BME 4910 Final Report

Treadmill Support System for Dominic Gondreau
&
Pool Lift for Zak Mahoney

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Abstract

Our first project involved designing and building a partial weight bearing system for Dominic Gondreau. The Gondreau family wants their son Dominic, who has Cerebral Palsy, to begin exercising on a treadmill on a regular basis. Due to his lack of mobility, Dominic will need a device to assist him in his workout. The project will fully support Dominic’s weight as he walks on a treadmill. It makes use of a track actuator, mounted to an 8020 aluminum frame, which will be attached to a harness system. The harness can be put on Dominic while he is in his wheelchair. In addition to the harness, a neck and back brace and will be worn to provide the client with adequate support while exercising. The actuator allows for Dominic to be lifted directly from his wheelchair, making the transfer from sitting to exercising as simple as possible. The amount of the client’s weight the device will support changes based on the position of the track actuator. A safety feature has been implemented on the actuator to automatically shut it down if the harness gets lowered to a point where Dominic is unable to support himself. Another unique feature of this design is that the frame is constructed in a way that allows for easy disassembly and storage. The frame sits on four casters, so that it can easily be wheeled directly over Dominic’s wheelchair to pick him up, and then be positioned over the treadmill.

The second project assigned to the team was to design a pool lift for Zak Mahoney. Zak also has Cerebral Palsy and enjoys swimming in the Mahoney’s above ground pool on a regular basis. However, as he has gotten older and continued to grow, his family has had trouble transferring him in and out of the pool. This project will do the work for the Mahoneys, with minimal effort needed on their part. A harness system has been incorporated in place of the original sling seat of the pool lift such that it can be put on Zak while he is still in his wheelchair, and be lifted directly out of it. The harness will make use of both neck and back supports since Zak has limited muscle control. The neck brace and back support will be separate from the harness so that they can be either worn or taken off by the client while in the pool, depending on necessity and comfort. The lift itself uses a hand crank to lift Zak out of his wheelchair and into the pool. It can also rotate a full 360°, providing easy maneuverability.

1 Introduction

1.1 Background

The first project assigned to the team requires designing a support system for a treadmill so that Dominic Gondreau, a child with Cerebral Palsy, may use it for exercise. Cerebral Palsy is a condition that effects nervous system functions and commonly leads to muscle weakness and possibly paralysis. Dominic is 7 years old, approximately 3 feet tall, and weighs about 40 pounds. He is unable to fully support himself, though he can stabilize himself on occasion (hold head upright, flex/tense arms, etc.)

The second project our design team was assigned involves building a pool lift for Zak Mahoney, a child who was born with Cerebral Palsy. This condition has affected Zak’s quality of life. The Mahoney’s recently purchased an above ground pool, and Zak has found great joy in swimming in the pool. Unfortunately, as Zak has grown, it has become increasingly difficult for his parents to assist him in getting in and out of the pool. Zak will continue to grow, and so a lift must be designed which can help support Zak as he enters and exits the pool.
1.2 Purpose of the projects

Dominic needs a means of exercise so that he can strengthen his muscles and remain physically active. This project will provide variable support and constant stabilization for Dominic as he exercises by walking on a treadmill. The harness system will must be flexible to maximize movement, but also rigid enough to stabilize him in the support system. Use of an existing neck and back brace will help to ensure Dominic’s head and body are fully supported as he exercises.

The purpose of the second project is to provide a means for Zak to swim in the Mahoney’s above ground pool as he continues to grow with age. The Mahoney family is planning on building a deck for their pool. Mounting the lift to the deck may be the best solution. The deck will be accessible to Zak by means of a ramp for his chair, and so the lift will still move him from the deck to the pool. Many existing pool lifts implement chairs in order to provide assistance in getting in and out of pools. A chair design would require Zak to move from his chair to the lift’s chair. A better design would allow Zak to put on the harness while he is still in his chair, eliminating the need for him to be assisted in getting into a lift chair. The majority of the lift modifications will be implementing this harness. He must be supported and stabilized while he is assisted in entering and exiting the pool. Moreover, creating a corrosion resistant harness will allow him to wear the harness while he is in the pool. This will eliminate the need for him to take off the harness when he is in the pool, and put it back on when he is finished swimming. An existing neck and back brace

1.3 Previous Work Done by Others

1.3.1 Products

There are products currently on the market that are very similar to the design the team has in mind. One product is called LiteGait® manufactured by a company called Mobility Research, while the other is named Lokomat® made by Hocoma. Both of these models implement a weight bearing mechanism, so that the user can be supported to different degrees depending on his current weight and/or leg strength. The latter product has a feedback mechanism built in such that it can synchronize the speed of the treadmill to match the speed of the patient’s leg movement.

Many assistive pool lifts have been designed to assist the disabled in entering and exiting pools. Moreover, many of these designs are similar to designs we came up with. The EZ Pool Lift Model: F-003EZPLNA, World Wide Seating Inc.’s Triton Pool Lift, and Hoyer’s Classic Pool Lift all have similar designs to the lift we plan to build. However, many patents for more advanced lifts also exist.

1.3.2 Patent Search Results

A patent was found for the device made by Mobility Research. Its patent number is 5,569,129 and it was issued on October 29, 1996 to Mobility Research L.L.C [1]. A patent was also found for the system by Hocoma. This patent was issued on November 23, 2004 with a number of 6,821,233 to Hocoma AG [2].

Keith Krumbeck holds Patent 5218727, issued June 15th, 1993, for a fully automated lift for above ground spas [3]. Krumbeck also holds Patent 6170612, issued January 9th, 2001, for a hydraulic pool lift which is more similar to our design [4].

1.4 Map for the rest of the report
Many topics concerning the two projects will be covered throughout the rest of the report. First, the original designs of the projects will be discussed, with the optimal designs following this. The optimal designs are the ones that will actually be implemented as a solution for the client. Next come the constraints faced with designing these devices, as provided by multiple aspects which should be taken into account. The safety features and considerations of the two projects follow the constraints. Then, the report will go into impacts that the projects had on us, as engineers. Finally, the budget and timeline for the projects will be discussed, as well as the contributions from each individual team member throughout the semester.

2 Project Designs

2.1 Background

Both projects must meet certain engineering, safety, and budget requirements in order to be applicable solutions to the problems presented in these projects. The following sub-sections describe design ideas which eventually led us to the optimal design solution selected for each project.

2.1.1 Modified Treadmill Design

A design which would allow the partial weight bearing system to be directly connected to the handle bars of the treadmill would be advantageous because the bill of materials would be minimized. Modifying the existing treadmill to include the weight bearing system eliminates the need for a separate weight bearing system, which saves money and space. Furthermore, electrical components from the partial weight bearing system could be directly integrated into the treadmill. It also allows Dominic to adjust the amount of support he requires and the quick release of the straps allows for other family members to use the treadmill as well. The motors powering the partial weight bearing system would sit on the handle bars of the treadmill. The straps from the harness would feed into the motor system from the harness which is suspended over the treadmill. Placing the straps at ninety degree angles off of the harness would ensure stability. Dominic can put on the harness while still in his wheelchair, and then attach the straps using quick release clips. This harness strap design is shown in Figure 1.

Figure 1: Direct bar strap design.
Therefore, this design will allow Dominic to easily adjust the amount of weight supported using the existing treadmill user interface. It is also more efficient in terms of use of space. However, the treadmill bars must be strong enough to support Dominic’s weight. Additional components may need to be purchased to further support the bars. Furthermore, this design would require multiple stepper motors. Stepper motors rated to support large loads can be quite expensive. These considerations are important in choosing an optimal design.

2.1.2 Collapsible, Rollaway Aluminum Frame

This design utilizes an aluminum frame to support Dominic while he uses the treadmill. The legs of the frame will be fully collapsible, so that the harness can be removed from the treadmill when Dominic is not using it. This design is non-invasive and it allows other family members to use the treadmill. Furthermore, it is easy to use and provides adjustable support, but it also eliminates the need for a ramp to push Dominic’s wheelchair onto the treadmill before he puts on the harness.

Figure 2 displays the harness floating in the middle of the support apparatus. The nylon harness will be suspended by two straps (not shown) which run up to two winches on the frame. The system sits on four, lockable wheels. Two will only provide linear motion while the final two will not have restricted degrees of freedom. The legs of the frame will be extended and locked into place with heavy duty pins capable of supporting Dominic’s full weight while the support system is in use. Next, the frame will be rolled over Dominic’s wheelchair. Once he has put on the harness, the tension in the straps can be adjusted to hoist him out of his wheelchair. The support system can then be rolled over the treadmill system. Once Dominic is finished using the treadmill, this process can be reversed to move Dominic back into his wheelchair.

2.1.3 Robotic Leg Orthosis

The third design option for the treadmill support system for Dominic Gondreau involves using robotic leg braces (a type of orthosis) in addition to a harness system. The harness system will be similar to one of the systems previously described, with slight modifications. First, the
harness would no longer require winches to adjust the weight support experienced by Dominic, as the orthosis mechanism will account for this. Once Dominic has put on one of the existing harnesses, he could put on the legs while suspended in the support system. The robotic legs would be connected to a unit that houses the power supply, motors, processing equipment, and other equipment necessary for proper execution of the orthosis. The orthosis would begin at hip level, and adjust for different heights. It would extend out to the center of each hip of the patient. From there, it would follow each leg down to the ankle. There would be one joint at the knee for flexion. Additionally, there would be two straps for each leg, one at the thigh and one at mid-calf level. The apparatus can be seen in Figure 3. These would ensure proper leg support is given, with the majority of the patient's weight being supported by the harness system. The robotic legs would guide the patient's legs in a gait motion to assist with exercise.

The orthosis would have active sensors in it that would feedback to the processing unit. Here, the system would be able to monitor the amount of assistance that should be supplied to the legs. For instance, as the client grows stronger and can use his legs more on his own, the orthosis will sense this and allow for more movement on Dominic's end. However, in the early stages of using the treadmill, it will be able to provide more locomotion assistance for Dominic.

This design is advantageous because it will assist Dominic in practicing proper gait while he walks. However, the orthosis design is very complicated and could prove to be too expensive. Furthermore, all components purchased would need to be very small and light weight in order to make the orthosis practical for Dominic.

2.1.4 Pool Lift Concrete Base:

For the alternate designs concerning the pool lift for Zak, three separate mounting systems were determined. The first consists of securing the pool lift to the ground via a cement base. A hole with the appropriate dimensions in accordance with Connecticut laws would be dug in the ground near the pool. A metal frame, as seen in Figure 4, would then be placed into the hole and filled with cement. The lift would then be placed inside the center cylinder protruding from the base and secured via screws. It could be removed from the base as needed and stored. This option will be difficult to implement, as the cement would require hiring a contractor, rather
than doing it ourselves. Furthermore, the expansion and contraction of the cement block with the change of seasons may damage the metal housing.

2.1.5 Pool Lift Deck Mount:
The second option involves mounting the pool lift directly to the pool deck. The mount would be securely fastened to the deck with large nuts and bolts in its four corners, as seen in Figure 5. The lift would then slide into the center pole of the mount, and be secured with screws. The deck mount would be set off to the side of the deck and be somewhat permanent, but the lift could be removed as needed, for times such as storage in the winter.

2.1.6 Mobile Pool Lift Base:
The third option is very similar to the one previously described, however instead of mounting to the pool deck, it will be on wheels and be mobile. With this design, a counterweight should be implemented to ensure the lift will not tip over when lifting the client. Also for more stability, the base will extend farther in the direction that the boom arm of the lift is located.
2.2 Optimal Design

2.2.1a Partial Weight Bearing System Objective

This design is a treadmill support system for children with Cerebral Palsy. Through using this device, the user is able to gain adequate exercise which may not be possible otherwise. Sufficient exercise is important to avoid additional health issues which may arise from inactivity. A support system such as this one will promote strengthening of the leg muscles and a level of activity which would not otherwise be possible. Additionally, the device provides a safe environment for the user to practice walking. The details regarding the design and implementation of this device are outlined in this report.

The device will incorporate an aluminum frame which can support the weight of the user and other mechanical and electrical parts. The frame will be constructed from 8020 Al-6105-T5 aluminum alloy beams with one and a half inch square cross sections. The frame will be square will three support beams running across the top, and two additional beams will be added to the sides for improved stability. The square frame will attach to two beams running parallel to the ground with four 8020 casters.

The support function of the support system will be accomplished by implementing a track linear actuator. The actuator will be fixed to the side of the frame and will be powered by plugging into a wall outlet. A wireless remote will be used to adjust the track actuator, providing variable support for Dominic as he uses the support system. A steel cable will be attached to the slide on the track actuator by means of a machined aluminum plate. The other end of the cable will be fed up through a pulley system before attaching to the support harness. The actuator track is 40 inches long, which will allow the weight support system to hoist Dominic directly out of his chair. Figure 7 summarizes the support frame design.
The support harness used will be a rock climbing harness. Dominic will pass one leg through each leg loop of the harness, and additional straps will pass over his shoulders and across his chest to secure him within the harness. The support system cable will attach to two hoops on the shoulder straps of the harness. The cables from the harness will then attach to a machined part which connects to the cable from the actuator. Important considerations for this harness system include neck and back support for Dominic, and a rock climbing harness by itself will not provide this. Therefore, a neck and back brace will need to be put on Dominic before the harness. Using a separate back and neck brace will not require modifications to the existing harness, which could prove difficult and possibly dangerous if something goes wrong. Furthermore, this design allows the braces to be easily cleaned separately from the harness.

Safety systems will need to be implemented to prevent injury to Dominic while he uses the treadmill support system. This will be accomplished by fixing a push button to the track actuator. If the slide moves down far enough to push the button, the button will immediately shut off the track actuator, preventing it from moving any further. This will prevent Dominic from being pulled too far up and into the pulley system.

The alternative designs heavily influenced the design of this support system. The direct attachment to existing treadmill handle bars was not appropriate for achieving the stability and support Dominic required. This design prompted us to design a safer and more stable system. The second design was more stable, but the variable support system using cable winches was too expensive, difficult to implement, and possibly unsafe. This led us to using a track actuator, which could easily be controlled by the wireless remote, and would provide safe and accurate weight support. Furthermore, the 8020 frame provided a much stronger and cheaper solution versus the welded frame. The final design of leg prosthetics was unrealistic. Use of leg braces in our current support system may provide Dominic with proper gait mechanisms, but the incorporation of a variable weight support system into the prosthetics will be far too difficult.
2.2.1b Pool Lift Objective

The optimal design for the pool lift will be one that mounts the pool lift directly to the wood deck. The deck mount would be set off to the side of the deck and be somewhat permanent, but the lift could be removed as needed, for times such as storage in the winter. The harness that will be used will provide as much support as possible for Dominic as he is being transferred in and out of the pool to ensure his safety.

This design was chosen over the other two for safety and price concerns. A mounting system on wheels could turn out to be quite dangerous for the client, as it could begin rolling as Dominic is using the device. On the other hand, creating a cement base in the ground for the pool lift would require hiring a contractor to come in and make the base for the team to ensure it was up to code with Connecticut laws. This would increase the cost exponentially and not be worth all the hassle.

2.2.2a Partial Weight Bearing System Sub-units

2.2.2a.1 Casters

The frame will use four wheels, or casters, in order to allow for mobility. This means that the frame will be able to move to Dominic, have him be strapped in to the harness, pick him up, and be wheeled back over the treadmill. Two different types of casters will be used on the frame, two that will swivel and two that will be rigid. All casters used are provided by 8020 and have a weight capacity of 280 pounds, meaning that four of them will be more than enough to support the whole mechanism and the client. The casters are all 4” in diameter, with a total height of 5.13”. The two rigid wheels will be placed under the two of the support legs at one end of the frame, and the other two support legs will be supported by the swivel casters. These will be able to rotate in a full 360 degrees in order to easily turn and maneuver the entire system. The swivel wheels include a total lock brake to prevent the frame from moving while in use. Only having brakes on the swivel casters is adequate for the design because the brakes prevent motion in one direction and the rigid casters prevent motion in the other. The following figure shows the two 8020 casters that will be used for the device.
2.2.2a.2 Frame

The frame will consist of three main components. These components are the two sides of the frame and the beams which attach the two sides together. As stated previously, the frame will sit on four casters to allow for easy mobility. All beams discussed are 8020 1515-LS aluminum beams. Figure 9 shows the 1515-LS cross sectional profile, and Figures 4 and 5 show respective close ups of the frame bottom and top.

![Figure 9: 1515-LS cross sectional profile.](image)

The two beams which run parallel to the ground and attach the casters to the vertical support legs are 6’ long beams. The casters will attach to 8020 fixation plates (part number 2426), which attach to the 6’ beam underneath the vertical support legs. The vertical support legs are also 6’ long, and they attach to the bottom beam one foot away from each end. The vertical support beams are attached to the legs by 8020 4-hole 90 degree corner brackets (part number 4301). The vertical support beams will be connected to one another on top by a 4’ beam. This beam will be fixed to the vertical support legs with 8020 squared tri corner connectors (part number 4442) and 90 degree inside corner connectors (part number 3364). Figure 10 below shows the frame bottom.
The two halves of the support frame are connected by three beams across the top and two more beams on the sides. One 39” beam attaches the halves at their centers by sitting on top of the two top beams of each half. It will be fixed to the two halves by 8020 3-hole 90 degree corner brackets (part number 4376). The other two top connector beams are 3’ in length and attach to the two frame halves with the squared tri corner connectors and additional 90 degree inside corner connectors. Figure 11 below shows the frame top.

The other two connector bars will attach the frame halves at the sides. These beams add rigidity to the structure. The first beam will appear at the front of the support system towards the bottom of the frame. This beam will be high enough to clear the treadmill track as the frame slides over the treadmill, but also low enough to allow the handle bars of the treadmill to pass
through the frame so they can be used by Dominic. The second bar will appear on the back of the frame just high enough so that it will clear Dominic’s wheelchair as he passes under it. Both beams will be attached to the vertical support legs by 90 degree inside corner connectors. Both beams are 3’ in length, and the frame is shown over a wheelchair and a treadmill in Figures 12 and 13 to help illustrate how the design will be implemented.

![Figure 12: Frame over a wheelchair.](image)

![Figure 13: Frame over the treadmill.](image)

The final component of the frame is an additional 4’ beam which will span the vertical support legs on one side of the frame. This beam is 4 feet above the parallel 6’ base beam which attaches the casters to the support legs. The purpose of this beam is to provide a fixation point for
the other end of the track actuator. It will be attached to the vertical support legs by two more 90 degree inside corner connectors.

2.2.2a.3 Weight Bearing System

The major component of the weight bearing system is the track actuator. The actuator being used is a Firgelli Automations FA-450-TR-24-40 track actuator. The actuator has a 40” stroke length, which is important because it allows the steel cable to be lowered far enough to attach to Dominic’s harness while he is still sitting in his chair. This means Dominic will not need to be moved out of his chair prior to using the weight bearing system. The actuator has a 24-36V input, but comes with a plug in power supply. This will provide an easy to use method of power because the support system can be plugged into the same outlet as the treadmill. The track actuator also features a low noise, light weight aluminum design. It has a maximum load capacity of 450 pounds, which is more than enough for this application. Also, this track actuator has a slide speed ranging from 0.14 - 0.39 inches per second. This is important because it is slow enough to allow for fine adjustments in the weight support being supplied. More importantly, this load speed is slow enough to be safe. A load speed which is too fast could hurt Dominic if a sudden hard pull is applied by the actuator. The figure below shows the FA-450-TR-24-40 track actuator.

![Figure 14: FA-450-TR-24-40 track actuator.](image)

Additional options for purchase with the track actuator provide convenience and safety for the device. First, a wireless remote instead of the wired controller will provide additional convenience for Dominic’s mother as she is assisting him in using the weight bearing system. The wireless remote will allow her to be with Dominic at any position around the treadmill as he exercises. Furthermore, the wireless controller allows her to ensure Dominic has been properly strapped into the harness as he is being hoisted out of his chair. Second, an RF safety stop button provides important additional safety measures to the track actuator design. The stop push button will be screwed into the track at an appropriate height. If the slide on the track moves too far down, and presses the button, the button will immediately shut off the actuator. This stop button will prevent Dominic from being pulled up into the pulley system, which could cause severe injury. The wireless remote and the safety stop button are shown in the figures below.
The track actuator will be held in the frame between one of the base beams and one of the support beams inside one half of the frame. This set up is shown in Figure 16. The actuator will attach by means of an existing fixation kit provided by the manufacturer. This fixation kit provides a plate to fix the motor end of the track actuator to the bottom beam support beam of one half of the frame. Additionally, it will give two L-shaped brackets which allow the track slide to be attached to the load it is moving. For this application, a plate will be machined and bolted to the L-shaped brackets. The plate will have a hoop extended from its center similar to the part used to attach the motor end of the track actuator to the frame bottom. A carabiner attached to a steel cable will attach to this hoop. Figure 17 below shows both the fixation plates and the entire actuator weight bearing system within the weight bearing system.
The steel cable will then feed up through a system of two pulleys and then to a metal bar that is attached to the cable immediately following the second pulley. The purpose of the bar is to create four points of attachment from the cable to the harness rather than one, preventing Dominic from falling forward or backward as well as left or right. The bar is made out of a 1"x1"x18" steel rod. At the center, a 1/2" hole is drilled through that is countersunk on both sides to allow for the carabiner to smoothly fit through. On each end, at 1/2" in, a notch is milled out that is about 3/4" deep. This is where two cables run to create the four points of attachment; the midpoints of the cables are put in the slots, allowing for both ends to be free to attach to the harness. In order to secure the cables in place in the slots, a bracket is used to cover them. The bracket screws in at 3" from the slot, and once securely tightened, it is more than sufficient to hold the cable in place and not allow for it to fall out. This bracket can be seen in Figure 18, while the entire bar system is shown in Figure 19.
2.2.2a.4 Harness System

The harness that will be used for this design will be a children’s rock climbing harness. The harness is shown in Figure 18 below. The harness will be used to suspend Dominic over the treadmill. Dominic’s mother can assist him in putting on the harness while he sits in his wheelchair. Once Dominic has put on the harness, it can be attached to the cable at the end of the adjustable weight system and hoisted out of his chair. This eliminates the need for Dominic to be standing to put on the harness and allows him to be easily placed back into his wheelchair following exercise.
To put on the harness, Dominic’s mother will first assist him in passing his legs through the loop holes towards the bottom of the harness. The harness can then be pulled up so that the loops sit snugly around his thighs. Next, the waist band portion of the harness can be wrapped around his waist and then securely tightened, as it fastens similar to how a typical belt operates. Then, the four ends of the cable that extend from the splitting bar at the top of the frame can be attached to the waist band via quick release clips. Two of these cables will attach to the front of the harness, where the white loop in Figure 20 is located, while the other two will be looped around the back of the waist band. Operation of the track actuator will hoist Dominic out of the chair and place him back in once he is finished exercising.

To account for the neck and back support that Dominic will need while exercising, a couple of braces will be implemented to be used in conjunction with the harness. The first brace will be one to support his neck. It is a pediatric cervical collar and can be seen in Figure 21. It is made out of soft density foam, is microban treated for antibacterial protection, and will keep Dominic's head in the neutral position while we uses the system. since it is made out of foam, it will be comfortable for him to wear while still providing adequate support. The second brace that will be used is a soft foam pediatric posture control brace for his back, as seen in Figure 22. This will promote proper posture while he uses the treadmill, keeping his shoulders back and his back straight. It has two removable aluminum stays that will provide additional support and can be shaped to the proper contour of Dominic's back. Both of these braces can be easily put on and taken off while Dominic is still in his wheelchair.
Constraints exist with regard to the harness system of the device. First and foremost, the harness should be able to support all of Dominic's weight, while providing a means to connect to the cable system. Second, it should provide Dominic with the proper amount of support for his neck, as he is unable to fully support and stabilize his head on his own. Third, the harness system will need to provide additional support for his back. The back brace will be used to account for this constraint. Dominic can put on the neck and back brace prior to donning the harness. Using an existing neck and back brace will not require modifications to be made to the harness which is purchased. This design also allows the braces to be cleaned easily separately from the harness.

2.2.2b Pool Lift Sub-units

2.2.2b.1 Base

The base being used for this design would be made of stainless steel to ensure it will support the load of the lift. It will feature a 12" by 12" plate, with 4 holes in it for 0.5" diameter nuts and bolts to secure it to the pool deck the Mahoney family will be building. Centered on
this plate will be a stainless steel pipe with an outer diameter of 4" and a wall thickness of 0.5". The cylinder will stand 8" tall. This will allow for the pool lift to both fit inside the base properly and be adequately supported. The base will be covered with a white epoxy powder coat finish to match the pool lift. The design of the base can be seen in Figure 23.

![Figure 23: Base of pool lift design.](image)

### 2.2.2b.2 Lift

The pool lift will be a pre-purchased part for this project, and as of now, will be the EZ Pool Lift made by Aqua Creek with an item number of F-03EZPL. It will feature a hydraulic lift system that allows the lift to support up to 400 pounds. It is made up of stainless steel protected against the environment with a white epoxy powder coat finish. The lift will be manually rotated and operated by the client's family. It will have an operating range of 53". Figure 24 shows the pool lift that will be used.
2.2.2b.3 Harness System

The pool lift system already comes with a mesh sling which can be used to move Zak in and out of the pool. Originally, the plan was to modify the harness system and use a harness similar to the one being used for the treadmill support system. However, after talking with the Mahoneys, they believe the existing mesh sling that the lift comes with will suffice. The sling is made of a synthetic fabric that is safe to go in the water. Differing from Figure 24 however, the sling that came with the lift uses fabric straps/loops to attach to the pool lift, rather than the chains shown. The sling to pool lift bar and its quick release clips are shown below in Figures 25 and 26.
2.3a Weight Support System Prototype

The idea of designing and building the weight support system is based around both the size of the client and its use with a treadmill. It is a completely independent system, separate from the treadmill, with its own power cord to supply power to the actuator. However, it must fit around the treadmill and suspend Dominic at the proper height for it to successfully work. The whole system that was developed can be seen in Figure 27 below.
The frame of the prototype that was constructed is made out of 8020, as described previously. It has four main support beams running vertical in its four corners. There are two crossbeams running lengthwise along the bottom of the frame, to which the casters are mounted to. There are two additional crossbeams running perpendicular to the bottom ones to provide additional structural support. One is placed at a height to just clear the treadmill base, which is approximately 18 inches. The other is at a height that allows for Dominic's wheelchair to pass underneath it, so that he can be easily attached to the cable system and then the wheelchair pulled back out.

The component that allows the system to lift Dominic out of his wheelchair and support his weight is the track actuator, which has a 40 inch stroke and can lift 450 pounds. This is mounted between one of the base crossbeams and another that runs parallel to it further up the frame. A part was machined to fasten to the actuator so that the wire cable could be attached to it. The cable has carabiners, or quick release clips, connected to each end of it. One end is hooked to the actuator, while the other is hooked to a machined bar to split the cable. Along the way up the frame, the cable passes through two pulleys to guide it to the middle of the frame. After the second pulley, the cable is attached to a steel bar. This machined bar has two slots on either end, in which two more cables are inserted in to. By putting the midpoint of each cable in the slot, four points of contact between the system and the harness are made, allowing for maximum stability. These two cables also have one carabiner at each end so that they can connect to the harness that Dominic will be wearing. This is shown in Figure 28. In the figure, the machined bar is circled in red, and the four separate points of attachment to the harness are clearly visible.
The system is relatively simple in its implementation and use. The device starts out pulled back from being over the treadmill. At this point, Dominic can put on the harness and braces with the help of a family member who will be assisting him during his exercise. Next, Dominic gets wheeled under the higher crossbeam and into the middle of the system. Then, the four cable ends that hang down from the top of the frame can be connected to the harness that Dominic is wearing. After this, the actuator can be controlled by the assistant to lift Dominic up and out of his wheelchair. When this is complete, the wheelchair can be pulled out of the frame and the frame can be rolled over the treadmill. It is important that the casters with brakes be locked so that the system cannot roll around during Dominic’s exercise. The assistant can then lower Dominic down onto the treadmill at this point. The amount he gets lowered is crucial to the effectiveness of the machine. The higher off the treadmill he is, the less support is provided by the system; however, if Dominic is too high off the treadmill, he won’t be able to reach it with his legs and thus not be able to exercise properly. On the other hand, the lower he goes, the more he will be required to support his own weight. If the assistant lowers him too much, he will be supporting his full weight. Depending on his motor control and fatigue, he might not be able to do this, meaning he could get injured by the moving belt of the treadmill.

It is also imperative that the assistant keep a close eye on the speed of the treadmill. The treadmill being used for this application is a Precor model 946, and it has speed increments of 0.1mph. This is a very important feature, as very fine adjustments should be used when finding
the proper speed to have Dominic exercise at. An additional safety feature is present with this specific treadmill; a red clip is attached the clothing of the person using the treadmill, and if the clip gets pulled too far (the person falls), the treadmill will automatically shut off. The main controls of the treadmill are located directly in front of the person using the treadmill, grouped together on a control panel. The entire treadmill is shown in Figure 29, while its control panel is shown in Figure 30.

Figure 29: Precor model 946 treadmill.

Figure 30: Control panel of the treadmill.
When Dominic has completed his exercise session, the person assisting him will turn off the treadmill and activate the actuator to lift him up off of the treadmill. Then, they will unlock the wheels and roll the system back away from the treadmill. The wheelchair can then be rolled back underneath the system and Dominic can be lowered back into it. When he is back in his wheelchair, the assistant can detach the cables from the harness and remove the braces that he will be wearing for the extra support, as well as the harness that he was wearing during exercise. At this point, Dominic will be completely detached from the system and can be wheeled out from underneath it and go about his day.

2.3b Pool Lift Prototype

The pool lift is basic in its design and is very easy to use. Zak will be able to bring his wheelchair right up next to the pool and lift on the deck that is being built. While still in his wheelchair, his family can put the mesh sling underneath him while it is detached from the lift. Then, he can be moved close enough to the lift so that the sling can be attached to it directly from his wheelchair. At this point, a family member can begin to lift him up by pumping the lift system, which is powered by hydraulics. When he is high enough out of his chair, the lift can then be rotated over the pool. By turning the knob to release the built up pressure of lifting Zak, the lift will slowly lower him down into the pool where a family member will be waiting to assist him in getting out of the sling. Once out, the sling can then be lifted back out of the pool so that it is out of the way while he and his family swim in the pool. Afterwards, the lift can be lowered back in to the pool and Zak can be helped back in to the sling. He can then be lifted out of the pool in the same manner he was lifted out of his wheelchair. Then, he can be rotated back over his wheelchair, the lift can be lowered down, and then the sling be taken off.

3a Partial Weight Bearing System Realistic Constraints

All engineering projects will contain specifications which constrain the design process. This project contains strict budget and safety constraints which have heavily influenced the final design. Additional constraints have been added upon speaking with the client. Practicality and common sense also have played a major role in the final design of this system. The constraints have been summarized below.

3a.1 Engineering Standards

Safety is a major concern when designing a product for any client. This project absolutely cannot fail in order to prevent the risk of injury to Dominic. As previously stated, the frame is constructed from high strength 8020 aluminum beams. These beams are very strong, and since Dominic is relatively light, the 1.5 inch cross sections will be more than sufficient to support his weight without failing. The track actuator has a maximum load of 450 pounds, which is again more than sufficient to bear Dominic’s weight. The quarter inch steel cable which will suspend him is also more than strong enough for this application. The same holds true for the harness, although a larger harness may need to be purchased as Dominic grows.

The 8020 frame is also very light and easy to assemble. This means that the frame will be easy to maneuver and move. Furthermore, it can be easily disassembled than a comparable welded frame. An 8020 frame allows the beams which provide rigidity passing over the treadmill bottom and Dominic’s treadmill to be height adjusted for a variety of treadmills. Furthermore, the bar under which Dominic’s wheelchair passes may need to be raised as he grows. Our design allows for this.
3a.2 Economic

Economic constraints play a large role in a product such as this one. There are multiple partial weight bearing gait training devices on the market for people who need assistance with walking. However, these products are very expensive, and only large physical therapy and rehabilitation clinics can afford to have these machines. Going to these places on a weekly basis for therapy can be quite costly. The hassle of having to travel to these clinics with multiple children only augments the problem.

In this project, the final goal is a product which provides all of the benefits of a professional partial weight bearing system at a fraction of the price. Furthermore, with our team designing the frame, the system will be specifically tailored to Dominic’s needs. This provides the client with a superior product for much less.

3a.3 Sustainability

Device sustainability is a very important constraint. While our design may be cheaper than commercially available models, the components of which it is comprised are not cheap. Failure of key components such as the track actuator would render the device useless, and replacement of such a component could prove difficult. However, sufficiently strong materials have been used in this design and the track actuator will be operating well under its maximum loading conditions. Therefore, as long as the electrical and mechanical components are well protected and cared for, the device should remain completely functional for a very long time.

3a.4 Manufacturability

The manufacturing of this device should be relatively simple. The use of 8020 aluminum components allows for the frame to be quickly snapped together. However, the fixation of non 8020 components, such as the track actuator, to the 8020 beams could prove to be difficult. These components must be fixed such that they do not compromise the strength and integrity of the 8020 beams.

Additionally, certain components, such as the cable to actuator fixation plate and the cable to harness fixation bar, will need to be manufactured in the machine shop. The frame was designed with the idea of minimizing the amount of machined components. This is because the replacement of such parts would prove to be very difficult since they are one of a kind. In order to avoid this problem, the components will need to be manufactured correctly the first time. Furthermore, designing these components with superior mechanical properties will ensure that they have a very long lifetime within the partial weight bearing system.

3a.5 Safety and Ethical

There are no real ethical concerns for a project such as this one. However, safety concerns are one of the greatest issues raised by this project. Again, significant concerns exist with regard to component failure. Additionally, safety measures must be implemented to prevent Dominic from being pulled up into the pulley system. This will be prevented with the implementation of the emergency shut off button as described previously. Safety concerns are further discussed in Section 3 of this report.
3a.6 Social

The partial weight bearing system must be designed to store easily and occupy a minimal space when it is in use. Dominic is fortunate to have multiple, loving siblings, and so a large device would further impede on a space which already may seem small at times. The folding treadmill which is being purchased will allow for the easy storage of the treadmill when it is not in use. Furthermore, the 8020 design allows for easier storage and portability of the partial weight bearing system itself. The Gondreau’s will not want to disassemble the frame after every exercise session Dominic completes, but should long term storage of the device be required, the 8020 frame will allow for this.

3b Pool Lift Realistic Constraints

3b.1 Engineering Standards

Engineering constraints include the choice of material which will be used to construct the base of the pool lift and the materials used to construct the harness. The base must be strong and stable enough to support Zak’s weight and the weight of the pool lift. Furthermore, the deck must be strong enough to support the pool lift. Use of a strong wood of appropriate dimensions should provide a safe surface to which the pool lift can be bolted. The sling is effective for most assistive pool lift applications, but Zak will require extra support and stabilization for this project to be safe.

3b.2 Economic

This project must remain within the budget. With the pool lift being purchased prefabricated, additional purchases should be kept to a minimum. Materials for the modifications to the harness can likely be harvested from the treadmill support system for Dominic. These materials would include extra nylon straps and rigid stabilization components.

3b.3 Sustainability

This project will be used by the Mahoney family for years. In order to maximize the life of the pool lift, it should be easy to remove from the deck during the winter months. Since the deck mount consists of a few bolts to the deck, unfastening the bolts should be simple enough for the lift to be removed during winter months. The use of stainless steel components and the epoxy coat finish will provide corrosion resistance to the lift, further maximizing its life time.

3b.4 Manufacturability

Since the pool lift is being purchased pre fabricated, there are not many manufacturing constraints to consider. Perhaps the most prominent is constraints of attaching the rigid components to stabilize Zak within the harness to the harness. If the mesh is not strong enough, these rigid parts could tear out of the sling. When the sling is obtained, the design team will have a better idea of how the rigid components can be attached, and then decide whether a modified sling or a new harness solution should be implemented.

3b.5 Safety and Ethical

Safety considerations have constrained the design to a fixed support system as opposed to a mobile base which was considered as an alternative design. Safety considerations will determine whether the sling can be modified to adequately stabilize Zak or if another harness
needs to be implemented. The design team will have a better idea of what modifications need to be made once the sling is obtained.

3b.6 Social
There are no social constraints of this pool lift. The social impact is on the Mahoney family, as now they have an opportunity to enjoy their pool with Zak even as he continues to grow larger.

3b.7 Environmental
The pool lift will be environmentally friendly once mounted to the deck. The epoxy powder coating during manufacturing has little environmental impact due to the low to zero carbon emissions during the process and its low toxicity.

4a Partial Weight Bearing System Safety
This partial weight bearing system needs to be safe for Dominic to use. Failure of the components of this system could result in significant injury to Dominic, and this must be prevented at all costs. Failures could occur in the mechanical or electrical components of this device.

The major mechanical failure which could occur in the partial weight bearing system is in the frame itself. If one of the beams breaks, this could compromise the integrity of the structure, and cause injury to Dominic or someone else who is near the device. However, failure of the frame is extremely unlikely. As previously stated, 8020 1515-LS aluminum beams were used to construct the frame. This material is more than enough to support Dominic’s weight, and the 1515-LS material is vibration proof, which will help to prevent any fatigue the beams may experience as the structure is continuously used. The frame has been designed to be very rigid and very stable. Bending and torques generated by a relatively non rigid structure would weaken the beams over time, and possibly lead to their failure. This frame has sufficient support beams within the design to prevent bending. Furthermore, the 6’ by 3’ base will keep the frame upright and prevent it from tipping over. Failure of the cable will not occur because the quarter inch steel cable which will be used is also more than strong enough to bear Dominic’s full weight. The pulleys purchased for this design will need to be able to bear Dominic’s full weight and properly secured to the 8020 frame.

Failure of the electrical components of this partial weight bearing system could be just as catastrophic as a mechanical failure. The linear track actuator could experience a mechanical or an electrical failure. The track actuator has a load capacity of 450 lbs, and so a mechanical failure within the component itself is unlikely. However, connection method between the linear track actuator and the 8020 frame is of particular concern. This design calls for the track actuator to be bolted to the frame using an existing mounting kit which comes with the track actuator, but the actuator will need to be mounted in a way which does not compromise the mechanical integrity of the 8020 beam. The actuator could also fail electrically.

The failure of the most concern is a failure in one of the wireless remotes or in the actuator which causes Dominic to continue to be raised even when the button on the remote is not being pressed. If Dominic is hoisted too high, he could be pulled into the pulley system, which could cause significant injury. Moreover, the actuator and cable may be strong enough to cause further damage to the frame. Damage to the frame could result in further failures and further injuries to Dominic. Obviously, this problem needs to be accounted for, and to do this,
the cable system was set up to stop at a maximum height before the metal bar gets pulled up into the pulleys. The inclusion of an emergency shut off button was incorporated to prevent the opposite from happening; Dominic getting lowered too far on to the treadmill. As previously described, the safety button will be screwed into the top of the track. The slide moves up as Dominic is hoisted down, and it will eventually approach the shut off button. The button is placed on the track at a point which corresponds to a height which is unsafe for Dominic. This height should be right after Dominic’s full weight is being supported by himself, because further lowering of the system is unnecessary after this point. The button placement on the track can be calibrated upon assembly at the Gondreau’s house. Once the button is pressed, a signal is sent to the actuator to shut off, preventing further motion in that direction. Other electrical concerns are found in the mounting of the power supply to the frame and the safe insulation and protection of all wires and components.

The harness is the final area of concern with regard to safety implementation. However, the rock climbing harness being purchased will be sufficient to support Dominic’s weight, and so failure of the harness is unlikely. As Dominic grows, a new larger harness with a greater weight capacity may need to be purchased. Additionally, the harness must secure Dominic such that he will not be injured by exercising. As previously stated, the inclusion of an existing neck and back brace will help stabilize him within the frame so that he is adequately, comfortably, and safely supported while he walks. Furthermore, whoever is assisting Dominic in his exercise process will be able to help him use the handle bars of the treadmill for greater support in addition to making necessary adjustments to the harness system for increased support and comfort.

4b Pool Lift Safety

The structural integrity of the lift is assumed to be safe, as it is a pre-existing product currently on the market. The lift itself is made of stainless steel, which will be more than adequate to support Zak’s full weight, and this is reflected in its rating to 400 lbs. The rock climbing harness which is being used here will need to be able to support Zak’s full weight as well. The harness being purchased is a children’s harness, and we will ensure it is rated to support Zak’s weight. As Zak gets older, a larger harness may need to be purchased to fit him and support his full weight. The base of the lift yields major safety concerns. If it is not strong enough, the whole lift could fail while in use. Additionally, if it is not secured in an appropriate fashion to the pool deck, it could detach while being used, and cause injury. By purchasing the existing deck mount which comes with the pool lift, we know that the base is compatible with the pool lift, and it will be able to support the lift with a 400 lb load at the end of it. The base features a 0.5” thick plate and cylinder, as well as the 4 0.5” diameter bolts used to secure the base to the deck. As long as the deck itself is constructed properly and is well maintained, the pool lift will be safe for Zak to use.

5a Partial Weight Bearing System Impact of Engineering Solutions

The design of a device which helps the disabled to exercise has a great impact on society. Similar devices have helped to rehabilitate many people who have been injured and have assisted many people born with disabilities in obtaining a more active lifestyle. The latter case is
especially important because it improves quality of life as well as the overall health of the patient. With regards to Dominic, our device will help him not only help him exercise and strengthen his muscles, but it will help him practice proper gait. This reinforcement of proper techniques is very important.

Similar devices are very expensive. If this device were to one day be marketed, it could have significant market impact due to its relatively cheap cost in comparison with analogous systems. Furthermore, our device can be designed to fit any treadmill and built to any height that may be required for a very tall person. The 8020 components can be machined to any length and therefore account for any specifications. Our design is also easily adjustable and simple to assemble and disassemble, which once again makes our device advantageous over equivalent systems. With the proper partnerships with companies like 8020 and Firgelli Automations, our device could have significant economic impacts.

The economic cost of our frame could result in a global impact as well. Clinics which may not be able to afford one of the current systems on the market could purchase our system and begin to heal local people through exercise which may not be otherwise possible. Furthermore, the engineering and design of devices like this brings more recognition to people with disabilities. Success of this product on a global market could lead to further innovations in physical therapy. It could also lead to greater donations to the organizations which help cure conditions like Cerebral Palsy due to the awareness it could generate. Therefore, this product, if properly marketed, could have significant impact on society at a number of different levels.

5b Pool Lift Impact of Engineering Solutions

The impact that this will have on the Mahoney family will be great. Zak has enjoyed the Mahoney’s above ground pool for the time they have had it. Swimming provides Zak with great happiness and a valuable means of exercise. This pool lift will allow Zak to enjoy this pool into the years to come as he continues grows larger. The Mahoney family will now get to enjoy the pool together, enjoying time together as a family while using the pool with Zak.

6a Partial Weight Bearing System Life Long Learning

There are a number of areas in which skills were or are being learned or improved upon by designing and creating this design.

Perhaps the most important skills which will be gained through the design and fabrication of this project are time management skills, group design skills, and engineering standards. Senior design presents us with an enormous, yearlong project of a scale and scope which we have never encountered before. Time management skills are crucial to the success of any engineering project. Moreover, they are vital to a successful career within the profession. Our team has a total of three projects which has resulted in a greater number of clients, meetings, and designs which all require attention. Our time will need to be planned effectively to accomplish all of our goals in a timely and effective manner. This skill will prove to be invaluable once we have graduated and are working as young professionals. Working in a team environment is another important skill we are learning through this design process. Finally, the design process itself is a valuable learning process which is teaching us to think critically and effectively. Therefore, the senior design process is providing us with the perfect simulation of industry by challenging us in these three skill areas.

Our group has already gained a great amount of technical skills so far in the development of this project. Perhaps one of the most basic, yet one of the most important, skills which we will
be learning is how to machine parts. By taking the machine shop course, we will have a much better idea of how to engineer safe and cost effective parts for use in our design. The fabrication and implementation of these parts in our frame will help to cement this skill. Furthermore, this project may call for the welding of components further along in the fabrication process. This is also a very valuable skill to have.

The manufacture and implementation of electrical components, which is especially important in biomedical engineering, is another skill which the senior design course reinforces. While our treadmill support system includes many pre-manufactured electrical components like the linear track actuator and the remote controls, our previous designs required the manufacture of our own circuits and components. The design of these circuits required the use of software like MultiSim and the research of many electrical components. Therefore, the design process alone helped us gain further knowledge in the engineering process with regards to electrical components.

The use of computer aided design has been quite extensive throughout this design process. Engineering applications like Solidworks, which is the CAD program we are using, are invaluable tools in the creation of functional engineering devices. The knowledge we have gained from the extensive use of Solidworks will aid us in the design of any devices we may create later in life.

6b Pool Lift Life Long Learning

This project will challenge the design team to utilize engineering principles to ensure the pool lift is adequately mounted and stabilized on the Mahoney’s pool deck. Furthermore, we will need to analyze the harness system extensively in order to maximize stability and comfort while Zak is using it.

7 Budget

7.1a Project for Dominic Budget
Partial Weight Bearing System:
- Actuator: $229.00
- Mounting Kit: $19.50
- Wireless Remote System: $65.00

Cable System:
- 3/16 x 25’ Wire Cable: $17.00
- Pulleys: $20.00
- Cable Accessories (Thimbles, Sleeves, etc.): $21.79

8020 Frame: $680.00

Harness:
- Rock climbing harness: $53.00
- Neck Brace: $15.00
- Back Brace: $50.00

Total: $1170.29

7.1b Project for Zak Budget
Lift Price with Base Mount: $846.00
Total: $846.00
8 Team Member Contributions to Project

8.1 Craig’s Contributions:
I did everything that was involved with the construction of the 8020 frame, including the selection of all of the components. This included contacting 8020 multiple times to figure out what components would be best for our project. I also looked into using a welded frame, but decided against it because it would not be as practical or as inexpensive as an 8020 frame. I made the original frame, and then redesigned it to be lighter and cheaper by replacing the 3030 and 3060 cross sections with 1515-LS cross sections. I contacted two local 8020 distributor and received a discount from one of them on our frame components. After all the parts came in, I realized we didn’t have enough hardware to properly assemble the frame, so I got back in touch with the distributor and ordered the appropriate parts. When everything necessary to assemble the frame was in, I spent a lot of time putting the frame together. I ended up having to thread some holes in the bars, making the process take much longer than anticipated. I also made all of the Solidworks drawings for this project and updated them as we changed our design.

I came up with the idea to use a linear actuator to pull Dominic out of his chair when we realized that a winch system would not be safe. I also built the old weight bearing system we were going to use in Solidworks. I also helped with the design of all of the weight bearing systems.

After getting certified over winter break to use the machine shop, I did a substantial amount of work machining parts that were needed for the support system to work successfully. Some of these parts include a piece that was bolted to the actuator allowing for the cable system to be connected to it, mounting plates so that the actuator could be properly connected to the frame, sleeves that the pulleys were mounted to which went around the top of the frame, and a metal bar to split the single cable into two separate cables with four points of attachment for the harness.

I worked with Nick to find the proper pulleys to use in the support system. I traveled to local hardware stores with him and we inquired there about their thoughts on what pulleys to use and how to mount them properly. In the end, the stores didn’t have what we needed so I found some online and ordered them.

I was the main contact between the group and our clients throughout the project. I sent the clients the grade sheets and asked them other questions regarding the design and what they wanted. After hearing back from Christiana concerning how tall the room was where the support system will go, we determined our initial frame design was too tall. I worked with Kyle to modify the frame and shorten it by about six inches. I also shortened the bottom crossbeams where the casters are connected by a foot in total, to reduce overhang and ultimately increase the safety of the system for anyone walking around it.

In trying to find ways to reduce our budget, I came across a refurbished version of the pool lift we were looking into purchasing. I ended up ordering this for our project, saving us a large amount of money. When the pool lift came in, I assembled it with Kyle and we did some initial testing of it, using it to lift him.

I wrote the optimal design report for the project for Dominic. I helped create the PowerPoint presentation for our final presentation, and I helped in writing all of the other reports. I was also responsible for writing the owner’s manual for BME 4910.
**8.2 Kyle’s Contributions:**

In the initial stages of the partial weight bearing system project, I researched products similar to the client’s needs that were already on the market in order to get some ideas. For the initial optimal design, I looked into how the actual weight support system of the device would work, and came up with the idea to use a linear actuator and load cell system. I also found a harness to use from a company called Biodex, but upon receiving a quote from them, determined it was way out of our budget.

With all the patent research I had been doing, I was very helpful in completely changing the design of our project. With the idea of using a winch to support and lift Dominic, I helped Nick in designing a system of pulleys to slow the cable speed. I also came up with the method to measure the tension in the cable, which correlates to the weight of Dominic, using a Wheatstone bridge circuit with strain gages and a lever system at the top of the device. I was able to find a microcontroller/touch-screen display kit that was going to be used to automatically adjust the amount of weight supported by the system with some inputs, but that idea was never implemented.

For the final design, I looked into the idea of using a stepper motor to support Dominic's weight, but could not come up with anything viable. After being told that we would use a linear actuator for this, I was able to find the track actuator that we will use.

For the pool lift project, I found a pool lift online already tailored to the client’s needs for a price within our allotted budget. After the pool lift came in, I assembled it with Craig and we did some initial testing of it, using it to lift me.

I did a lot of work dealing with the harness and braces to use in our design. I did a ton of research on this matter and contacted the Gondreau family with what I thought were the best options. Christiana got back to me about this and had a slight modification to the harness choice, which we ended up using. I also did a lot with the cable system. I found a distributor online that supplied weight lifting accessories, specifically cable and cable hardware used in weight lifting machines, which worked perfectly for our application.

I spent a lot of time in the machine shop this past semester after getting certified over the winter break to fabricate parts used in the design. Some of these parts include mounting plates for the actuator to mount it to the 8020 frame and a piece for the actuator so that the wire cable could be attached to it. I also spent time modifying the 8020 frame by shortening it after we learned it was too large for the basement of the Gondreau's house, which is where it will be used.

Throughout the project design and construction, I was responsible for making a project timeline and updating it on a weekly basis based on what we had accomplished and where we were at. Additionally, I was responsible for updating and editing our final report used for BME 4900 with new sections and design ideas to be used as the final report for BME 4910. When we encountered a problem with being over budget, I wrote a new budget proposal and submitted it to Dr. Peterson for approval.

**8.3 Nick’s Contributions:**

The first thing I did on this project is get in contact with the clients, along with my group members, to get a better understanding of what the client wants. From there, I began brainstorming different ideas to solve the problem posed by the client. To create our first optimal design I aided the group by coming up with some important dimensions to ensure the design would fit together the properly. This allowed Craig to make an accurate SolidWorks design. I
also spent time researching linear actuators and load cells which were important aspects to the first optimal design. However, after reanalyzing the first optimal design, we decided it had many flaws and had to be redone.

I had a hand in designing the new optimal design, which is the design we are going to end up building. Again, I helped decide on important dimensions that allowed for the treadmill to slide under our frame, but still have the stability to support Dominic. I also researched about parts that could accompany this design. For a few weeks I was looking into different devices for the lifting mechanisms. I thought of different configurations of pulleys and linear actuators or winches to ensure Dominic could be lifted slowly and safely. I called multiple manufacturers to learn about different options in terms of winches and actuators. I have also researched different methods for harnesses that our optimal design will utilize.

I did a lot of work in obtaining a treadmill for our project. I inquired about a possible donation from the UConn Rec Center, and they told me get in touch with a man named Peter Lamagna from New England Fitness Distributors. I contacted him and stayed in touch throughout the second semester, and in the end, he was able to donate a treadmill to the School of Engineering for us to use with our weight bearing system project.

I did some research on pulleys to use for our support system design. I traveled to different hardware stores and asked the employees there their opinion on the matter. This led to me looking for the proper pulley online and ordering it there.

I was responsible for creating the final presentation for BME 4910, as well as designing the poster for our project.

I created the website and keep it updated in addition to the work I have done in creating the optimal design. I am responsible for uploading all of the up to date reports and power points to the website in time for meetings and presentations.

9 Conclusion

Our design team was presented with two different clients, each with a problem that they were seeking a solution to. The first client, Christiana Gondreau, has a son, Dominic, with Cerebral Palsy. Due to his lack of mobility, they want a way to provide him with exercise on a daily basis, namely, a device that will support him while he walks on a treadmill. To do this, we will be constructing a frame out of 8020 that can sit over a treadmill that will be purchased for the client. The frame will be set on four casters, with brakes, allowing it to be either mobile or stationary. Mounted on the side of the frame will be a linear track actuator, which will provide the power for the system. The track actuator will be powered by plugging it in to the wall, and will be controlled with a remote. Attached to the actuator will be a cable that runs up the side of the frame, to the top center, and then hangs down in the middle of the frame. Attached to the end of the cable will be a harness, much like that which rock climbers use. It will hook over both shoulders and around both legs. This will allow for it to be easily taken on and off while Dominic is still in his wheelchair. A neck and back brace will also be implemented to provide adequate support and safety while exercising. A safety feature will be added to the actuator such that it will not be able to pull Dominic up into the frame, and instead will shut down if the cable reaches a dangerous height. Dominic’s wheelchair will roll under the frame, where he will put the harness on, and then the actuator will pick him up out of his wheelchair. At this point, the frame can then be rolled over the treadmill, and Dominic can be lowered to the appropriate height to begin exercising.
The second client, the Mahoney family, also has a son with Cerebral Palsy, Zak. Zak really enjoys swimming in the summer and currently gets in and out of the pool with the help of his brother and dad. However, as Zak grows, this task becomes more difficult for them to do on their own. To solve this, a pool lift will be implemented on the deck of their pool. This pool lift will be purchased from Aqua Creek, called the EZ Pool Lift. An optional base will also be purchased with the lift that is made for wood decks. However, the design team will implement a harness system to simplify the transfer from the wheelchair to the pool. It will be similar to a typical climbing harness, in that it will go over the shoulders and around each leg. This can be put on Zak easily while he is still in his wheelchair. A back and neck brace will also be used to add more support and safety during the transfer process. The lift will take him directly from the wheelchair to the pool, and then back again after he is done. The harness and braces allow for the option of leaving them on while in the pool or easily taking them off, whichever the client prefers based on the situation. The lift is powered by a hydraulic pump attenuated by a hand crank. The lift can also freely rotate a full 360 degrees.

10 References


11 Acknowledgements

Our design team would like to thank Dr. John Enderle and Marek Wartenburg for their continuous guidance and support throughout this project. We would also like to thank Christiana Gondreau and Linda Mahoney for providing us with help and information whenever possible throughout the design process. Peter Glaude and Serge Doyon from the School of Engineering machine shop were also a big help to us throughout the entire project, providing us with advice and guidance while machining parts for the support system. We would like to thank Peter Trainor for providing us with a discount on our 8020 frame components, which significantly helped us in meeting our budget requirements. Additionally, we would like to thank Peter Lamagna of New England Fitness Distributors for his generosity in donating a treadmill to the School of Engineering for use with our project. Finally, we would like to thank Jennifer Desrosiers for all of the work she has done in ordering the parts we need to complete this project.
## 12 Appendix

### 12.1 Price Quotes and Data Sheets

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STORRS, CT 06269

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343 MANSFIELD RD
STORRS, CT 06269

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**Order Number:** 1013427

**Order Date:** 11/4/2011 09:09:55

**Page:** 1 of 2

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39
## QUOTATION

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FRANKLIN, MA 02038
USA
508.528.3020

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