Project(s) for Carolyn Martin: Final Report
Team 10: Nishant Patel and Eric Puffer

Project 14 – Sponsor Dr. Enderle
Client: Carolyn Martin, 1 Wheatfield Circle Shelton, CT
06484
Phone: 203-225-0123
Email: Carolyn8289@sbcglobal.net
Table of Contents

Abstract: 3

1. Introduction: 3-7
   1.1: Background
   1.2: Purpose of the Project
   1.3: Previous Work Done by Others
      1.3.1: Products
      1.3.2: Patent Search Results
   1.4: Map for Report:

2. Project Design: 7 - 29
   Project 1: 2-in-1 Exercise Machine: 7 - 17
      2.1.1: Introduction
      2.2.1: Optimal Design
         2.2.1.1: Objective
      2.2.1.2: Subunits
   Project 2: Mobile Stander – 2-in-1 Exercise Machine: 18 - 29
      2.1.2: Introduction
      2.2.2: Optimal Design – Mobile Stander
         2.2.1.2: Objective
         2.2.2.2: Subunits

3. Realistic Constraints: 29 – 30

4. Safety Issues: 30 - 31

5. Impact of Engineering Solution: 31 - 32

   6.1 Mechanical
   6.2 Social
   6.3 Computer Software

7. Budget & Timeline: 34 - 38
   7.1: Budget
   7.2: Timeline
8. Individual Contributions: 38 - 39
   8.1: Nishant Patel
   8.2: Eric Puffer

9. Conclusion: 40

10. References: 41

11. Acknowledgements: 42
Abstract

The project features two distinct products custom built to fit the client, Carolyn Martin’s, needs. Our client has Multiple Sclerosis (MS) which limits her mobility and has rendered her reliant on a power wheelchair for the last ten years. This disease has affected our client’s mobility more specifically she has lost most motion from her hips down. Carolyn has full brain function and has full strength on her upper body.

The first project is a 2-in-1 exercise machine that incorporates two distinct exercising mechanisms. The exercises are a pedaling system and a stretching mechanism each of which will help Carolyn in her rehabilitation endeavors. This machine is being built because Carolyn currently cannot exercise using her standard exercise bicycle. This is due to the fact that mounting and dismounting from the exercise bike is difficult due to her current condition. This custom built machine will allow Carolyn to remain comfortably seated in her wheelchair while still getting all the physical activity she desires.

Project number two is a mobile stander which involves the customization of a mechanical stander to become fully mobile. This involves equipping a stander frame with a joystick, microcontroller, motor(s), and battery mechanism to allow for full motion. The stander frame already features a hydraulic pump which the client will use to mount and dismount to and from the stander. This stander will allow our client to stand upright and navigate throughout her kitchen. Carolyn desires to cook and clean in her own kitchen, but she has a hard time doing so while confined to the dimensions of her power wheelchair. This stander will allow her to comfortably be erect and have full function of her upper body to do what she pleases.

1. Introduction

1.1: Background

Carolyn Martin is a 42 old woman who is currently diagnosed with Multiple Sclerosis (MS). Carolyn has been using the aid of a powered wheelchair for the past ten years. She is only able to walk very short distances with the help of an assisted device such as a walker. She lives with her mother in a home in Shelton, CT which has been slightly modified to be easily accessible to her.

Multiple Sclerosis (MS) is an inflammatory disease in which the fatty myelin sheaths around the axons of the brain and spinal cord are damaged. MS affects the ability of nerve cells in the brain and spinal cord to communicate with each other effectively. Studies show that MS usually occurs in young adults, and it is more common in women. Although much is known about the mechanisms involved in the disease process, the cause remains unknown. Theories of how MS occurs include genetic or infectious causes. There is no known cure for multiple sclerosis. Treatments attempt to return function after an attack, prevent new attacks, and prevent disability.
1.2: Purpose of the Project

Due to Carolyn’s Condition and her continual use of a powered wheel chair for the past ten years she has developed much atrophy in her legs. She has a great desire to reverse this condition and rehabilitate herself back to health. In order to solve this issue we suggested exercise for our client. She currently has a standard exercise bicycle which does not fit her needs. She has a difficult time mounting and dismounting from said exercise bike which is very discouraging and limits how much exercise our client gets. To solve this issue we decided to construct a custom exercise machine that our client will be able to use from the comfort of her own wheel chair. This machine will not only employ a pedaling exercise but also incorporate a stretching system that will only further help our client in her rehabilitation process. Rehabilitation is our client’s first priority so this project will help her achieve this goal.

A secondary desire our client expressed is being able to cook, clean, and reach items in her kitchen. Due to her current dimensions and constraints of her powered wheelchair Carolyn is unable to do much in the kitchen area. She is unable to reach things that are not on the edge of her countertop and using the stove is simply out of the question. Carolyn is able to use her walker to stand and get a better reach but this only allow hers to use one hand at a time which once again limits her. To solve this issue we proposed designing a mobile stander which will not only keep her in an erect position, but it will allow full use of both her hands. She will be able to move her powered wheelchair up to the stander fasten a harness around her midsection and hydraulically pump herself up in an erect position. Once upright and secure our client will be able to move the stander via joystick and navigate throughout her kitchen. With the use of this machine our client will be able to reach anything on her countertop, use the high cabinets without the help of others, and finally be able to cook for herself. Dismounting from the stander is as simple as holding the hydraulic pump up and it will slowly place her back in her power wheelchair. This system will make our client more independent which has been a one of her great desires.

1.3: Previous Work Done by Others

1.3.1: Products

The EasyStand Evolv (model # NG50084 Evolv Large) is a stander developed for adults with special needs. The stander accommodates users that are up to 82” and 350 lbs. The entire design was to make the sitting to standing transition as easy and pain free as possible. The image of the machine can be viewed on fig. 1.
To use this stander the user will have to manually transfer to the seat provided by the EasyStand Evolv. Once secure on the seat the user will place his/her feet in the footrests and make sure the knee stabilizers are properly adjusted. Using the hydraulic actuator, as mentioned on the website, the user will easily be able to pump his/her self to the upright position while maintaining support on the back and knees. The seat that the client was originally seated on doubles up as back support when the client is erect. This product is fully customizable with an additional fifty accessories that include features for further support to assist seat transfer.

One major optional configuration is also available. The Evolv Mobile feature changes the stander from a stationary stander to a manually mobile machine. It’s designed for people who can push a manual wheelchair because it allows the user to stand upright and self-propel the stander. This can be done by pushing set of wheels that resemble wheelchair wheels and that located directly to each side of the stander when in the erect position as seen on figure 2.

The mobile feature in the EasyStand Evolv (model#PNG50025) is controlled by highly efficient chain drives, and is controlled by the pace at which the user rotates the drive wheels. A braking system is also featured so stopping the stander will never be an issue. The Rifton Large Dynamic Stander is a mobile standing aid designed for use by children and adults with lower extremity disabilities as seen on figure 3.
Figure 3: Rifton Large Dynamic Stander
The stander comes with a contoured padded body support, straps, seat pad, and fleece, and contoured padded body support that can be adjusted to accommodate users. Its wide standing platform helps the user to spread his or her legs for hip development, or to accommodate leg braces. The platform is free of obstruction to facilitate placing the user in the stander. Lockable rear casters enable the stander's use outdoors on hard, level terrain. Additionally a mobile option is available that includes large drive wheels and a one hand pumps to navigate and move the stander.

The Theracycle 100 is an adaptive exercise bike built specifically for users who have lower body disabilities. It allows users in wheelchairs to exercise without mounting or dismounting as seen on fig. 4.

Figure 4: Theracycle 100
Unlike traditional leg exercise machines and other stationary exercise equipment, Theracycle 100 takes the strain off the user’s joints and muscles with motorized technology that assists you through the cycling motion so you can continue to move your legs. The structural steel frame, wide legs, and low center of gravity are ideal for users in wheelchairs. It features several different settings that will allow the user to exercise at their own pace. The only issue is that the dimensions of the actual machine are 25" W x 45" L x 37" H which may be too large for some customers.
1.3.2: Patent Search Results

Recumbent bicycle for disabled users has been patented by a Michael N. Mann. The bicycle includes a seat unit that is adjustable in both the horizontal and vertical directions. The recumbent bicycle features a pedal unit that has a motor for controlling both the time and rotational speed of the pedals. Straps are located both on the pedals to secure the user's feet and on the seat to secure the user's midsection. The pedals also feature a heel engaging ledge for further support. The overall system has a very low center of gravity so a disable user will be able to mount and dismount with assistance.

A mobile prone stander with positioning chair has been patented by a Talton C. Kendrick. The mobile inclinable stander with positioning chair includes a mobile frame and a body support frame mounted to the mobile frame for movement between upright and reclined orientations. Chest, waist, and knee supports are mounted to the body support frame. A removable seat is mounted to the body support frame below the waist support so that the waist support acts as a back and arm rest of a positioning chair for a user seated on the seat. The positioning chair is table to be tilted with the body support frame. The seat frame has two sides pivotally attached to each other to permit opposed clamp plates. The knee supports include a horizontal support post mounted to the body support frame and a pivot tube mounted over the support post. This stander is completely mechanical but as previously mentioned does feature mobility.

1.4: Map for Report:

The remainder of the report further describes each project in detail, focusing on major objectives and the subunits which are associated with each design. Each project has its own set of alternative designs and ultimately a final design. The report will thoroughly cover each alternative design as well as the reason and details of selecting the optimal design. After the technical aspects of each project, the report will outline constraints and solutions that are associated with each project. Finally the report will discuss the updated budget and a rigid timeline responsible for outlining the work needed to complete the project on time.

2. Project Design

Project 1: 2-in-1 Exercise Machine

2.1.1: Introduction

The design of the 2-in-1 exercise machine is divided up into three distinct mechanical sections: the base, the rotating plate, and the upper structure as seen on fig. 5.
The entire mechanical design will be constructed with aluminum rods and plates. Aluminum was chosen due to its light weight features, low cost, and good strength properties. The base consists of 14 distinct square pipes and all need to cut and welded to meet our Solid Works specifications. The rotating plate is made up of two distinct circular aluminum pieces. The outer disk serves as a mold for the inner disk which the piece that is actually doing the rotation. Also mounted to the bottom of the outer disk will be an engine box which will also be made of aluminum. The inner disk will be cut so that it fits within the outer disk with just enough room to rotate. Four circular holes will be created on the inner disk to fit the four aluminum pipes of the upper structure. The upper structure will be directly welded to the rotating plate so that it rotates with the system. This structure consists of four circular rods that extend vertically as seen on fig. 5. Mounts for each of the exercise attachments are also featured on the upper structure. Each mount will be located on opposite sides of each other and at different levels. The base, the rotating plate, and the upper structure will all be cut, according to our specifications, and welded together so that there are no moving parts in terms of the mechanical design of the exercise machine.

The rotation system will be achieved by the use of a stepper motor which is a brushless electric motor that can divide a full rotation into a large number of steps. This stepper motor, as seen on fig. 16, will come with a controller that will take inputs such as direction, number of steps, speed, torque, and acceleration. This control is easily programmed and will be set to meet the designs needs. With these properties assigned to the input, a push button will initiate the rotation of the system. Our system is such that it needs to rotate 180 degrees every time the push button is pressed. So each time the user presses the button the system rotates 180 degrees and a different exercise apparatus will be directly in front of the user.

The exercise attachments will be mounted to the upper structure of the exercise machine for ease of use. The pedal system will be attached to any one side of the upper structure. As can
be seen on fig. 5 the mount extends out towards the user with the peddler welded to the end of the extension. This is due to the design of the base which may intrude on the exercise if an extension is not present. The stretching mechanism will be located on the opposite side of the pedal system as depicted on fig. 5. To use the stretching exercise our user will place her feet into a set of footplates and pull on a set of rubber coated galvanized steel ropes which will be attached to the head of each plate. This will stretch the user’s calves and hamstrings in an effective manner. The attachment of the footplates will be such that they hang on to each side of the upper structure giving enough spacing for the user to stretch properly.

The optimal design is far more practical, cost effective, and useful that any of the alternative designs proposed in the next few sections. It features two distinct exercises, all in one system, and allows the clients to perform these exercises from her wheelchair. The two exercises are essential to our client’s rehabilitation process because they provide both physical and passive stimulation via the peddler and stretcher respectively. The rotation system will allow the user to remain stationary when she has the desire to perform the other form of exercise. This feature provides additional convince to the client. The mechanical design is ergonomic which is essential to our client due to her living situation. She already has many medical and exercise machines accumulated so saving space with this design is a priority.

**Alternative Design 1**

This alternative design requires splitting the machine into two distinct parts essentially creating two different standing structures for each exercise. The design structures would need to be very compact since they will be taking up more space being two separate entities instead of one machine. The lack of extra space in our client’s home will also come into play with the design of the two machines. Each mechanism will be mounted to the wall to save space because the rotation system will not be required in this particular design.

The pedal machine would involve using a simple peddler because the wall will not be able to support something as heavy as the Chattanooga Deluxe Pedal Exerciser, figure 7, which weighs upwards to 30 lbs. The Instride XL Peddler, fig. 6, would be a better fit due to ergonomic design and lightweight properties while still offering resistive pedaling.

A heavy duty chrome shelf bracket system can be used as the mounting structure for the pedal system. Two of these pieces, as seen on fig. 8, can be drilled on the wall in parallel to each other to make a sturdy structure. The hooks will be encompassing an additional steel rod that will go across the system. With this rod enclose by the hooks and welded for additional safety the
pedal system can be mounted to the rod. Some modifications need to be made to the attachment on fig 8.

Figure 8: Chrome shelf bracket
The support beam may need to be replaced with a thicker piece of steel due to the stress that it will face when the user is pedaling.

The same structure as mentioned prior will be created for the stretching mechanism. For the stretching exercise our client will require full foot plates to be installed. The plate will only be attached to the wall structure, fig. 8, from the back portion of the mounts, i.e. the portion corresponding to the heel of a human foot. The attachment type will allow the plates to have full motion radially. Our client will be able to place her feet in these mounts, use the pulleys attached to the front the mounts, and pull back. This will allow for stretching of the ankles, calves and hamstrings to the extent at which our client desires.

This design lacks the use of any electronics that can be seen in the other alternative designs. It is a very simple but an effective design that will help our client in her rehabilitation process. Space will be an issue as to where the systems can be mounted without being a hindrance. Also mounting can be a problem if the walls in our clients home aren’t strong enough to support the weight of the machines. Additionally our client lives with her mother who is doesn’t like the idea of having any permanent changes being made to her home.

Alternative Design 2
The second alternative design involves buying and modifying a recumbent exercise bicycle for our client Carolyn Martin. A recumbent bike provides all the benefit of a regular exercise bike but the design is built with a lower center of gravity as seen on fig 9 with the Schwinn 240.
Figure 9: Schwinn 240 Recumbent Exercise Bicycle

This will allow for the user to mount and dismount from the exercise bike with having to struggle climbing onto a traditional bike. The system features a padded ergonomic seat and dual-position lumbar support essential for users with disabilities. It features oversized stabilizers and levelers that are built-in for a stable workout platform.

The major modification that needs to be made involves changing the pedals themselves. The pedals are designed to be flat and the only support they feature is a flimsy strap going over the top of the user’s foot. This will not suffice for our client due to her current condition. The pedal itself will need to replaced will full foot plates where the client will be able to place her entire foot into. This plate will then have to be covered with a case so when the client places her foot on the plate it will be fully enclosed. This will ensure full safety for when out client wants to exercise.

The problem with this machine is that it’s too bulky. It will take up too much room in our client’s home which is a problem. The machine will also only allow the user to perform a single form of exercise. The peddler is a highly physical exercise that will surely help our client in her rehabilitation process. This being said it’s not the only form of exercise she needs. The benefits of passive exercise that involves different ways of stretching will not be achieved by using a recumbent bicycle. Finally, even with the Schwinn 240 low center of gravity design our client will have a tough time transferring to the machine. She will still have to get off her power wheelchair and manually transfer herself to the recumbent bike. We want to avoid this process at all cost because our client has expressed becoming very tired after this process.

**Alternative Design 3**

The final alternative design will be a single machine that is completely stationary. This will implement a pedal exercise system and a stretching exercise system on opposite ends of a single machine. Since the system is stationary the client will have to move from one side of the machine to the other if she wants to perform each of the exercises. This design will create a higher stability for the system because all the parts will be welded together leaving no moving parts.

The base will consist of 10 aluminum tubes that are strategically placed to ensure sturdiness, as observed on fig. 10.
Another four steel tubes will be vertically welded to the top of the base which will make up the portion of the machine. Four horizontal rods will be welded at the top of the vertical rods essentially make a rectangle on top of the base. These horizontal rods will be where the exercise mechanisms will be welded on.

The pedal system is connected to the base of the attachment where the primary exercise will be done. On the opposite side of the pedal system movable footplates will be implemented for a stretching mechanism. The plates will be pulled via a pulley system so Carolyn can stretch her calves without much resistance. The footplates will resemble the notion of ski bindings as seen in fig. 11.

This system allows our client to exercise from her wheelchair. The stationary aspect does mean our client will have to move to the opposite side of the machine when she want to perform another exercise, but her power wheelchair does allow for this action to be done.

2.2.1: Optimal Design – 2-in-1 Exercise Machine

2.2.1.1: Objective

The 2-in-1 exercise machine is a custom built device for our client Carolyn Martin. The exercise machine, as seen on fig. 5, is divided into three distinct mechanical parts known as the base, the rotation system, and the upper structure. Each of these parts plays a key role in
comprising the machine as a whole to ideally fit the needs of our client. The machine will serve as a platform for exercise that our client is not currently getting from any other source. The upper structure will host two forms of exercise which will be attached on its own body of work. These attachment points will be welded to the upper structure so that there are no moving parts.

The first attachment will be an exercise peddler the Instride XL Peddler, as seen on fig. 6, which will be modified to fit the upper structure. The pedals themselves provide very little support when the client is using the system. We will replace them with full foot pedals and a full encasing so that when our client places her feet on the plates she has full support when exercising. When mounting the modified peddler an extender piece that brings the peddler closer to the user needs to be installed, this can be viewed on fig. 5. The extender is so the user will not hit the base when exercising. The peddler itself will be welded to the extender for full functional use.

The second attachment will require the use of additional footplates and its attachments making up the stretching apparatus. This will be mounted directly on the opposite side of the foot peddler for spacing purposes. The head of the foot pedals will be attached with galvanized rubber coated steel ropes. The ends of the ropes, which are not attached to the foot pedals, will feature handles for pulling. The attachment of the footplates to the upper structure will be made at the bottom of each plate. The style of attachment will allow for the plates to rotate freely with some tension. When the client places her feet on the plates she will pull on each rope to cause her toes to rotate towards her thus stretching her legs. This exercise can be done at any stress level the client desires based on how far back the rope it pulled back.

The rotating plate system will be achieved via two aluminum plates and a stepper motor, as seen on fig. 16. With the outer plate encompassing the inner plate the rotation will only occur via the inner plate. This will rotate the upper structure which will be welded to the inner plate. A push button will initiate the rotation 180 degrees each and every time the user pushes the button. This will ensure one of the two exercise machine will be directly facing the client at all times.

The stepper motor will be set to rotate 180 degrees by setting the device to the correct number of steps. This can be done via the controller which takes inputs of speed, torque, number of steps, acceleration, and direction. Connecting the motor to the inner plate requires the use of a drive shaft. This piece will be in direct connection with the stepper motor and rotate the metal plate according to the control settings. A basic layout of this process can be seen in a flow chart on fig. 12.

[Diagram of flow chart]

Figure 12: basic flow chart for a stepper motor
2.2.2.1: Subunits

**Mechanical Base**

The base needs to be sturdy enough to support the full weight of the custom exercise machine for Carolyn Martin. Aluminum, specifically 6063 Aluminum Square Tubes, will be the material used to layout the foundation. All in all, as seen on fig. 13, fourteen distinct square aluminum tubes will be used to design the base. The tubes have a dimension of 1 in. x 1 in.

![Figure 13: Aluminum Base](image)

The bottom of the base, as seen on fig. 13, is constructed by laying down four square tubes in the shape of a square. Each of these tubes will be cut to a length of two feet to create a 2 x 2 foot square for bottom of the base. The pipes themselves will be cut and mitered to fit each other as one joint piece. Once cut and aligned the bottom of the base will be welded together.

Now that the bottom of the base is constructed we must construct up from this point. Another four square aluminum pipes, once again two feet in length, need to be cut and mitered. The four pipes will be welded to each of the four corners of the square base bottom in a vertical fashion. On top of these vertical pipes the exact same structure that was built for the base bottom will be placed at the top. This will enclose the system creating a cube like structure. Finally at the top of the base two horizontal pipes must be welded to the structure 6 inches from the edge of each side. This will leave a foot of space in between the two horizontal pipes. This finishes the mechanical design and construction of the 2-in-1 exercise machine base. Finally, anti-scratch pads will be placed on the bottom base so the floor does not get damaged when the machine is in use.

**Rotating Plate Structure**

Mechanically the rotation plate structure is made up of two aluminum plates with one encasing the other. The outer plate will act as a mold for the inner plate essentially holding the inner plate in position. The inner plate will rotate according to the desired setting input via the stepper motor. This system will allow the user to constantly have one of exercise mechanisms directly in front of her at all times.

The outer plate will also be made of aluminum more specifically 6061-T651 Aluminum. The circular structure itself will be cut from a 1 ft x 1 ft square metal plate that is .5 inches thick.
Once the plate is cut it will have a radius of 6 inches and we will keep the plate .5 inches thick. Once the plate is cut to these specifications it will still need to be modified. Another circular cut needs to be made on the outer plate. This cut will have a diameter of 10 inches and a thickness of .25 inches. Once this piece is cut the circle needs to be removed from the overall outer plate structure, as seen on fig. 14. This will intern create a mold like structure which will be used to house the inner plate. One more circle needs to be removed from the outer plate for the stepper motor to do its job. The circle will begin in the center of the outer plate and will have a diameter of four inches. Its thickness of the cut will be the thickness of the overall plate itself so a complete hole will be created by making this cut. Overall the outer plate has three distinct circular cuts that once again can be viewed on fig.14.

![Figure 14. Big Disk](image)

Also attached on the bottom of the outer disk will be a motor box, also made of aluminum, that will secure hold the stepper motor. This addition, as seen on figure 5 will be welded to the bottom of the outer disk.

The inner disk will also be made of 6061-T651 Aluminum but it will feature several distinct differences from the outer plate. The metal sheet used for the inner plate will one be of size 1 ft x 1 ft but the thickness will only be of .25 inches. The diameter of the circular inner plate will be 9.5 inches. This plate intern will directly fit with a small amount of wiggle room into the second cut made on the outer plate. Making the inner plate slightly smaller than the outer plate not only ensures it will fit into the molding of the outer plate but friction won’t stop the inner plate from rotating. The structure of this plate can be seen on fig. 15.

![Figure 15: inner disk](image)

With the inner disk plate placed within the outer disk rotation of the inner disk can be achieved via a stepper motor and a drive mechanism. With the final and smallest hole cut in the outer plate
and the stepper motor mounted within the motor box, a drive mechanism that links the motor to the inner plate to the motor needs to be implemented.

**Stepper Motor**

The device that will be performing the rotation will be a stepper motor. Several different models have been researched, but the Exitron SM60-86 stepper motor, as seen on fig. 16, best fits our needs.

![Stepper Motor Image](image)

*Figure 16: Exitron SM60-86 stepper motor*

This motor features a max speed of 6900 rpm and a torque of 380 in-oz which will be able to rotate a 70 lb structure which is more than enough for our design. The stepper motor will rotate the plate and upper structure system 180 degrees each and every time the push button is pressed. This can be done via the stepper motor control that comes with the design of the motor itself. The control can easily manipulate change of direction, number of steps, speed, acceleration, and torque. All the supplies for full motor control are provided with this design all we will need to do is provide a power supply.

Using the motor control feature we will set the rotational speed between 15-20 rpm as a safe speed to rotate between devices. The acceleration needs to be set to zero because we want the speed of rotation to remain constant. Since this design is a half-step system means each step is equivalent to 1.8 degrees the system must be set to 100 steps to achieve a 180 degree rotation each and every time.

**Upper Structure**

The upper structure of the 2-in-1 exercise is made up of four 6061 Aluminum Round Tube that are all 1 inch in diameter. Each of these four tubes will be cut to a length of 1.5 feet. The tubes themselves will be directly welded to the corresponding circular cuts made on the inner plate. This will intern create the vertical structure as seen on figure 5. With this mechanism set mounts for the exercise attachments need to be created. The tops of each of the four tubes will be capped off for safety and style purposes.

**Pedal and Stretching Mechanisms**

The most important aspect of this machine is the exercise mechanisms. The first exercise method requires the user to place 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 that requires the user to insert her feet in foot plates. Then the user will grab rubber
coated steel ropes, 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 and welded to the upper structure can be seen on fig. 6. The instride XL is a highly ergonomic and cost effective peddle system which also features built in resistance that can be changed via the built in display. Also the net weight of the product is only 9 lbs. which is ideal for mounting to the overall structure of the machine.

Looking back at the upper structure of the 2-in-1 exercise machine the peddler will be mounted 7 inches from the bottom of the upper structure. Before doing so, several changes have to be made, first of which will be to the upper structure itself. Due to the wide design of the base an extension off of the upper structure towards the user needs to be created in order to ensure the base doesn’t hinder the client when exercising. This extension will once again be made from the same aluminum square rods as used for the base structure. The rods will be cut and fitted around the upper structure in a square like manner as can be viewed on fig. 5. The extension will then be welded to the upper structure to ensure proper attachment. The extension itself will jut out towards the client 1 foot away from the upper structure.

With the extension built the only modifying that needs to be done is to the actual peddler itself, which involves changing the pedals themselves. The pedals are designed to be flat and the only support they feature is a flimsy strap going over the top the plate. This will not suffice for our client due to her current condition. The pedal will need to replaced will full foot plates where the client will be able to place her entire foot onto. The plates will then have to be covered with a case so when the client places her feet in the plates they will be fully enclosed. This will ensure full safety for when our client wants to exercise. With this crucial modification made the peddler can now be welded to the end of the extension finishing the installation of this particular attachment.

The stretching mechanism, as previously mentioned, will be located on the opposite end of the pedal system. This will allow for correct spacing between each of the exercise mechanisms. The attachment point of the stretcher will also be four inches from the top of the upper structure as to also create leveling between the exercise attachments.

The stretcher itself will be created out of footplates as seen in figure 17.

Two of these plates will be attached to each side of the upper structure so both feet can be stretched at the same time. To the top of the footplates an attachment point will be installed along with installing rubber coated galvanized steel ropes with handles. This will act as the pulling ropes the user will use to stretch her legs. For the foot plate corresponding to the left foot an attachment point hole will be drilled where the plate will be mounted to the upper structure. The exact opposite will be done for the right foot plate. On the upper structure itself we will attach a rotating attachment piece that will allow full rotation for the plates. The rotation itself will be
resistive so that the plates don’t flop when the user wants to stretch. With these plates attached she will insert her feet on these footplates and pull the rope towards her own body. This will stretch her calves and hamstrings and further help her in her rehabilitation process.

Project 2: Mobile Stander

2.1.2: Introduction

The second project being designed for Carolyn Martin is a mobile stander that will allow her to move freely around in a standing position. The design hinges on the modification of an immobile stander by transposing components of a powered wheelchair to make the stander fully mobile via joystick control. The design contains several subunits which will solve the three major objectives of the project. The first objective of the stander will be to lift Carolyn from her wheelchair and bring her from a sitting to erect position. The second objective is to have Carolyn be able to control the stander via joystick so she can move about her kitchen. The final objective was to have it so Carolyn will be able to reach her counter tops by limiting the distance of the stander being between Carolyn and her counters.

![Figure 18: Mobile Stander model](image)
The design shown in fig. 18 was selected for the optimal design because it best fit the time, monetary, and size constraints that accompany the project. Also the design completed each objective. By leaving the lifting mechanism as a hydraulic pump the design can overcome the project constraints. The hydraulic pump is smaller and already attached to the stander frame. By changing it with a linear actuator, a significant amount of changes would need to be made. A strong enough actuator would need to be purchased as well as a separate power source and microcontroller. The more attachments needed, the larger the frame would be which would exceed practicality when being used in the kitchen, and also it could exceed the standard 3 feet space for doorways. The hydraulic pump was tested and can support over 500 lbs of weight, far exceeding our client’s weight, and use of the pump is fairly easy and within the range of our client’s physical ability.

The stander cannot have a drive shaft, which prevents the use of a one armed drive; the wheels must turn the device by alternating spinning. The C program is very intensive time allotted to finish the project. Instead the controller and code will be taken from a powered wheelchair and the components of the wheelchair will carefully have to be transcribed to the stander. Several modifications will be needed to house the DC motors, batteries, and electronics. Also the wiring will need to be extended because it is going from a condensed wheelchair to a more spread out stander frame.

The necessary modifications will be added directly to the stander frame itself. By directly connecting the DC motors to the stander frame, space can be saved in terms of width of the final product. The base will need to be extended in order to serve as the mounting bracket for the motors. The extension will come in the form of welding and bolting steel to each side of the frame base and drilling holes in the steel for the screws of the motor’s mounting plate to be attached. A shelf will also be built to house the batteries and electronics; the shelf will be located in the front of the stander.

**Alternative Design 1:**

The design focuses on altering a currently immobile stander frame and making it fully mobile via joy stick and automating the lifting mechanism. Currently the frame cannot be moved by the user and must be pushed around in order for the user to move. The first objective of this design will be to bring mobility to the user via joy stick control. In order to achieve fully controlled mobility two DC motors, a power supply, wheels, a microcontroller and a joystick will need to be installed to the frame. Mounting brackets for the DC motors will be made of steel and will fasten to the side of the frame and directly attached to each of the powered wheels. The powered wheels and motors will be placed as far in front of the frame as possible in order to minimizing the torque forces of the standing client and the frame, minimizing the potential of the device tipping. The flow chart shown in fig. 19 outlines the line from the joystick to final movement of the device. A PWM motor controller and an H-bridge are needed in this design to make the motors move both forwards and backwards. The flow chart will serve as the basis for the C program that will be written in order to code the microcontroller to send proper outputs.
based on the joystick inputs.

![Microcontroller Flow Chart](image19.png)

**Figure 19: Microcontroller Flow Chart**

The second objective of the design is to change the hydraulic pump lifting mechanism with a linear actuator in order to automate the lifting process. The actuator purchased will have to be able to support the client and will need its own custom mounting bracket to fit in place of the hydraulic pump.

![Linear Actuator](image20.png)

**Figure 20: Linear Actuator**

The linear actuator, as seen in fig 20, will function by the use of a switch. The switch will require a microcontroller and will function very similar to the flow chart seen in fig 19. The H-bridge is required in order to reverse the actuator to be able to bring the client both up and down.

**Alternative Design 2**

This design deals with the customization of an already existing stander frame. Unlike alternative design one, as previously mentioned, this design makes the entire stander mechanical as opposed to electronic. The frame would utilize four wheels on each end of the base and would be linked together and controlled using a one armed drive. A one armed drive is a mechanical device which allows the user to move the stander by cranking the drive with one hand forward and backwards and turning by rotating the arm drive. In order for the drive to be in working order each wheel needs to be connected so the drive can control all wheels at once.
Figure 21: One Armed Drive Wheeldrive

The design will prevent the needed adaptation to the already mechanical design of the stander to make it electronic friendly. This design requires no electronics thus making the stander more compact in size.

The problem with the design lies in the fact that with a one armed drive there cannot be a lifting mechanism. The connection of each wheel, seen in fig 21, will block the passage for Carolyn to wheel her wheelchair up inside the stander. Without the lifting mechanism the design fails to be independent for Carolyn to get safely in and out of the stander.

Alternative Design 3:

The final design differs from the first two as it is an adaptation to a powered wheelchair. The change to the wheelchair will focus on having the seat bring a user from sitting to standing. The main components of the sitting to standing wheelchair are the linear actuators that will lift the seat to an upright position. In order to do this a powered wheelchair will need to be purchased and reconfigured to make from for the actuators. The actuators will work via button control and with the use of an 8 bit microcontroller and an H-bridge. The button will give the input to the microcontroller which the H-bridge will ultimately determine the polarity of the input changing whether the actuator goes up or down.
The second component of the sitting to standing wheelchair is the chair. The conventional chair will have to be removed from the wheelchair in order to put in a new chair. The new chair will have to be two separate pieces that are connected by a hinge in order to be able to bend from a chair to a straight line. The chair will also have its own actuator in order to complete the straightening process simultaneously as the seat is being raised so the client does not get hurt in the raising process.

The problem with this design compared to the optimal design is after the client is in the raised position she will remain immobile. Due to safety concerns standing wheelchairs lose their functionality to move via joystick control after they are fully raised. This because the balance of the wheelchair is completely altered and torques from a much greater height are being applied.

2.2.2: Optimal Design – Mobile Stander

2.2.1.2: Objective
The mobile stander is a customization of a pre-existing stander frame in order to give the user complete mobility via joystick. The design is catered towards Carolyn Martin and her desire to perform tasks in her kitchen. Currently Carolyn has difficulty doing anything in her kitchen due to the constraints from her powered wheelchair. The stander will hoist her out of her wheelchair and allow her to be able to move from station to station across her kitchen in order to use whatever appliance she wishes.

The design of the stander involves taking key components of a powered wheelchair and mounting them onto a stander frame. In order to properly mount the components, DC motors,
batteries, joystick, and microcontroller attachments and modifications need to be made to the stander frame. To mount the DC motors the base needs to be extended in order to match the width of the motor’s mounting plate. The extension will come in the form of welding and bolting steel to each side and drilling holes in the steel for the screws of the motor’s mounting plate to attach too. The motors will be directly under the frame, which will prevent widening the entire device as well as making it easier to conceal the motors to make the final device physically appealing. The other alteration will be to build a shelf which will be responsible for holding the electronics as well as the batteries.

The main component of the mobile stander is the full mobility control for the user by use of a joystick. By using the joystick and microcontrollers from the power wheelchair, the motors will function the same. The inputs affect how each wheel turns individually. Turning is made possible by alternating the direction each wheel spins.

The final component of the design is the lifting bar and mechanism that will lift Carolyn from her seat onto the stander. The lifting mechanism is a hydraulic pump that lifts a steel bar up. Attached to the steel bar is a harness which Carolyn will attach herself too. Once in the harness she will be able to crank the pump and be brought to a secured erect position.

2.2.2.2: Subunits

Base
The base shown in fig. 23 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 wheels being the larger powered wheels and the back wheels being caster wheels.

![Frame Attachment Site](image)

![Wheel Attachment Site](image)

![Back→Front](image)

Figure 23 Aerial View of the Base of the Stander.

The base is comprised of steel which provides needed weight and strength in order to support the constant load on the device. As previously mentioned the design resembles two horseshoes for further stability of the device, as well as minimizing the size of the machine to allow the largest range of motion. 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 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 the larger powered wheels are used on the front of the base for load bearing purposes along with a pair of caster wheels. The back of the base is furnished with caster wheels in order to maximize mobility and allowing for controlled and more precise movements.

The base also serves at the attachment site for the DC motors. The base will need to be widened in certain area by bolting more steel to either side. The widened area will have holes drilled through them and will be where the DC motors mounting brackets will fasten.

Frame

The frame, in fig. 24, of the design is the frame of an already existing immobile stander. The frame contains two major functional pieces. 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 body 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. The frame will also house a shelf which will hold the electronics and battery supply needed to use and run the stander.

The stander frame was stress tested in order to 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 was performed using Solidworks and the results gave back high coefficients of safety dealing with stresses heavier than Carolyn, showing the frame is safe for usage.
Foot Support

Figure 25: Foot Support Pedal.
The foot supports shown in fig. 25, 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.

Leg supports

Figure 26: Thigh Pad Leg Supports.
The leg supports are made of hard plastic and padded molds that are attached to the lower section of the frame, fig 26, 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.

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.
**Hoisting Bar**

The hoisting bar is a staggered bar made of steel, fig. 27, 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 underwent stress tests like the frame and resulted in similar safety results.

**Lifting Waist Harness**

The lifting harness is a nylon waist harness, shown in fig. 28, 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. The final harness purchased will be Carolyn’s decision, but the harness mentioned above will be the one recommended to her and recommended for the design.
Wheelchair Scrapping

The majority of the parts required for the mobile stander design will come from scrapping an older power wheelchair. The power wheelchair purchased from the NEAT market allows the project to remain under budget for the parts gathered. The parts including a microcontroller and code will be transferred to the stander frame to achieve fully controlled mobility.

Power Supply

The power supply for the power stander will be based on two 12 V lead-acid batteries, fig. 30. 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. Because the design requires taking the microcontroller from a powered wheelchair, changing the code to control the speed will not be possible. By limiting the voltage from the battery to the motors the amount of power will be limited, slowing the device down.
Microcontroller/PIC/Joystick

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. The 16 bit microcontroller along with motor controller will be taken from the powered wheel chair. The joystick will be attached to the right arm rest of the power stander and will be taken from a scrapped power wheelchair. The joystick will be attached to the right arm rest due to our client’s preference of being right hand dominate and desiring more precise control. The joystick will be the client’s main method of controlling the speed and direction of the stander. The turning function of the stander relies on the inputs from the joystick/microcontroller. Because the wheels are directly connected to the motors the stander will turn by opposite spinning. The motor controller along with the microcontroller will cause one wheel to spin backwards and one wheel to spin forwards which will allow for the stander to turn either left or right, depending on the joystick input.

Wheels

The wheels shown in figure 32 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, caster wheels, function is to be a guide and provide stability and
an increased range of movement. Caster wheels will be placed in the back and the very front, mimicking the wheel chair design, which will eliminate the chance for the stander to tip over.

**Hoisting Bar Mechanism**

Figure 33: Hydraulic Pump.

The mechanism that moves the hoisting bar will be comprised of a hydraulic pump shown in figure 33. The hydraulic pump is a hand controlled pump that is directly connected to the lifting bar. The pump is rated to lift over 500 lbs of force and is more than sufficient to fit the needs of our design and client.

3. 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. 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 which stands at 1000 dollars. We do not have an endless sum of capital so some parts preferred parts may not ideally suit the design. Specifically, Aluminum will be used in our design for the framework of the attachment. Aluminum 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.

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 being designed. 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 was not practical for our exercise machine design. Instead the design went with the instride XL peddler.

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 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.

4. Safety Issues

One of the most important features of each product will 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.

Several safety issues were addressed with the exercise machine. The machine will be stationary in her home in an easily assessable location for her wheelchair. She will then be able to navigate to this location, by the use of her wheelchair, and use the machine without the help of others. Ensuring that the machine is fully stationary and safe to use is essential. Since she will be pedaling the framework will need to endure a certain stress and strain, but after 3D testing the design has shown it can withstand the load.

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. She needs to be able to reach the push button, but also must not be able to accidently hit it during use of the machine.

Once again overall sturdiness of the frame will come into question. Aluminum is the ideal choice because of it strong and light properties and price compared to steel. It is easily manipulated and can be shaped to nearly any shape. Having a strong and sturdy framework for the attachment is essential for the safety of the user.

For the mobile stander that will be customized for Carolyn some safety issues did arise. The strength of the hydraulic pump as well as the harness needed to be determined. The harness is rated for over 1000 pounds of force, far exceeding the weight of our client. Also the hydraulic pump can lift over 500 pounds without significant effort. Due to Carolyn’s strong upper body and the ease of using the pump, lifting herself will not be a strenuous activity.

The other major safety issue associated with the mobile stander is tipping. By using four caster wheels and two larger wheelchair wheels the stability of the stander is assured. The power wheels will be placed as far forward on the stander as possible and will be accompanied with a set of caster wheels. This will limit the torque force from Carolyn reaching her cabinets while in the stander. The other set of caster wheels will be place in the back which will help with balance as well as increase range of motion.
5. Impact of Engineering Solutions

2-in-1 Exercise Machine

5.1.1 Global:
The global impact of the design 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 associated with exercise.

5.1.2 Economical:
It is hard to judge the device as a whole on the economic level. There are not 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.

5.1.3 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 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.

5.1.4 Social:
The social aspect of the solution is catered directly towards our client, Carolyn Martin. The device is custom equipment that is specialized to her needs. It allows minimal effort for her to use while 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.
Stander:

5.2.1 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. In the case of our client, Carolyn, she will be able to use her appliances throughout her kitchen.

5.2.2 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.

5.2.3 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.

5.2.4 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.

6. Life Long Learning:
6.1 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 disperses 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 is a stepper motor and needs to be controlled by a microcontroller in order to rotate the needed 180 degrees. Learning the proper steps to achieve a 180 degree rotation is needed. The other motor, stander motors, are controlled by a joy stick and will be used in a kitchen. It is important to limit the amount of power from the DC motors to keep the speed of the stander to a minimum. 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 earned when dealing with the electrical components.

6.2 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.

6.3 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.
7. Budget & Timeline

7.1: Budget

<table>
<thead>
<tr>
<th>Product</th>
<th>Cost ($)</th>
<th>Shipping ($)</th>
<th>Total Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stamina 15-0120 Instridy Cycle XL Pedal Exerciser</td>
<td>$40.00</td>
<td>Free</td>
<td>$40.00</td>
</tr>
<tr>
<td>10 ft Aluminum Square Tube 1.5 in</td>
<td>$35.70</td>
<td>$103.64</td>
<td>$243.78</td>
</tr>
<tr>
<td>10 ft Aluminum Square Tube 1 in</td>
<td>$21.90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>.25 inch Thick Aluminum Plate (1x1)</td>
<td>$22.45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>.5 inch Thick Aluminum plate (1x1)</td>
<td>$60.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stander frame</td>
<td>$250.00</td>
<td>Free</td>
<td>$250.00</td>
</tr>
<tr>
<td>Exitron SM60-86 stepper motor</td>
<td>$95.00</td>
<td>$14.95</td>
<td>$110.00</td>
</tr>
<tr>
<td>PA-02-10-200 Linear Actuator</td>
<td>$129</td>
<td>$9.99</td>
<td>$139.99</td>
</tr>
<tr>
<td>Miscellaneous ( ie. Anti-scratch pads, handles, microcontroller etc.)</td>
<td>$100</td>
<td>TBD</td>
<td>$100</td>
</tr>
<tr>
<td>Total</td>
<td>$754.55</td>
<td>$128.58</td>
<td>$883.13</td>
</tr>
</tbody>
</table>

Figure 34: Budget

The budget shown in fig. 34 represents the up to date spending on the two projects. As of now everything needed for the mobile stander has been purchased and some of the components for the exercise machine. The major purchase was the stander frame from the NEAT marketplace which cost 250 dollars, a quarter of our 1000 dollar budget. The rest of the mobile standers parts are going to come from a powered wheelchair. As far as the 2-in-1 exercise machine goes the attachments were ordered, but the two major components still need to be ordered, the aluminum and the stepper motor. The aluminum will be put on hold until after taking the machine shop class because Serge and Pete had mentioned they might have some scrap aluminum that can be used. The stepper motor needed calculations done to see if it was strong enough and once they are completed the part will be ordered. As far as the miscellaneous parts go they will be ordered as the project progresses in completion.
7.2: Timeline

The timeline shown in fig. 35, is organized by week. Each week each group member has their own individual and group tasks that need to be completed in order to complete both projects before the due date. Because of both members not taking the machine shop class in the fall, the first half of the timeline focuses on 3-D modeling with solidworks and working with any programming needed. Purchasing major components was another focus for the fall semester. Winter break and spring semester deal mostly with welding the exercise machine, programming the stepper motor, making mounting attachments to the stander frame, and stripping and testing the power wheelchair.

<table>
<thead>
<tr>
<th>Task Name</th>
<th>Duration</th>
<th>Start</th>
<th>Finish</th>
<th>Job</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model Stress Testing (Stander)</td>
<td>5 days</td>
<td>Wed 10/26/11</td>
<td>Tue 11/1/11</td>
<td>Eric</td>
</tr>
<tr>
<td>Create Human Model</td>
<td>5 days</td>
<td>Wed 10/26/11</td>
<td>Tue 11/1/11</td>
<td>Eric</td>
</tr>
<tr>
<td>Complete exercise machine model</td>
<td>5 days</td>
<td>Wed 10/26/11</td>
<td>Tue 11/1/11</td>
<td>Nishant</td>
</tr>
<tr>
<td>Model Stress Testing (Exercise Machine)</td>
<td>5 days</td>
<td>Wed 10/26/11</td>
<td>Tue 11/1/11</td>
<td>Nishant</td>
</tr>
<tr>
<td>Meet with Client to Discuss Optimal Design</td>
<td>5 days</td>
<td>Wed 10/26/11</td>
<td>Tue 11/1/11</td>
<td>Nishant &amp; Eric</td>
</tr>
<tr>
<td>Make Actuator on Solidworks (Stander)</td>
<td>5 days</td>
<td>Wed 11/2/11</td>
<td>Tue 11/8/11</td>
<td>Eric</td>
</tr>
<tr>
<td>Make Motor on Solidworks (Stander)</td>
<td>5 days</td>
<td>Wed 11/2/11</td>
<td>Tue 11/8/11</td>
<td>Nishant</td>
</tr>
<tr>
<td>Begin C program for microcontroller (exercise machine)</td>
<td>5 days</td>
<td>Wed 11/2/11</td>
<td>Tue 11/8/11</td>
<td>Nishant</td>
</tr>
<tr>
<td>Pick up order parts from NEAT Market</td>
<td>5 days</td>
<td>Wed 11/2/11</td>
<td>Tue 11/8/11</td>
<td>Nishant &amp; Eric</td>
</tr>
<tr>
<td>Begin C program for microcontroller (Stander)</td>
<td>5 days</td>
<td>Wed 11/2/11</td>
<td>Tue 11/8/11</td>
<td>Eric</td>
</tr>
<tr>
<td>Order 8 pin microchip to control wheels (Stander)</td>
<td>5 days</td>
<td>Wed 11/2/11</td>
<td>Tue 11/8/11</td>
<td>Eric</td>
</tr>
<tr>
<td>Order wire and plug (Exercise Machine)</td>
<td>5 days</td>
<td>Wed 11/2/11</td>
<td>Tue 11/8/11</td>
<td>Nishant &amp; Eric</td>
</tr>
<tr>
<td>Order wire for microcontrollers</td>
<td>5 days</td>
<td>Wed 11/2/11</td>
<td>Tue 11/8/11</td>
<td>Nishant &amp; Eric</td>
</tr>
<tr>
<td>Continue C program for microcontroller (Stander)</td>
<td>5 days</td>
<td>Wed 11/9/11</td>
<td>Tue 11/15/11</td>
<td>Eric</td>
</tr>
<tr>
<td>Continue C program for microcontroller (Exercise Machine)</td>
<td>5 days</td>
<td>Wed 11/9/11</td>
<td>Tue 11/15/11</td>
<td>Nishant</td>
</tr>
<tr>
<td>Order peddler &amp; foot plates</td>
<td>5 days</td>
<td>Wed 11/9/11</td>
<td>Tue 11/15/11</td>
<td>Nishant</td>
</tr>
<tr>
<td>Order nylon rope, push button and actuator switch</td>
<td>5 days</td>
<td>Wed 11/9/11</td>
<td>Tue 11/15/11</td>
<td>Eric</td>
</tr>
<tr>
<td>Order circuit boards for microchips</td>
<td>5 days</td>
<td>Wed 11/9/11</td>
<td>Tue 11/15/11</td>
<td>Eric</td>
</tr>
<tr>
<td>Finish C program for microcontroller (Exercise Machine)</td>
<td>5 days</td>
<td>Wed 11/16/11</td>
<td>Tue 11/22/11</td>
<td>Nishant</td>
</tr>
<tr>
<td>Continue C program for microcontroller (Stander)</td>
<td>5 days</td>
<td>Wed 11/16/11</td>
<td>Tue 11/22/11</td>
<td>Eric</td>
</tr>
<tr>
<td>Order aluminum rods and sheets (Exercise Machine)</td>
<td>5 days</td>
<td>Wed 11/16/11</td>
<td>Tue 11/22/11</td>
<td>Eric</td>
</tr>
<tr>
<td>Remove and add new wheels to frame</td>
<td>5 days</td>
<td>Wed 11/16/11</td>
<td>Tue 11/22/11</td>
<td>Eric</td>
</tr>
<tr>
<td>Task Description</td>
<td>Duration</td>
<td>Start Date</td>
<td>End Date</td>
<td>Assignee</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------------</td>
<td>----------</td>
<td>------------------</td>
<td>----------------</td>
<td>----------</td>
</tr>
<tr>
<td>Strip old wheelchair for parts (Stander)</td>
<td>5 days</td>
<td>Wed 11/16/11</td>
<td>Tue 11/22/11</td>
<td>Eric</td>
</tr>
<tr>
<td>Create stand for push button soldiworks(exercise machine)</td>
<td>5 days</td>
<td>Wed 11/16/11</td>
<td>Tue 11/22/11</td>
<td>Nishant</td>
</tr>
<tr>
<td>Convert C file for microcontroller (exercise machine)</td>
<td>5 days</td>
<td>Wed 11/16/11</td>
<td>Tue 11/22/11</td>
<td>Nishant</td>
</tr>
<tr>
<td>Continue C program for microcontroller (Stander)</td>
<td>5 days</td>
<td>Wed 11/23/11</td>
<td>Tue 11/29/11</td>
<td>Eric</td>
</tr>
<tr>
<td>Order 8-pin PIC microcontroller (exercise machine)</td>
<td>5 days</td>
<td>Wed 11/23/11</td>
<td>Tue 11/29/11</td>
<td>Nishant</td>
</tr>
<tr>
<td>Attach nylon rope to control foot pedals (Exercise Machine)</td>
<td>5 days</td>
<td>Wed 11/23/11</td>
<td>Tue 11/29/11</td>
<td>Nishant</td>
</tr>
<tr>
<td>Test stripped wheel chairs parts for feasability (Stander)</td>
<td>5 days</td>
<td>Wed 11/23/11</td>
<td>Tue 11/29/11</td>
<td>Eric</td>
</tr>
<tr>
<td>Finish C program for microcontroller (Stander)</td>
<td>5 days</td>
<td>Wed 11/30/11</td>
<td>Tue 12/6/11</td>
<td>Eric</td>
</tr>
<tr>
<td>Test push button with microcontroller (exercise machine)</td>
<td>5 days</td>
<td>Wed 11/30/11</td>
<td>Tue 12/6/11</td>
<td>Nishant</td>
</tr>
<tr>
<td>Modify leg peddler to fit exercise machine (Exercise Machine)</td>
<td>5 days</td>
<td>Wed 11/30/11</td>
<td>Tue 12/6/11</td>
<td>Nishant</td>
</tr>
<tr>
<td>Install push button, microcontroller, engine (exercise machine)</td>
<td>5 days</td>
<td>Wed 11/30/11</td>
<td>Tue 12/6/11</td>
<td>Nishant</td>
</tr>
<tr>
<td>Meet With Client to Discuss Progress</td>
<td>5 days</td>
<td>Wed 11/30/11</td>
<td>Tue 12/6/11</td>
<td>Nishant and Eric</td>
</tr>
<tr>
<td>Test Harness (Stander)</td>
<td>5 days</td>
<td>Wed 11/30/11</td>
<td>Tue 12/6/11</td>
<td>Eric</td>
</tr>
<tr>
<td>Install Power source (Exercise Machine)</td>
<td>5 days</td>
<td>Wed 11/30/11</td>
<td>Tue 12/6/11</td>
<td>Nishant</td>
</tr>
<tr>
<td>Convert C file for microcontroller (Stander)</td>
<td>5 days</td>
<td>Wed 12/7/11</td>
<td>Tue 12/13/11</td>
<td>Eric</td>
</tr>
<tr>
<td>Test Programs of completed product (exercise machine)</td>
<td>5 days</td>
<td>Wed 12/7/11</td>
<td>Tue 12/13/11</td>
<td>Nishant and Eric</td>
</tr>
<tr>
<td>Install harness (stander)</td>
<td>5 days</td>
<td>Wed 12/14/11</td>
<td>Tue 12/20/11</td>
<td>Eric</td>
</tr>
<tr>
<td>Order 8-bit PIC microcontroller (stander)</td>
<td>5 days</td>
<td>Wed 12/21/11</td>
<td>Tue 12/27/11</td>
<td>Eric</td>
</tr>
<tr>
<td>Test motion( stander)</td>
<td>5 days</td>
<td>Wed 12/21/11</td>
<td>Tue 12/27/11</td>
<td>Eric</td>
</tr>
<tr>
<td>Reinforce Stander with more padding</td>
<td>5 days</td>
<td>Wed 1/11/12</td>
<td>Tue 1/17/12</td>
<td>Eric</td>
</tr>
<tr>
<td>Make a joystick stand (Stander)</td>
<td>5 days</td>
<td>Wed 1/11/12</td>
<td>Tue 1/17/12</td>
<td>Eric</td>
</tr>
<tr>
<td>Cut &amp; Weld Rotating Plate (Exercise Machine)</td>
<td>5 days</td>
<td>Wed 1/18/12</td>
<td>Tue 1/24/12</td>
<td>Nishant</td>
</tr>
<tr>
<td>Create Push button apparatus (Exercise Machine)</td>
<td>5 days</td>
<td>Wed 1/18/12</td>
<td>Tue 1/24/12</td>
<td>Nishant</td>
</tr>
<tr>
<td>Install further support beams (Stander)</td>
<td>5 days</td>
<td>Wed 1/18/12</td>
<td>Tue 1/24/12</td>
<td>Eric</td>
</tr>
<tr>
<td>Install wheels (Stander)</td>
<td>5 days</td>
<td>Wed 1/18/12</td>
<td>Tue 1/24/12</td>
<td>Eric</td>
</tr>
<tr>
<td>Test C Program of completed product (Stander)</td>
<td>5 days</td>
<td>Wed 1/18/12</td>
<td>Tue 1/24/12</td>
<td>Eric</td>
</tr>
<tr>
<td>Task</td>
<td>Duration</td>
<td>Start Date</td>
<td>End Date</td>
<td>Assignee</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>----------</td>
<td>------------------</td>
<td>-----------------</td>
<td>----------</td>
</tr>
<tr>
<td>Cut and Weld Base (Exercise Machine)</td>
<td>5 days</td>
<td>Wed 1/25/12</td>
<td>Tue 1/31/12</td>
<td>Nishant</td>
</tr>
<tr>
<td>Create Motor box (Stander)</td>
<td>5 days</td>
<td>Wed 1/25/12</td>
<td>Tue 1/31/12</td>
<td>Eric</td>
</tr>
<tr>
<td>Create Motor box (Exercise Machine)</td>
<td>5 days</td>
<td>Wed 1/25/12</td>
<td>Tue 1/31/12</td>
<td>Nishant</td>
</tr>
<tr>
<td>Test rotation with just engine and rotation plate mechanism (exercise machine)</td>
<td>5 days</td>
<td>Wed 1/25/12</td>
<td>Tue 1/31/12</td>
<td>Nishant</td>
</tr>
<tr>
<td>Install joystick + motor + microcontroller (stander)</td>
<td>5 days</td>
<td>Wed 1/25/12</td>
<td>Tue 1/31/12</td>
<td>Eric</td>
</tr>
<tr>
<td>Install circuit board (Exercise Machine)</td>
<td>5 days</td>
<td>Wed 1/25/12</td>
<td>Tue 1/31/12</td>
<td>Nishant</td>
</tr>
<tr>
<td>Make bottom structure to support battery (Stander)</td>
<td>5 days</td>
<td>Wed 1/25/12</td>
<td>Tue 1/31/12</td>
<td>Eric</td>
</tr>
<tr>
<td>Weld Upper structure (Exercise Machine)</td>
<td>5 days</td>
<td>Wed 2/1/12</td>
<td>Tue 2/7/12</td>
<td>Nishant</td>
</tr>
<tr>
<td>Gearbox (Exercise Machine)</td>
<td>5 days</td>
<td>Wed 2/1/12</td>
<td>Tue 2/7/12</td>
<td>Nishant</td>
</tr>
<tr>
<td>Install circuit board (Stander)</td>
<td>5 days</td>
<td>Wed 2/1/12</td>
<td>Tue 2/7/12</td>
<td>Eric</td>
</tr>
<tr>
<td>Install battery (stander)</td>
<td>5 days</td>
<td>Wed 2/1/12</td>
<td>Tue 2/7/12</td>
<td>Eric</td>
</tr>
<tr>
<td>Test Joystick inputs with Microcontroller outputs (Stander)</td>
<td>5 days</td>
<td>Wed 2/8/12</td>
<td>Tue 2/14/12</td>
<td>Eric</td>
</tr>
<tr>
<td>Test rotation of exercise machine via pushbutton control</td>
<td>5 days</td>
<td>Wed 2/8/12</td>
<td>Tue 2/14/12</td>
<td>Nishant</td>
</tr>
<tr>
<td>Install mount for pedal + stretching mechanism</td>
<td>5 days</td>
<td>Wed 2/8/12</td>
<td>Tue 2/14/12</td>
<td>Nishant</td>
</tr>
<tr>
<td>Mount both exercise mechanism</td>
<td>5 days</td>
<td>Wed 2/8/12</td>
<td>Tue 2/14/12</td>
<td>Nishant</td>
</tr>
<tr>
<td>Test mounted exercise machine for stability</td>
<td>5 days</td>
<td>Wed 2/8/12</td>
<td>Tue 2/14/12</td>
<td>Nishant</td>
</tr>
<tr>
<td>Install Actuator on Frame (stander)</td>
<td>5 days</td>
<td>Wed 2/8/12</td>
<td>Tue 2/14/12</td>
<td>Eric</td>
</tr>
<tr>
<td>Mount Enginer Box (Stander)</td>
<td>5 days</td>
<td>Wed 2/8/12</td>
<td>Tue 2/14/12</td>
<td>Eric</td>
</tr>
<tr>
<td>Wire microchips, joystick, battery, motor (Stander)</td>
<td>5 days</td>
<td>Wed 2/8/12</td>
<td>Tue 2/14/12</td>
<td>Eric</td>
</tr>
<tr>
<td>Weld Base, Rotating plate, and Upper structure together (Exercise Machine)</td>
<td>5 days</td>
<td>Wed 2/15/12</td>
<td>Tue 2/21/12</td>
<td>Nishant</td>
</tr>
<tr>
<td>Weld foot pedals for stretching mechanism (Exercise Machine)</td>
<td>5 days</td>
<td>Wed 2/15/12</td>
<td>Tue 2/21/12</td>
<td>Nishant</td>
</tr>
<tr>
<td>Test rotation with both exercise machines welded to upper structure</td>
<td>5 days</td>
<td>Wed 2/15/12</td>
<td>Tue 2/21/12</td>
<td>Nishant</td>
</tr>
<tr>
<td>Reinforce stander with rear weight</td>
<td>5 days</td>
<td>Wed 2/15/12</td>
<td>Tue 2/21/12</td>
<td>Eric</td>
</tr>
<tr>
<td>Test installed Actuator and harness (Stander)</td>
<td>5 days</td>
<td>Wed 2/15/12</td>
<td>Tue 2/21/12</td>
<td>Eric</td>
</tr>
<tr>
<td>Install wheel mechanism (Stander)</td>
<td>5 days</td>
<td>Wed 2/15/12</td>
<td>Tue 2/21/12</td>
<td>Eric</td>
</tr>
<tr>
<td>Stress Testing welded base, rotating plate, upper structure (exercise machine)</td>
<td>5 days</td>
<td>Wed 2/22/12</td>
<td>Tue 2/28/12</td>
<td>Nishant</td>
</tr>
<tr>
<td>Install Safety rubber padding (exercise machine)</td>
<td>5 days</td>
<td>Wed 2/22/12</td>
<td>Tue 2/28/12</td>
<td>Nishant</td>
</tr>
<tr>
<td>Task Description</td>
<td>Duration</td>
<td>Start Date</td>
<td>End Date</td>
<td>Responsible Person</td>
</tr>
<tr>
<td>-------------------------------------------------------</td>
<td>----------</td>
<td>------------</td>
<td>------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>Fill cut holes with caps (exercise machine)</td>
<td>5 days</td>
<td>Wed 2/22/12</td>
<td>Tue 2/28/12</td>
<td>Nishant</td>
</tr>
<tr>
<td>Smooth out edges (exercise machine)</td>
<td>5 days</td>
<td>Wed 2/22/12</td>
<td>Tue 2/28/12</td>
<td>Nishant</td>
</tr>
<tr>
<td>Anti-rust spray the entire system (exercise machine)</td>
<td>5 days</td>
<td>Wed 2/22/12</td>
<td>Tue 2/28/12</td>
<td>Nishant</td>
</tr>
<tr>
<td>Create instruction manual (exercise machine)</td>
<td>5 days</td>
<td>Wed 2/22/12</td>
<td>Tue 2/28/12</td>
<td>Nishant</td>
</tr>
<tr>
<td>Create Instruction manual (stonder)</td>
<td>5 days</td>
<td>Wed 2/22/12</td>
<td>Tue 2/28/12</td>
<td>Eric</td>
</tr>
<tr>
<td>Make upper table smaller for wider range of motion (Stander)</td>
<td>5 days</td>
<td>Wed 2/22/12</td>
<td>Tue 2/28/12</td>
<td>Eric</td>
</tr>
<tr>
<td>Make foldable tray (Stander)</td>
<td>5 days</td>
<td>Wed 2/22/12</td>
<td>Tue 2/28/12</td>
<td>Eric</td>
</tr>
<tr>
<td>Test Stander by simulating exercising in a wheelchair substitute</td>
<td>5 days</td>
<td>Wed 2/29/12</td>
<td>Tue 3/6/12</td>
<td>Nishant</td>
</tr>
<tr>
<td>Stress Test Stretching Exercise</td>
<td>5 days</td>
<td>Wed 2/29/12</td>
<td>Tue 3/6/12</td>
<td>Nishant</td>
</tr>
<tr>
<td>Stress Test Pedal Exercise</td>
<td>5 days</td>
<td>Wed 2/29/12</td>
<td>Tue 3/6/12</td>
<td>Nishant</td>
</tr>
<tr>
<td>Stress test rotation system via button (exercise machine)</td>
<td>5 days</td>
<td>Wed 2/29/12</td>
<td>Tue 3/6/12</td>
<td>Nishant</td>
</tr>
<tr>
<td>Safety inspection (exercise machine)</td>
<td>5 days</td>
<td>Wed 2/29/12</td>
<td>Tue 3/6/12</td>
<td>Nishant</td>
</tr>
<tr>
<td>Safety Inspection (Stander)</td>
<td>5 days</td>
<td>Wed 2/29/12</td>
<td>Tue 3/6/12</td>
<td>Eric</td>
</tr>
<tr>
<td>Put pads on base ends (Stander)</td>
<td>5 days</td>
<td>Wed 2/29/12</td>
<td>Tue 3/6/12</td>
<td>Eric</td>
</tr>
<tr>
<td>Test actuator (Stander)</td>
<td>5 days</td>
<td>Wed 3/7/12</td>
<td>Tue 3/13/12</td>
<td>Eric</td>
</tr>
<tr>
<td>Weld folding table to stander</td>
<td>5 days</td>
<td>Wed 3/7/12</td>
<td>Tue 3/13/12</td>
<td>Eric</td>
</tr>
<tr>
<td>Make minor adjustments for clients size and condition (Stander)</td>
<td>5 days</td>
<td>Wed 3/7/12</td>
<td>Tue 3/13/12</td>
<td>Nishant and Eric</td>
</tr>
<tr>
<td>Make minor adjustments for clients size and condition (exercise machine)</td>
<td>5 days</td>
<td>Wed 3/7/12</td>
<td>Tue 3/13/12</td>
<td>Nishant and Eric</td>
</tr>
<tr>
<td>Meet with Client To Test Exercise Machine</td>
<td>5 days</td>
<td>Wed 3/14/12</td>
<td>Tue 3/20/12</td>
<td>Nishant &amp; Eric</td>
</tr>
<tr>
<td>Meet with Client to Test Stander</td>
<td>5 days</td>
<td>Wed 3/14/12</td>
<td>Tue 3/20/12</td>
<td>Nishant &amp; Eric</td>
</tr>
<tr>
<td>Pack Exercise Machine</td>
<td>5 days</td>
<td>Wed 3/21/12</td>
<td>Tue 3/27/12</td>
<td>Nishant</td>
</tr>
<tr>
<td>Pack Stander</td>
<td>5 days</td>
<td>Wed 3/21/12</td>
<td>Tue 3/27/12</td>
<td>Eric</td>
</tr>
<tr>
<td>Polish final product (Stander)</td>
<td>5 days</td>
<td>Wed 3/21/12</td>
<td>Tue 3/27/12</td>
<td>Nishant and Eric</td>
</tr>
<tr>
<td>Polish final product (exercise machine)</td>
<td>5 days</td>
<td>Wed 3/21/12</td>
<td>Tue 3/27/12</td>
<td>Nishant and Eric</td>
</tr>
<tr>
<td>Install machines in client's home</td>
<td>5 days</td>
<td>Wed 4/4/12</td>
<td>Tue 4/10/12</td>
<td>Nishant and Eric</td>
</tr>
</tbody>
</table>

Figure 35: Microsoft Project Timeline
8. Individual Contributions

8.1: Nishant Patel

I have been steadily working over this semester to make sure both of the projects have been going according to our Microsoft project plan. This plan assigned individual tasks to me and Eric which we have been following on a weekly basis. My major focus this semester was to designing a 3-D Solid Works model of the 2-in-1 exercise machine based on our specifications. I also focused heavily on materials needs and part ordering for the 2-in-1 exercise machine. Based on my own preference, our client’s opinion and the advice given to me I made detailed decisions on the layout of the machine. I have also been a key contributor to the design ideas behind the automatic stander which will be built using parts from a power wheelchair.

Solid Works was a brand new program for me so designing the model, at first, was highly challenging. I ended up working several weeks on the model but the final design is perfectly to scale of what the actual machine should be, as seen on figure 5. Stress testing on the model was done in order to prove it is a successful design and it managed to pass every single test. Sustainability testing was also done on the design giving many favorable results.

Deciding what material to make the mechanical design of the 2-in-1 exercise machine and choosing which parts to implement are part of my contribution to the overall project. Steel was my first metal of choice until my advisors diverted me away from the idea. Steel happens to a highly dense and heavy metal that would make my design unpractical. It also is highly expensive which would really hurt our budget. Aluminum seemed to be a viable replacement with its good strength characteristic and lightweight design. Also cost wise aluminum is far less expensive than steel. Welding the machine together seemed to be a potential issue seeing that aluminum will go from solid to liquid state rather quickly. Upon further research at the machine shop building we the shop featured an arc welder system which would help with welding the aluminum making it a viable option. Parts such as the XL instride peddler, figure 6, were chosen with my design in mind. Many other peddlers featuring built in resistance weighed upwards to 30 lbs. and cost upwards to $130. The XL instride peddler is light weight at 9.8 lbs. and cost significantly less.

8.2: Eric Puffer

Over the course of the semester the major focus was following the outline and tasks given on the Microsoft project outline. Following the budget and conferring with the other group member of specifics about the project was necessary in completing individual work. The main focus of the individual report was to handle the mobile stander, specifically with the Solidworks drawing. A majority of time was spent creating the stander as well a human model on Solidworks. The Solidworks design consisted of creating the stander frame, caster wheels, wheelchair wheels, DC motors, and an actuator. The Solidworks model of the projected final product was useful in both determining how the product was going to be built as well as testing to see if the additional weight and the clients weight will be supported.

After discussion with the other group member stripping a powered wheelchair and using the parts became the ideal method in completing the stander. In order to do so the stander frame and wheelchair had to be purchased and picked up from the NEAT market. After the wheelchair was purchased, measurements of the stander frame were taken and the wheelchair was brought
home. At home the wheelchair was stripped down to its key component parts and each part was tested to see if the motor, microcontroller, and joystick were in working order. While stripping the wheelchair for parts each part was labeled to make it easier to reassemble the electronics when placed back on the stander frame. The next step will be to begin work on the attachments to make sure the battery shelf can support the batteries and the mounting plates of the DC motors will be able to be mounted to the frame. Also the electronics need to be able to reach each motor and the joystick otherwise the wires will have to be spliced and wired longer to fit.

The other task given was to be responsible for the making and upkeep of the website via dreamweaver. The overall design and function was a task that involved learning on the go. Being new to website design and dreamweaver improvement on the website was made as more experience was gained with use of the program.

9. Conclusion

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 mobile 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 the client having to leave or move from her wheelchair. The design consists of three major components, the base, stepper motor/controller/push button system, and the upper structure. The base is comprised of a square aluminum base which is used to support the exercise apparatus and the motor. Aluminum square tubes 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 button a stepper motor and controller the plate will turn 100 steps to rotate the plate 180 degrees 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 mobile stander has the ability to hoist the client from her wheelchair via a harness and hydraulic pump onto the stander in a secured standing position. Once she has reached the standing position, the stander can be controlled via joystick. The joystick gives inputs to the microcontroller and is directly responsible for moving and directing the wheels. The joystick and controller will be transferred from a powered wheelchair and the speed will be changed by limiting voltage to the motors from the battery. By making the stander automatic, Carolyn will be able to navigate around her kitchen as she pleases. By turning the joystick left or right, one wheel will rotate forward while the other wheel will rotate in reverse, causing her to turn in the desired direction with a high turning radius. The stander frame and base are both made from steel to compensate for the high load and stress placed on the system. Unlike normal standers, the design allows a user to interact with the surroundings around them by minimizing the length of the structure in the front.
10. References


11. Acknowledgements

- Dr. Enderle – Our professor whom advised us with the overall project

- Marek Wartenberg – Our TA whom advised us with the overall project

- Don Hoerman – Works at the Neat Market Place and helped us pick out parts.

- Carolyn Martin – Our Client