2 Wheels:

The wheels shown in figure 8 are wheels being taken from a power wheel chair that has been scrapped for parts. The wheels have been tested to support the weight of a wheelchair as well as a human and provide both the larger and smaller wheels required in the design.

The larger wheels, shown in figure 8, will be used in the front of the base and are responsible for weight bearing functions as well as being the main powered wheels for movement. The smaller wheels function is to be a guide and provide stability and an increased range of movement.
1.2.2.3 Foot Support:

Figure 10: Foot Support Pedal.

The foot supports shown in figure 10, are on the market foot pedals that are made of a hard plastic base and contain Velcro straps. The foot pedals will be attached to the base and provide an area in which Carolyn can stand as well as secure her feet. The pedals selected will have safety testing results that show the pedals can support Carolyn’s body weight.

1.2.2.4 Frame:

Figure 11: Stander Frame
The frame is a steel frame that is attached near the front of the base. The frame contains two major functional pieces. The first piece is the main stem of the frame, which is directly connected to the base shown in figure 11. The other piece is another horseshoe shaped attachment of steel which will sit on top of the stem and as a result will form the arm rests for Carolyn to use. The frame contains many attachments that ultimately make the device functional.

The function of the frame is to provide stability and support by transferring the load of hoisting and supporting Carolyn down the stem and onto the base. The frame also serves as a major attachment point for the devices that provide dynamic functionality. Attached to the stem is the lifting mechanism and bar and attached to the arm rest will be the joy stick which will control the movement of the stander.

Just like the base, the frame will need to be stress tested after all welding is complete. During the test we will see if the frame can support the load of an individual as well as the load from hoisting an individual out of a wheelchair and onto the stander. The testing will be performed after the frame is connected to the base in order to confirm the frame is transferring the load to the base.

1.2.2.5. **Leg supports:**

![Figure 11: Thigh Pad Leg Supports.](image)

The leg supports are made of hard plastic and padded molds that are attached to the lower section of the frame, figure 11 shows a model for the design. The leg supports provide a comfortable and structural support in which Carolyn will rest her legs against while erect in the
machine. The width of the supports will be adjustable so over time continued use of the device is possible regardless of physical changes to an individuals’ body.

1.2.2.6. Arm Rest Covers:

The arm rest covers have two major functions for the device. The first function of the left arm rest is to support the joystick mechanism that will control the movement of the entire standing device. The joystick is located in a position in which little effort is needed to reach and use it. The second function of the arm rest is to provide support and comfort of the arms should the client wish to have her arms supported.

1.2.2.7. Hoisting Bar:

![Hoisting Bar Diagram](image)

Figure 12: Hoisting Bar Diagram.

The hoisting bar is a staggered bar made of steel, figure 12, that will be fastened at a joint on the front of the frame. The bar will support the entire weight of Carolyn during the lifting phase, and will be the main support unit during the standing phase. The bar will be attached to a pivot point at the front of the frame to allow for range of motion as well as support from the frame and base of the load of the client. The bar will undergo stress tests like the frame and the base both before connection to the device and after, to ensure that failure will not happen during the lifting phase and the supporting phase.
1.2.8. *Lifting Waist Harness:*

The lifting harness is a nylon waist harness, shown in figure 13, which is attached to both ends of the hoisting bar. The harness will attach at points on the hip and thighs and will provide a safe and comfortable transition from wheelchair to the standing device. Once in the standing position the harness will remain on and be the main personal support for Carolyn’s body weight. By relieving her lower body from a significant portion of her weight she will be able to stand and use the stander without having to support herself with her upper body. Despite Carolyn’s condition she is easily able to attach herself to a harness that fastens around the hip and waist. Prior to purchasing a harness, its strength will be researched, ensuring that the load experienced from the hoist points and Carolyn’s body weight will be enough. Further physical testing will also be implemented in order to confirm the harness system is safe.

1.2.9. *Handbrake:*

The handbrake will be a mechanical brake that will prevent the movement from the front tire. This will allow the client to reach a desired location and prevent any unnecessary movement while using any of the appliances throughout her kitchen. Each tire will have a respected handbrake, which will also be fastened with a locking mechanism. The brake will be pulled and the device will be moved both physically and with the joystick in order to test the braking ability of the handbrake.
1.1.2.10. **Power Supply:**

The power supply for the power stander will be based on two 24 V lead-acid batteries, figure 14. Lead-acid batteries will be used due to their inexpensive nature, sufficient charge, and large size variety. The batteries will be the main supply of power to both the motor and the control circuit. In order to allow usage over time from the continuously draining battery, DC-DC converters, shown in figure 15, will be installed along with the batteries to provide the lower voltage required for both the control circuit and the motor functions. For the testing phase, the batteries will be tested for their recharge time as well as estimated life expectancy. As for the DC-DC converters, the voltage output will be measured in order to monitor the proper voltage is converted.

1.2.2.11. **Microcontroller/PIC:**

Figure 14: Lead-Acid Battery. Figure 15: DC-DC Converter.

Figure 16: Microcontroller.
The microcontroller is the key electrical component to the power stander. The microcontroller will receive inputs from the joystick and untimely be responsible for the overall speed and direction of the power stander. By use of a protoboard and LCD the code and working condition of the microcontroller can be tested and show the proper inputs are coded for.

1.2.2.12 Joystick:

Figure 17: Joystick.

Form: The joystick will be attached to the left arm rest of the power stander and will be taken from a scrapped power wheelchair. The joystick will be attached to the left arm rest due to the client being right hand dominate. By keeping the dominant hand free the world around her will be more accessible. The joystick will be the client’s main method of controlling the speed and direction of the stander. Testing will be done with the code of the microcontroller and the input of the joystick in order to eliminate any jerky motions as well as keep the inputs to reasonable speeds and turning radius.
1.2.2.13 Hoisting Bar Mechanism:

Figure 18: Linear Actuator.

The mechanism that moves the hoisting bar will be comprised of a linear actuator, shown in figure 18, and an electrical switch that will command the actuator to go forward or in reverse. The actuator will simultaneously bring the hoisting bar towards the client and lower the bar to match the client’s height in a wheelchair. Once the client is in the harness, the client will use the same electronic control located on the frame to lift the bar back and up, hoisting the client into the standing position and onto the foot pedals and leg pads of the standing device.
1.2.2.14 Kill switch:

![Kill Switch Image]

Figure 19: Kill Switch

The kill switch will be a physical switch that once removed will cease power towards the motor. With the kill switch removed the user will not be able to move the device with the use of the joystick. If the user wishes to remain in a location without the fear of bumping the joystick, the kill switch can be pulled. To test if the kill switch works, the switch will be physically removed and the system will be checked if power still is going to the motor.

2. Realistic Constraints

Constraints come with the engineering of any product, new or old. The fewer the constraints a product faces the more likely it will be a successful invention. The exercise machine faces several issues that cannot be overcome due to the constraints we face as a team. One of the largest constraints is our client’s condition, multiple sclerosis. This disease has rendered our client to have very little function in her lower extremities. The purpose of creating a customized exercise machine for Carolyn is to cater to her specific limitations. The design was primary made to function for the specific needs our client requires. The flexibility of the design is clearly limited by Carolyn’s physical condition and ability to actually use the device with ease.

Economically we are restricted to the budget that has not yet been allotted. We do not have an endless sum of capital so some parts may or may not ideally suit the design. Specifically we would like to use stainless steel in our design for the framework of the attachment. Stainless
steel is a high sturdy and reliable metal that will increase the products sustainability. It also comes in a glossy finish which is appealing to most customers. This being said it cost twice the amount aluminum cost which is also a metal in consideration for the framework of the attachment. According to metalsdepot.com a 1/8 x ½ 6061 Al flat panel is $4.50 and a 1/8 x ½ 304 stainless steel flat panel is $9.00. This is double the price for the same amount of metal. Potentially a combination of the two metals may need to be used based on the budget allotted by the sponsor.

Another Economic constraint includes being able to buy a prebuilt product, such as an EasyStand Evolv as seen in figure 7.

![Figure 20: EasyStand Evolv](image)

This product mimics the function we desire for a standing machine for our client. We would simply have to make a few changes to the existing design, mostly motorizing the standing mechanism, which would simplify the building process. The cost of this product is $2775 as a starting base with over 50 customization options. This is clearly out of our budget and is just not practical for Senior Design.

Our client lives in her mother homes in Shelton, CT. This being said she has expressed the need to keep her equipment as much “out of the way” as possible. She wants to be able to keep everything in her bedroom which is already filled with other medical devices like her wheelchair, walker, etc. This intern limits the size of the machines we plan on devising. The design needs to be compact enough to fit into her living quarters, but still be able to support the force they endure while the client is using them.
The sustainability of the product will be determined by the parts used to piece this exercise machine together. The Chattanooga deluxe pedal exerciser as seen on figure 8 was initially the pedal exerciser of choice because of its impeccable design and two year warranty. With this being said the cost was nearly $140 and weighed over 30 lbs so it wasn’t practical for our exercise machine design.

Figure 21: Chattanooga Deluxe Pedal Exerciser

The steel vs. aluminum issue is once again brought up. Aluminum is a light weight metal that is easily portable, but it not practical for long term use. Steel is a strong reliable metal and would be ideal for the framing of the attachment, but is a far more expensive than aluminum.

Safety is the largest issue when it comes to designing any sort of product for a client with disabilities. The entire design is based around the fact that the client will not be able to use a conventional exercise machine safely so a custom version will be built to fit her specific needs. The client must be able to mount and dismount from the exercise attachment easily without the slightest chance of injury. The rotating central apparatus will be slowed down considerably so injury is not an issue when the client decides to perform the second form of exercise associated with this attachment.

Socially we face one major problem, the distance the client is from our working quarters. The hour and fifteen minute drive cannot be made on a weekly basis so email communication is essential. We would like to visit her more often and get feedback, but it just isn’t practical.
3. Safety Issues

One of the most important features this device should feature is top notch safety for the user, Carolyn Martin. Due to Carolyn’s current condition she does not have much function from the hips down so she is very limited in her ability to move without a wheelchair. When she does attempt to walk, without the wheelchair, even with the support of a walker falling over is not out of the question. She need to be able to use our exercise designs without tiring herself out in some sort of transfer process, such as her current issue with her existing exercise bicycle.

Several safety issues were addressed with the exercise attachment. The idea of the attachment is to have it mounted to a certain wall in Carolyn’s home. She will then be able to navigate to this location, by the use of her wheelchair, and use the machine without the help of other. Mounting the machine securely is essential. Since she will be pedaling the framework will endure much stress and strain so the foundation that the attachment is secured to needs to stable.

Since Carolyn has very little leg function she will have to insert her feet into the pedals by the use of her arms. This may lead to difficulty and potential injury for the client if the pedals aren’t placed in an easy to reach position. The rotation mechanism to switch between exercises is also another cause for concern. The joystick sensitivity will need to be turned significantly down so the rotation is slow and steady for safety concerns.

Once again overall sturdiness of the frame will come into question. Steel is the ideal choice because of it strong properties. It is easily manipulated and can be shaped to nearly any shape. The problem of steel is the overall cost. Aluminum is the alternative choice for its readily availability and cheapness. The problem is the strength properties of aluminum aren’t on par with those of steel. Having a strong and sturdy framework for the attachment is essential for the safety of the user.

For the standing machine that will be customized for Carolyn some safety issue did arise. This machine will require the user to transfer from a wheelchair to the seat of the standing machine. The client has expressed her ability to be able to do this without much strain because the seat of the machine is fairly low. Regardless this is a safety issue that potentially needs to be addressed. When the thrust lunges the client upward the speed needs to be slow so a jerk or other paint doesn’t occur. Once again the joystick sensitivity needs to be tinkered. This is also the case for when the user wants to return to the sitting position.
The point of the standing machine is to secure the user by stabilizing both the knees and back so the user is in an erect standing position. For safety concerns the machine should not strain or overextend when stabilizing with the back or the knees. This mechanism will once again be controlled by the joystick which will be lowered for sensitivity for secured movement.

4. Impact of Engineering Solutions (Dual Exercise Machine)

4.1.1 Global:

The global impact of this design solution can apply to all physical therapy fields. By creating exercise equipment that is catered towards those with disabilities it is possible to further active approaches against degenerative diseases. Although physical therapy is not a cure, leading an active healthy life has shown signs of slowing disease as well as other physical benefits.

4.1.2 Economical:

It is hard to judge the device as a whole on the economic level. There aren’t any machines out on the market to compare the device too. Although the device cost slightly more than higher end leg peddlers and leg stretching devices. The overall product is affordable by almost all physical therapy clinics and is not a large strain for most families to purchase individually.

4.1.3 Environmental:

The environmental impact of this device is of small concern. The device is electric and its usage is minimal compared to other exercise machines. The device is not a large or heavy piece of exercise machinery, meaning shipping and handling efforts are reduced, reducing the carbon footprint of the vehicle required to move it. Disposing of the device also causes minimal environmental concern. Due to the frame being comprised of both steel and aluminum the scrap metal can be reused in the future. The devices’ power source is from an outlet as opposed to a battery, eliminating the hazardous removal required with batteries.
4.1.3 Social:

The social aspect of the solution is catered directly towards our client, Carolyn Martin. The device is a custom exercise equipment that is specialized to her needs. It allows minimal effort for her to use in her wheelchair, while allowing her to perform her required physical therapy as well as further her physical therapy with the addition to stretching. Carolyn wishes to be able to walk on her own power some day and she feels that her best route to that destination is through physical exercise.

4.2.1 Global:

Power standers are already on the market, but most power standers have the same physical design, to create a device to help an individual to stand and give them a workspace. The design built is catered to interacting with the world around the individual, not making a world for them to interact with. By minimizing the front of the device the user will be able to use and reach objects without obstruction.

4.2.2 Economical:

For an automated stander with an automatic lift, the price range starts at a 2,000 dollar minimum. Our finished design will cost no more than 1,000 dollars, and will contain all the functions of a top of the line model. For most owning a stander provides a much needed convenience and change from just a wheelchair, but the steep price range prevents most potential buyers from ever purchasing one. By providing a cheaper and comparable quality product, the device will affect the market as a more affordable stander is introduced.

4.2.3 Environmental:

The stander does not cause any immediate environmental concerns in both the building and using phases. The only major concern environmental wise is the disposal of the batteries. The batteries are lithium which is easier and safer to dispose of, but each battery contains its own environmental risks. The steel that the frame and base are made up of can be reused as scrap metal. As far as the electronics they leave a smaller carbon footprint than gasoline powered motors, but also need proper disposing action.
4.2.4 Social:

Socially, this device was created in order to improve the quality of life of our client. Carolyn has stressed how important cooking and using her kitchen is to her, but she is unable to use it while in a wheelchair. The stander will allow her free range of motion with her reach and access to all her kitchen appliances. Standing, even assisted, is a healthy passive form of exercise and will hopefully provide a healthier life for her.

5. Life Long Learning:

5.1 Mechanical:

Each project needed a strong supporting base in order to ensure the safety and functionality of the device. The bases were made of metal and it was an important skill learning how to join and weld different metals. Steel and aluminum require different skill levels, with aluminum not turning red hot before it melts. It was vital to have experience welding steel first before moving on to the more challenging aluminum. Despite just using strong metals, the bases for each project had to be built in a manner which dispersed the load, preventing any mechanical failures, specifically at the joining points.

Each device also contains a motor, it was important that each motor was correctly connected. One of the motors needed to be controlled by a microcontroller and a potentiometer in order to rotate the needed 180 degrees. The other motor needed to be safely secured and give the proper output to the gearbox and the wheels. This motor was also controlled by a joy stick, and it was essential the joystick was easy to use and void of all jerky motions.

Along with the electrical components and the machine shopping skills associated with the welding and cutting of metal, soldering is another important technique that was learned when dealing with the electrical components.

5.2 Social:

The entire design project brought forth many educational lessons with one of the most important experiences being the social aspect. The team needed to be able to cooperate and trust each other while constantly keeping communication open. The group members all had strengths
and weakness and in some instances in the projects were both members’ weak points. It was vital to work together to overcome the harder aspects of the project, specifically with the electronics, and to keep level heads.

The other social aspect that the project entailed was communicating with the bosses and the client. The client had to be kept up to date just like the bosses. No member could slack in responding to an email or updating the status of the project. Learning how bosses want results and concise work in order to quickly catch them up to speed with an idea is a skill that will carry over into the workforce. The design project showed that a boss that you represent demands quality work just like a client would. As for the client communication and understanding is essential. By learning as much about the client as possible and understanding their needs and wants, better devices can be made oriented to them. Especially dealing with clients with disabilities, by understanding their conditions better the greater understanding of the final goal can be understood.

5.3 Computer Software:

Computer Software was another essential in completing the designs. CAD designs as well as SolidWorks designs helped create a visual picture and a theoretical testing model. By using SolidWorks to help show how each component connected, the experimental success rate greatly increased, creating a theoretically perfect blue print. Also with the programming of the joystick and PIC the group was able to learn and utilize the MPLab software.
6. References

