Treadmill for Dominic and Pool Lift for Zak
By
Craig Hanna, Kyle Hamilton, Nicholas Woolsey
Team 11

Client Contact:

Christiana Gondreau
(401)-231-0647
cgondreau@gmail.com

Linda Mahoney
(203)-910-0942
**Executive Summary:**

The pool lift portion of this design project will be constructed from an existing pool lift which will be modified for Zak Mahoney. The majority of the modifications to the lift will be done to the harness itself. The harness will need to support and stabilize Zak while he is being moved in and out of the pool. Furthermore, the harness will need to be corrosion resistant so that Zak can wear the harness while he is in the pool. This will make the process more efficient by eliminating the need for the harness to be removed while he is in the pool and then put on again when he is finished swimming. The other design consideration for this portion of the project is finding an effective way to mount the pool lift. The Mahoney family would prefer if the lift were mounted off of the deck so the design is less invasive. However, pouring a concrete base is very expensive, and mounting the lift to the deck would be a much more stable and safe design. This may be the best method of mounting for this project.

The treadmill support design will be a more intensive design. The support system will roll over an existing treadmill. Dominic will put on a harness before he uses the treadmill, and the harness will attach to the support system. Dominic should be able to put on the harness while he is in his chair. Furthermore, the harness should be able to attach to the support system while Dominic is still in his chair. This way, the support system can assist Dominic in getting on the treadmill. Therefore, the support system will need some kind of adjustable height system. Furthermore, a system which can adjust the amount of Dominic’s weight which is supported will allow him to exercise more efficiently. With continued use, he will be able to support more of his own weight, and the reduction of supported weight will allow him to do so. Therefore, this design will maximize support and efficiency.
1 Introduction:

Pool Lift for Zak Mahoney:

1.1a Background:

The first 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.

1.2a Purpose:

The purpose of this 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, but do not want to mount the lift to the deck itself. This design, which is very common in handicap pool lifts today, is invasive, and will remove area from the pool deck which could serve other purposes. However, this design would likely require a concrete base to be poured to stabilize the lift. This would require a contractor to pour the concrete as per Connecticut state regulations. The combined cost of hiring the contractor and the concrete itself may be too high. Moreover, mounting the lift directly to the deck may stabilize the lift better than a concrete block. Therefore, 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.

1.3a Previous Designs:

1.3.1a Products:

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.

1.3.2a Patent Search:

Keith Krumbeck holds Patent 5218727, issued June 15th, 1993, for a fully automated lift for above ground spas, and his design is shown in Figure 1. Krumbeck also holds Patent 6170612, issued January 9th, 2001, for a hydraulic pool lift which is more similar to our design. This design is shown in Figure 2.

Treadmill Support System for Dominic Gondreau:

1.1b Background:

The second 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 affects 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.)

1.2b Purpose:

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. These rigid components will likely be found along the back of the harness and round his head.

1.3b Previous Designs:

1.3.1b 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.

1.3.2b Patent Search:

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. This patent can be seen in the following figure.
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. The following figure shows this patent.

2 Project Description:

2.1 Project Overview:

Pool Lift for Zak Mahoney:

The pool lift for Zak Mahoney will need to lift him directly from his chair and place him into the pool or a raft in the pool so that his parents do not need to carry him. The Mahoney’s requested that the pool lift be mounted in the ground, but this method may not be feasible. Zak will be able to be wheeled up onto the deck in his chair, so if the lift is mounted in the ground, the mast of the pool lift must be long enough to clear the deck and any railings or enclosures
surrounding the deck itself. Finally, a harness must be used to lift Zak out of his chair so that he will not have to be carried from his wheelchair to the chair on the pool lift. This would defeat the purpose of the lift.

The first major component of the lift project is the lift itself. Upon discussing the project with the Mahoney family, they would like a very simple design. We suggested a design similar to pool lifts already available on the market. The design we suggested would be a hydraulic lift either motorized or powered by a hand crank. Zak would put on the harness while he sits in his wheelchair. The harness would then be attached to the lift itself by means of a quick release clip. The lift will then hoist Zak out of his chair. The operator of the lift will then swing Zak over the pool and lower him down. The swinging action of the lift will be manual, a design that the Mahoney family requested for ease of operation. The mast will be able to pivot in its base. The operator will be able to swing the boom by using two handles attached to the mast at ground level or perhaps a rope hanging from the boom at deck level for a greater ease of operation. The final component of the design is the base itself. A safe and effective way is required to mount the lift. The best way to accomplish this is likely using the existing deck mount that will come with the pool lift. Pouring a concrete base will likely be too expensive and difficult. The final component required to use with the existing pool lift is the harness itself. Zak should be able to put on the harness easily while he is in his chair. The other requirement of the harness is that it is waterproof. The harness will be remaining on Zak while he is in the pool so that he can be quickly removed when he is done swimming. The harness also needs to be able to support his weight in such a way that Zak will not be hurt while being moved. It should also be comfortable for him while he is in the pool and being moved in and out.
**Treadmill Support System for Dominic Gondreau:**

The treadmill support system for Dominic Gondreau will have three major components to design. The first major component is the frame of the support system itself. The frame will be similar to other designs created for this application. It will consist of a rectangular base which can roll over the treadmill, a mast for adjusting the height of the support system, and the arms which come off of the mast to hold Dominic in the harness above the treadmill. The adjustable height system will allow Dominic to use this support system for years because the height of the support arms can be raised as he grows. The second major component of the treadmill support system is the harness. The harness will need to be created from a material which is strong enough to support his weight. Heavy duty nylon straps will likely be the best option. Secondly, the harness will need to have rigid components in order to stabilize Dominic within the support system. Rigid pieces will likely be implemented on the back of the harness where Dominic’s head and back are in order to keep him upright while he exercises. Finally, the electrical components of the support system will need to be designed. These components will consist of a remote control which can raise the arms up and down. The arms will be raised up and down by a hydraulic arm attached to both the masts and the arms. By implementing force sensors on the arms attached to the straps of the harness, the system will be able to read how much weight is being supported. This weight will be displayed on a screen, and the weight can then be further adjusted using the remote control.

**2.2 Methods:**

**Pool Lift for Zak Mahoney:**

Perhaps the most important factor in designing this pool lift is the method by which it will be mounted. As described earlier, the Mahoney’s would like the lift to be mounted to the
ground. However, this option will likely be very expensive to implement. If a concrete block is poured and used as the base, simple static analysis can be used to figure out the correct volume of concrete required to be purchased and implemented. In order for pool lifts to be approved by the American Disability Advocates, the lift must be able to support 400 pounds of static load. We will need to by an approved lift for this application. Another mounting option would be one that mounts 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. 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. A third mounting option would be the construction of a mobile base. 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. The lift could be rolled onto the deck or remain on the ground depending on which design the Mahoney’s like.

By replacing the chair at the end of the boom with a harness, Zak can be lifted directly out of his wheelchair instead of his parents needing to transfer him by hand to a chair. The harness will be similar to a bungee harness. There will be two hoops which wrap around his legs and tighten to secure the bottom portion of his body. The harness will then fasten around his torso and above his shoulders in order to firmly secure him while the transfer is occurring. By attaching the boom of the lift to the chest region of the harness, Zak will be able to sit comfortably in the harness while he is being transferred to a floating apparatus within the pool. Zak’s head and neck will need to be supported while he is being moved as well. Implementation of rigid pieces may be needed to accomplish this. Moreover, the harness will be designed to be
waterproof so that Zak can be left in the harness while inside the pool, thus simplifying the transfer. A quick release click on the end of the boom attaching to the harness can be used to rapidly maneuver Zak from the pool to the deck and vice versa.

**Treadmill Support System for Dominic Gondreau:**

The frame for the support system will consist of two main parts, the base and the vertical support section. The frame will be on wheels to allow for easy mobility. All beams discussed will be made of steel square piping of various dimensions, with the exception of the handlebars, which will be made from circular pipe. The two main support beams of the base that will run parallel to the ground will be 2” by 4” and 5’ in length. They will have a thickness of 0.25”. Two wheels will be attached to each beam, one at the front and one at the back. At the back of each beam, another beam will be fixed on top, to account for proper clearance of the treadmill. These sections will be 2” by 5” with a length of only 1’. Including the wheels, this will allow for a total of 14” of clearance, which will be adequate to clear the height of the treadmill base. On top of these 2” by 5” beams will be two more beams spanning the width of the base. These spanning beams will be 2” by 4” with a length of 3’. This will provide enough width to span the treadmill that will be used. The spanning beams will be located at the two ends of the 2” by 5” beams, making them 10” apart, measuring from each beam’s center. At the center of the two spanning beams will be a metal plate for the base of the vertical support. This plate will be 12” by 12” with a 0.5” thickness, located a foot from each edge. Mounted on top of this will be a beam housing the lever support system and handles. The vertical beam will be 4” by 4” and stand six feet tall. This will be more than enough height to compensate for any growing Dominic will do. The beam will have six 0.5” holes drilled into it, spaced at 6” apart. This will provide a way to mount the lever support system securely to the beam. The sleeve in which the lever will
be on will also have 0.5” holes in it; two of them one foot apart. Two bolts will be used to secure the sleeve to the beam, which will go all the way through the two components and have a clasp to ensure they cannot come out on their own. Using a system like this will provide an easy method to adjust the height of the support system, based on the client’s height. The handles located on the vertical beam will be round steel pipes. They will be bent by an s-curve in the middle such that they will be 4” apart where they attach to the beam and 30” apart at the end where Dominic will hold on to them. A rubber grip will be placed on each end of the handlebars for comfort and safety. The handlebars will be attached to the beam in a similar fashion as the lever support system, but only use one bolt to secure them instead of two. Only one is needed because of the small amount of weight that they will support. The bars will be more for stability of the client than anything else. They can be adjusted to different heights just as the lever support system can.

The harness will attach to the upper lever arm part of the design via metal clips. The metal clips attach to the metal rings at the end of the arms. From each clip, two heavy duty nylon straps will hang down. These straps will loop through the clips which attach to the support arms. The straps will also contain a plastic piece on one side in order to adjust the length of the loops. The plastic piece will allow someone to adjust how much the harness hangs down from the support arms by pulling on a loose strap to tighten the loop, or pulling up on the loose strap to extend the loop. Each extension which attaches to the harness will also contain a spring. This spring accounts for the variable tension needed as the user walks on the treadmill.

The harness itself will be made of heavy duty nylon straps which can sustain the stresses exerted by holding up the user’s weight. The design will be similar to a bungee or rock climbing harness. Dominic will put on the harness by stepping through each of the loop holes at the
bottom of the harness. Straps will run up his back and pass over his shoulders. Straps will also pass across his chest to finish securing the harness. Metal clips will be used in order to sustain the stresses and forces placed on the harness as Dominic’s weight is supported. A rigid, plastic component will be found on the back of the harness as well. This piece will help stabilized Dominic’s back and head as he exercises. Cushioning and padding will be added to the plastic components, as well as the straps, in order to promote a comfortable design. The straps which hang down from the support arms will be clipped to the upper portion of the harness.

The variable weight support system will be implemented by utilizing two force gages. Each force gage will be attached to the support arms and the straps of the harness. The electrical signal from these force gages will be deciphered using a microcontroller. The microcontroller will use analog to digital conversions to analyze the force gages’ electrical outputs. From there, the microcontroller will prompt the assistant to enter to user’s weight in pounds. The microcontroller will then calculate the amount of weight, in pounds and percentage, which the user is supporting himself. This value will be outputted to an LCD screen. This allows the assistant to adjust the hydraulic pump to allow the user to support the desired weight.

3 Budget:

3a Pool Lift for Zak Mahoney:

1. Pool lift: $1000
2. Additional pole to increase height: $200
3. Harness/Seat system: $100

TOTAL: $1300

3b Treadmill Support System for Dominic Gondreau:
1. Treadmill with 0.1 mph speed increments: ~$500

2. Support Mechanism
   a. Frame: ~$566.32
      i. 2” x 4” x 16’ Steel Tubing (1/4 in. thickness): $186.20
      ii. 2” x 5” x 2’ Steel Tubing (1/4 in. thickness): $38.28
      iii. 4” x 4” x 6’ Steel Tubing (1/4 in. thickness): $85.59
      iv. 4.5” x 4.5” x 3.5’ Steel Tubing (1/4 in. thickness): $67.16
      v. 2” x 2” x 6’ Steel Tubing (1/4 in. thickness): $40.71
      vi. 2.25” radius x 6’ Steel Tubing (1/4 in. thickness): $27.12
      vii. 12” x 12” Steel Plate (1/2 in. thickness): $21.26
      viii. Additional Fixation Components (nuts, bolts, steel, etc): ~$100

b. Harness system
   i. Straps: $50
   ii. Carabiner/Hooks/Bolts: $60
   iii. Springs: $75
   iv. Back support: $130
   v. Neck brace/support: $75

c. Electronics: ~$300

TOTAL (own design): ~$1756.32

4 Conclusion:

Both projects involve designing safe and effective systems to improve the quality of life for Dominic and Zak. Both projects have certain criteria that must be met to create successful designs for each client. The lift must be stable on its mounting system, and Zak must be stabilized and comfortable within the harness itself. The lift will likely need to be mounted on the deck, as mounting it in the ground will likely not stable or cost effective. The treadmill support system must be strong enough to support Dominic’s full weight, and the harness must be
comfortable and able to stabilize Dominic as he exercises. A sensor system needs to be implemented in order to measure the amount of Dominic’s weight which is supported by the treadmill support system. The supported weight will be sent to a microcontroller, processed, and the output will be sent to an LCD display. The weight supported can then be adjusted accordingly by using the remote control.