Project Proposal

All-Terrain Power Chair Fix
Project 1 for Annalee Hughes

All-Terrain Wheelchair Fix
Project 2 for Nathan Lamb

Beach Wheelchair
Project 23.1 for Danielle Giroux

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Executive Summary

This project involves fixing the all-terrain power chairs that were built over the past two years for Annalee Hughes and Nathan Lamb, and designing a beach wheelchair for Danielle Giroux.

The power chairs that were previously built for Annalee and Nathan did not function properly when they were completed and the teams did not have time to test and troubleshoot before the project deadline. The tilt mechanism in Annalee’s power chair and the overall control in Nathan’s power chair malfunctioned, making the chairs unsafe for Annalee and Nathan to use. The team must trace back to the cause of these malfunctions and make the appropriate corrections to bring the power chairs into proper working order. The clients have also requested a few other modifications be made to the chairs to accommodate the growth of their children since the chairs were first built.

The beach wheelchair needs to be easy to move on and to the beach via the family’s handicap accessible van. The wheelchair must either be collapsible or be safe any comply with standards to allow Danielle to be transported in the wheelchair in the van. The wheelchair will allow Danielle’s family to enjoy more time at the beach because it will be easier for Danielle to be moved at the beach.

1 Introduction

1.1 Background

Annalee and Danielle are both young girls with cerebral palsy. Cerebral palsy is a condition that usually involves brain and nervous system functions. Cerebral palsy is caused by injuries or abnormalities in the brain and symptoms of the condition vary from individual to individual. In the case of both Annalee and Danielle, their cerebral palsy has resulted in underdeveloped muscles in their legs and upper body. The lack of proper stimulation of the muscles by the brain and nervous system has resulted in their being relatively weak, meaning that Annalee and Danielle cannot stand up and support their own weight on their own.

Nathan is also physically challenged, unable to stand or move great distances on his own. Nathan has a condition called myelomeningocele, which is a form of spina bifida. Myelomeningocele is a birth defect in which the spinal canal and backbone do not fuse properly. In Nathan’s case, the myelomeningocele caused partial paralysis of the legs, thus resulting in weakness in his hips, legs, and feet. The myelomeningocele also caused hydrocephalus, which is a buildup of fluid in the brain. Nathan underwent surgery to drain the fluid built up in the brain into his bladder, where it could be excreted by the body naturally. Nathan also has weak trunk strength, which results in an abnormal, slanted sitting posture. As mentioned by his parents, this may be causing Nathan to develop scoliosis. Along with his physical disabilities, Nathan has an autism spectrum disorder. Autism is a developmental disability that causes problems or difficulties in social interaction and communication. Autism is called a “spectrum” disorder.
because it is a group of disorders with similar symptoms and symptoms can range from mild to severe.

Annalee is very adventurous and likes to move around independently. Her family owns three acres of land that Annalee loves to explore. She enjoys picking blueberries from the blueberry bushes on the property, as well as going to the pond and family’s barn. The terrain, however, is very rocky and hilly. Annalee has tipped over one of her power chairs before, but in the event that this happens, she cannot right herself or the chair on her own.

Nathan thoroughly enjoys going to the beach and to other outing events with his family and friends. His current power chairs do not allow him to move freely on rough terrain or at the beach. In these situations, Nathan must be helped along in a manual wheelchair or very carefully watched if he is in his power chair. This prevents Nathan from enjoying as much freedom and independence as he could if were able to move about on his own in these situations.

Danielle and her family also enjoy going to the beach during the summer on vacations. Danielle’s power chair is not made to traverse the sand so it is not usable when the family is at the beach. Because Danielle cannot move herself, it makes it very difficult for her family to bring her to the beach because they have to move her from chair to chair in order for her to play in the sand, or hold her in the water if she wants to be in the ocean.

1.2 Purpose

The goal of the project for Annalee is to fix the low center of gravity power chair that was built for her two years ago. It was originally designed with an auto tilt correction mechanism built into the seat of the chair. It was supposed to keep Annalee level, giving the chair more balance as it traversed the hills and rocks in her family’s yard. This anti-tilt mechanism and the braking system of the power chair are not working correctly, making the chair unsafe for Annalee to use on her own. The team needs to analyze the mechanical and electrical systems of the power chair to determine what is causing the malfunction and correct any issues that are found.

The goal of the project for Nathan is to fix the all-terrain power chair that was built for him last year. It was designed to allow Nathan to traverse his yard, the beach, and other rough terrain on his own. It was built with four-wheel drive to make it more efficient and capable of traversing the varying terrain types that he would encounter. When the chair was completed, there was little time to test all of the mechanisms of the chair and when Nathan tried to first use it, his parents noticed that the chair did not respond properly to the movement of the joystick. Nathan was unable to use the chair after that because it was not safe for him to operate on his own. The joystick was also very small and not very strong. Nathan’s parents said that Nathan has a tendency to be more forceful with things because he doesn’t understand that he is damaging them. They asked that the joystick be upgraded to one that was more robust and would withstand the more aggressive treatment that Nathan would give it. The team needs to analyze the electrical systems and programming to determine what is causing the power chair to malfunction and make the appropriate changes to make it safe for Nathan to use. In doing this, the joystick will be replaced with a new, more robust, joystick that will last the lifetime of the chair.
The goal of the project for Danielle is to make her movement easier on the uneven terrain at the beach. The beach wheelchair that we will build is going to be designed to allow Danielle’s parents to easily move Danielle over the sand when they go to the beach. Traditional manual wheelchairs have very thin wheels that do not move across the sand, but rather cut into it, making them impossible to use at the beach. The beach wheelchairs that the family usually rent when they go to the beach are also not easy to move through the sand. The wheelchair that we design will move across the sand with the least amount of effort possible, allowing Danielle and her family to spend more time enjoying the beach and less time trying to get there.

1.3 Previous Work Done by Others

1.3.1 Products

All-terrain power chairs are becoming more popular, however, they are generally very expensive. PlanetMobility.com features a number of all-terrain power chairs with a range of features. One such power chair is their Viking 4x4, which features four-wheel drive and a self-leveling seating system. The Viking 4x4 is capable of traversing sand, mud, snow, and other rough terrain with ease. The gyroscopic self-leveling seating system allows the power chair to climb hills, ramps, and stairs at an angle of up to 36°. Another all-terrain power chair featured on PlanetMobility.com is the X5-Frontier. The X5-Frontier is a mid-wheel drive all-terrain power chair. Unlike the four-wheel drive power chairs, the mid-wheel drive chair drives off of only two wheels at the center of the length of the chair and has four smaller support wheels at each corner. This setup is less stable in general making it inadequate for off-road use, though the X5-Frontier claims to be comparable to the 4x4 chairs on most terrain. While both of these power chairs are very powerful and capable of handling all types of terrain, they come with a hefty price tag. Both the Viking 4x4 and X5-Frontier have base prices of nearly $10,000. With many of the available options, the price of either chair could easily increase by hundreds or thousands of dollars, making them even more expensive for the family to purchase.
Beach wheelchairs are also becoming very popular and in demand. Persons that need a wheelchair to move around used to never be able to go to the beach because it is near impossible to push a standard wheelchair across the sand. Beach wheelchairs use polyurethane or PVC wheels to easily traverse even the softest sand. They allow disabled people and their families to enjoy the beach without having to worry about how to get there.

Obstacle avoidance devices for power wheelchairs are hard to find. There have been a number of research papers written on the topic, though there are few available add-on devices available on the market.

### 1.3.2 Patent Search Results

In 1998, Adolph Hammer filed a patent for a self-propelled all-terrain vehicle designed for paraplegics. It used two track mechanisms in place of wheels and was powered by an internal combustion engine. The seat of the vehicle moved horizontal towards the front of the vehicle to decrease the distance needed for a person to move between their wheelchair and the powered vehicle.

In 1995, Micheal Deming filed a patent for an all-terrain wheelchair. It had large, wide wheels that allowed for easy maneuvering over sand and other similar terrain. The rear wheels swivel and pivot to allow for easy turning and greater stability over uneven terrain, which is common on beaches.

## 2 Project Description

### 2.1 Objective

The tilt mechanism in Annalee’s power chair should sense the angle of tilt that the power chair is experiencing and compensate for it to level the seat. With the seat level, Annalee will have more control and be safer using the chair on the hilly terrain in her yard.

The control mechanism for Nathan’s power chair should use the input from the new joystick to control the movement of the chair. Pushing forward on the joystick should cause the power
The beach wheelchair that will be designed for Danielle will allow her family to go to the beach more often without worrying about how they are going to have to move Danielle on the sand. The wheelchair will have wide wheels that move across the sand easily and prevent the chair from digging into the sand, which would make pushing more difficult. The seat will be designed to make Danielle comfortable as possible while she is in the chair. Due to her cerebral palsy, it will be important that Danielle be placed in and removed from the chair without too much effort and in a safe manner.

2.2 Methods

The tilt mechanism in Annalee’s power chair is comprised of an accelerometer, microcontroller, and actuators. The accelerometer is powered through the microcontroller’s battery. The accelerometer senses changes in tilt and converts the change into a voltage that is read by the microcontroller. The microcontroller takes the analog signal and converts it to a digital one via its analog-to-digital converter. The digital voltage value is then analyzed by the code that is programmed into the microcontroller. Based on the voltage that was read from the accelerometer, the microcontroller outputs a signal to the actuators. Based on the speed that the actuators move, the microcontroller turns them on for a calculated period of time to that they can correct the tilt of the seat.

Somewhere in the electrical circuitry or the programming of the microcontroller there is a problem or mistake. The auto correction of the seat is not working correctly, making it unsafe to use. The team will run the chair through some tests to see if it corrects the tilt of the chair in different situations in order to help pinpoint the problem. If nothing can be learned from testing the chair, the electrical system will have to be very closely analyzed and searched for wiring problems such as shorts or miss-wired pins. If nothing is found to be wrong with the electrical systems, the code will then be analyzed. Syntax errors, missing lines of code, or simple typos could cause the chair to malfunction or not work at all. Any possible mistakes will have to be researched, tested, and fixed so that the chair will function as it was intended to.

The control system in Nathan’s power chair consists of a joystick mounted on the left armrest, a microcontroller, an H-bridge, and four electric motors. The movement of the joystick is translated into an electrical signal that is read by the microcontroller. The microcontroller processes the joystick input to determine which direction the power chair should move. Based on the calculations that the microcontroller makes, a signal is sent to the H-Bridge that controls the power to each motor. The motors are turned on, sped up, slowed down, reversed, or turned off as necessary to move the chair in the right direction.

As with Annalee’s power chair, there is a problem in the electronic circuitry or programming of the microcontroller that is causing Nathan’s power chair to malfunction. Once the joystick is
Danielle’s manual beach wheelchair framework must be constructed of a relatively lightweight material that can be easily moved and stored, while keeping more than adequate strength to support her growth and increased weight in the coming years. Thus an appropriate and inexpensive material used for the framework will be 1-1/2” diameter PVC piping. Extrapolating from past designs and new improvements, the pipe frame will be carefully measured and assembled using PVC connectors to connect the pipe ends. PVC connectors come in a wide variety of styles; four styles will be used in this wheelchair. These connectors resemble different letters of the alphabet such as the 90 degree elbow “L” connector (Figure 4), the 3-way junction “T” connector (Figure 5), the 4-way junction “X” connector (Figure 6), as well as the ‘axis’ connector (Figure 7), which looks like the corner of a cube and has connections in the directions of all three axis. In order to fuse the piping and connectors together, specially made PVC cement must be used to hold the pieces together. In order to secure a more permanent fit, the ends of the piping that go into the connectors must be scored in order for the cement to have something more substantial to grip onto while setting. The wheels of the chair must also be specially considered while making this project. Typical wheelchair wheels are quite thin, and this is a problem for moving in sand because they cut into the sand and sink, making it very hard to move the chair. To solve this problem, special lightweight polyurethane tires will be used. These tires are special in that they are much wider than conventional wheelchair tires, causing the weight of the chair and occupant to be distributed over a much wider area of the tires. Much in the same way snowshoes work, the increased surface area contacting the ground causes the wheels to not sink nearly as much and therefore the chair is much easier to move across sand. These wheels are resistant to wear and corrosion, especially from sea water.
The wheelchair will be designed with four of these wheels. The two front wheels will be larger than the back two. This is because the back two will be made to swivel to make for easier turning for the one pushing the chair. At the request of Danielle’s parents, a beach supply/toy pocket will be included on the back of the chair seat so Danielle will have a place to keep and transport her sunscreen and beach toys. An umbrella stand will also be considered in the design of the chair so that Danielle can stay out in sun longer without the risk of getting sunburned. The wheelchair will be made to collapse or be disassembled for storage purposes, as Danielle’s parents will be using their handicap accessible van to transport the chair. It must condense to within 18” to fit into the van. The wheelchair must also meet handicap bathroom stall requirements, not spanning 36” in width while in use.

### 3 Budget

The project for Annalee, as of now, requires no purchases. At most, some money for gas to travel back and forth to see the client and her family would be the only budget money. About $50 should cover a number of trips to the client’s home and back.

Joystick controllers for wheelchairs cost anywhere from around $500 to over $1000. Based on our needs, we should not need to purchase the more expensive joysticks that include numerous other buttons. Gas will also be included in the budget, allowing us to visit the client whenever necessary. About $750 should be an acceptable budget for Nathan’s project seen as the wheelchair does not need any other major modifications.

The team plans on building the beach wheelchair frame from PVC pipes and connectors. The wheelchair will have two larger polyurethane wheels, and one to two smaller swiveling polyurethane wheels. The estimated budget for the wheelchair is $587.58, as seen in the table below.
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Table 1: Table containing estimated budget information for the beach wheelchair project.

4 Conclusion

The power wheelchair fixes will require learning the circuitry and programming code that was originally implemented in the designs. Once we know how they were supposed to work, we will be able to determine why they are not working and then be able to fix the problems that we find. The major budget constraint between the two projects is the new joystick controller for Nathan’s power chair.

The beach wheelchair will be lightweight and easy to maneuver on the uneven sand of the beach. The large, wide wheels will flatten the sand and distribute the weight of the chair and its occupant, helping make it easier to move.

5 References

8. http://www.google.com/patents?id=q5YmAAAAEBAJ&pg=PA1&dq=%23380,991+Deming&hl=en&ei=YnB2TrGMI4Te0QHm05HnCA&sa=X&oi=book_result&ct=result&resnum=7&ved=0CEMQ6AEwBg#v=onepage&q=%23380%2C991%20Deming&f=false