# Projects for Elysa

## Zip Line Walking Device, Water Bike, Stationary Bike, Adaptive Skiing Device, and Saddle Eating Chair

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**Abstract**

The project assigned is to provide multiple movement assist devices. These are absolutely essential to aid in her development due to how her premature birth has affected her. Her muscular development will allow her to gain strength like any girl her age. However, her neural development for motor coordination is impaired. She has the physical ability to complete simple tasks and the capacity to gain strength for more complicated tasks. However, the wiring in her brain doesn't allow her to complete them.

This is incredibly frustrating for her because she can see and plan the activity but simply cannot complete it. For these reasons, it is absolutely essential to have multiple devices assisting different kinds of motion. Simple movements require many complicated connections in the brain. The more sensory input we can provide for her, the more connections will be created and the existing faulty connections will be adjusted in her brain so that she can properly master the skills for independent motion.

When she can do these motions on her own, her muscles will be strengthened. This is important because she does have muscle weakness. Once she masters the motions of the two fold requirement of coordination and strength, she will be able to complete motions of her own will and can have further progress. The more she can move independently, the better her overall health will be. It is well known fact that a life style that is too sedentary can lead to many health issues. For all these reasons, we are providing five different assist devices that focus on common activities and sports.

The saddle eating chair will allow her freedom of motion with her arms and legs and allow for core support while she is sitting at any table doing activities to help stimulate her brain. The stationary recumbent bike will aid her strength and coordination in her legs while supporting her core. Biking is a common activity and this will allow her to master the skills necessary to progress towards riding a bike. Skiing is another very common and fun sport. Exposing her to skiing using an adaptive device will be fun for her and give her more stimulation since she is often stuck inside the house. The zip line walking aid will allow her the ability to experience walking independently and safely, while strengthening her muscles. The water walking device will also add another way to strengthen her muscles in a safe environment.

# 1. Introduction

## 1.1 Backround (Client and disability)

Elysa was born very prematurely. She did not receive the normal inputs during development and her brain developed differently. The motor control section of her brain was affected. Though her muscles are underdeveloped, she has the capacity for improving her strength. She has control of her arms and with therapy has learned center position for her body. This results in her having limited motor function and needs support. Elysa is bright and cheery little girl and can be very stubborn at times. She enjoys moving and lights up when anyone talks about going swimming or riding horses. She requires these devices to aid her brain developing the correct connections for coordinated motor functions.

## 1.2 Purpose of Project

All of the devices in the project are going to help her muscles develop, as well as increase her coordination, in various kinds of motion and in a fun manner. They will provide the sensory input that she needs to create new connections in her brain while adjusting the existing faulty connections so that she eventually will have the skills needed to be more independent. Her muscles will strengthen as she learns the motions of each device. Over time, as her strength and coordination increase, she will be able to move on her own and continue to have progress.

## 1.3 Previous Work Done by Others

### 1.31 Products

**Zip line Walking Device:**
There are various products on the market that allow mobility, while keeping the child supported and secure. One of these products is the Gait Trainer Comet Anterior Mobility Product by Heliohealth, shown in Figure 1 below. It combines the quality, safety, and durability of a walker with the added support that a traditional walker cannot provide, such as a seat harness, pelvic stabilizer, and ankle prompts that prevents the legs from scissoring. However, products like these are on the bulkier side and are not ideal for patients with a lack of core strength. Elysa's parents bought one for her, but because it is bulky, she does not have the physical strength to walk too far with it.

Another product is the Kaye Suspension Conversion Kits, which can be seen in Figure 2, which is an attachment that can be placed on a walker and can suspend a harness off of. The concept is similar to what we had in mind for our device, though it is a less bulky version, as the conversion kit requires the use of a walker. With that product, just like with the walker, it would not be the easiest thing to move, especially since it is attached to a walker. Also, neither product provides any neck support, which Elysa needs to prevent her head from leaning towards one side, as she is used to doing.

A senior design team from Spring 2011 designed a jumper for their client, which is similar in concept to what we are going for. Like for our harness, theirs provides support for the client's torso and legs. They were also thinking about adding neck support to keep their client's head aligned properly. However, their device is much more bulky than ours, due to the large frame and motorized parts. Also, as a jumper, it is not providing the means of them learning how to walk, but just how to stand upright and jump in place. Our design has a minimal frame and harness and does not have any motorized parts.

**Figure 1: Gait Trainer Comet Anterior Mobility Product**

**Figure 2: Kaye Suspension Conversion Kit**

**Adaptive Skiing Device**

Many assisted skiing devices provided by different companies. The devices are made for people who have disabilities but want to enjoy skiing or snowboarding. Those assisted skiing devices can be divided into two categories: rider controlled or assistant controlled. Most people with trouble moving their lower body who just want to have a feeling of skiing usually use the skiing devices that require another person to steer. The bi-skis provided by Enabling Technologies in Figure 3, provides an example of that. Bi-ski features a seated ski that allows the disabled person to sit comfortably while keeping him secured and fixed. The assistant who steers the ski then holds on to the bar on top and control its direction.

The other kind of skiing devices are for disabled people who want to ski or skateboard independently. Devices such as mono-ski and sit-ski require no assistant. Products such as snow slider and rider bar, manufactured by Freedom Factory, are devices that allow users to skateboard and ski normally with only minimum supports. Snow slider, shown in Figure 4, has some features that are similar to our purposed device. First of all, it has knees and hip belts that fix the skier's lower body in place. Second, it has an arm resting feature that the skier can support his upper body by holding on to it. The second feature, however, differs from our device because it does not provide back and neck support to the skier. Since our client, Elysa, is unable to hold her head in the center position, neck support is necessary for our device. Also, our design requires a suitable seating device.

**Figure 3: Snow Slider**

**Figure 4: Bi-Ski**

**Saddle Eating Chair**

Companies and individuals have had similar concepts to the saddle eating chair. The senior design team from spring 2011 designed a chair that could be adjusted for height and had a pommel to support the child. A few items from a company that specializes in devices for children with disabilities are similar to the eating chair we are trying to design. The company is called Achievement Products and has many products available online.

Figure 5 is the mobile adjustable chair from the company. It has the back and head support we are looking to mimic as well as the ability to roll we desire in our product. It is padded for comfort and still has the ability to properly strap the child in for their safety. The seat is not the same design we are looking for and the tray is not necessary for our project.

Figure 6 is the chair with the seat type we require. This is meant to aid with abduction and to keep the legs from "scissoring". This is the seat type we look to mimic as well as the back but it isn't mobile but it can be adjusted 8 inches.

**Figure 5 (left): Mobile Adjustable Chair**

**Figure 6: Roll Chair**

**Recumbent Stationary Bicycle**

For the recumbent stationary bicycle we are to build, there are an enormous number of options and modifications available on the market. Some brands include Shwinn and Nautilus. Figures 7 and 8 below are just two examples of stationary bikes.

**Figures 7-8: Examples of Stationary Bikes**

**Water Walker**

Honda has created a device similar to this and is used to assist walking, as shown below in Figure 9. This device however is used on dry land and supports the weight of the patient. Although this device is not used to teach a person how to work the concepts are very similar. They both restrict the operator to only use a normal walking motion. People who have tested this device say that at first the device feels very awkward to use but they quickly adapt to using it. This is promising for the underwater design in that hopefully her muscles will remember the walking motion at a relatively quick pace.

**Figure 9: Honda's Assist Walking Device**

1.3.2 Patent Search Results

**Zip Line Walking Device**

There are no patents that are equivalent to what we have to design for this type of walking apparatus. The closest patents that could be found were for various child harnesses or jumpers, which none of them required the use of a zip line. All the patents that were relating to zip lines were for trolleys and zip line braking, not for assisted walking apparatuses. With the child harnesses, one that was somewhat similar to our design does not have an official patent number as of yet. Its Publication No. is US 2008/0018163 A1, seen in Figure 10. The design includes support for the torso and back, while keeping the legs free to move. There are also shoulder straps that can be held by another person or hung from a frame. However, the design lacks in having any neck support, which the client needs.

Another one that could be used as a potential alternative design was Patent No. 3,447,832, as shown in Figure 11 below, which was for a jumper harness. This design featured a body belt that could be adjusted to accommodate for a child's growth, as well as having snap fasteners for easy removal. The carabiners at the end of the suspension lines provide easy assembly and removal from where it is hung off of. That aspect of the design will be useful in our harness design. A problem with this design is that like the previous design, this one does not have any neck support. This one did not seem to have much padding, which from extended use can cause discomfort.

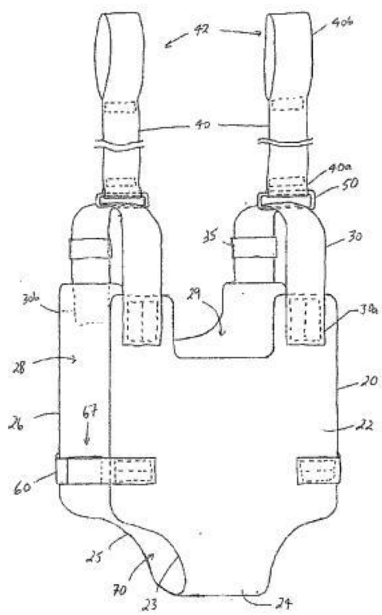


**Figure 10: Publication No. US 2008/0018163 A1**

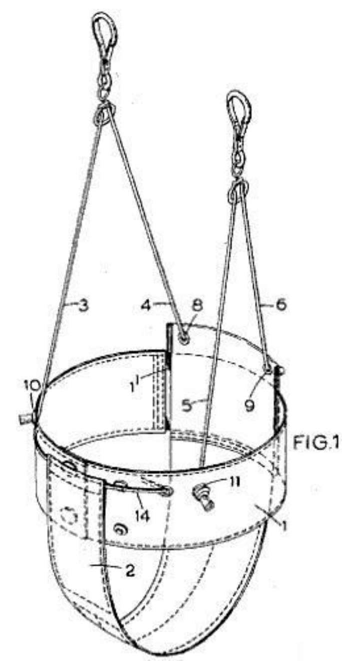


**Figure 11: Jumper Harness, Patent No. 3,447,832**

**Adaptive Skiing Device**

The patent for the ski assembly is 4,759,570, as seen in Figure 12. The ski assembly provides support to the skier by shifting the upper body weight of a skier from the skier's legs to the skier's skis and ski boots to reduce the strain on the legs of the skier. This product provides us an insight of how we should design our skiing device.

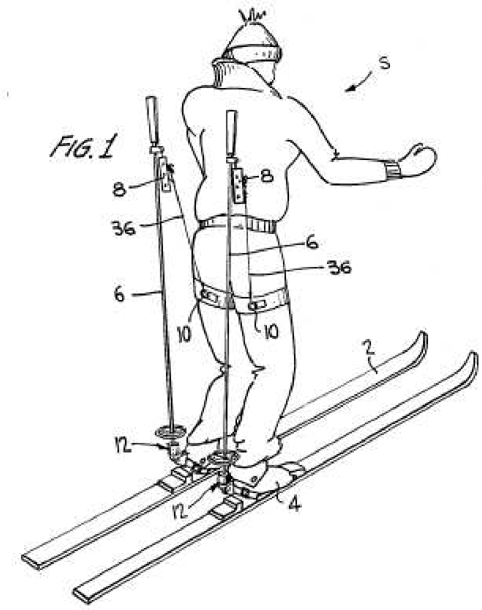


**Figure 12: Ski Assembly, Patent No. 4,759,570**

**Recumbent Stationary Bicycle**

The recumbent bicycle had many patents but patent number 7,662,070, shown in Figure 13 below is the device that most matches with our goals. This bicycle was made with motorized pedals so the user can have aid in moving their legs. Elysa is going to need some kind of adaptation to allow her parents to help move her legs since she can't do it on her own. This bike has the straps we would require as well as the adjustability for leg length.

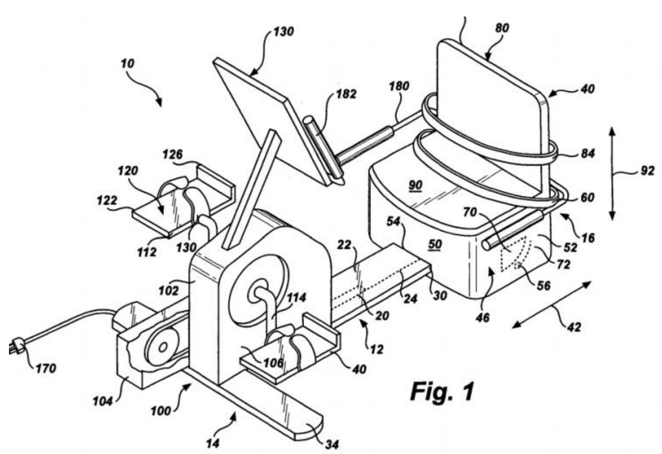


**Figure 13: Diagram of Patent 7,662,070**

**Saddle Eating Chair**

The saddle eating chair had a patent granted in 1989. Its patent number is 4,852,942 and a diagram of the design can be seen in Figure 14. This is very similar to what her parents are asking for. This chair has the ability to move by the rollers in the back and is a very fun design. The rubber stoppers in the front keep it stationary while the child eats. It has no ability however to adjust to table heights. It also does not have any back support so it would need to be modified to allow for that. Straps would also need to be added to hold her in so she could not slip off.

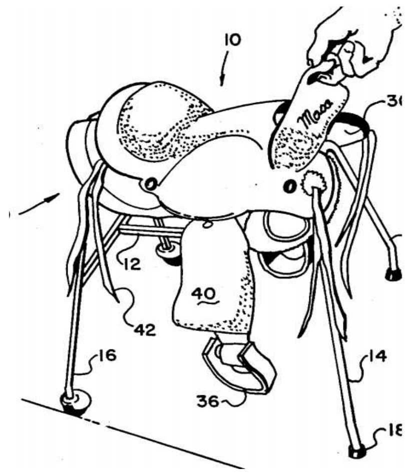

**Figure 14: Diagram of Patent 4,852,942**

**Water Bike**

Hydro-Physical Therapy is a popular form of physical therapy and there are many devices for leisure in the pool however we were unable to find any patents that combine the two forms of activity. The closest any patented product has come to the design of this device would be an above water bike. These are used for recreational activities and do not have a common PT application. Also, the pedaling is used to propel the bikes through the water and the bikes are not at all stationary.

### 1.4: Map for the rest of the report

The report will contain the alternate designs that were created for each project, along with the final design that was chosen for each prototype. In the optimal design section of the report, the subunits provide explanations of all of the parts for each project and why these parts were chosen. The constraints, safety issues, and engineering lessons for each device will be mentioned to explain the limitations of the devices and the knowledge that will be gained from the overall project. The project timeline and complete budget will be shown in both a table and a written description. Lastly, the report will include the contributions of all of the team members, as well as the acknowledgements from outside assistance.

## 2. Project Design

### 2.1 Project Introduction

**Zip Line Walking Device**

Elysa does not have the muscle strength needed to be able to stand up for long, let alone walk on her own. This device will allow Elysa to stand upright, without needing her parents to support her, and allow them to more easily be able to teach her how to walk properly. Over time, as her core muscles and legs develop and strengthen, Elysa will be able to rely more on her own strength to stand upright and increase her coordination abilities to walk without assistance. It will help her gradually become more independent and be able to experience the freedom of being able to move around freely in her home.

The design will be based off of the Kaye Suspension Conversion Kit, with only the top part of the frame connects to the straps of the harness. A padded torso and pelvic harness will provide back and neck support in order to give Elysa support to stay upright. The harness will be made to be adjustable, so it can accommodate her future growth. It will also have removable padding, which can accommodate for Elysa's need for the support. Attached to the harness are adjustable elastic straps that will suspend from the lightweight, metal bar being hung from the zip line. The metal bar will hang down from a swivel that is attached to a guiding wheel on the zip line, which will allow for the structure to rotate 360° to allow for maximum mobility.

**Adaptive Skiing Device**

The primary purpose of this project is to design a skiing device that will allow our client, Elysa, to enjoy the excitement of skiing. Her parents want her to be able to stand on the ski on her own with minimum support, therefore she can enjoy the freedom and independence when skiing down the hill. The other purpose is to teach Elysa the proper stance of skiing. To do that, the device will keep her legs and hip in place, and the 3-point safety harness straps can prevent Elysa from falling off the device and provide support when she cannot stand up on her own. By using the skiing device, Elysa will be able to extend her activities to outside of the house.

**Stationary Bicycle**

The major difference in this bike from other stationary bikes is the addition of the component that allows her parents to pedal the bicycle for her. This recumbent bicycle will include a harness to make sure Elysa is safely seated and doesn't fall out. The seat back will be adjustable as well as have head and neck support. The leg distance will be adjustable as well as the seat height. Also a toy will be added and powered by the pedal rotations. The toy will dance in response to her pedaling to motivate her and add a sense of play to the activity. Also this will be made to fit her smaller size as compared to the normal size of a stationary bicycle.

**Saddle Eating Chair**

This device is meant to allow Elysa to participate in activites at the table and allow her arms and legs to be free to move around. First for her safety it will have a harness to help support her sitting upright and keep her from sliding off the chair. The harness will be soft and comfortable and with the least bulk possible. The chair will have a seat to imitate the appearance of a riding saddle with a pommel for extra support and reduce her sliding. The chair will have wheels to allow for mobility. The wheels will have a locking mechanism so that it stays in place while she is at the table. The base will be wide so it does not tip. The chair height will be adjustable so it can reach several different table heights.

**Water Walker**

The water walker has a simple enough design with little room for error. The harness and frame only allow the user to move their legs in a walking motion. The purpose of this device is to stimulate the repetitive motion of walking in hopes to create muscle memory that will translate to walking on land. The design is similar to that of the Honda walker but the main difference is that this will operate under water and will not have to support Elysa's weight. Also, the water walker will have a lot more straps and be more restrictive than Hondas walker.

### 2.1.1: Alternate Designs

**Zip Line Walking Device**

Alternate Design 1:

This design will maximize the area which Elysa will be able to travel across by a system of poles and wheels, as shown in Figure 15. She will be able to walk across the room, as well as side to side. The zip line will be an Aluminum tube that will provide a lightweight "zip line" for which Elysa will be able to move across. As one, continuous long tube running across the room would most likely bend in the middle due to its weight, the "zip line" will be made up of several pieces of Aluminum tubing.

These tubes will be connected together with screws, which will allow for easy assembling and disassembling when not in use. Two stainless steel cables, one on each side of the room, will be mounted to the wall and is where the wheels that are attached to the tube will glide along as Elysa moves around the room. The harness set up will be like the one that was mentioned in the proposals, which can be seen in Figure 16.

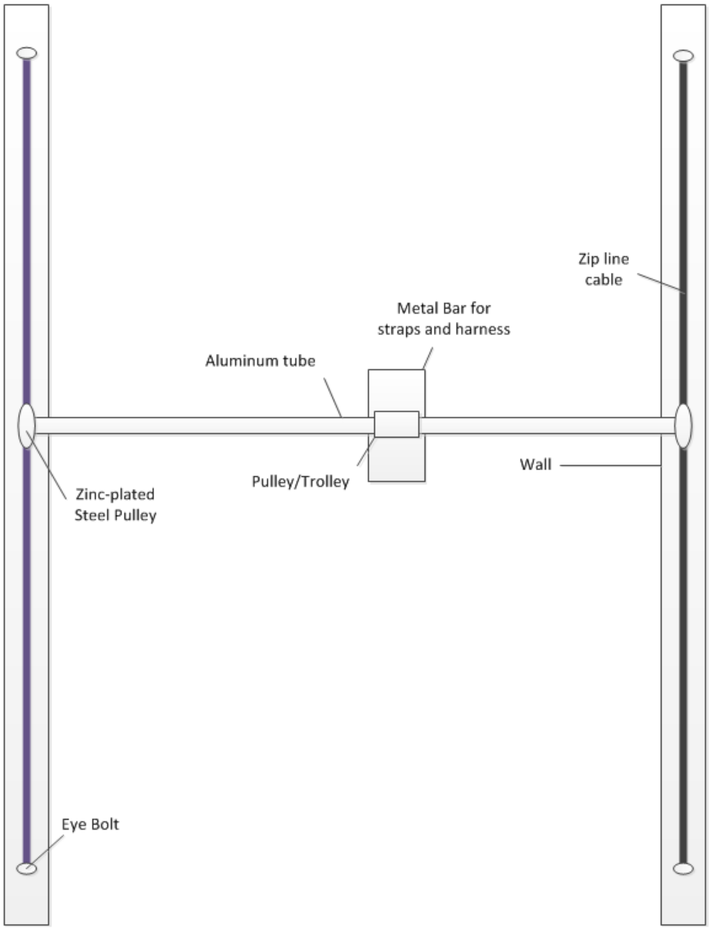


**Figure 15: Top View of Alternate Design 1**

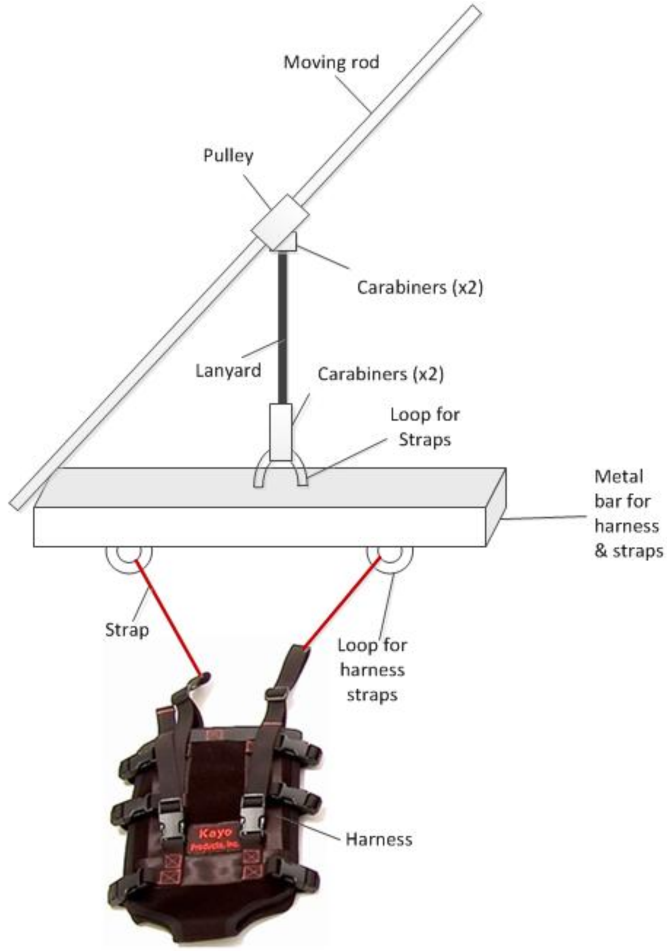


**Figure 16: View of Harness Structure**

<u>Alternate Design 2:</u>

The zip line part of this design is very similar to the design that was mentioned in the proposal. Instead of having a single line that the pulley is moving across, there will be two lines, which therefore, will have two pulleys moving on the two lines. The two pulleys will be connected to the hooks on the metal bar by two pairs of carabiners, which cannot be seen in both Figures 17 and 18. Three hooks are on the bottom of the bar, which are where three adjustable straps will connect to the harness.

The straps will be attached to the shoulders and back of the harness to maximize support and stability. As an added support feature and something that Elysa can hold on to, are a set of handlebars. The bottom section of the handlebars will be wrapped with bike grip wrap, which will make holding the bars easier. The harness itself will be a modified kids full body rock climbing harness. More padding will be added to make the harness more comfortable for extended use. The finished harness should look similar to a suspension trauma harness, seen in Figure 19. This type of harness would be perfect for this device, but there are two problems: a) it only comes in adult sizes and b) it is expensive.

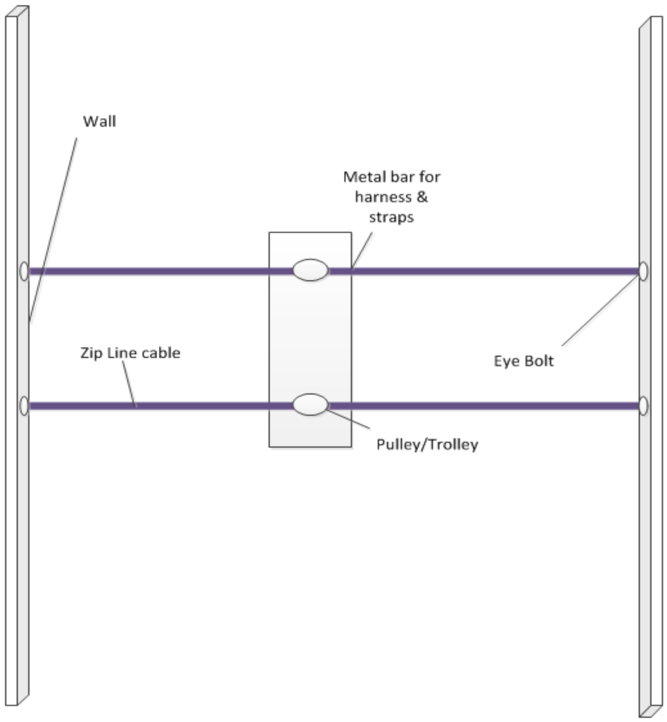


Figure 17: Top View of Alternate Design 2

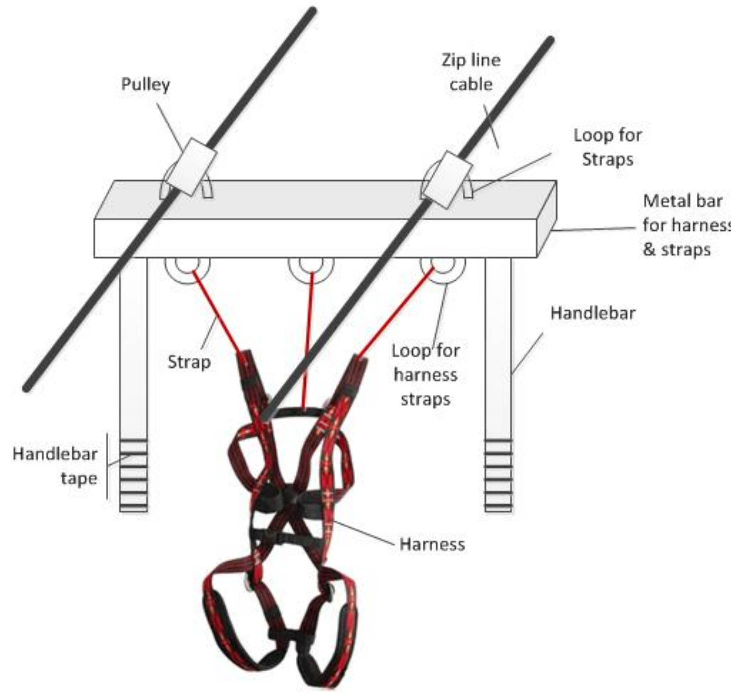


Figure 18: View of Harness Structure for Alternate Design 2


Figure 19: Suspension Trauma Harness

Alternate Design 3:

This design has a similar structural set up to Alternate Design 1. Instead of having the two zip line cables mounted to the wall, two Aluminum tubes will take its place and will be attached by two pairs of standoff hangers or another type of hanger, which can be seen in Figure 20. As the aluminum tubes are in place of the cables, flanged track wheels will move along the tubes much easier than the zip line pulleys. The moving tube is where the flanged track wheels will be attached to and the tube itself is the exact same set up as in Alternate Design 1. The harness set up is like that of Alternate Design 1, minus the lanyard, and the bar will be attached to the pulley by carabiners. Like Alternate Design 2, the harness will be a modified kids full body rock climbing harness, instead of the harness that was mentioned in the proposal, as shown in Figure 21 below. Unlike that design, there will not be any handlebars.

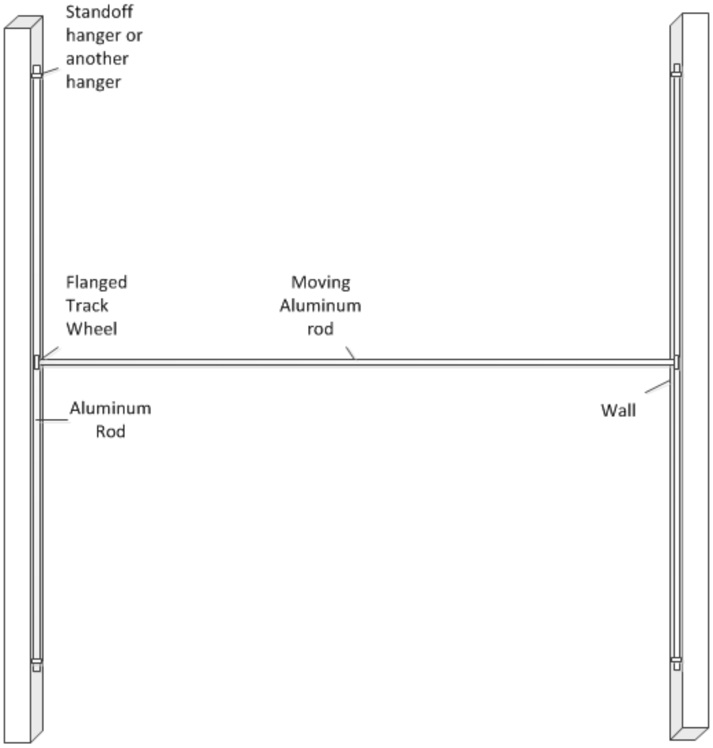


**Figure 20: Top View of Alternate Design 3**

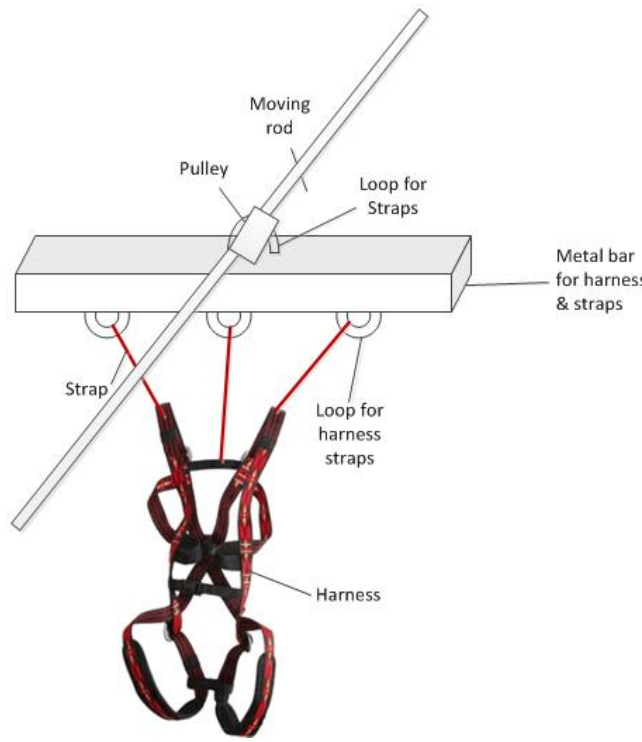


**Figure 21: View of Harness Structure for Alternate Design 3**

**Adaptive Skiing Device**

Alternate Design 1:

This has structure similar to the assisted walker device, shown in Figure 22. Its main structure consists of four poles perpendicular to the ski, where each pole is rounded off on top for protection. There are also two bars parallel to the ski between two perpendicular poles for better support of the whole structure, as shown in Figure 23. Elysa can enter from the opening at the back.

A full-body safety harness, shown in Figure 24, is needed for this design since there is no back support. The full-body safety harness needs to be attached to the four poles for stability, and it has to be high enough for Elysa to remain in standing position.  Some advantages for this design are that it is simple and does not need require many parts to build it. One of the disadvantages is that in order to secure the full-body safety harness, the poles have to be high enough to hold the upper part of the harness, which would make the design really bulky.

Also, the full-body harness would restrict Elysa's freedom while using the skiing device. Even though that's what the harness does, her parents are hoping that the device can provide minimum support and have as less restriction as possible while she is on the device.

**Figure 22: Assistive Walking Device**

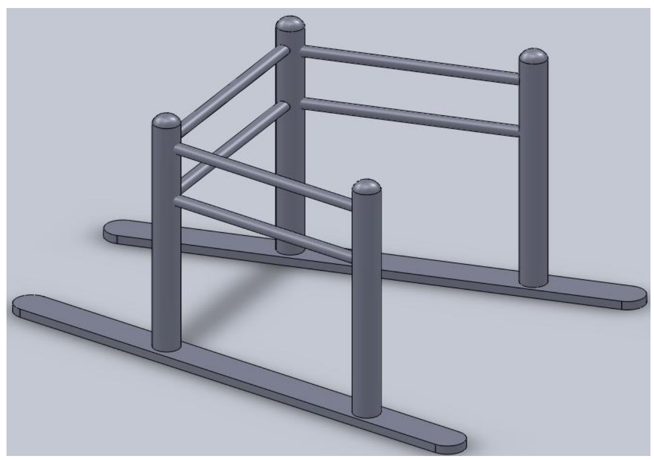

**Figure 23: Adaptive Skiing Device - Alternate Design 1**

**Figure 24: Full Body Safety Harness**

<u>Alternate Design 2:</u>

Alternative Design 2 has completely a different structure than Alternate Design 1. Design 2 consists of a back support and arm rest for each arm, as shown in Figure 25. The structure of the back support is a combination of many horizontal bars, so safety straps such as seat belt can be tied on to the bars. Cushion can also be tied to the back support, so it is more comfortable while Elysa is operating the skiing device.

Cushion can also be placed in the U-shaped arm rest for maximum comfort. Rubber grips are used to cover the handle bar for better grip. To support Elysa's body, a 3-point safety harness, as shown in Figure 26, can be placed about her waist area to keep her in standing position and secure her position.

The advantage of this design is that the straps and harness can keep Elysa secure while operating the ski, and the arm rests and cushion can keep her comfortable. The disadvantage about this design is that she has to stay in standing position the whole time, but the 3-point safety harness can relieve her stresses when she feels tired or keep her from falling off the device. Overall this design provides less restriction but same amount of supports compared to Alternative Design 1.

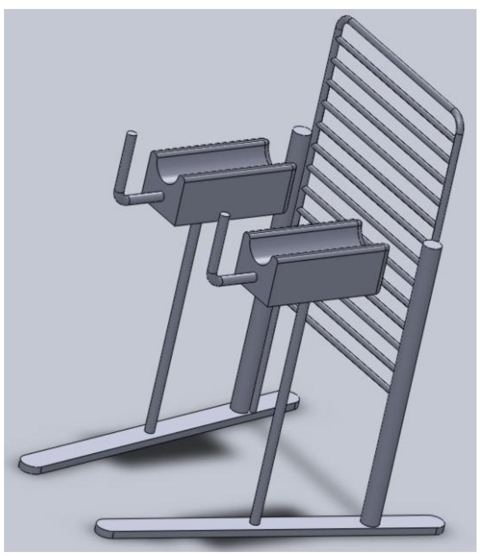

**Figure 25: Adaptive Skiing Device – Alternate Design 2**

**Figure 26: 3-Point Harness**

Alternate Design 3:

Alternative Design 3, shown in Figure 27, has pretty much the same design as the Alternative Design 2. The only difference between these two designs is the lower part of the back support; some horizontal bars are taken away and the lower part of the back support can be turned into a chair. While Elysa is standing, the chair acts as a part of the back support, so Elysa's can still lay on it. But if she feels tired and wants to sit down, instead of just letting the 3-point safety harness to support her, her parents can easily turn the lower part of the back support into a chair by twisting the knob on the side, and lock it when the chair is in position. The advantage is that Elysa can now sit down if she is tired and still enjoy the ride, but on the other hand, her 3-point safety harness needs to be released in order for her to sit comfortably, which can be troublesome and time consuming.

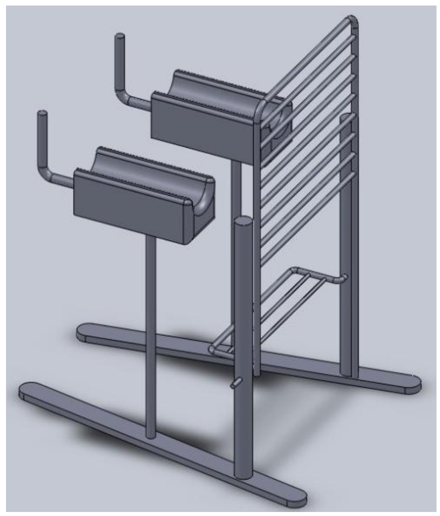

**Figure 27: Adaptive Skiing Device – Alternate Design 3**

**Recumbent Stationary Bike**

<u>Alternate Design 1:</u>

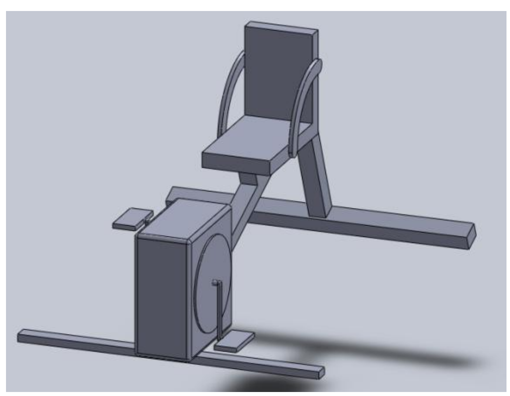

**Figure 28: Recumbent Stationary Bike – Alternate Design 1**

This is very similar to any normal stationary recumbent bicycle, as shown in Figure 28. The seat will slide towards to pedals and lock into place by adding a pin that locks in place through the machined holes in the frame. Inside the housing for the pedals a magnetic sensor will sense the inner fly wheel spinning. When the magnetic sensor detects motion this will set the electrical components housed in the box to drive the toy that will be placed on top of the housing component to move and light up.

The other addition not shown here will be a handle added to the pedals to help Elysa's parents help her move the pedals at first. The chair will be padded more for her comfort and head supports will be added. The same harness will be used as was used for the saddle eating chair to keep her in place. A hinge will be placed where the base attaches to the frame the chair rests on. This hinge will allow the base behind the seat to fold underneath and make the bike smaller for easier storage. Also straps will be added to the pedals to keep her feet.

Alternate Design 2:

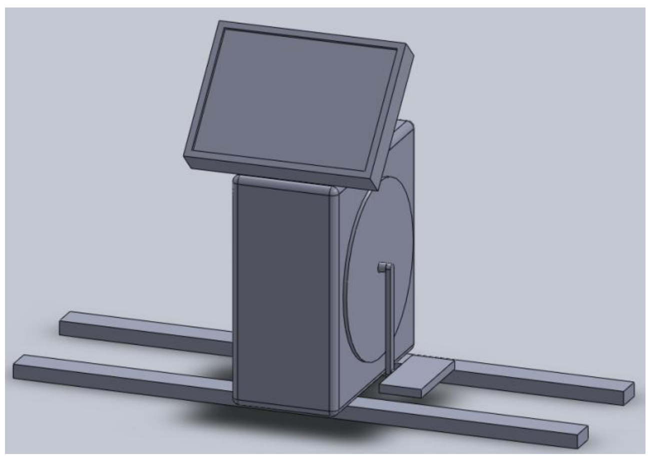

**Figure 29: Recumbant Stationary Bike – Alternate Design 2**

For this design, shown in Figure 29, we simply have the pedal system and the housing component that contains the fly wheel and sensor for the monitor. When the pedals move the sensor will be activated that will then activate the monitor. The advantage of this design is that she can use this for more than just strengthening her legs. Components like this are used in physical therapy so one can strengthen coordination in her legs, as well as arms.

She can be placed in her normal chairs or a chair that can be on the floor. This could be placed at the appropriate distance for her legs easily. The particular design will take up less space in the house. The attractiveness of this is that she will never outgrow it. This will have more than just use in strengthening her legs. It is also a compact design. We don't have to worry about her falling and this component is light so if she did tip it she would not injure her foot if she rolled it on herself.

**Saddle Eating Chair**

Alternate Design 1:

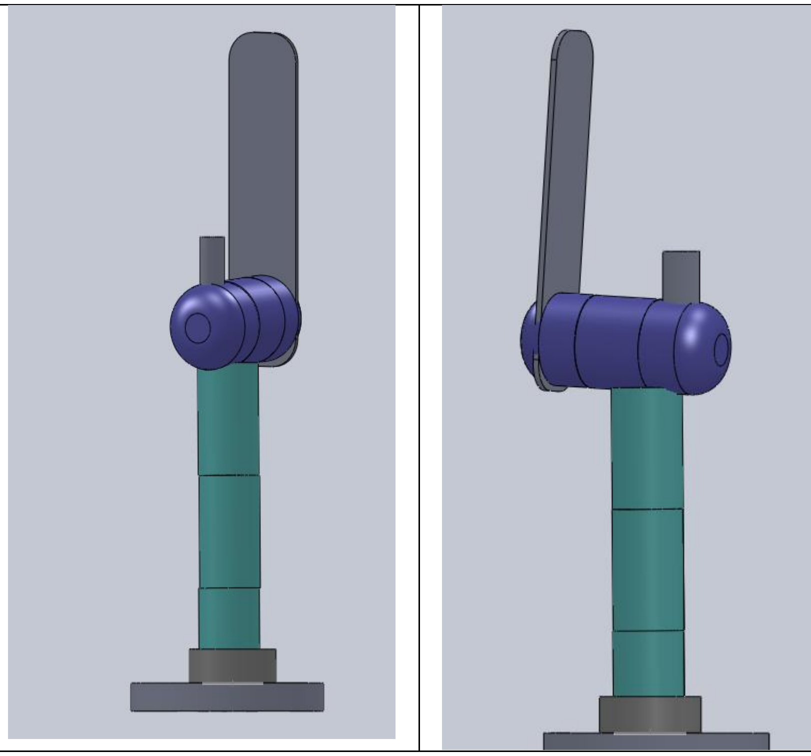

**Figure 30: Multiple Views of the Saddle Eating Chair**

This design is based off a regular barber chair, as shown in Figure 30. The wheel components would be mounted underneath the base. We think it would be best to house the wheels in recessed machined sections under the base. This would keep the chair bottom lower to the ground and make it less likely to tip. The chair would have the typical hydraulic component to make the seat go up and down. The seat has the proper shape for the saddle and we decided based upon the size the diameter of the seat will be eight inches. The similar chair made by achievement products has this sized diameter for a girl Elysa's size.

In the final chair the seat will have the added padding to appear more like a saddle that will be positioned over this seat. We thought it was best to show the main structural components without the added decorations. A pommel would be best to ensure Elysa does not slip off the end when sitting closer to the table as well as aiding her posture and helping position her to sit up. The chair back will also have additional padding to make this more comfortable. Where Elysa's head will be will have additional padding to help keep her looking forward. We will attach the harness on the chair back.


**Figure 31: Harness**

This harness, shown in Figure 31 will be attached at the appropriate height to ensure Elysa's comfort. This design allows a sturdy structure as well as easy of adjustment. The seat height can be changed while Elysa is still in the seat and can be adjusted more precisely.

Alternate Design 2:

The main difference between this design and the first is the base, which can be seen in Figure 32 below. The same harness, back padding, and extra seat cushioning will be added on this design as well.

**Figure 32: Alternate Design 2 – Base**

Six wheels will be attached underneath this base component. one will be under the very front rod. One wheel will go right beneath the rod that attached the chair. Four wheels will be placed under the back section. At the very end of the bent rods one wheel will be placed under both/also where the back T section joins the bent pieces a wheel will be placed under both those junctions. The other different in this chair is the seat height adjustment mechanism.

The chair will move up and down by the rods sliding past each other similar to adjustments in exercise equipment. Several holes will be machined in the rod beneath the seat and a pin will be inserted through both rods that will hold the seat at the selected height. The seat will also be able to be tipped forward or backward by a similar mechanism. Hinges will be placed at every point where the chair posts join the base frame.

As the rod in front of the main post is shortened or lengthened by the same hole and pin mechanism as the chair height is controlled, the seat will tip forward or backward respectively. The back rod can be adjusted in the same manner. The advantages of this design are that it has a less bulky base overall, so that the chair will be lighter and the base should be more stable. The disadvantage is the seat height adjustment will be more difficult as it requires the seat height be adjusted before putting Elysa in the chair.

Alternate Design 3:

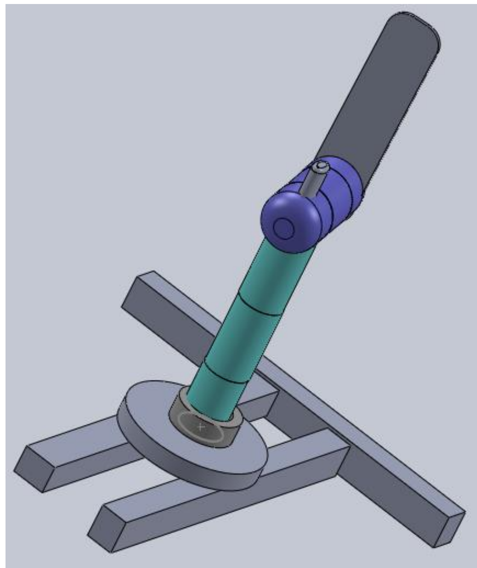

**Figure 33: Saddle Eating Chair - Alternate Design 3**

This design, shown above in Figure 33, has the same barber chair base but underneath we used a similar base as Alternate Design 2. This point of this design is to try and mix the good components from each. Here, we still have the ease and precision of changing the height as well as the stable base. This design will also use the same harness and same chair padding that is used in the other two Alternate Designs.

**Water Bike**

Alternate Design 1:

The first design we have decided on for our water walker and our current front runner for implementation is a recumbent bike that is submerged halfway under water. The Bike will work similarly to a normal recumbent exercise bike but instead of having a wheel to create resistance the pedals on this bike will be slowed by water resistance. The water tension will not create a great deal of resistance but the point is not to strengthen Elysa's leg muscle but rather create a muscle memory.

The bike will be supported by two barrels on either side that will keep the majority of the seat and Elysa's body submerged in the water yet keeps her head afloat. The barrels will be filled with polyurethane foam that will create more than enough buoyancy to keep the device afloat with a person much bigger than Elysa.

The seat will have some restraints but leave room for Elysa to wear her personal floatation device she uses during a normal visiting the pool. The pedals will have handles off the side to allow someone to assist Elysa at first so she can get used to the correct motion of the bike. Below in Figure 34 is a rough CAD of what the project will look like.

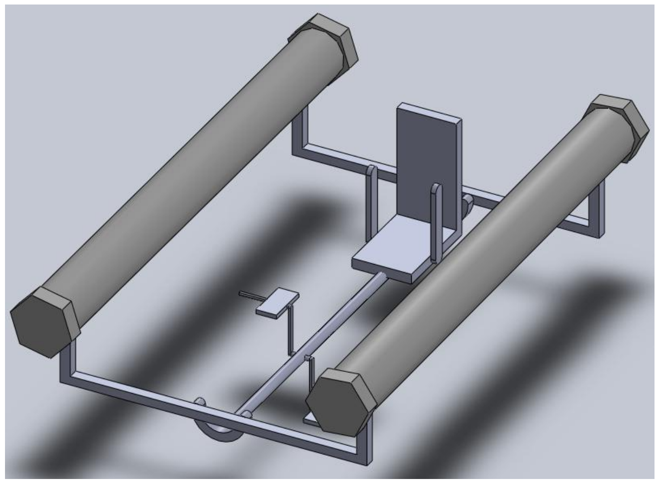

**Figure 34: Water Bike – Alternate Design 1**

<u>Alternate Design 2:</u>

This design is closer to the design from the proposal, using ideas from the Honda dry land walker. Elysa will be wearing small nonrestrictive harness around her midsection that will be attached to the water walker. She will also be attached to the walker just below the knee and above the ankle. There will be hinges at the hip knee and ankle that work similarly to the joints in the leg. The design will allow for a free kicking/swimming motion however will not allow for irregular movement.

The idea is to still allow Elysa to move on her own but again try and create a muscle memory that will continue without the aid of the water walker. One setback to this design is that it does not allow for assistive handles, meaning Elysa will be completely on her own with this device. Figure 35 below is a CAD of the frame that would be built and attached to the harness. Note* this device does not have a floatation device. Elysa will be supported by her normal Personal Floatation Device (PDF) she is currently using.

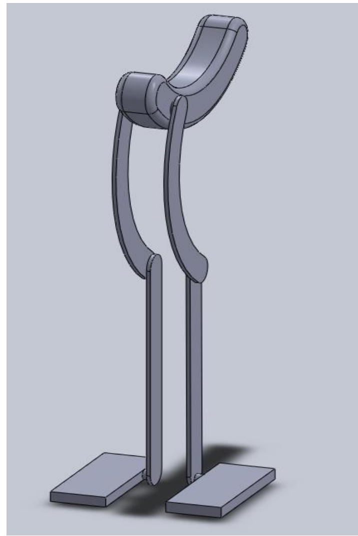

**Figure 35: Water Bike – Alternate Design 2**

Alternate Design 3:

The third design is a spin-off of Alternate Design 2 but creates the option for assistive handles. Again Elysa will be in a small nonrestrictive harness around her midsection. However, instead of the frame being on the inseam of Elysa's legs it will be moved outward and attach to the harness on the outside of her hip. The same basic principles are applied from this point.

The frame allows for back and forth kicking/swimming motion. There will be four handle off the device that allow someone to assist Elysa until she gets the motion on her own. Again the device would once again be attached below the knee and above the ankle. Figure 36 below shows the frame to be built if the design is chosen. Again Elysa will use her own PFD to stay afloat.

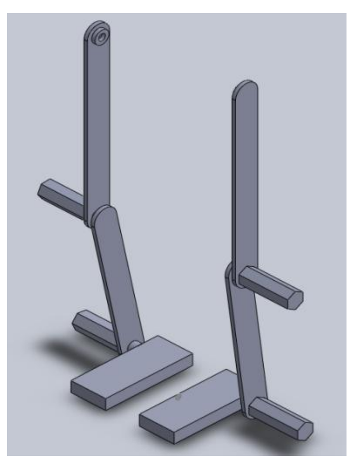

**Figure 36: Water Bike – Alternate Design 3**

## 2.2: Optimal Design

### 2.2.1: Objective

**Zip Line Walking Device**

For the optimal design, it was based off Alternate Design 1, seen in Figures 15 and 16, which allows for the most movement around the room. It consists of a zip line cable attached on either side of the room and a wheeled pipe that glides along the cables. Our concern for this design was the worry that the pulley wheels might fall off the track if there were any sudden movements. After doing further research, we found a steel track system that could eliminate the need for the wheels and pipes and the need for extra pulleys.

Since our initial Optimal Design report, there have been several changes to the device. When we ordered and received our parts, several parts, such as the tracks and much of the zip line parts, were much heavier and bulky than we were anticipating. The track system in particular was rather heavy and as a result, we decided to change the tracks to a lighter material. After talking to Pete in Machine Shop regarding this problem, he recommended using Aluminum strut channels. After more research on the strut channels, we were able to find ones that were eight feet, same length as the Steel tracks. The Aluminum strut channels are much lighter than the steel tracks, but still durable for the purposes of this device.

The trolleys that went along the strut channels came with eye bolts, which eliminated the need for the two bolt-on tie down ring. Another change was to the harness structure piece where the connectors and harness would hang off of. Instead of wood, we are going back to using a metal bar for the structure. This is because after we talked to Elysa's parents, as well as Dr. Enderle and Marek, they had concerns that the medium density fiberboard and wood would not be strong enough to support the tension from the connectors and zip line.

For the zip line, other than the lanyard, everything else: zip line, turnbuckle, cable clamps, thimbles, and swivel were much too bulky and heavy duty for the device. All of those components needed to be down sized from 3/8" to 1/4" or 3/16" wide. Besides the changes to the track system, zip line and accompanying parts, and to the harness structure, the remaining parts of the device remained unchanged.

Most of the parts of the device are premade, thus there is not much fabrication needed, other than for the harness structure. The harness itself needs to be adjusted to fit Elysa's body. The device needs to be structurally stable enough to support Elysa's weight, the tension from the cable, and the weight of the individual parts that are hanging from the track. Taking into consideration of these factors, we are planning on installing the tracks as close to the ceiling as we can. This is so that we are able to bolt them into the support beams and keep the track stable and in place.

**Adaptive Skiing Device**

The main purpose of this skiing device is to provide support and enjoyment for children with difficulty coordinating movement and supporting their bodies. The device allows the user to enjoy and experience the feeling of skiing, and at the same time, being secured when standing on the ski. This device does not target handicapped people since it still require the users to stand still and hold on to the devices for minimum support. The device includes a back support, arm rests, and a full-body safety harness that provides support.

For the optimal design, we chose Alternative Design 2 since it matches the client's expectations of being simple and not bulky. Aluminum will be used to create the frame for the back support. A piece of outdoor canvas will be used to provide a more comfortable and simple support. Arm rests will be added with aluminum tubing between the arm rests and the back support. To connect the tubes of the structure to the ski, the pivot mounting feet will be used for better connectivity; one side connects to the tubes and the other connects to the ski.

**Recumbent Stationary Bike**

This devicesis meant to aid Elysa in strengthening her legs. This is a typical recumbent exercise bike that will be modified to fit Elysa. Also for motivational purposes a toy will spin in response to the pedaling power. The exercise bike has eight different resistance levels and will be well suited to any level of strengthening she can try. An aditional handle will be added to help her parents spin the pedals to help her learn how to do it. This device will securly strap her into place and the chair will be modified to be more comfrotable .

This frame fits the desired forms from the optimal design. The A20 model is lightweight and small. It has the fly wheel and electrical housing packaged well and based on the design has enough room for the small amount of additional electrical components that will be added to fit inside. The full frame design was best as compared to simply the pedals because the special seating will allow Elysa support and security while exercising. The simple pedal set up would make it more difficult for Elysa to have assistance while pedaling.

**Saddle Eating Chair**
This chair is designed to give Elysa freedom of motion with her legs while sitting in the chair and also this chair will allow her arms free motion. This chair will provide minimal restriction the chair has a base with locking wheels. The base will be made from aluminum rectangular tubing 2 inches in length and one inch wide (2.54cm). A figure of the base design from above is shown in Figure 68. The base is wide to prevent lateral tipping.

The piece connecting the base and the seat will be telescoping tubing and will be the same width and length as the base piece. The telescoping tubing will be used to adjust the seat height. Holes will be machined in the tubing. As the seat is pulled higher the user will align the holes and spring loaded pin can be inserted through the hole and hold the seat at the desired height. Also there will be an additional support attached between the base and the seat adjustment that will allow the seat to be tipped forward or backward.

The mechanism will be similar to the one pictured in Figure 69. The seat will be a modified bicycle seat that was a left over part from past senior design projects. A pommel and additional cushioning will be added to the seat. Another extra part available from the la will act as the lower back support and this piece will be mounted by connecting it to the chair. The rest of the seat back will be fabricated from wood and cushions available in the lab.

**Water Bike**
The objective of the water bike is the same as the recumbent bike to be set up in the living room. It is meant to strengthen the muscles in Elysa's legs as well as develop a rhythmic motion that will translate back to the dry land recumbent bike. The Carlson family often visits the local public pool to enjoy a family swim. This is a great opportunity for Elysa to have fun as well as work in some hydro-physical therapy. The water will provide a significant enough resistance to strengthen Elysa's muscles. Elysa has taken trips to the pool in the past however this will offer a source of restricted movement she will not experience otherwise.

The design will float on the surface of the water with the majority of the frame and Elysa's body just below the surface. The farm built from PVC and filled with polyurethane foam will offer more than sufficient support to keep both Elysa and the bike afloat. Also, the PVC will be strong enough to remain rigid while in use, which is essential to the efficiency of the bike.

2.2.2: Subunits

**Zip Line Walking Device**

2.2.2.1: Track System

The track component of the device is made up of the aluminum strut channels and the trolley with accompanying eyebolt. A pair of aluminum strut channels will be mounted on two of the entryways, via screws. They will mounted as close to the ceiling as possible to allow the channels to bolted into the support beams and keep the track stable and in place. The tracks themselves are hollow, slotted-hole channels. The holes are 9/16" wide by 1 1/8" long and are spaced on 2" centers. We decided on getting the slotted-hole aluminum channels instead of the solid channel as the slotted-hole channel would be lighter. It would also save time from drilling the holes since the holes have been drilled out already.

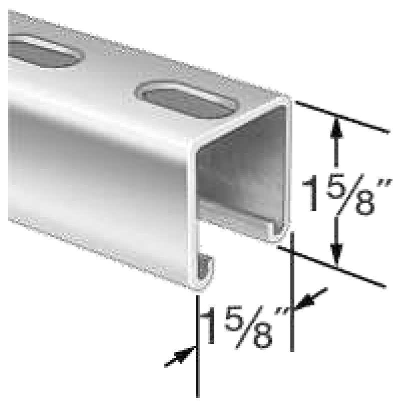


**Figure 37: Aluminum Slotted-Hole Strut Channel**

The channel itself is 1 5/8" x 1 5/8", is 0.08" thick, and has a length of eight feet, as seen in Figure 37. We ended up getting the eight foot track, as it was the same length that the original steel tracks were. The tracks, if they are painted, would be either green or white, which would match the color scheme of the family room. We have not decided if we are going to paint them, but if we end up doing that, we might end up either spray painting them ourselves or sending them out to get them painted professionally.

The wheels of the trolley are inside the track, rather than rolling on top of the cable. In the original version of Alternate Design 1, the zinc-plated steel pulley rolled on top of the cable. If for any reason Elysa were to move suddenly in any direction, there would be a risk of the wheels falling off, since the wheels were not connected to the zip line cables. The enclosed track will prevent the wheels from falling off as they roll within the track.

The trolleys, shown below in Figure 38 one in each channel, are made of zinc-plated steel. Each of them has a horizontal plate with a 3/4" diameter eyebolt. As this particular trolley comes with an eyebolt, this will replace the bolt-on tie down rings, and will provide a sufficient place for a carabiner and zip line to attach to.

**Figure 38: Zinc-Coated Steel Trolley for Strut Channel**

<u>2.2.2.2: Zip Line Cable</u>

3/8" galvanized aircraft cable will be used in the zip line portion of the device, shown below in Figure 39. The cable is strong and flexible. It will span the width of the room (13' ½"), but there will be around two feet of extra cable to allow it to be tied off. Steel cables are impossible to tie a traditional knot around. To accomplish this, cable clamps, seen in Figure 40, also known as wire rope clips, are use to tie off the cable.

**Figure 39: Galvanized Aircraft Cable**

**Figure 40: Galvanized Cable Clamp**

**Figure 41: Galvanized Thimble**

The cable is folded around a device called a thimble, as seen in Figure 41. These prevent the cable from crimping and protecting it from wearing at the anchor points. Once around the thimble, three cable clamps are clamped onto the cable. More than three cable clamps can be used to tie off cable. However, three clamps is the minimal amount of clips needed to tie of the cable. Usually three to four clamps are used in normal applications, but more can be used if there is an extra excess of cable. Figures 42 and 43 show how a finished tied off cable should look like.

**Figure 42: An Actual Cable with Cable Camps and Thimble**

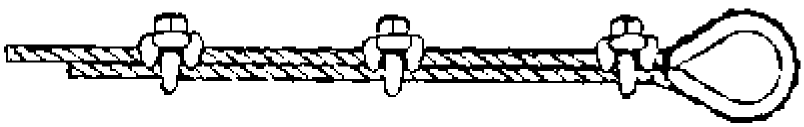

**Figure 43: Drawing of a Tied Off Cable**

2.2.2.3: Attachment Connectors

To connect the zip line to the eye bolt, a carabiner will used. Carabiners have many applications, but for this device, they provide the connection between the zip line, trolley/pulley, lanyard, and harness.

**Figure 44: Locking Carabiner**

**Figure 45: Non-Locking Carabiner**

There are two different types of carabiners: Figure 44 displays a locking carabiner and Figure 45 shows a non-locking carabiner. Figure 42 shows an example of a locking carabiner used to connect the zip line to the eye bolt. We are planning on using non-locking carabiners as they are cheaper than locking ones. Locking carabiners not necessary unless they are needed in applications where something could push against the latch, which would unhinge the carabiner. We might consider using the locking carabiner between the harness and straps so that Elysa cannot accidently unlock the carabiner if she were to accidently push the latch. For now, all of the carabiners that will be used will be non-locking, unless otherwise needed.

2.2.2.4: Rotating Dynamic

A swivel is used to add a rotating dynamic when one is riding a zip line. In this case, we are using the swivel to allow Elysa to turn around and walk back in the direction that she just came from. The swivel can connect directly on the pulley, as to provide the connection for the carabiners and various attachments, shown in Figure 46.

**Figure 46: Swivel and Attachments**

2.2.2.5: Trolley

Zip line trolleys are used to glide a person down a zip line. The trolleys must have hardened steel sheaves to protect the trolley from wear and tear of cable riding. As this device uses a zip line and trolley in a more unusual fashion, the hardened steel sheath does not make a significant difference, if it even makes a difference at all.

**Figure 47: Petzl Tandem Speed Trolley**

All of the trolleys that we found that are specifically used for zip lining have a double-wheel design with ball bearings. This design is there to prevent the cable from twisting as the trolley rolls down the cable and provide minimal to no friction while doing so. There are various kinds of trolleys, ranging to ones with handles, ones that come with an integrated carabiner, and ones that have high speed capacities. Since we do not need any of the extra features, let alone extra speed capacity, we decided to go with the simplest and cheapest design we could find, which is pictured above in Figure 47.

2.2.2.6: Harness Structure

The harness structure will be a rectangle block of aluminum that is 10” x 3” x 1/4” (L x W x H). In the Optimal Design, we were initially going to replace the aluminum with wood or medium density fiberboard, but there were concerns that it might not be strong enough for the application. Now, the aluminum block is back and we were able to find a block in Machine Shop that is 1/2” thick. It is going to be milled to 1/4” thick. The block does not need to be the original thickness and it will also reduce its weight.

On the top and bottom of the block, there will be three steel eye bolts, as shown in Figure 48. The top three eye bolts will be connected to the lanyard and adjustable bungee cords, while the bottom three eye bolts will be connected to the straps that are connecting to the harness. The eye bolts will be painted to match the rest of the device. This is mainly for aesthetics, rather than for functionality.

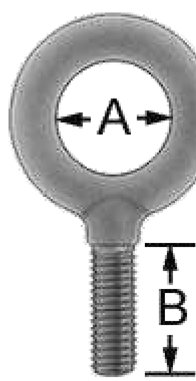


**Figure 48: Steel Eye Bolt**

2.2.2.7: Harness

Elysa’s parents requested that we found a harness that would provide minimal support as they do not want her to have so much support that she is constrained to limited movement. They want her to be able to have just enough support to keep her upright and to allow for maximum movement. We were able to find padded harnesses that provided just enough support to allow for movement, as shown in Figure 49.

Similar harnesses have loops built into the shoulder and back straps, which are useful for attaching straps or bungee attachments to. However, as mention the zip line alternate designs, these kinds of harnesses are only made in adult sizes, which even though they are adjustable, they are too big to fit Elysa's tiny frame, and are expensive. As a result, we are planning on buying a cheaper, similar looking in appearance and adding padding to it to make it comfortable enough for Elysa.


**Figure 49: Suspension Trauma Harness**

**Figure 50: Trango Junior Kids Rock Climbing Full Body harness**

The harness that we plan on modifying is kids full body rock climbing harness, as shown in Figure 50, which is fully adjustable and also comes with leg padding. We would have to add padding to the shoulders, torso, and back, but at least there is one less part to pad. When we meet up with the client again after purchasing the harness, we will determine how much padding we need to add and location of where we need to place it. Cloth will be added to the padding to provide protection from wear over time.

<u>2.2.2.8: Suspension</u>

Lanyards, bungee cords, and straps will be used to connect the harness to the structure and to the pulley. Lanyards are most commonly used as a connection between the trolley and harness in zip lines. The lanyard, as shown in Figure 51 for this apparatus will connected in a similar fashion to how it is connected for zip line use. One end of the lanyard will connect to the trolley with a carabiner and the other end is connected to the harness at its tie in point.

**Figure 51: Lanyard Connected to Pulley via Carabiner and Tie Point in Harness**

The difference in this case is that the end with the carabiner will connect to the swivel (which is attached to the trolley) and the other end will be tied into the Aluminum u-bolts on the harness structure. The lanyard will be placed on the top middle u-bolt on the block, as it will take most of the weight of the rest of the structure. Two adjustable bungee cords, shown in Figure 52, one on either side of the lanyard, will be attached to the other two top u-bolts at one end, and attached to the swivel carabiner at the other end. These two cords will be used because they will help keep the structure balanced. They also come with clips on either end, which reduces the number of carabiners that are needed for connections. Since the cords themselves are adjustable, they can be adjusted as needed.

**Figure 52: Adjustable Bungee Cord**

**Figure 53: Strap with Buckle**

To connect the harness to the u-bolts on the block, three 60” buckle straps, shown in Figure 53, will be used. These will be connected to the harness via carabiners that are placed on the shoulders straps and on the back. The reason why we are using longer straps is that the longer straps allow room for adjustments as Elysa grows.

**Adaptive Skiing Device**

2.2.2.9: Overall Components

Three major components are going to be added to this device; the back support, arm rest and mounting feet. These components will be explained and they are also pictured below in Figure 54.

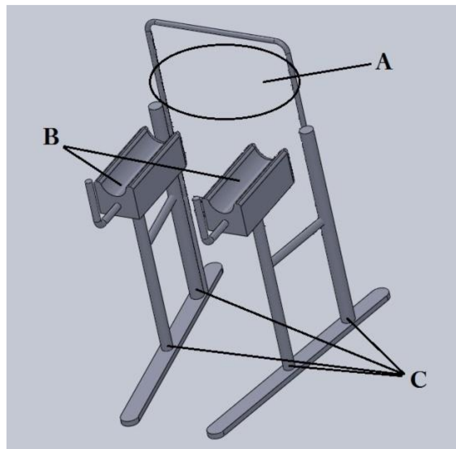


**Figure 54: Overall Structure**

**Parts: A) Back Support. B) Arm Rests. C) Mounting Feet**

2.2.2.10: Back Support

In the optimal design, we were planning on using several horizontal steel bars as our back support. But now, instead of using the horizontal bars, a piece of outdoor canvas that is about 1 yd * 54.3” will be used as our back support. It can provide support and it is also more comfortable for Elysa to lean on it. Outdoor canvas is sturdy, cold/water resistance, and corrosion resistance, so it is suitable for our design. The outdoor canvas will be tied around the side bars like the design for outdoor canvas chair, as shown in Figure 55.

**Figure 55: An Outdoor Canvas Chair**

2.2.2.11: Arm Rests

The arm rests are essential for the skiing device because they provide support and balance to Elysa. The arm rests are shown in Figures 56 and 57 below. While riding on the device, Elysa can put her arm comfortably in the U-shaped arm rests that are inserted with comfort foam. This way, Elysa can easily balance herself on the ski. Rubber grips or grip tape will be wrapped around the handle bar in order for her to have a better grasp. There will be two aluminum tubes welded to the bottom of the arm rest, and will be adjusted to Elysa's arms position. Also, between the tubes of the arm rests and side bars of the back support, a horizontal bar will be welded to connect each arm rest tube and side bar for better stability of the whole structure.

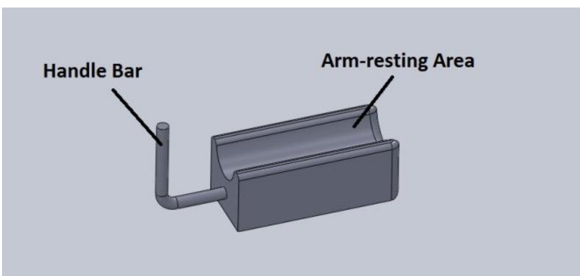


**Figure 56: Illustration of an Armrest**

**Figure 57: The Actual Armrest That Will Be Used**

2.2.2.12: Mounting Feet

In order to connect the ski and the aluminum steel tubes, perforated base studs and tube adapters, shown in Figures 58 and 59 respectively, are needed. Tube adapters have threaded holes, which can be screwed onto the perforated base studs that consists of threaded rods and connect the tubes and ski together. Tube adapters with the suitable size can be inserted to one end of the hollow tube. The perforated base studs can be fixed on the ski by using screws and standoffs.

A standoff, shown below in Figure 60 is a round tube with threads on the inside. Holes will be drilled on the skis but not all the way through, and then the standoffs will be inserted into the holes in order to hold the screws that are used for fixing the base studs. Four perforated base studs and tube adapters will be needed.

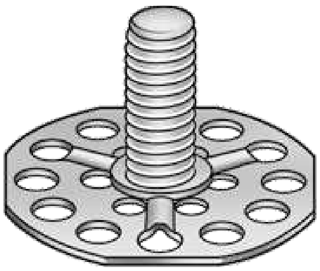

Figure 58: Perforated Base Stud

Figure 59: Tube Adaptor (round)

Figure 60: Standoff

<u>2.2.2.13: Harness</u>

The model we will use for a harness is the Trango Junior Kids Rock Climbing Full Body Harness, as shown in Figure 50. The harness will be attached to the back cushion and back support. It will be adjusted to her appropriate height and keeps her steady in standing position. This is also the same harness that will be used for the Zip Line Walking Device when this device is not in use.

**Recumbent Stationary Bike**

<u>2.2.2.14: Overall Structure</u>

A top down aproach will be used to look at this machine. First we will examine to over all apearance and deisrability of the dimensions. This bicycle offers many interesting features. The display is easy to read and control, which can be seen below in Figure 61. The housing shown in Figure 61 is plastic and light weight.  it can be easily painted or decorated to add more flare and fun for Elysa.  The total weight of the machine is 60.1 lbs (27.3 kg), which is light weight and desirable.

The weight capacity of the machine is 275 lbs (125 kg) and its dimensions are as follows: 61" L x 16.5" W x 40.5" H (155 x 42 x 103 cm). This machine is relatively small and is optimal for in home fitness. This recumbent bicycle is more than capable of handling Elysa’s weight and is large enough for her to use this machine for as long as she wants. This machine will be able to adjust to her full adult height.

**Figure 61: Overal Bike Structure**

2.2.2.15: Wheels and Pedels

The base wheels are n the front of the machine, which allow it to be easily rolled from room to room.

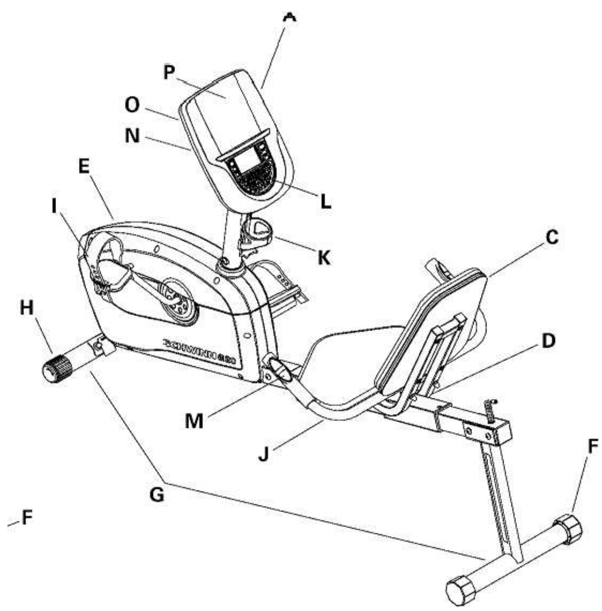


**Figure 62: Diagram of the Parts of the Stationary Bike**

In Figure 62, Part H corresponds to the wheels. One modification we are making is using normal bicycle pedal with cages. These will keep Elysa's foot most securely in place. They will replace part I. A handle will be added to the wheel to allow Elysa's parents to guide her feet and to help her move the pedals. The handle is pictured below in Figure 63.

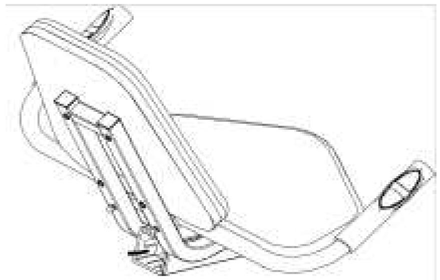

**Figure 63: Handle Bars**

2.2.2.16: Seat and Track

The seat and track sliding parts of the bike will be modified. In Figure 64 below, Part H shows the knob that allows the bike to slide and lock into the holes to lock into place. Also in the figure it is clearly shown how the track, labeled Part 4, and seat pieces are placed together to allow the seat to slide down the track. Holes will be machined closer to the pedals to allow the seat to move farther forwards for Elysa to reach the pedals.

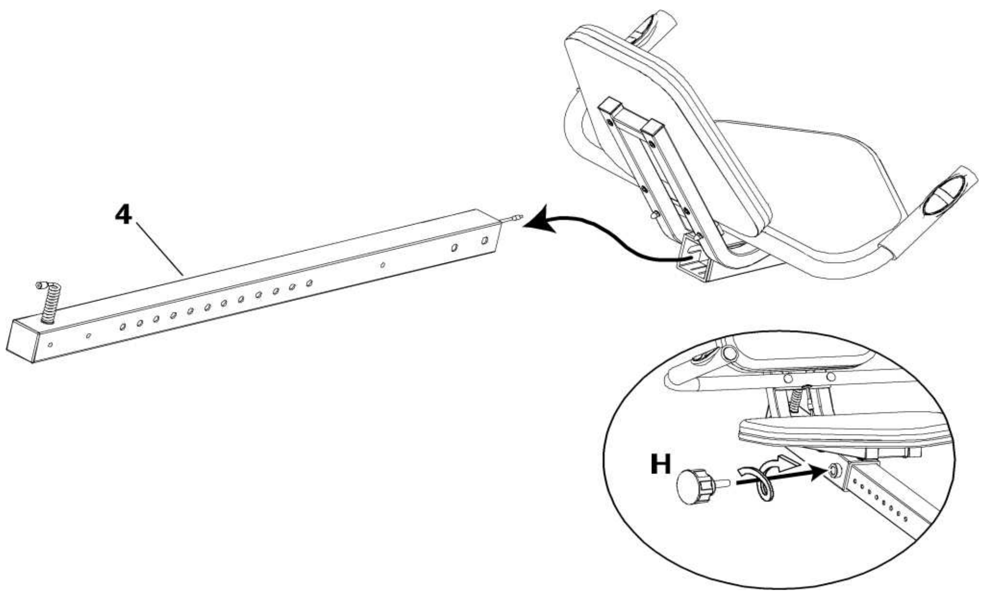


**Figure 64: Seat and Track**

The largest modification to the seat will be a piece securing her head looking forward. This will be attached by adding it to the metal components of the seat back pictured in Figure 64. Two pads will be added to either side of her head. The same EZ on adjustable vest (Model 103z), which can be seen in Figure 75, that will be used for the eating chair will also be used here to hold Elysa securely into place. It will also attach and be held in place by straps that connect to the metal rods in the back of the chair.

2.2.2.17: Electrical Components

In the new display design for the recumbent bike we will create a mood light RGB led system. The RGB LEDs will be housed similar to the picture below in Figure 65. An opaque cylindrical case will be placed over the lights. The opaque shade will spin as Elysa pedals. The shade will have images of a horse printed on it. It will spin and create the same effect as a zoetrope so that the horses will appear to be running. This will all be powered by a 12 v ac/DC transformer that can be plugged into the wall. We will also need a microcontroller to drive the changes in the LEDs to create the different colors for effect.

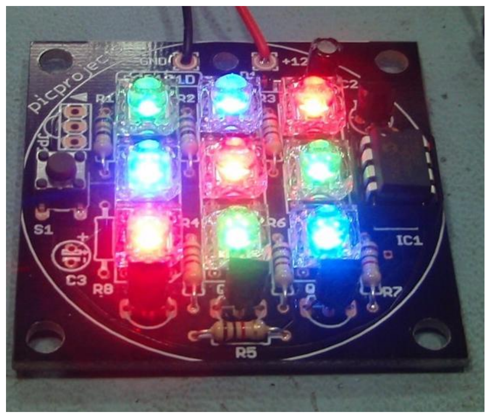


**Figure 65: RGB LEDs**

An outboard brush motor will be used the model will be similar to Figure 66.


**Figure 66: Outboard Brush Motor**

**Saddle Eating Chair**

2.2.2.18: Wheels

Caster wheels from the McMaster-carr website will be used to allow the chair to be mobile.

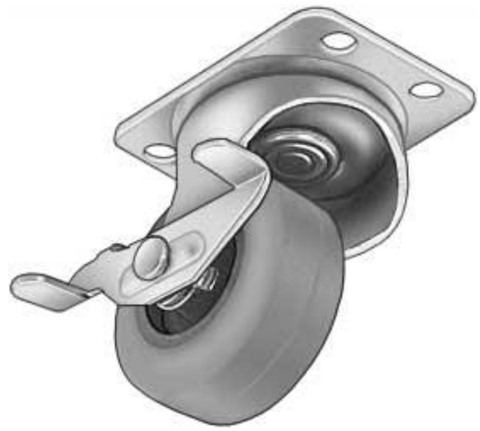

**Figure 67: Caster Wheel**

In Figure 67, you can see the locking mechanism is attached on the side of the wheel. Each wheel and caster has a 100 lb. capacity. This is also a swivel mount to allow for easy movement of the chair in any direction. The holes will allow the wheel to be attached directly by screws through machined holes in the aluminum base frame. The design plans for 8 wheels.

This will allow an 800lb capacity. This is safe enough to handle Elysa's weight (32 lbs.) and the weight of the frame and seat. The wheels are non-marking so will be good to use indoors. The 4 holes will allow 4 attachment points that will provide a very secure connection to the tubing frame. The mounting is 2 and ½ inches (6.35 cm) off the ground.

2.2.2.19: Base Frame

The base frame will be made from rectangular aluminum tubing. The dimensions will be 1 inch (2.54 cm ) wide by 2 inches(5.08cm) long. This will also be ordered from McMaster. The wall thickness is 1/8 inch (.32cm) the frame will have a similar shape to the following device that was found at the Neat Marketplace.


**Figure 68: Base Frame Mechanism**

The frame for our design will be very similar to this picture. There will be another piece of frame perpendicular to the frame at point one. This extra piece will be about a foot and half this will help with any lateral motion. Two wheels will be placed on the ends of the additional perpendicular piece.

A wheel will be placed under the frame in the position labeled 2 in Figure 68. Wheels will be placed under sections labeled: 3, 4, 5, and 6. The aluminum frame will be able to withstand the weight requirements and also be easily welded able. Aluminum is also light weight. Where the frame has bends those will be formed by pieces that were cut and welded together.

<u>2.2.2.20: Frame Attachment to Seat</u>

Telescoping Aluminum rectangular tubing with the same length and width as the base frame will be used to connect the seat to the base frame. The telescoping tubing will allow easy vertical adjustment of the seat. The placement of this tubing will be similar to the Figure 69, points 3 and 4, except the distance depicted by point A will be about a foot and a half.

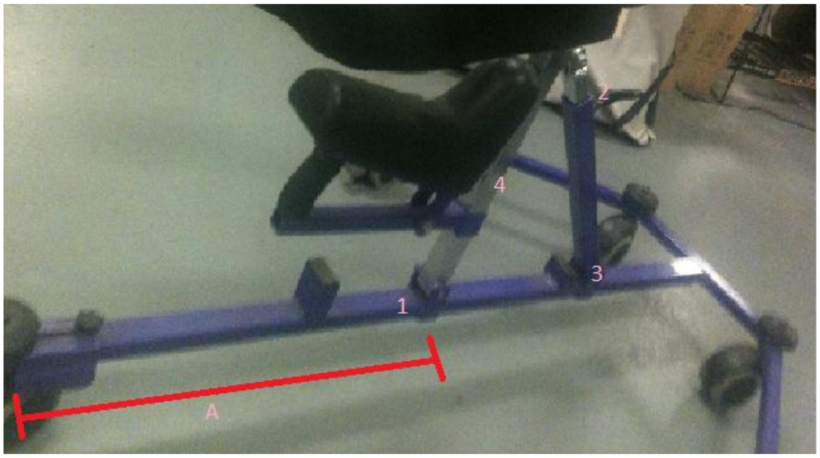


**Figure 69: Tubing Placement**

As shown at Point 1, the telescoping tubing is attached to the lower frame by a hinge. Also at the point labeled 3 there is another hinge. At point 2 this support is also telescoping tubing. The telescoping tubing at point 2 and the hinges at Points 1 and 3 create the mechanism to tip the chair forward and back. Locking mechanisms keep them firmly in place. In the frame for our design the seat will need to be at least 18 inches off the ground for Elysa to sit and at the lowest table height of 28 inches. That is much higher than this picture. So the tubing section under the seat depicted as between Points 1 and 4 will be about 18 inches when the inner tube is completely inside the outer tube. If this piece is 18 inches this will allow the next table height of 36 inches to be reach easily.

<u>2.2.2.21: Seat</u>

The seat will be a modified bicycle seat from the spare parts from the senior design lab. The seat is shown in the Figure 70. The width below the seat is 11 inches wide. This width is wide enough to comfortably fit under Elysa and fully support her. The length of the seat is 11 and ½ inches. Three rods are already underneath the chair to allow for easy mounting this is shown in Figure 71. A sheet of aluminum will be welded to the telescoping inner tubing. Holes can be drilled through this sheet and the 3 rods insert into these holes. The rods are threaded so by using the appropriate nut the bicycle seat can be attached to the lower frame.

**Figure 70: Bicycle Seat**

**Figure 71: Seat Attachments**

A small pommel will be fabricated by the group from cushioning material in the lab. The pommel will be placed at the tip if the bicycle seat shown above Figure 70. This will keep her from slipping forward and also help with her posture.

Another spare part from the design lab will be used to add lower back support arms rest and extra stability to keep Elysa from bending her torso too far to either side. In the back you can see any rectangular insert that can be used to attach this to the sheet under the bicycle frame using any rectangular post, as seen in Figure 71. Any simple hinge and bolts can be used. This would allow the seat back to be adjusted slightly.

The seat and lower back support are shown together and will be similar to how they are arranged for the final design. They are depicted below in Figures 72 and 73 showing a couple different views.

**Figures 72 and 73: Seat and Lower Back Support Views**

Her shoulder width is 11 inches so the support for her upper back and shoulders will be that wide. We will fabricate it ourselves from the memory foam cushioning, fabric and wood as the back. For around her head extra cushion will be added.

The piece to be used to support her shoulders and head will be similar to the picture shown below in Figure 74.

**Figure 74: Head and Shoulder Support**

Here the back and head rest are attached to a rod and the connection to the seat bottom similar to the one for our design.

2.2.2.22: Safety Harness

To strap Elysa securely to the chair, the EZ on adjustable vest will be used, which can be seen below in Figure 75.


**Figure 75: EZ Adjustable Vest**

This vest was chosen because it is minimalistic. It has easy zipper adjustment for quick changes. It can also be put on Elysa before she is placed in the chair for ease. The attachment above the shoulder will keep her shoulders firmly back into the chair. The attachments low on the waste will help keep Elysa's lower back firmly against the seat. Both these attachment points will help her posture in the seat. These will be attached through straps that will attach to the chair back. They will be adjustable.

**Water Bike**

2.2.2.23: Seat

The seat we are planning on using we will purchase from the neat marketplace. It is already fabricated to the specifications we need. The frame is some form of PVC piping and is already fitted with a mesh material as the actual seat. This will be ideal for the water bike because it will be completely water resistant. There are already holes used to connect the seat to another PVC frame, so it should be no problem to transfer this seat to our new frame. The only addition that will need to be made is the attachment of a small slightly restricting belt. We simply want to keep Elysa in the chair, however if she does fall out her personal floatation device (PFD) will keep her afloat. The idea of the belt is to help

Elysa stay in the chair but not necessary keep her there. Figure 76 below is an image of the chair sitting at the Neat Marketplace.

**Figure 76: Water Bike Seat**

2.2.2.24: Pedals

The pedals will go right through the frame of the center frame of the bike. They will work similarly to the pedals on any regular exercise bike but will have no need for any sort of resistance. The water itself will cause a certain amount of resistance but the idea is not to strengthen Elysa's legs but rather get them familiar with the motion of using the exercise bike. There are two unique features about the pedals on the exercise bike. First is that there will be handles on each of the two pedals facing outward.

The purpose of this is so somebody can stand in front of the bike and help guide Elysa into the correct motion. The second adaptation is between the handles and the pedals themselves will be a set of arms extending upwards to just below Elysa's knee joints. There will be an extra strap here to wrap around her calf and add more support to the entire leg not just the feet. The arms will be attached but still allow the pedals to rotate freely.  This should make the bike motion easier to learn. Figure 77 below is the basic concept for the pedals and how they will be installed on the bike.

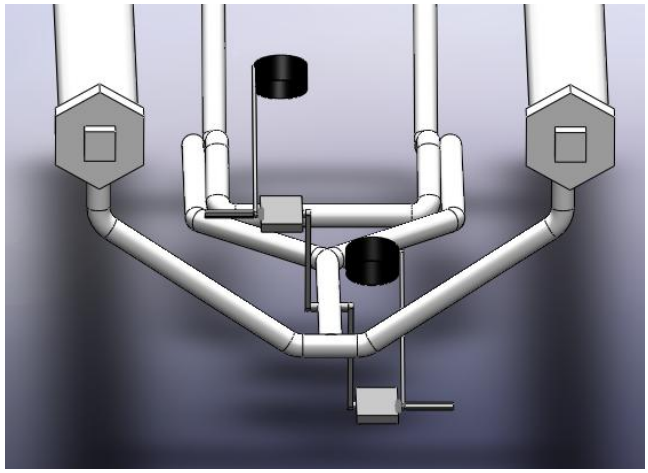

**Figure 77: Water Bike Pedals**

<u>2.2.2.25: Frame</u>

The frame itself is very simple. It will consist of 1 ¼” PVC tubing. PVC is ideal for the frame assembly for a number of reasons. First and foremost it that it is waterproof and will float. It also comes in a variety of sizes and allows for unique assemblies with many different parts. It will be durable enough for our design and it is also relatively inexpensive in comparison to other options. The two side tubes will consist of 4” PVC and will be roughly 3 ½’ long.

These will be filled with expanding Polyurethane foam for added buoyancy. When the foam has dried one cubic foot is enough to support roughly 60 lbs of dead weight in water [1]. With roughly ¾ a cubic foot of foam in addition to the tubes natural buoyancy staying afloat should not be a problem. Figure 78 is a diagram of the frame assembled with the pedals and chair.

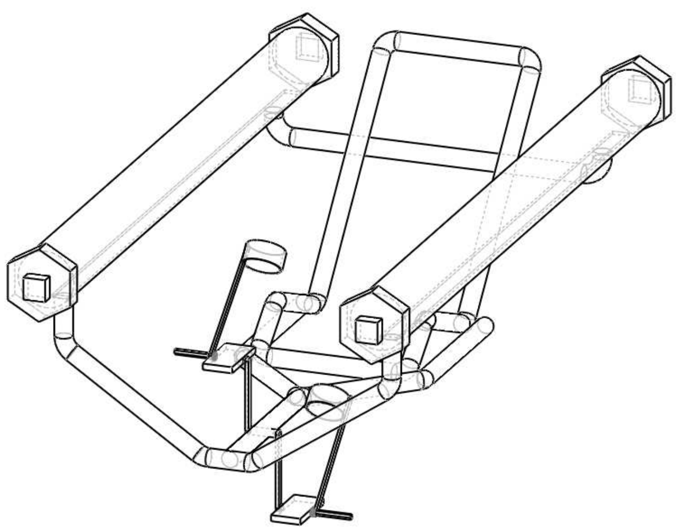

**Figure 78: Water Bike Frame**

## 3: Realistic Constraints

### 3.1: Economic Constraints

**Zip Line Walking Device**

There is going to be limits on the budget as a whole for two reasons: 1) our budget has to be divided among our several projects and 2) we can only ask for so much money so that all groups will be able to get money for their projects. Another constraint is with the harness. Ideally, we would hope to have enough money purchase one that is already padded, more durable, and safe than a cheaper harness. However, these more expensive harnesses are not an option because even if we have the money for one, the harnesses only come in adult sizes, which are too big for Elysa.

We plan on buying a more affordable harness that can be adjustable and made to be more comfortable. With the tracks, there is the option that we could buy additional tracks that can be installed on the rest of the first floor, but that is only if the family was willing to have more than one set of tracks installed in their house. However, if they wanted to have multiples tracks installed in their house, it is uncertain if we would even have the money to get more than 1 set of track.

**Adaptive Skiing Device**

The design itself should be affordable to anyone. There are many commercial products in the markets but they are all pretty expensive. Our goal is to design the similar device compared to the commercial products but more specific for Elysa's situation, while the price is low enough that if other family with the similar situation can also afford to buy it.

**Recumbent Stationary Bike**

The economic constraints will be minimal for the recumbent bicycle. The model we are going to use is cheap and the safety vest will be the same as the one used for the eating chair. The electrical components will be cost effective as well.

**Saddle Eating Chair**

Economic constraints are minimal for this design. The materials for the base seat post and seat are very inexpensive. We need to be very careful in fabricating this design so that costs do not accumulate due to extra parts being ordered to replace others.

**Water Bike**

For the most part this project should be very affordable. The PVC piping that the frame support barrels will be made from is relatively inexpensive. It will be important to only order the parts needed as to not waste time and money. The seat picked up from the NEAT marketplace as well as the exercise pedals were also fairly inexpensive.

3.2: Environmental Constraints

**Zip Line Walking Device**

This device is made to be used inside the client's house, which would limit the usage to indoor settings. As the track needs to be installed in the walls, it limits the mobility of the track portion of the device as it can only be installed in one room at a time. While it can be removed and installed in a different room, as all of the rooms on the first floor are 13' ½" wide, we were planning on keeping the tracks permanently installed in the family room since it would be a hassle to move the tracks into different rooms of the house. It is doable, but not practical. The family room in particular provides the most open space, which limits the chances of Elysa bumping into something.

**Adaptive Skiing Device**

Since the device is made for skiing, the device can only be operated on the snow, otherwise the skis would be damaged due to rough surface. Also, due to Elysa incapability to control her body, this device is only suitable for her to operate it in the backyard; there is no control mechanism on the device, and the design is not made to be operated on the slope, not even for bunny hill.

**Recumbent Stationary Bike**

This device will be used indoors so it does not need any consideration for extreme temperatures or rainy conditions.

**Saddle Eating Chair**

The eating chair is to be used indoors so no components need to stand any environmental extremes. The chair will need to have materials that can stand up to spills and necessary cleaning.

**Water Bike**

The water bike will be used in an aquatic environment at the local pool. For this reason the bike will have to be completely water proof and able to withstand long periods of time in water without the worry of corrosion. Also, the bike must be able to stay afloat while supporting its own weight at well as Elysa's weight. Finally the bike must be able to withstand mild to moderate waves and still work efficiently as it is a public not private pool.

3.3: Sustainability and Mechanical Properties

**Zip Line Walking Device**

As we are planning on Elysa to use the device for a long time, to maximize the amount of strength she gains from using the device, the materials used to make the device are important. Most of the materials are either for zip lining or made for industry, so they are all very strong and durable.

**Adaptive Skiing Device**

Sustainability is important since we want the design to be used by Elysa frequently until she is able to voluntarily control her movement. Therefore, it is important to decide which material should be used for the design. We are using aluminum 6061, which exhibits high wear resistance, high mechanical strength, light weight, and good corrosion resistance. Aluminum 6061 has been used for an assistive skiing device made by Freedom Factory, thus it is also suitable for our design. With this material, the sustainability of the device can be greatly increased.

**Recumbent Stationary Bike**

The biggest worry about sustainability will be the electrical components in the display. The case for the display must be able to dissipate heat well. LED's are adversely affected by heat. The casing mood light case must be resistant to small disturbances. If it can be bumped at all without breaking this would be an inefficient design.

**Saddle Eating Chair**

The largest concern for sustainability is to make sure the telescoping sections stay wear proof as they slide past one another. Also the harness and straps Need to be able to stand up to use by Elysa. The wheels should be strong and Durable to withstand moving it around and also the locking mechanism should Be able to stand up to usage.

**Water Bike**

The water bike must be able to withstand long periods of time in water without filling with water or having any sort of corrosion form. The bike must also be able to withstand long periods of time without use and still be ready for water at any point. The bike must be able to support Elysa's weight and movements without compromising its integrity while in use.

2.4: Health and Safety

**Zip Line Walking Device**

The device is designed specifically for Elysa. While all of the main parts of the zip line and track have capacities of over a few hundred pounds or more, it should not be used by adults. She should always have parent supervision, at least at first, until she can stand and walk around on her own without needing her parents' assistance. Even though the track can be moved to different rooms on the first floor, as they are all the same width, it is not practical to move the tracks and could be dangerous if someone were to drop them. For the zip line and the lower portion of the device, it can be brought outside, but it needs to be attached to a wall, pole, or tree to do so.

**Adaptive Skiing Device**

Since the design is built specifically for Elysa, it can only be used by her or people that are her size. The device is not suitable for adults. Another constraint is that the device is designed to operate on only small inclination because Elysa's parents want her to step outside and have fun in the snow. Since she cannot control her movement, she is not able control the regular ski with her legs. Therefore her parents will be side by side with her when she is on the device. After using the device for a fair amount of time, she should be able to stand with the proper stance and her leg muscle should be more strengthen.

**Recumbent Stationary Bike**

All of the electrical components and parts must be heat controlled and appropriately encased. If this is to be used with a child, all electrical parts must be kept away and safe from the child.

**Saddle Eating Chair**

The largest health concern with this device is that it must be able to stand up to disinfecting. This chair will be used in the kitchen and as an eating chair. Anything that will be around Elysa while she eats must be able to be properly cleaned. We will use some vinyl material to cover the seat so it can be cleaned.

**Water Bike**

As stated earlier in realistic restraints. Safety is of the utmost importance when it comes to this design. Water will create a fun and enjoyable environment for Elysa but this also creates that safety issue. Each tube will have to be completely sealed and if necessary filled with polyurethane foam. The bike should be able to support a person much larger than Elysa, as far as weight. Also there should be no possibility of tipping even if waves occur in the pool. The large side tubes should prevent this but thorough testing in real aquatic conditions will be done prior to any actual use.

## 4: Safety

**Zip Line Walking Device**

As the device will be mainly used indoor, corrosion should not be an issue. The aluminum metal of the strut channels is resistant to corrosion in general. The steel eye bolts are the only part of the device that would have any corrosion issues, but that is only if the device were used outside. The harness and all of the straps connecting to it and to the rest of the device need to be secure so she does not tip the structure over or slip out off the harness. As long as the straps for the harness are taut, the straps should not come undone from the eye bolts.

**Adaptive Skiing Device**

The material, aluminum 6061, shows great mechanical properties and corrosion resistance properties, and therefore it is suitable for our assistive skiing device. Since our design will be operated in winter on the snow, material with good corrosion resistance and wear resistance are important, so the device will not be worn out or collapsed if it is properly operated. To avoid Elysa from falling off the skiing device, the full body safety harness will have to be fully secured and able to tightly keep her in place while the skiing is moving.

**Recumbent Stationary Bike**

By using electrical components with low voltage chances of causing damage to the machine or any person who might touch them is reduced. Also, the plan to house the extra electrical components inside the current housing will reduce any chance of components hurting people. Elysa's safety is paramount and the harness and strapping system are certified to be used to keep her safe in a car so their use as a strapping device for the chair is plenty sufficient.

**Saddle Eating Chair**

The four attachment points of the wheels should be very secure and ensure that the wheels will not slip from the frame and make the chair tip and possibly injure Elysa. Having eight wheels will also allow a more even pressure distribution and should keep the frame stable.  The wheel and caster has the lowest mounting height in order to keep the frame lower to the ground. The lower the center of gravity the less likely this is to top.

The frame shape will prevent tipping as well. The frame parts that extend laterally will help this. Also in the frame is long enough that should Elysa kicks the table the chair will not be able to tip backward. Also the frame extends far enough in front to keep her from tipping forward as well.

The extra pommel adds stability to keep her firmly in the chair and from slipping off.  The strapping system is very secure and will surely keep her from falling off and keep her safe.

**Water Bike**

As stated earlier in realistic restraints. Safety is of the utmost importance when it comes to this design. Water will create a fun and enjoyable environment for Elysa but this also creates that safety issue. Each tube will have to be completely sealed and if necessary filled with polyurethane foam. The bike should be able to support a person much larger than Elysa, as far as weight. Also there should be no possibility of tipping even if waves occur in the pool. The large side tubes should prevent this but thorough testing in real aquatic conditions will be done prior to any actual use.

## 5: Impact of Engineering Solutions

### Zip Line Walking Device

The zip line walking device will help give Elysa the support that she needs to stay upright and will allow her parents to freely help her learn how to walk. As she progresses, she will be able to walk across the zip line, as well as the rest of the room. It will help her to become more independent, like other children, which will make her and her family happy. There is no product on the market currently that is like this device. It is a device that can help families that have children with similar physical conditions and it something that company could look into for mass production.

### Adaptive Skiing Device

The immediately and easily seen impact of this particular adaptive skiing device is on the Carlson's family. The device help extend Elysa activities to the outdoor, while at the same time her parents don't have to worry about the safety concerns and her being too constrained by the device. The device maximizes the freedom and provides the least amount of constraints for Elysa while operating the device.

On a larger scale, the success of building this adaptive skiing device can create innovation in the assisted devices market, especially for the assisted skiing devices. Since most of the assisted skiing devices in the market require the user to be somewhat able to control the device, our design targets the users that have no strength to hold their weight but want to have fun in skiing.

Currently, our design is uncontrollable, so another person needs to steer the skiing device for the user while they are fixed on the device. Our design allows the user to stand on their own if they want to, unlike most of the device, the user is usually seated. This way, the user is allowed to enjoy skiing in normal standing position like the others, without having constraints like safety belts or blanket, which make user uncomfortable. The device itself is economical, since the adaptive devices in the market are very expensive.

### Recumbent Stationary Bike

By making more devices such as this, children with developmental challenges can get the tools they need to progress and develop to another level of capability. Devices like this help reduce a child's handicap. Also an exercise machine like this will greatly improve Elysa's health. Physical movement helps with circulation in the whole body. By using this she will improve circulation in her legs. The improved circulation will aid her muscles. As she uses this machine her leg muscles will get stronger and eventually this should help her gain strength to walk.

Also this type of coordinated movement will help her brain develop the ability to coordinate her motions and help her learn to walk or ride a bike. This will significantly increase Elysa's ability and strength. We will test the electrical components first. Before modifying the chair to fit Elysa we will simply use the machine ourselves and test the electrical components and trouble shoot. We can test the operation of the handle at any time by just spinning the wheels with it. This way we can adjust it so it's not too hard for a user to assist Elysa.

**Saddle Eating Chair**

This design will add a versatile tool for Elysa to experience freedom of motion of her arms and legs while having her core supported. This way she can participate independently in activities at the table without needing her parent to sit. This will help her fine motor control the addition of extra movement will greatly increase the benefits to her health.  If she is allowed more freedom of motion with support this will help increase her activity level and independence. Increased activity greatly effects health and development. Regular activity helps circulation which affects every single part of the body.

**Water Bike**

The device will aid Elysa when teaching herself to walk with the zip line walker. The recumbent bike design will get her legs to work together in an in sync motion. This concept of her legs working together and in sync will transfer back to the zip line walker to help her walk, which is the ultimate goal.

## 6: Life-Long Learning

**Zip Line Walking Device**

This project required us to learn how to attach this device in a house. We had to research the structural design of the house and make sure loads did not exceed the capacity of the struts and supports of the house. We had to design the attachment points for the track system that would allow it to be secured to the wall safely. We had to plan attachment points for the tracks that matched up with the spacing of the studs in the walls. We learned some basic construction planning and design techniques for houses.

**Adaptive Skiing Device**

For the ski device we had to think of light weight non bulky solutions to creating a support system for Elysa. We had to pick materials that could weather the outdoor usage. We had to think of safety constraints and learn some of the basic principles behind skiing and proper body positioning for safety and comfort during sports related activities.

**Recumbent Stationary Bike**

For this we have to program a microcontroller to set the colors and rate of change for the colors to be displayed. We have to make a circuit and set all the components and adequately house them for safety

**Saddle Eating Chair**

While creating this chair we will have to weld the materials welding is a very useful skill to learn. Also cutting pieces to fit and machining drill holes are all useful shop skills.

**Water Bike**

When designing this water bike we developed a new skill in the use of the computer software SolidWorks. Knowledge of this software will be useful in the not so distant future. The program allows for a 3-D analysis of a design before the actual assembly of it. This will save time and money and a thorough understanding of SolidWorks is something we can highlight when searching for a job this upcoming year.

Also, a better understanding of buoyancy and the principles associated with keeping object afloat is sure to be a lesson worth learning. There is a huge market out there dealing with hydro-physical therapy and it would prove essential to know these concepts when designing a device.

Working together as a team on this project we learned how to use Solid Works and Microsoft Visio. SolidWorks is a CAD (computer assisted design) program that is commonly used by industry and has become industry standard. Many engineering company require illustration from SolidWorks in order to fabricate or manufacture the design accurately for other companies. Since we are designing device that are not commonly or does not exist in the market, we need to provide illustration for other people, and SolidWorks is our best choice. We have learned to create parts, extrude parts, assemble parts in specific position, and modified parts on SolidWorks, and our proficiency improves every time we use SolidWorks.

We also gained a lot of experience in time management skills and cooperation on a project. We learned how to prioritize tasks and work collectively to complete the larger goals of the team. We learned to asses each individual on their strengths and weaknesses to assign each person to the tasks that suited them best. Also we as a group got to look into the life of those with disabilities and see how their lives are greatly affected. We see how their family unit as a whole supports and helps them become more independent. We all learned book keeping skills as we need to stay on budget. We have gained much experience in different types of presentations and got to practice different presentation styles. We learned how to handle problems as they arose and adjust plans when necessary.

## 7: Budget and Timeline

### 7.1: Budget

The tables below are organized to show the individual budgets for each of our five projects. The combined total of the predicted budget is just under 1400 dollars. This is a preliminary amount and will most likely be much higher when accounting for shipping and handling and taxes. Also, we must take into account returns, which include expenses such as restocking fees as well as additional shipping fees. We have already returned two track systems for our zip line walker and took some losses there. We have currently spent $718.82 before the returns and our allotted budget is 2,000.00 for the entire year. This leaves us with $1221.18 left in our budget. Our hope is to come in under budget and allow additional funds for other groups that may need it.

**Zip Line Walking Device**

| Parts | Cost |
|---|---|
| 3/8" Galvanized Aircraft Cable | $12.45 |
| 3/8" Cable Clamps | $7.50 |
| 3/8" Thimble | $2.98 |
| Swivel | $13.50 |
| Petzl Tandem Speed Pulley | $79.95 |
| 24" Lanyard | $9.85 |
| Turnbuckle | $16.45 |
| 8 ft. Steel Roller Track System | $57.95 |
| Hanger with Mounting Plate | $35.26 |
| End Caps | $3.12 |
| Bolt-On Tie Down Ring | $3.50 |
| Steel Eye Bolt | $24.36 |
| 8 ft. Aluminum Strut Channel, 1-5/8"x1-5/8" | $72.44 |
| Zinc-Plated Steel Trolley | $41.66 |
| Adjustable Bungee Cord | $19.90 |
| 60” Strap with Buckle | $13.50 |
| Steel Eye Bolt | $24.36 |
| Trango Kids Full Body Harness | $42.46 |
| **Total** | **$481.19** |

**Adaptive Skiing Device**

| Parts | Cost |
|---|---|
| Aluminum 6061 Tubes (3 ft) | $120 |
| Load-Rated Tube Adapters | $25 |
| Perforated Base Stud | $41 |
| Outdoor Canvas | $20 |
| Stainless Steel Female Threaded Round Standoffs | $25 |
| Arm Rest | $20 |
| **Total** | **$251** |

**Recumbent Stationary Bicycle**

| Parts | Cost |
|---|---|
| Model A20 exercise bike | $220 |
| Pedal crank | $14 |
| Ac/dc transformer | $14 |
| Brush motor | $9 |
| LED | $20 |
| **Total** | **$277** |

**Saddle Eating Chair**

| Parts | Cost |
|---|---|
| Caster Wheels | $40 |
| Tubing Sections | $40 |
| EZ on Adjustable Vest 117 | $117 |
| Pins | $10 |
| Fabric | $20 |
| **Total** | **$227** |

**Water Bike**

| Parts | Cost |
|---|---|
| PVC Connections (x20) | $20.00 |
| 1 1/4" PVC (20 ft) | $8.70 |
| 4 " PVC (10 ft) | $17.95 |
| Polyurethane Foam | $47.25 |
| Seat | $90.00 |
| Calf Straps (x2) | $10.00 |
| Belt | $10.00 |
| Bike Pedals | $26.48 |
| Arms (x2) | $15.36 |
| Handles (x2) | $6.00 |
| Nuts/Bolts | $10.00 |

| | |
|---|---|
| Plastic Board | $15.36 |
| PVC Caulking | $21.90 |
| Shipping | $65.00 |
| Tax | $22.32 |
| **Total** | **$386.32** |

## 7.2: Timeline

| Task Name | Duration (hours) | Start | Finish | Resource Names |
|---|---|---|---|---|
| Order Zip Line Parts | 5 | Mon 10/24/11 | Mon 10/24/11 | Janice |
| Trip to Mansfield Supply | 3 | Wed 11/2/11 | Wed 11/2/11 | Melissa,Bob |
| Assemble new zip line track design | 2 1/2 | Wed 11/2/11 | Wed 11/2/11 | Team |
| test efficiency of track and cable | 2 | Thu 11/3/11 | Thu 11/3/11 | Team |
| Discuss design with Peter | 1 | Fri 11/4/11 | Fri 11/4/11 | Team |
| Modify Design | 2 days | Fri 11/4/11 | Sun 11/6/11 | Janice |
| Select new track system from McMaster | 2 | Mon 11/7/11 | Mon 11/7/11 | Janice |
| select appropriate wheels | 1 | Mon 11/7/11 | Mon 11/7/11 | Melissa |
| trip to Joann fabric | 3 1/2 | Mon 11/7/11 | Mon 11/7/11 | Janice,Mark |
| talk to REI associate about mounting skis | 1 | Mon 11/7/11 | Mon 11/7/11 | Mark |
| work on efficiency of track and wheel frame | 2 | Thu 11/17/11 | Fri 11/18/11 | Team |
| assemble harness for zip line | 2 | Fri 11/18/11 | Mon 11/21/11 | Bob |
| talk to cliff about ski design | 2 | Sun 11/6/11 | Sun 11/6/11 | Mark |
| work on Circuit board for recumbent chair | 5 | Fri 11/11/11 | Tue 11/15/11 | Melissa |
| order ski device fabric | 3 | Thu 11/10/11 | Fri 11/11/11 | Mark |
| trip to Neat Marketplace | 3 1/2 | Tue 11/8/11 | Tue 11/8/11 | Team |
| test harness weight forgiveness/ comfort | 1 | Mon 11/21/11 | Mon 11/21/11 | Janice |
| modify zip line design again | 2 days | Thu 11/10/11 | Fri 11/11/11 | Bob,Mark |
| order new strut channel tracks | 2 | Wed 11/9/11 | Wed 11/9/11 | Bob,Janice |
| Returning of unnecessary parts | 7 | Thu 11/10/11 | Tue 11/15/11 | Team |
| Finalize Optimal Water Bike Design | 5 | Sun 11/13/11 | Thu 11/17/11 | Bob |
| Send out Design to client for approval | 1 | Thu 11/17/11 | Thu 11/17/11 | Bob |
| Purchase Side barrel PVC | 1 | Thu 11/17/11 | Thu 11/17/11 | Bob |
| assemble newest zip line design | 2 | Mon 11/14/11 | Tue 11/15/11 | Team |

| | | | | |
|---|---|---|---|---|
| Order Water Bike parts | 3 | Tue 12/22/11 | Tue 12/22/11 | Bob |
| Assemble Side Barrels with Foam | 4 1/2 | Thu 11/17/11 | Thu 11/17/11 | Mark |
| Test barrels weight capacity in water | 4 | Mon 11/21/11 | Mon 11/21/11 | Team |
| Determine adjustments to design | 4 | Mon 11/21/11 | Mon 11/21/11 | Janice |
| Assemble Water Bike Frame | 7 | Mon 11/21/11 | Tue 11/22/11 | Team |
| order pedals for water bike | 1 | Tue 11/29/11 | Tue 11/29/11 | Melissa |
| Disassemble exercise Pedals | 3 | Fri 12/2/11 | Fri 12/2/11 | Mark |
| Fabricate new pedal design | 4 | Mon 11/28/11 | Tue 11/29/11 | Bob |
| Install adjusted pedals | 4 | Thu 12/1/11 | Fri 12/2/11 | Bob |
| Attach Frame to side barrels | 2 | Mon 12/5/11 | Tue 12/6/11 | Janice |
| Waterproof entire design | 2 | Wed 12/7/11 | Wed 12/7/11 | Melissa |
| Test efficiency and capacity of bike in pool | 3 | Mon 12/19/11 | Tue 12/20/11 | Team |
| Determine adjustments to water bike | 3 | Wed 12/21/11 | Fri 12/23/11 | Team |
| Make adjustments to water bike | 3 | Mon 1/9/12 | Fri 1/20/12 | Team |
| Re-Test Efficiency and Capacity of bike in pool | 3 | Mon 1/30/12 | Tue 1/31/12 | Team |
| Decorate Water Bike | 3 | Wed 2/1/12 | Fri 2/3/12 | Melissa |
| Deliver Bike to Elysa | 5 | Mon 2/6/12 | Mon 2/6/12 | Team |
| Modify Sled Design | 3 | Mon 11/21/11 | Fri 11/25/11 | Mark |
| look up fabrics for back support | 2 | Sat 11/5/11 | Sat 11/5/11 | Janice |
| go to ski repair shop | 3 | Wed 11/2/11 | Wed 11/2/11 | Mark |
| look up the mounting foot | 2 | Thu 11/3/11 | Thu 11/3/11 | Bob |
| Look up the folding mechanism and parts for the aluminum tubes | 5 | Thu 11/3/11 | Thu 11/3/11 | Melissa |
| create new water bike design in Solidworks | 5 | Mon 11/14/11 | Tue 11/15/11 | Bob |
| order parts for ski | 2 | Thu 12/1/11 | Thu 12/1/11 | Janice |
| pick up parts from neat marketplace | 3 | Mon 11/7/11 | Mon 11/7/11 | Bob |
| pick up parts from Mansfield Supply | 2 | Fri 12/2/11 | Fri 12/2/11 | Mark |
| arm rest assembly | 2 | Mon 12/5/11 | Mon 12/5/11 | Team |
| Drill holes and put screws and pins on two of the aluminum tubes | 3 | Tue 12/6/11 | Tue 12/6/11 | Mark |
| Drill holes on the poles of the arm rest pieces | 4 | Tue 12/6/11 | Tue 12/6/11 | Melissa |
| Place cushion on arm rest | 1 | Thu 12/8/11 | Thu 12/8/11 | Janice |

| | | | | |
|---|---|---|---|---|
| Assemble the arm rest pieces and the aluminum tubes | 2 | Fri 12/9/11 | Fri 12/9/11 | Mark |
| Put the rubber grip/tape around the handle bar | 1 | Fri 12/9/11 | Fri 12/9/11 | Bob |
| Back Support Assembly | 4 | Mon 2/6/12 | Mon 2/6/12 | Team |
| Connect the aluminum tubes to the mounting foot | 3 | Tue 2/7/12 | Tue 2/7/12 | Melissa |
| Drill holes on the skis and aluminum sheet | 1 | Wed 2/8/12 | Wed 2/8/12 | Bob |
| Insert threaded round standoffs on the skis | 1 | Thu 2/9/12 | Thu 2/9/12 | Janice |
| Attach the folding mechanism to the tubes | 2 | Fri 2/10/12 | Fri 2/10/12 | Melissa |
| Sew the Nylon fabric | 3 | Mon 2/13/12 | Wed 2/15/12 | Melissa |
| Put the fabric through the tubes and stabilize it with tube clamps | 1 | Wed 2/15/12 | Thu 2/16/12 | Bob |
| Attach the harness to the back support | 1 | Fri 2/17/12 | Fri 2/17/12 | Mark |
| Test ski device | 1 | Sun 2/19/12 | Mon 2/20/12 | Team |
| modify ski device if needed | 2 | Tue 2/21/12 | Fri 2/24/12 | Team |
| Restest Device | 2 | Sat 2/25/12 | Sun 2/26/12 | Team |
| complete final design of rising seat | 4 | Mon 11/7/11 | Fri 11/11/11 | Team |
| | | | | |
| measure and cut base pieces for rising seat | 3 | Mon 2/20/12 | Mon 2/20/12 | Bob |
| welding base of seat | 4 | Tue 2/21/12 | Thu 2/23/12 | Mark |
| attach wheels to base | 1 | Fri 2/24/12 | Fri 2/24/12 | Janice |
| test durability and weight capacity of base | 3 | Mon 2/27/12 | Mon 2/27/12 | Melissa |
| cut pieces for seat post | 2 | Fri 2/24/12 | Fri 2/24/12 | Mark |
| machine holes on frame pieces | 2 | Tue 2/21/12 | Tue 2/21/12 | Bob |
| cut and install shims | 3 | Mon 2/27/12 | Tue 2/28/12 | Melissa |
| assemble frame | 3 | Wed 2/29/12 | Fri 3/2/12 | Team |
| install half hinge for base | 3 | Mon 3/5/12 | Mon 3/5/12 | Bob |
| seat post telescoping tube | 1 | Mon 3/5/12 | Mon 3/5/12 | Janice |
| cut pieces for seat/seat back | 3 | Mon 3/5/12 | Mon 3/5/12 | Mark |
| machine screw holes in seat and seat back | 2 | Tue 3/6/12 | Tue 3/6/12 | Bob |
| welding seat on | 2 | Wed 3/7/12 | Wed 3/7/12 | Bob |
| install hinge for seat | 3 | Thu 3/8/12 | Thu 3/8/12 | Melissa |
| attach hinges together | 2 | Thu 3/8/12 | Thu 3/8/12 | Melissa |
| test durability of device | 3 | Fri 3/9/12 | Fri 3/9/12 | Team |
| Modify Design (if needed) | 4 | Mon 3/12/12 | Wed 3/14/12 | Team |

| | | | | |
|---|---|---|---|---|
| implement new design changes | 6 | Thu 3/15/12 | Wed 3/21/12 | Team |
| complete optimal recumbent bike design | 5 days | Mon 11/28/11 | Fri 12/2/11 | Team |
| order A20 recumbent bike | 1 | Mon 2/20/12 | Mon 2/20/12 | Melissa |
| assemble bike frame | 3 | Thu 3/15/12 | Thu 3/15/12 | Janice |
| add padding and support to seat | 2 | Thu 3/15/12 | Thu 3/15/12 | Melissa |
| add straps to seat | 2 | Fri 3/16/12 | Fri 3/16/12 | Mark |
| attach seat to bike | 1 | Mon 3/19/12 | Mon 3/19/12 | Bob |
| test efficiency of bike | 2 | Tue 3/20/12 | Tue 3/20/12 | Team |
| make changes to adjustments to bike | 3 | Wed 3/21/12 | Fri 3/23/12 | Team |
| retest bike efficiency | 3 | Mon 3/26/12 | Mon 3/26/12 | Team |
| design PCB | 2 | Tue 3/20/12 | Thu 3/22/12 | Melissa |
| assemble PCB with LED lights | 4 | Fri 3/23/12 | Sun 3/25/12 | Bob |
| test PCB | 2 | Mon 3/26/12 | Mon 3/26/12 | Team |
| create running horse design for display case | 2 | Wed 3/21/12 | Fri 3/23/12 | Janice |
| assemble display case with horses and LEDs | 3 | Mon 3/26/12 | Tue 3/27/12 | Mark |
| attach display case to chair | 1 | Wed 3/28/12 | Wed 3/28/12 | Melissa |
| test complete unit | 2 | Thu 3/29/12 | Thu 3/29/12 | Team |
| make needed modifications | 4 | Fri 3/30/12 | Tue 4/3/12 | Team |
| retest complete unit | 1 | Wed 4/4/12 | Wed 4/4/12 | Team |

## 8: Team Member Contributions to the Project

### 8.1: Melissa Cooling

We decided to break the project work up and have each person be lead on a project while still ensuring others helped out. Since we have five projects and only 4 people I was the lead for two projects; the Saddle eating chair and the recumbent exercise bike. I greatly contributed to the Alternate designs for the recumbent exercise bike and the eating chair. I completed the report for the alternate designs for the recumbent bicycle and eating chair. I worked on the optimal designs for the recumbent stationary bike and saddle eating chair. I researched and worked on parts for the LED display as well as coming up with the original design. I worked on editing and compiling the project specifications and project proposal. I organized our meeting with the client as well as staying in touch and contacting them when necessary. Edited the final version of the project statement and specifications and put it up on the website. I edited our main page with the description of each project. I formatted the page for the weekly reports. I have worked from the beginning to try and organize and prioritize our meetings and agenda.

8.2: Robert Keohane

As stated earlier we decided for each group member to take a lead on each project. We felt this was the best way to keep on top of each project without letting on project fall behind. Although there is only one person leading each project we are all still making sure to add our fair share of input and work into every project. The majority of this semester was devoted to the Zip-Line walker, which was lead by Janice. This was a learning experience for all of us and we all worked together to assemble the initial design. When we decided the design was too bulky we worked together to redesign the track system and reassemble the new part, twice. We also all worked to return non-used parts

The project I am leading this semester is the water bike. I have spent many hours working on various designs until finally deciding on the optimal design, which my group members have added input every step of the way and agree on the final design. I have spent time learning and working with Solidworks on not only the water bike design but also on the other designs. I have also been put in charge of the timeline for the year. I have spent time both learning to work with updating our timeline as work has progressed.

8.3: Janice Eng

As we had five projects, we all decided have each person focus on ones project, but also help out with the other projects when possible. I spent most of my time to the zip line walking device. She has done research on the various parts and contributed to the designs. I made several Visio drawings for the zip line design. This device is the furthest along, as it is mainly premade parts, so very little actually needs to be fabricated. Also, our group concentrated on this project, more than the other, especially in the latter end of the semester. I helped out with deciding what material to use on the Adaptive Ski Device I also did research on various LED circuit designs for the Recumbent Stationary Bike. I have helped out with revising and was the one who set up the website and helps updating the site, as I was the only member of the group who had any experience with web design and Dreamweaver. For the weekly reports, I was the one who mainly created the PowerPoint presentations and left spaces for the other members to fill in for their work for the week. I also helped out with formatting the reports and was the one who formatted and compiled the final report.

8.4: Jo-Ku Teng

Since we have five projects for our group, we decided to break them down and assigned each person a project to focus on, but at the same time, come up with ideas for other projects. I was assigned to the adaptive skiing device. I did research on the assisted skiing equipments that are currently in the market and tried to figure out the design that best suit our client's need. I came up with the current design that consists of the back support and the arm rest that can provide support and also meet the client's specification, simple and not bulky. I looked up parts that we need for the design and talked to Cliff for suggestion on the design. I also help the team with looking up parts and testing for the zip-line walking device, preparing PowerPoint presentation for the weekly meeting, researching for RGB LED circuit design, visiting the ski repair shop in REI, visiting Mansfield Supplies for parts, returning unused parts, etc. Most of the time we met up to discuss our progress on and the new ideas we have for other projects. So far we have been working a lot on the zip-line walking device and hope to get it done as soon as possible, and will be focusing on the skiing device over winter break and at the beginning of next semester.

## 9: Conclusion

The objective of this project is to create different devices to aid Elysa in her physical therapy to be able to gain strength and coordination so that she can gain independent function. The hope is that the variety will be more fun for Elysa and the options will provide her with the stimulation that any child needs for development. Also, we hope that multiple types of movement will help her gain a more comprehensive set of motor functions that will lead to her being able to complete more complicated tasks like walking.

The zip line walking device is a very vital physical therapy tool. This will allow Elysa the opportunity to learn how to walk even though her legs are not strong enough yet. The zip line device will allow Elysa the opportunity to explore the room in her house independently and any child should. This will allow her an important milestone in her development.

The skiing device is another tool for Elysa. This device will allow her to be exposed to the outdoor environment. We hope this will be very mentally stimulating as well s teaching her the very basic aspects of the sport of skiing.

The recumbent stationary bike is meant to be a more normal form of physical therapy. The pedaling motion is meant to help strengthen her legs. Also, as she learns to do the motions on her own this will add to her coordination and control of her muscles. We hope the LED display will be fun and motivating and will be another form of mental stimulation necessary for young children.

The saddle eating chair is meant to do many things including promoting hip abduction. This chair will allow her to sit up that should help strengthen her core. Also the saddle eating chair will allow her legs to hang down which is different than her normal sitting position. This deviation from the norm is essential to stimulate her mentally as well as physically. This design will allow her arms which are strong to be free for her to move while allowing her legs to move. This way she can try and learn to write or play with toys.

The water bike is meant to be a physical therapy tool. The sensation of water is rather ordinary but seeing as Elysa is mostly sedentary all day exposing her to this different environment can be very mentally stimulating. Also having her body in the water while pedaling will slightly change the resistance she experiences while pedaling. Also this will add some much needed fun to her every day routine. This water bike is meant to supplement the skills she learns while using the recumbent cycle.

All these devices cover multiple objectives that will allow Elysa the ability to gain many skills and progress as rapidly as she can.

## 10: References

[1] "Foam Flotation for Marine Applications - Spray Foam Information Directory - SprayFoam.com." *Spray Foam Insulation, Roofing and Equipment Directory - Find Contractors, Suppliers, and Information - SprayFoam.com*. Sprayfoam Inc, July 2009. Web. 12 Oct. 2011. <http://www.sprayfoam.com/spps/ahpg.cfm?spgid=19>.

[2] "Physics Forums Buoyancy Force." *Physics Help and Math Help - Physics Forums*. Scientific America. Web. 09 Nov. 2011. <http://www.physicsforums.com/library.php?do=view_item>.

## 11: Acknowledgements

- Dr. Enderle: for obtaining funding for this project, advice and support.
- Marek Wartenberg: for helping us with ideas, advising, and answering any questions that we had.
- The Carlson family: for coordinating meetings and communicating with us by telephone and e-mailing us, as well as providing input to what they want from the project.
- Peter Glaude and Serge Doyon: for advice and recommendations for machined parts
- Jennifer Desrosiers: for parts ordering.
- The Cooling family: for donating a set of skis, bindings, and boots

## 12: Appendix

### 12.1: Updated Specifications

**Zip Line Walking Device**

**Physical:**

**Type of Material:**

Aluminium bar
Stainless steel cable
Kids Full Body Harness

**Mechanical:**

Metal bar: 16” x 3” x 1/4”
Zip Line Cable Length: 100’
Zip Line Cable Thickness: 1/4”
Total Weight: < 20 lbs
Harness Weight Capacity: 100 lbs
Zip Line Weight Capacity: 350 lbs

**Environmental:**

Storage Temperature: 40-90°F
Operating Temperature: 60-75°F
Operating Environment: Indoors

**Safety:**

Cable strength can weaken over time
Improper use can shorten the life of the cable and harness

**Maintenance:**

Checking on the cable to make sure that it is operational
Adjusting the splint as needed to accommodate for Elysa’s growth

**Adaptive Skiing Device**

***Physical:***

**Type of Material:**

Steel Tubular Bars, 3-point safety seat belts
Straps, Existing pair of Skis, Foot straps

**Mechanical:**

Approximate Size: 39” x 22“ x 35”
Approximate Weight: < 20 lbs
Passenger Weight: 40 – 70 lbs

**Environmental:**

Storage Temperature: 10 - 150˚F
Operating Temperature: -5 - 42˚F

**Operating Environment:**

Outdoors in the snow with small incline

**Safety:**

Design will prevent Elysa from rolling over
Safety seat belt strap will hold Elysa in place
Can be only used by children and only one person at a time
Not designed for a steep incline

**Maintenance:**

Stored indoors when not in use
Safety seat belt straps should always be checked for tears
Device should be adjusted before every use.
Any damage on the device should be replaced as soon as possible

**Recumbent Stationary Bike**

***Physical:***

**Type of Material:**

Stainless steel frame
Plastic or woven seat

**Mechanical:**

Adjust leg length
Fit height: 33-35 in

**Saddle Eating Chair**

***Physical:***

**Type of Material:**

Metal: stainless steel
Plastic cover seat over foam

**Mechanical:**

Reach multiple table heights (28 ½ inch, 36 inch, 30 inch)

**Environmental:**

Operating temp: 65-75˚F

**Safety:**

Harness
Locking wheel

**Water Bike**

***Physical:***

**Type of material:**

PVC frame, (potentially filled with foam)
Plastic Seat, exercise pedals, straps

**Mechanical:**

Size: Roughly 2.5” x 2” x 2”
Weight: Roughly 12 lbs

**Environmental:**

Temperature: 55˚F-80˚F

Operating Environment: In Water

**Safety:**

Buoyant enough to support 75 lbs
Unable to tip
Safety harness to prevent falling out

**Maintenance:**

Minimal, keep clean