Final Report

Project for Steven Macary

Modified All Terrain Vehicle (ATV)
Button-Operated Doorknob Opener

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Abstract

This ultimate purpose of this senior design project is to design and build two devices for a child with cerebral palsy. This condition is one that negatively affects the client’s motor control as well as normal cognition. Due to these inhibitions, the client, Steven, has limited coordination that hinders him from doing various activities. In order to accommodate these limitations and improve the client’s quality of life, modifications to the client’s electric quad will be made in addition to engineering a button-operated doorknob opener to aid the client in opening doors in his house. The quad will be modified to include a joystick control system that will eliminate the need for the harder to use steering wheel and pedals, a bucket seat that will allow for trunk support, a restraint system for safety and kill switch/remote control for additional safety. The final product will be a safer, easier to use quad that the client can maximally enjoy. The button-operated doorknob opener will allow Steven to move freely about his house without becoming trapped in a room because he cannot open doors. It will implement a big red button that the client will have no problem pressing to retract that latch on the door, thus opening it. Both these items will effectively improve Steven’s quality of life.

1. Introduction

1.1 Background

Cerebral palsy is a persistent disorder caused by an abnormality of the brain that affects movement and posture. This condition involves brain and nervous system functions such as movement, learning, hearing, seeing, and thinking. It develops when a newborn without oxygen and essentially causes brain damage. Although, there is no cure for cerebral palsy, there are treatments that aid the person to be as independent as
possible. Depending on its severity, motor controls can be seriously hindered. It is a fairly common disorder as one in every 400 live births. Hence, the need for modified products is necessary to aid patients with their disorder.

Steven McCary, an 11 year old, suffers with cerebral palsy. He is able to walk, but he is still dependent on adults for support. Steven has some severe communication problems due to his inability to speak or use words. In addition, Steven has some significant issues with his motor skills, which prevent him from being able to write or even type as a means of communication.

Currently, Steven’s ready means of communication are through loud incoherent noises produced through the use of his vocal chords, which can be used by others to distinguish only general emotions of positivity or negativity, and also a self-taught gesture of raising his arm to indicate a “yes” or agreement with a statement made by someone else.

Additionally, Steven uses a device known as a ProxTalker in school, which makes use of a picture exchange (PECS) system to form primitive sentences with the use of little pieces of plastic with pictures on them and sensors on the back, which when placed on the allocated areas of the device, are verbalized and spoken out loud by the device. This device, however, is too expensive for Steven’s family to purchase and so the school has rented it specifically for him during school hours. While at home, Steven uses an even more manual form of PECS, where he identifies specific pictures out of several binders filled with pictures to communicate. The issue that Steven’s mother, June, has with this is the inconvenience of having to carry around multiple binders full of pictures for Steven to communicate while outside the house.
Steven is currently in the 6th grade at Mansfield Middle School, where he spends most of his time in the special education classroom. However, he is also attending classes with non-special education students for Science and Social Studies. Steven is very full of emotion and displays a particular sense of joy when receiving attention. Steven’s lack of muscle strength prohibits him from daily tasks, where he has difficulty opening a door or comfortably driving his battery operated all terrain vehicle (ATV). His lack of motor control and coordination makes it difficult for him to effectively use the steering wheel provided by the manufacturer. His involuntary movements make it hard for him to stay safely on the quad with the provided seat. Also, by providing him with a button-operated doorknob opener Steven can freely access household doors throughout his home. At home, he finds humor in closing the door and locking himself in his own bathroom, but does not have the ability to open or let anyone else inside. Ultimately, another goal of this project is to help Steven adapt to his surroundings and become self-reliant.

By providing him with these devices, Steven will be allowed to become more independent, to have a more verbal identity, causing others to pay more attention to him, which in turn would increase his happiness quotient. All in all, it will enhance his sense of individualism and happiness and provide a higher quality of life for Steven.

1.2 Purpose of the project

The purpose of this project is to design two separate devices, battery-operated ATV, and button-operated doorknob opener, which will allow Steven to communicate easier, provide more convenience for his parents and others, and to be able to enjoy outdoor and daily activities comfortably. Steven is a very enthusiastic child, while also finding pleasure getting attention from his peers. However, he needs a means of
communicating with others and a way to help him carry out every day tasks, such as
opening a door or riding his ATV around his backyard. His involuntary movements and
muscle spasms and poor muscle control causes Steven the lack of ability to take pleasure
in such activities. By adapting the battery-operated ATV, a bucket seat and shock
absorber will be implemented to minimize unwanted movement and jostling. The
automatic doorknob opener will allow Steven to be able to get in and out of his bedroom
by himself by a press of a button. The objective for the ATV will be to design and create
modifications to the client’s electric quad. Its negative effects on motor control and
bodily movements in addition to other symptoms mark this condition. Due to the
inhibitions engendered by this condition Steven, the client, has much difficulty enjoying
his battery powered quad or any standard all terrain vehicle. To improve his level of
enjoyment a modified vehicle will be designed that accommodates his needs brought
about by this condition. With no reliable use of his limbs, a joystick control that
incorporates the actions of accelerating, breaking and lateral steering all into one easy to
use device will be implemented. In addition to the clients dearth of dependable motor
control the client must also be positioned in the best way for the most comfort and to
optimize the motor control he does have. A restraint system must also be implemented to
ensure safety of the rider and make sure that his waist is always at an angle of about 90
degrees.

The design implements a five point safety harness secured to a bucket seat that
provides back support. A remote control kill switch will be designed to provide the
guardian the means to kill the power to the motor if the need for this arises. A radio
receiver will be integrated into the vehicle that will take the transmitted signal outputted
by the remote control kill switch and be fed into the microprocessor that will then kill the power to the engine. A remote control will also be implemented so that the guardian may assume full control of the vehicle if need be.

Also, another goal of this project is to design a button-operated doorknob opener. This device will be used on the client’s bedroom door and bathroom door. The doorknob will be controlled by a large red push button or a remote control. Once pressed, the door will automatically open and release the door closed, allowing for Steven to pass through it. The handle of the door will turn and the axel, upon rotating. This axel rotates and moves that catch that holds the door locked. This will make it easier to go from one room to the other.

The button-operated doorknob opener will be screwed and hinged to the door using screws and the device will be encased in a wooden case, with dimensions of 15 x 7 x 2 ¾ inches. This case will be divided into two compartments, battery and mechanical parts. Compartment 1 will contain a circuit that includes a 12-volt rechargeable battery that will power the device, two relays, two limit switches and DC 12 volt Micro Motor. Compartment 2 will contain the other mechanical parts of the device. Two push buttons will also be integrated into the circuit, which will allow the client to assess doors freely without assistant.
1.3 Previous Work Done by Others

1.3.1 Products

There have been numerous other products as well as projects that have been designed in the past very similar to the devices taken on by this one. Now, some products on the market have similar functions as the devices in this project. There have been many here at the University of Connecticut that include both the modified ATV as well as the button-operated doorknob opener both making accommodations for children with cerebral palsy.

*Modified All-Terrain Vehicle*

There have been numerous designs and products that prepare and aim in an attempt to achieve goals related to this project. One would be the ARGO 8x8 HDi, a special edition model device that is road capable and has effective throttle response. Its features include 3-way adjustable suspension seats, handlebar-mounted light, signal and horn switches, side view mirror, one-piece handlebar steering control, load capacity of up to 1150 lbs. Another product would be Electric ATV ZAP Dude Mobility Vehicle, which is a powerful, rugged and versatile ATV meant for off-road use only and climbs hills with ease. A similar model to this project is the ARGO 6x6 Frontier 580 All-Terrain Amphibious Vehicle. Its features include, premium padded bench seat, one piece handlebar steering control, all-wheel traction for extra stability, low emissions, and automatic continuously variable transmission.

In 2009 at the University of Connecticut, a go-kart was built for a child with limited mobility due to cerebral palsy. This design had three differing types of controls: a joystick, a remote control as well as a steering wheel. It utilized a combustion engine and
had power steering, power braking and power throttle. This project ran a total cost of $7,300. Another quite similar project at the University of Connecticut in 2001 was an electric go-kart dubbed the E-racer. This was carried the design of steering through joystick control as well. The 2008 E-racer also used a steering wheel with switch controls, so the go kart could be operated completely by hand. This project cost roughly $2,500.

*Button-Operated Doorknob Opener*

Many products are currently available from places such as Power Access Corporation and offer a variety of choices, ranging from wireless or wired, surface or flush wall-mounted, keyless wall-mounted and hand-held devices. These products include wall switches, radio controls, electric door lock, and keypad entry systems. Wall switches are mostly available for surface or flush mount, whether they are wireless or wired. Usually, they come in a square or round plate or a push button on brown surface mount or formed box. Sizes ranges from 4”x4”x1”-6”x6”x2” in depth Radio controls are automatic door operations with wireless codes that eliminate signal duplication and frequency overlap. Transmitters with 1, 2, or 4 buttons are included with this device that require a receiver inside the operator to actuate opening cycle. Keypad entry systems use access codes, coded wireless or wired type switches for individuals. Electric door lock permit doors to be secured when closed, but release automatically when user receives signal. This allows the user to manually unlock or lock with a key. Another product’s design that is similar to this device is a heavy-duty automatic door opener that can be installed both interior and exterior. It has low and full energy applications and an adjustable hold open time for about 60 seconds. An opening signal will activate the
operator for access and when the door is hindered, opening force is restricted and the
door immediately begins to close.

North Dakota State University’s electrical and computer engineering department
in 2007 designed an automatic locker door opener specifically designed for someone with
cerebral palsy to aid that person in opening their locker door. This automatic locker door
opener operates by lifting the door latch with a solenoid and then forcing the door open
by using energy that had been stored in a spring. The door can be opened by pressing a
button on the exterior of the door or by using a remote control. The design aspect of this
project cost roughly $550 and each additional locker unit cost $210 each [3].

1.3.2 Patent Search Results

Modified All Terrain Vehicle

Hugues, Maltais, Simon Constantineau, Claude Gagnon, and David Betzlle
patented this model of an ATV in 2008. The ATV consists of a rear platform between the
rear wheels, which provides standing room and access to the seat. The vehicle includes a
rear and side passageway to access the seat. The rear wheel track featured is smaller than
the front wheel track. It was designed to be able to operate off-road multiple
environments. Its features include of low-pressure tires that allow the ATV in soft
terrains and increase level of absorption of shocks and impacts.

Button-Operated Doorknob Opener

Paul A. Merendino and Fred I. Albrecht patented the remote controlled opening
device in 1991. The model was designed to allow efficient and extended operation to
automatically and selectively open or close a door, window or other closure system,
which is operated by a hand-held remote signal generating device. The opening and
closing system is battery operated and is easily installed or mounted on existing door, window frames. The opening device consists of a receiver to detect control signals generated from a remote location.

1.4 Map for the rest of the report

The remainder of this report will take a close look at various different designs for this project. There are three alternative designs that will be discussed in addition to a final optimal design. The optimal design will go into further detail relating to the vehicle and ADO subunits. The report will finish with the projects various realistic constraints, safety issues, impact of engineering of solutions and lifelong learning. The budget for this project as well as the timeline for building this project will be mentioned as well. The contributions of each team member will be mentioned as well.

2. Project Design

Modified All Terrain Vehicle

Alternative Design 1

This design is based on the current ATV that our client has. It is an electric quad with all of its original factory settings, but not specifically adjusted to meet the needs of a child with CP. Extensive modifications to the original factory quad design will be made to accommodate the client. A restraint system will also be implemented and will include a steering system that meets the requirements of the client and accommodates his inability to effectively steer. A joystick mechanism will offer easy lateral steering, such as acceleration, deceleration and reversing all in one easy to use device in replace of the conventional steering wheel. The use of a joystick allows for better range of motion as
and eliminates the need to switch to reverse and press the pedal for acceleration. An analog stick will be implemented as the joystick and will use continuous electrical signals running through potentiometers. This will help to determine the location of the stick.

There will be potentiometers that will convert the analog sticks physical position into an electrical signal and will be interpreted by a processor. After this, it will convert this to the mechanical process of turning the front wheels of the ATV. The joystick will have double axis potentiometer control system. Also, the supply voltage from the ATV battery will run through each individual potentiometer of each axis and then outputs two separate signals. In response to any mechanical movement of the joystick, the movement causes change in the variable resistance of the potentiometer. The difference in input versus output voltage will allow for the determination of position on each of the axis by the analog to digital converter. The different axes of the joystick correspond to different mechanical functions that the ATV will perform. The x-axis will correspond to the position of the front two wheels to control steering. The y-axis will correspond to two different functions. Pushing forward on the joystick will cause acceleration of the ATV and pulling backwards will activate the brakes.

The restraint system will be used to keep the client secure in on the quad, while not compromising his comfort. The current restraint on the ATV is a plastic saddle seat, which does not provide a great deal of security for our client. To increase safety during usage of this ATV, a bucket seat with a safety harness will be implemented in replace of the original flat plastic saddle seat. Foot holders will also be implemented to minimize involuntary leg movement. This will involve a form fit depression exactly the size of the client’s feet on the lower sides of the
**ATV.**

*Alternative Design 2*

Alternative design II is based on the idea of creating a modified ATV from scratch as opposed to building upon the existing factory model. It will include an elongated front chassis with a fully enclosed roll cage for safety. There will be an electrical system implemented to control steering, braking, as well as forward and reverse throttle, which will be controlled by a joystick device. A bucket seat will be implemented to accommodate the client’s safety needs.

This particular design implements a full roll cage into the chassis of the vehicle. It has an elongated chassis to allow for the motor to be placed in the rear. This extended design will also allow for adjustments in seating to be made to accommodate the client. The complete end design objective is a safe and rigid structure with a low center of gravity to minimize possibility of rollover. The roll cage will also be designed in a way that will make entering and exiting the go kart not a difficult task as our client’s motor skills are impaired. Bumpers will be placed all around the vehicle to provide an impact buffer if collision with another object were to occur. There will also be a remote control kill switch to allow whoever is supervising the client the ability to kill the power to the engine if the need for this arises.

The electrical system for the ATV includes the remote control kill switch system and the joystick. Also included are the controller components that encompass the steering motor, the motor for controlling the throttle, the motor for switching between forward and reverse, and the motor for applying the brake. In addition to these, the power supplies
and different buttons are electrical components for this vehicle as well. LabView will serve as the main software control system.

A DC motor speed controller will control the steering and the braking. This DC motor speed controlled via a potentiometer will effectively control the speed for DC motors up to 100 volts with 7 amps of current and will not sacrifice and motor torque.

There will be several switches on the dashboard that perform different functions. There tasks are engine starting, speed control and a kill switch. The location of speed control will be next to the joystick control. The kill switch will be easily accessible next the bucket seat for safety. There will also be a speedometer gauge on the dashboard.

The seat the will be used will be a bucket seat for security and safety. It will be able to be modified for the client’s best comfort. The restraint system that will be implemented is a five point safety harness to maximum safety.

*Alternative Design 3*

Alternative design III is based on the idea of creating a modified ATV from scratch as opposed to building upon the existing factory model. However, it will include a shorter front chassis with a fully open roll cage. There will be the same electrical system implemented to control steering, braking, as well as forward and reverse throttle. This system will be controlled by a joystick mechanism, while a bucket seat will be used to accommodate the client’s safety needs.

An open roll cage into the chassis of the vehicle will have a shorter chassis, rather than an elongated chassis. This design will still allow for adjustments in seating to be made to accommodate the client. The objective will still be to design a safe and rigid structure with a low center of gravity to minimize possibility of rollover. The roll cage
will also be design to allow the client to enter an exit the vehicle with ease. Bumpers will be placed in the front if collision with another object were to occur. There will also be a remote control kill switch to allow whoever is supervising the client the ability to kill the power to the engine if the need for this arises.

The electrical system for the ATV includes the remote control kill switch system and the joystick. The components that encompass the steering motor, the motor for controlling the throttle, the motor for switching between forward and reverse, and the motor for applying the brake. In addition to these, the power supplies and different buttons are electrical components for this vehicle as well. LabView will serve as the main software control system.

A DC motor speed controller will control the steering and the braking. This DC motor speed controlled via a potentiometer will effectively control the speed for DC motors up to 100 volts with 7 amps of current and will not sacrifice and motor torque. Since, there will be several switches on the dashboard that perform different functions. These tasks are engine starting, speed control and a kill switch. The location of speed control will be next to the joystick control. The kill switch will be easily accessible next the bucket seat for safety. There will also be a speedometer gauge on the dashboard.

The seat the will be used will be a bucket seat for security and safety. It will be able to be modified for the client’s best comfort. The restraint system that will be implemented is a 5-point safety harness to maximum safety.

**Button-Operated Doorknob Opener**

*Alternative Design 1*
For this design of the button-operated doorknob opener, the device will be implemented on the doors of the client’s home. It will be hinged on the door by 5 screws and encased in a wooden case that will be 15 x 7 x 2 ¾ inches. This case will be divided into two compartments, battery and mechanical parts. Compartment 1 will contain a circuit that includes a 12-volt rechargeable battery that will power the device, a remote control transceiver, two relays, two limit switches and DC 12 volt Micro Motor. Compartment 2 will contain the other mechanical parts of the device. On the case, a large red button will be incorporated into the design. Once pressed, the door will automatically open and retract the door latch holding the door closed and allow for Steven to pass through it. The handle of the door will turn and the axel, upon rotating. This axel rotates and moves that catch that holds the door locked. This will make it easier to go from one room to the other.

The device opens by integrating the exchange of a rotational motion into a linear translation of the door latch, where the door latch will be pulled back and the motor will turn the threaded rod on which a bar is mounted. This bar will move forward and backward as the rod spins to pull the latch open and closed. A piece of aluminum will be attached to the latch apparatus for the bar to hold onto and pull the latch back. Each end of the rod that is mounted to the case will help achieve a smooth rotational motion.

Once again, the device will operate by a push of a button or a remote controlled mechanism. Once the remote control or push button is triggered, it will send an electrical signal to the motor and will provide enough force to retract the catch inside the door. This will force the door ajar, which can be easily pushed open by the client. The circuit is required to achieve the desired rotation of the motor. Once it is activated, the motor will
begin to rotate. When the latch is fully open, the bar goes along the threaded rod and hits a limit switch. This triggers a relay to switch the direction of the motor and close the latch. When the bar returns to its original position, another limit switch is pushed, causing the other relay to turn off the circuit.

*Alternative Design 2*

For this design of the button-operated doorknob opener, the device will be hinged on the door by 5 screws and encased in a holder that is made of aluminum. The dimensions for the case will be 10 x 17 x 2 ¾ inches. This case will still be divided into two compartments. The top compartment will contain a circuit that includes two 12-volt rechargeable batteries that will power the device, a remote control transceiver, two relays, two limit switches and DC 12 volt Micro Motor. The lower compartment will contain the rest of the parts. On top of the case, a large, square-shaped green button will be placed and easy to reach by Steven. Once pressed, the door will automatically open and retract the door latch holding the door closed and allow for Steven to pass through it. The handle of the door will turn rotate. This will move and rotate the catch that holds the door locked.

The device will operate by a push of a rounded button or a remote controlled mechanism, the size of a keychain. An electrical signal will be sent to the motor, once the button is depressed and provide a force to retract the catch inside the door. This allows force to partially open the door, where the client can easily push open the door. The circuit is required to achieve the desired rotation of the motor. Once it is activated, the motor will begin to rotate. When the latch is fully open, the bar goes along the threaded rod and hits a limit switch. A relay is directed to switch the direction of the motor and
When the bar returns to its original position, another limit switch is pushed, causing the other relay to turn off the circuit.

The exchange of a rotational motion into a linear translation of the door latch will allow the door latch to be pulled back, while the motor will turn the threaded rod on which a bar is mounted. This bar will move forward and backward as the rod spins to pull the latch open and closed. A little piece of aluminum will be attached to the latch apparatus for the bar to hold onto and pull the latch back. Each end of the rod a bearing mounted to the case will present a smooth rotational motion.

Also, this design will include an extra battery. This will serve as a back up, in case the main source is dead. The device will mechanically switch to the back up and alert the user that the main source needs to be charged. Indications of this will be provided through a LED light that will turn red with a high pitch sound. A voltmeter will be added on to this design in order to keep track of the re-chargeable battery. Indications of this will be provided through a LED light that will turn red with an alerting sound. The volume of the alarm can be adjusted on the remote.

**Alternative Design 3**

For this design of the button-operated doorknob opener will operate the same as the previous designs. The only difference it will have is the alternations of using a digital indicator. Again, the device will be hinged on the door by 5 screws and encased in a purple case that is made of thermoplastic. The dimensions for the case will be 18 x 10 x 2 ¾ inches. The left compartment will contain a circuit that includes two 12-volt rechargeable batteries that will power the device, a remote control transceiver, two relays, two limit switches and DC 12 volt Micro Motor. The right compartment will contain the
mechanical parts such as wiring. On the case, a large circular, green button will be incorporated into the design. Once pressed, the door will automatically open and retract the door latch holding the door closed and allow for Steven to pass through it. The handle of the door will turn and the axel, upon rotating. This axel rotates and moves that catch that holds the door locked. This will make it easier to go from one room to the other.

The device will operate by a push of a button or a remote controlled mechanism. The remote controlled mechanism will be made of thermoplastic with dimensions of 2 x 2 x 1 ½ inches, including a smaller green button. Once the remote control or push button is triggered, it will send an electrical signal to the motor and will provide enough force to retract the catch inside the door. This will force the door ajar, which can be easily pushed open by the client. The circuit is required to achieve the desired rotation of the motor. Once it is activated, the motor will begin to rotate. When the latch is fully open, the bar goes along the threaded rod and hits a limit switch. This triggers a relay to switch the direction of the motor and close the latch. When the bar returns to its original position, another limit switch is pushed, causing the other relay to turn off the circuit.

The device opens by integrating the exchange of a rotational motion into a linear translation of the door latch, where the door latch will be pulled back and the motor will turn the threaded rod on which a bar is mounted. This bar will move forward and backward as the rod spins to pull the latch open and closed. A little piece of aluminum will be attached to the latch apparatus for the bar to hold onto and pull the latch back. Each end of the rod a bearing mounted to the case will present a smooth rotational motion.
The extra battery will serve as a back up, in case the main source is dead. The device will immediately switch to the back up and charge the main battery. Once the main battery is charged, it will switch back to that source and recharge the back up battery. Also, there will be a digital indicator that will keep track of the percentage of the battery. There will be a green LED light that will indicate that the main source is charging.

2.1 Optimal Design
2.1.1 Objective

The objective of this project is to design and create a vehicle for our client that has been diagnosed with a condition called cerebral palsy. Its negative effects on motor control and bodily movements in addition to other symptoms mark this condition. Due to the inhibitions engendered by this condition Steven, the client, has much difficulty enjoying his battery powered quad or any standard all terrain vehicle. To improve his level of enjoyment a modified vehicle will be designed that accommodates his needs brought about by this condition. With no reliable use of his limbs, a joystick control that incorporates the actions of accelerating, breaking and lateral steering all into one easy to use device will be implemented. In addition to the client's dearth of dependable motor control the client must also be positioned in the best way for the most comfort and to optimize the motor control he does have. A restraint system must also be implemented to ensure safety of the rider and make sure that his waist is always at an angle of about 90°.

The design implements a full roll cage frame into the chassis of the vehicle. It has an elongated chassis to allow for the motor to be placed in the rear. This extended design will also allow for adjustments in seating to be made to accommodate the client.
complete end design objective is a safe and rigid structure with a low center of gravity to minimize possibility of rollover. The roll cage will also be designed in a way that will make entering and exiting the go kart not a difficult task as our client’s motor skills are impaired. Bumpers will be placed all around the vehicle to provide an impact buffer if collision with another object were to occur. Attached to the chassis will be the suspension system, involving independent front suspension and dependent rear suspension.

The motor used will be an engine of around 10 horsepower to create power for the drivetrain. This will also power an alternator, which will convert the mechanical energy produced by the motor into electrical energy. The energy for all of the electrical components needed for the go-kart will come from a deep cycle lead-acid battery that will be charged by the alternator to ensure that there is always an electrical power that can be supplied to the electrical components housed by this vehicle. The electrical systems for this vehicle will encompass the following: control system, joystick, steering controls and pedals. The method of control will be the joystick control to steer, brake and accelerate. A remote control kill switch will be designed to provide the guardian the means to kill the power to the motor if the need for this arises. A radio receiver will be integrated into the vehicle that will take the transmitted signal outputted by the remote control kill switch and be fed into the microprocessor that will then kill the power to the engine.

To ensure the client’s safety, the seat will specially be designed to provides the driver of the vehicle the ability to maximize the movements of his arms so that he may drive the vehicle. The main drawback to this Tumble Forms seat is the price range. The
seat may not be able to be implemented given the budget constraints. If the seat proves too costly to purchase a cheaper bucket seat will be used in tandem with a five point safety harness to restrain the client without compromising mobility of his arms. Whichever seat is used will be attached to the seat plate strongly secured to the chassis of the vehicle.

Also, another goal of this project is to design a button-operated doorknob opener. This device will be used on the client’s bedroom door and bathroom door. The device will be controlled by a large red push button or a remote control. Once pressed, the door will automatically open and release the door closed, allowing for Steven to pass through it. The handle of the door will turn and the axel, upon rotating. This axel rotates and moves that catch that holds the door locked. This will make it easier to go from one room to the other.

The button-operated doorknob opener will be operated by a push of a button. First, the device will be screwed and hinged to the door using screws and encased in a wooden case, with dimensions of 15 x 7 x 2 ¾ inches. This case will be divided into two compartments, battery and mechanical parts. Respectively, compartment 1 will contain a circuit that includes a 12-volt rechargeable battery that will power the device, two relays, two limit switches and DC 12 volt Micro Motor, while the other compartment will contain the other mechanical parts of the device. Also, the push button will be incorporated into the circuit. There will be one installed on the exterior and interior of the household door.

2.1.2 Subunits

Modified All Terrian Vehicle
This section discusses the functions of the ATV by describing the several different components that will be necessary to assemble the ATV.

**Mechanical Systems**

**Chassis**

Buying a ready-made chassis, although expensive, saves time and money on purchasing raw materials and welding and assembling a chassis from scratch. In addition, welding and assembling a chassis without any previous experience or expertise could expand the horizons for unwanted and costly errors thereby increasing the expenditure. Furthermore, purchasing the chassis as part of a chassis kit has the added benefit of providing a good chunk of the other accessories and components required for the ATV, such as the wheels, tires, brakes and cables.

The chassis kit also comes with a 2-seat model. The client’s mother currently has to stand beside or behind the quad and run alongside it while the client tries to ride it. With the 2-seat model, the client’s mother can sit in the ATV with the client while he rides it so as to prevent any accidents and to help the client guide the ATV appropriately. This will also allow the parent to help the client learn how to use the basic controls to drive the ATV. Furthermore the parent of the client will be provided with a remote control to manipulate the ATV from afar if they wish to do so.

**Wheels & Tires**
The wheels and tires that come with the chassis kit will be used for the ATV. The assembly of the wheels will be done so according to the methods necessary and provided with the kit.

**Seats**

The seat provided with the chassis kit is like a bench and does not meet the necessary specifications of providing a safety restraint for the client. Therefore, the provided seat will not be used. Instead, two seats will be implemented - one for the driver and one for the passenger. The driver seat will be designed with a safety restraint system for the client, as he will be the driver of this ATV. The seat implemented for the driver, i.e. the client, will either be a modification of a Tumble Forms 2 Carrie Seat if it is affordable with our given budget, or an upright seat that provides supports for the head, neck and trunk with a 5-point harness, foot rests, leg straps.

The passenger seat will be a regular bucket seat with very minimal restraints in the case that the passenger desires to be restrained in their seat.

**Harness**

A 5-point safety harness will be implemented on the driver seat. This harness will provide safety for the client as well as comfort along with the other supports in the seat that will help hold the client in the optimal seating position while riding the ATV without being a hindrance to the client’s ability to control the ATV.

**Steering**
Since the client lacks the necessary motor skills to use foot pedals or steering wheels, the steering system for the ATV will be implemented with the use of a joystick that controls the acceleration, deceleration and left and right movements of the ATV. Pushing the joystick forward would accelerate the ATV to a specific speed level. Pulling the joystick back would initiate a reversing mechanism in the ATV. Pushing the joystick to the left or right would cause the ATV to turn left of right respectively.

Motor

A Briggs and Stratton Intek 900 Series motor with 250 cc will be used for the ATV. The motor will put out a maximum RPM of 3800 at about 20V.

Speed Controller

The drive motor needs a speed controller that gauges the input voltage and ultimately limits the maximum speed the ATV can reach. This is necessary so as to maintain the speed of the ATV at a reasonably safe level so that the client doesn’t meet with any unfortunate accidents caused by lack of control on the speed. The speed control will be designed for a joystick input, as that is the steering mechanism that will be implemented.

Additionally, an external potentiometer will be mounted on the speed controller to allow the client to manually set the top speed. The purpose of this is to allow the client for increased speeds, as he grows older if his parents feel that he has the ability to control the ATV at higher speeds. Similarly, if the parents feel that the client needs an even lesser speed limit, and then they can adjust that as well.
Brakes

Usually a standard ATV possesses a brake cable that attaches the brake pedal to the brake calipers. Pressing down on the brake pedal pulls the brake cable which causes the brake calipers to press down on the brake rotor which then slows down the ATV. Due to the client’s inability to use a brake pedal as a result of his insufficient motor skills in his legs, a brake “pedal” will be implemented in the form of a button on the dashboard next to the joystick controls for steering. This button will work exactly as a brake pedal does, only it will be pressed down on with the hand rather than the foot. The client has a very clear ability to press buttons with his hands and can therefore easily activate the braking mechanism by pressing down on the brake button with his hand.

Electrical Systems

Battery

Deep cycle batteries will be used to run the ATV. Flooded lead acid batteries will be the kind of batteries used due to their long life and cheapest cost per amp hour.

Electric Control Box

A secured control box will contain all the electrical components such as the speed controller, some wiring, and also the receiver for the remote control. Wood or plastic will be used to create the box and it will be secured to the chassis of the ATV. The purpose of this electrical control box is to secure the components from those using the ATV, particularly the client. Furthermore, electrical conduits will be used to insulate all other
wiring as well and the conduits will be secured to the chassis, so as to prevent any harm to the client or other users of the ATV.

**Control Systems**

**Remote Control**

A remote control will be designed to allow the parent of the client or other guardian to have control over the ATV from afar in the case that the client isn’t able to control the ATV properly himself. The remote control will have a maximum range of 1500 feet. It will use a very similar joystick control to that of the one implemented on the ATV dashboard for the client. The remote control will be designed in such a manner to allow the parent or guardian a higher level of control on the ATV than the client’s control mechanism. This is important because it further ensures the safety of the client while still allowing him to control the ATV by himself to a certain extent. The remote control will run on D cell batteries.

For the remote control to control the ATV a receiver will be implemented for the ATV. The receiver will receive signal inputs from the remote control but also from the dashboard controls. The receiver will be programmed to control the steering, braking, and speed control systems. The receiver will be secured in the control box.

**Kill-Switch**

For safety purposes, the remote control will contain a kill-switch in order to shut down all the receiver outputs and thereby stop all movement of the ATV. This is necessary in the case of a possible foreseen accident or problem upon which the parent of
the client will have to implement immediate control in order to prevent the accident from occurring.

**Button-Operated Doorknob Opener**

This section will describe the number of smaller part that come together to make this device work. Each of these subunits has been designed so that it will accomplish its tasks and also integrate into the complete system. The following sections contain details of the design for each subunit and describe how they work.

**Mechanical System**

**Outer Case**

The outer case will be made of plywood. The dimensions of the will be 15 x 7 x 2 ¾ inches. The purpose of this casing is to hold all the electrical and mechanical components inside securely. On top of the case, a push button will be incorporated, while there will be a second push button installed. Both push buttons will be integrated into the electrical circuit. It will be implemented on the door using screws and hinges. The purpose of these hinges is to allow access to the parts, which can only be assessed while the doorknob is off. Inside the case, it will hold two compartments that will house the batteries on one side and the mechanical parts on the other, such as the wiring.

**Electrical System**

**Battery**

The battery used in this device will be a 12-volt rechargeable battery. The type of battery used will be a rechargeable ion lithium battery, which will at least last up to 1000
openings. Then, using an AC adapter can charge it and left plugged it to charged for 3 hours.

**Motor**

The motor used in this device will be a DC 12V Micro Motor.

**Control System**

**Push Button**

A large red push button will be placed on top of the casing. This will easily allow the button to be wired into the components inside the case. The button will have a circular shape. The button will activate only when the user depresses the button. This will automatically send electrical signals to the motor, which in turn will allow enough force to release the catch.

**Remote Control**

The remote control will be as small as a car key chain. The remote control system will require a circuit. This circuit will be designed to fulfill the desired rotation of the motor, while the circuit will also include a 12V battery, remote control receiver, two relays, two limit switches and the motor. Once either the remote control or push button is pressed, the circuit will be programmed to activate the motor to start. A rod will hit a limit switch to open a latch, while triggering a relay to switch the direction of the motor to close. Then, the other limit switch will be pushed, to activate the other relay to shut off the circuit.

3. **Realistic Constraints**
3.1 Engineering Standards

Although, the client has an electric quad with all of its original factory settings, modifications will be used to accommodate the client. The standards for the production of ATV will also be maintained throughout this project to keep it close to the client’s ATV as possible. The required speed limit will be kept the same for the appropriate age, which will be 10-15 mph for ages 9+. [1] The steering system will be applied, along with a joystick device to offer easy steering that best fits the client’s condition and needs. The standards of button-operated doorknob opener production will also be kept. The required door size will be at least 36” wide, with a minimum width for passage of at least 32”. [2]

3.2 Economic

The most important constraint in designing these devices for the project is the economic constraint. Most models of ATV that are on the market now are very expensive. The most important as well as most pressing constraint is the financial one. There will be a fixed budget within which the design must be limited to. This budget is very important due to the fact that this device requires many high-end electronic components that could be quite expensive and difficult to have swapped with another part as many parts will most likely have to be customized. Currently, a fixed budget has not been confirmed. However, the estimation for the fixed budget, which the design for the ATV must be contained, is approximately $1310. Since the School of Engineering sponsors the budget for this project, a budget very high is unlikely. The availability and costs of materials may or may not be limited, which could affect the overall design. There will be limitations on what can or cannot be used for the designs. The button-operated doorknob opener’s fixed budget is roughly over $500, however the device will be
installed on both the exterior of the client’s bedroom door and the bathroom door. There will be a second push button in the interior of the door, where it will be wired to the circuit in the outer casing. Thus, knowing the budget will help determine what materials can be purchase to modify the electric quad and build an button-operated door opener.

3.3 Environmental

The environmental constraint that will affect the design of the button-operated doorknob opener is its ability to be installed on other common household doors and public places. While, the ATV should be design to withhold extreme temperatures, such as hot or cold. The ATV should be able to operate on varying surfaces such as the client’s yard or park. Also, to avoid pollution, the device will use a DC motor rather than a gas motor.

As the vehicle houses a motor that operates using a combustible fuel, environmental constraints are brought about. The engine will be gas operated, resulting the emission of carbon monoxide and other chemicals potentially hazardous to the environment. The deep cycle lead-acid battery that will be used to supply power to any electrical component of the vehicle will contain chemicals that are corrosive as well as dangerous. The vehicle will have to be designed to ensure the most number of miles per gallon. An efficient engine that minimizes gas consumption will be implemented.

Outdoor use of this vehicle also require that the vehicle be designed to resists the forces of whatever environmental factor there may be that could possibly undermine the components of the vehicle. Water and moisture may cause the electrical components in the vehicle to short and malfunction. To avoid this, all electrical components must be
waterproofed. All mechanical aspects of the vehicle must be able to withstand varying temperatures and the effects of dirt and dust within its components.

3.4 Sustainability

Sustainability will be another issue in designing both these devices. Each device must be durable through a given time. With the doorknob opener, there are no worries about adjusting any requirements or components that is involved in the device. The device can be removed and installed on other doors, since screws will be used to place on. This makes it easier to remove. Since the client is 11 years old, and will continue growing, the height of where the device is placed on the door will be reachable for him, regardless how tall he is.

Also, the ATV will accommodate to these changes. To do this, the bucket seat installed on the ATV will be replaceable for a bigger one in later time. Also, the DC motor will be efficient for the client’s weight and even when his weight increases. Another constraint involves determining a cap for the max speed the vehicle will be allowed to achieve. Through obvious reasons, the vehicle cannot be allowed to operate at very high speeds. A speed cap must be put on the vehicle to ensure continued safety of the client. A decision will have to be made to determine the optimal speed to maximize the client’s enjoyment without compromising his safety. The device should also preferably be designed to sustain adequate movement and damage without causing any malfunction with the internal workings of the vehicle.

3.5 Manufacturability
As each device is battery operated, the stock battery provided might not be powerful enough to provide enough energy to compensate for any additional, especially the addition of a bucket seat in the ATV. It may require integrating a more powerful power source and motor to make up for the additional added weight. Another constraint for the ATV may be the sensitivity of the joystick. It may be overly sensitive and respond to every involuntary action that our client makes. The combination of our two other projects may be financially constraining and may need to exercise a budget plan that best help us reach our goals while staying within our financial constraints.

3.6 Social

One social constraint is to make sure that the noise level from the ATV does not disturb the neighborhood. Also, another constraint is to make sure Steven can have freedom enjoying daily household tasks. Allowing him to explore the outdoors or accessing his bedroom door, he will become more independent and be able to reach new areas, which would help decrease the social gaps caused by his cerebral palsy. By creating these products for Steven, the prime goal is to provide him with an easier access to some aspects of a non-cerebral palsy child’s life that Steven lacks complete access to right now.

3.7 Ethical and Political

Ethical constraints could develop when a product is designed without considering the client, workers, and/or public’s safety and health. Political constraints become another major issue when the client and workers are physically or mentally harmful caused by the manufacturing of the device.
3.8 Health and Safety

Health and safety constraints will be that it needs to provide adequate support for his physical condition. The entire client’s needs will be met and Steven’s safety and best interest will be in focus throughout the project. Safety measures will be taken to make sure that Steven will be safely and comfortably harnessed to his seat and also a reasonable control on the speed limit of the vehicle will be implemented. This will aid Steven’s caretakers as well, by allowing them to give Steven a little more independence while using his vehicle, since their current areas of worry will be addressed. A remote control for the vehicle will be created for the parents to use from a distance, so they may control the vehicle if the need arises. The ADO will allow Steven to comfortably pass through doors without the help of others. It will also reduce Steven’s mother’s worry of him locking himself up in a room and being unable to get himself out.

In addition, safety constraints include making sure that the device doesn’t have any exposed wiring or other such flaws that could cause harm to. Another constraint is the issue of refilling the vehicle with more fuel that it combusts. To meet this constraint, the engine will have to be a fuel efficient one that will minimize the number of times the tank needs to be refilled.

4. Safety Issues

In designing both of these devices, safety is the most important concern. As discussed in the earlier section, safety is a constraint that must be shown some attention. It is a priority to keep the operator safe from harm at all times whether they are sitting within the vehicle or entering it. All wires of electrical components will be carrying potentially dangerous currents and will be enclosed in rubber coverings and enclosed to
shield them from the environment as well as from the operator of the vehicle. All wires will be secured to the chassis of the vehicle so that there are no loose wires that the operator can get tangled in. All wires used will be rated for a particular current magnitude and used properly to prevent any of the wires from overheating and potentially catching on fire. For the mechanical components of the vehicle, the biggest safety concern comes about from any moving parts that the client may be able to get caught in.

To prevent this, all moving parts will be situated in a way that will eliminate any possibility of this. As mentioned earlier, the chassis of the vehicle will be a steel roll cage frame that, in the event of a rollover accident, will prevent the client from becoming crushed under the weight of the overturned vehicle. Bumpers will surround the sides of the vehicle and absorb some of the force given a collision. All components of the vehicle will be secured to the chassis and no parts will become dislodged during operation to prevent injury to the operator. As there is a battery providing a power source to the electrical components, there is a potential chemical hazard if some of the corrosive elements leak out of the battery housing. This is unlikely however, even in the event of a collision. The gasoline used for fuel must be housed in a robust tank that will resist puncture in the event of collision. To keep all of the electrical components as cool as possible to avoid overheating, there will be a cooling system employed. These components will be enclosed but ventilated to prevent accidental contact with heated components that could potentially cause burn to the client. The exhaust of the vehicle will also be directed away from the operator.

Safety is a major concern in this project, when the devices are both active and not. For the button-operated doorknob opener, it is important for this device to be able to be
installed on any household door. Since this device will be encased in a wooden box, to avoid any accidents, the case will not protrude out too much for anyone to bump into, with rounded edges. Also, to keep Steven from being locked in or out of his bedroom or bathroom, the device must run on rechargeable batteries at a given amount of time. Since, all components will be contained in the case, it must be well sealed. Each component inside will be isolated from each other and any other possible connection or wiring should be secured.

5. Impact of Engineering Solutions

The potential global impact that would arise from the design and production of this vehicle is minimal as there are some existing models on the market already. There should be little to no impact given the engineering solutions present in this vehicle design. The vehicle is designed surrounding the needs of our specific client. Although in the event that this vehicle is recognized and commercially mass-produced, it could potentially influence economics, society and the environment as well as potentially even global effects. This vehicle’s purpose is to provide a release for any physically hindered person. By creating a product such as this for a market that have a couple of other products like it may have the potential for lucrative gain for a manufacturer. If this became the case, the product would become more widespread and in turn have a possible effect on society as they may begin to see physically disabled people in a different way. These handicapped individuals would be now seen enjoying the outdoors in a vehicle that many people would enjoy riding, making there differences less apparent. The environmental impact is less favorable. The designed vehicle does operate on combustible, emissions producing fuel which are released into the atmosphere,
contributing to the degradation of the ozone as well as acid rain and various other adverse effects on the environment. Changing the engine oil when it needs to be changed also creates an issue for disposing the oil. It must be properly disposed of in a way that minimizes its negative impact on the environment.

Since the goal of this project is to create a device that will allow our client to enjoy outdoor activities and to carry out daily tasks with hopes to make Steven’s life easier. Even though this product is made for only one client, it’s can be very versatile and may be used on any household door. There are many products in the market that are more highly advanced than the design of this button-operated doorknob opener we are using. The global impact of this device is hard to imagine. However, it could cause awareness of the disability, which could lead better products that could improve of the quality of life for disabled people. It will have a minimal environmental impact, since the product is used indoors. If it was used on the outside doors, then this could have an impact, since it would allow the people to be able to go outdoors. It would bring a new demographic of people to nature and the outdoors. If mass-produced, there would could be a large market for a low cost device, which can bring people who have disabilities closer to a normal stand of living.

6. Life-Long Learning

In order to design and construct this project, there will be many new skills learned. These skills can be carried with the team members with the group after college. Aside from technical and mechanical aspects of this design project, knowledge of the disease, cerebral palsy and how it can negatively effect a patient’s life will be understood and
appreciated so that further devices that will ameliorate there way of life and level of happiness will be designed and produced. Since the client of this project was diagnosed with cerebral palsy. Being aware of what and how cerebral palsy is developed would be the first thing learned in this project. It is important to this disability associated with this disorder, because it will become essential when building a specific product for a person who has cerebral palsy. Another learning component would be how to work in teams and build social skills. Group projects can be a difficult task without communication or teamwork because it becomes necessary to divide work efficiently and quickly to meet deadlines. While communicating with the client, it is required to be respect and intelligent interviewing to find out what the client needs and what they don’t need about their current situation.

While designing this vehicle, many new skills have been acquired and knowledge obtained. The electronics system for steering involved will no doubt involve a good deal of learning and understanding of new concepts. It will require obtaining knowledge of programming in embedded C. Additional extensive knowledge of motors, power trains, and shop experience will be required to assemble various components of this vehicle with minimal error and the unnecessary reordering of new parts due to error. As we will be using a PWM with our variable speed motor, thus understanding the basic concept of the PWM signal and knowing exactly how to apply it to the vehicle will have to be learned. At the end of this design project, one of the greatest lifelong learning skill that will be most likely be acquired will be hands on experience with the mechanical aspect of assembly and further knowledge of engines, suspension systems, electronics, and coding.

7. Budget and Timeline
7.1 Budget

<table>
<thead>
<tr>
<th>Modified All-Terrain Vehicle</th>
<th>Part Name</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DC Motor</td>
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<tr>
<td></td>
<td>Motor Controller</td>
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<td>Speed Controller</td>
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<td>Remote Control</td>
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*Table 1. Budget Plan for the Modified All-Terrain Vehicle*

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<th>Button –Operated Doorknob Opener</th>
<th>Part Name</th>
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<td>12V Lighted Push Button</td>
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<tr>
<td></td>
<td>12V 18 AH Sealed Lead Acid Battery</td>
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<td>Quantity</td>
<td>Unit</td>
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<tr>
<td>12V DC 500MA 2 Stage Charger for lead acid batteries</td>
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<td>12V DC Motor</td>
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<tr>
<td>Wires</td>
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<td>Slotted Oval Head, Stainless Steel, 3/4”</td>
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<td>Stainless Steel Hinges (Pair)</td>
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<td>Limit Switch, Prewired</td>
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<td><strong>Total</strong></td>
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<td><strong>193.45</strong></td>
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*Table 2. Budget Plan for the Button – Operated Doorknob Opener*

### 7.2 Timeline

*Figure 2. Project Timeline*
Figure 3. Project Timeline

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<tr>
<th>ID</th>
<th>Task Mode</th>
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<td>Bucket Seat</td>
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<td>5 Point Harness</td>
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<td>Wheels and Tires</td>
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<td>Button Controls</td>
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<td>Kill Switch</td>
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<td>Automatic Doorknob Opener</td>
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<td>Mechanical System</td>
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<td>Order parts for doorknob opener</td>
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<td>Fri 12/10/10</td>
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<td>47</td>
<td></td>
<td>Cutting plywood for outer casing of doorknob opener</td>
<td>3 days</td>
<td>Mon 1/3/11</td>
<td>Wed 1/5/11</td>
<td>46,47</td>
</tr>
<tr>
<td>48</td>
<td></td>
<td>Building outer casing for doorknob opener</td>
<td>5 days</td>
<td>Wed 1/5/11</td>
<td>Tue 1/11/11</td>
<td>46,47,48,49,50</td>
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Figure 4. Project Timeline

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<th>Finish</th>
<th>Predecessors</th>
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<tbody>
<tr>
<td>49</td>
<td></td>
<td>Create a prototype of the electrical circuit for the doorknob opener</td>
<td>7 days</td>
<td>Wed 1/12/11</td>
<td>Thu 1/20/11</td>
<td>46</td>
</tr>
<tr>
<td>50</td>
<td></td>
<td>Test prototype</td>
<td>1 day</td>
<td>Fri 1/21/11</td>
<td>Fri 1/21/11</td>
<td>49</td>
</tr>
<tr>
<td>51</td>
<td></td>
<td>Assembly of actual electrical circuit</td>
<td>3 days</td>
<td>Sat 1/22/11</td>
<td>Tue 1/25/11</td>
<td>50</td>
</tr>
<tr>
<td>52</td>
<td></td>
<td>Integrate a second push button to circuit 2</td>
<td>2 days</td>
<td>Wed 1/26/11</td>
<td>Thu 1/27/11</td>
<td>50</td>
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<tr>
<td>53</td>
<td></td>
<td>Assembly final product of doorknob opener</td>
<td>7 days</td>
<td>Fri 1/28/11</td>
<td>Mon 2/7/11</td>
<td>46,47,48,49,50</td>
</tr>
<tr>
<td>54</td>
<td></td>
<td>Final testing of doorknob opener</td>
<td>1 day</td>
<td>Tue 2/8/11</td>
<td>Tue 2/8/11</td>
<td>53</td>
</tr>
<tr>
<td>55</td>
<td></td>
<td>Rebuild another doorknob opener</td>
<td>7 days</td>
<td>Wed 2/9/11</td>
<td>Thu 2/17/11</td>
<td>54</td>
</tr>
<tr>
<td>56</td>
<td></td>
<td>Test device</td>
<td>1 day</td>
<td>Fri 2/18/11</td>
<td>Fri 2/18/11</td>
<td>55</td>
</tr>
<tr>
<td>57</td>
<td></td>
<td>Install devices in client’s home</td>
<td>1 day</td>
<td>Sat 2/19/11</td>
<td>Sat 2/19/11</td>
<td>56</td>
</tr>
<tr>
<td>58</td>
<td></td>
<td>Order parts for ATV</td>
<td>1 day</td>
<td>Mon 1/3/11</td>
<td>Mon 1/3/11</td>
<td></td>
</tr>
<tr>
<td>59</td>
<td></td>
<td>Pick up Steven’s Quad to campus</td>
<td>1 day</td>
<td>Fri 12/17/10</td>
<td>Fri 12/17/10</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td></td>
<td>Going to Neat Marketplace</td>
<td>1 day</td>
<td>Fri 12/17/10</td>
<td>Fri 12/17/10</td>
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<tr>
<td>61</td>
<td></td>
<td>Cleaning ATV</td>
<td>3 days</td>
<td>Mon 1/3/11</td>
<td>Wed 1/5/11</td>
<td></td>
</tr>
<tr>
<td>62</td>
<td></td>
<td>Removing/Disconnecting wiring for pedal/steering/braking</td>
<td>7 days</td>
<td>Wed 1/5/11</td>
<td>Thu 1/13/11</td>
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<tr>
<td>63</td>
<td></td>
<td>Install joystick</td>
<td>7 days</td>
<td>Thu 1/13/11</td>
<td>Fri 1/21/11</td>
<td></td>
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<tr>
<td>64</td>
<td></td>
<td>Test Steering</td>
<td>5 days</td>
<td>Fri 1/21/11</td>
<td>Thu 1/27/11</td>
<td></td>
</tr>
<tr>
<td>65</td>
<td></td>
<td>Install braking system</td>
<td>7 days</td>
<td>Thu 1/27/11</td>
<td>Fri 2/4/11</td>
<td></td>
</tr>
<tr>
<td>66</td>
<td></td>
<td>Test braking system</td>
<td>5 days</td>
<td>Fri 2/4/11</td>
<td>Thu 2/10/11</td>
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<tr>
<td>67</td>
<td></td>
<td>Remove seat from quad</td>
<td>7 days</td>
<td>Thu 2/10/11</td>
<td>Fri 2/18/11</td>
<td></td>
</tr>
<tr>
<td>68</td>
<td></td>
<td>Adapt seat to meet client’s needs</td>
<td>7 days</td>
<td>Fri 2/18/11</td>
<td>Mon 2/28/11</td>
<td></td>
</tr>
<tr>
<td>69</td>
<td></td>
<td>Install seat</td>
<td>7 days</td>
<td>Mon 2/28/11</td>
<td>Tue 3/8/11</td>
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### Figure 5. Project Timeline

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<th>Duration</th>
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<th>Finish</th>
<th>Predecessors</th>
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<tr>
<td>70</td>
<td></td>
<td>Install harness to seat</td>
<td>7 days</td>
<td>Tue 3/8/11</td>
<td>Wed 3/16/11</td>
<td></td>
</tr>
<tr>
<td>71</td>
<td></td>
<td>Test component</td>
<td>5 days</td>
<td>Wed 3/16/11</td>
<td>Tue 3/22/11</td>
<td></td>
</tr>
<tr>
<td>72</td>
<td></td>
<td>Assembly of chassis</td>
<td>7 days</td>
<td>Tue 3/22/11</td>
<td>Wed 3/30/11</td>
<td></td>
</tr>
<tr>
<td>73</td>
<td></td>
<td>Install chassis</td>
<td>7 days</td>
<td>Wed 3/30/11</td>
<td>Thu 4/7/11</td>
<td></td>
</tr>
<tr>
<td>74</td>
<td></td>
<td>Assembly of remote control components</td>
<td>7 days</td>
<td>Thu 4/7/11</td>
<td>Fri 4/15/11</td>
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<tr>
<td>75</td>
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<td>Test remote control</td>
<td>5 days</td>
<td>Fri 4/15/11</td>
<td>Thu 4/21/11</td>
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<tr>
<td>76</td>
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<td>Final Testing of ATV</td>
<td>5 days</td>
<td>Thu 4/21/11</td>
<td>Wed 4/27/11</td>
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<tr>
<td>77</td>
<td></td>
<td>Painting ATV</td>
<td>3 days</td>
<td>Wed 4/27/11</td>
<td>Fri 4/29/11</td>
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<tr>
<td>78</td>
<td></td>
<td>Product Finalized</td>
<td>2 days</td>
<td>Fri 4/29/11</td>
<td>Sat 4/30/11</td>
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<td>Wed 2/2/11</td>
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<td>80</td>
<td></td>
<td>Go Kart</td>
<td>19 days</td>
<td>Mon 1/3/11</td>
<td>Thu 1/27/11</td>
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<td>81</td>
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<td>Order Parts</td>
<td>1 day</td>
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<td>Backseat Seat</td>
<td>1 day</td>
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<td>83</td>
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<td>5 Point Harness</td>
<td>1 day</td>
<td>Mon 1/3/11</td>
<td>Mon 1/3/11</td>
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<td>84</td>
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<td>Wheels and Tires</td>
<td>1 day</td>
<td>Mon 1/3/11</td>
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<td>85</td>
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<td>Braking System</td>
<td>1 day</td>
<td>Mon 1/3/11</td>
<td>Mon 1/3/11</td>
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<tr>
<td>86</td>
<td></td>
<td>Joystick Steering</td>
<td>1 day</td>
<td>Mon 1/3/11</td>
<td>Mon 1/3/11</td>
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</tr>
<tr>
<td>87</td>
<td></td>
<td>Chassis</td>
<td>1 day</td>
<td>Mon 1/3/11</td>
<td>Mon 1/3/11</td>
<td></td>
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<tr>
<td>88</td>
<td></td>
<td>Automatic Doorknob Opener</td>
<td>1 day</td>
<td>Fri 12/17/10</td>
<td>Fri 12/17/10</td>
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<td>Fri 12/17/10</td>
<td>Fri 12/17/10</td>
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<td>90</td>
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<td>Push Button</td>
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<td>Fri 12/17/10</td>
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<td>91</td>
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<td>Lead Acid Battery</td>
<td>1 day</td>
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<td>12V DC Motor</td>
<td>1 day</td>
<td>Fri 12/17/10</td>
<td>Fri 12/17/10</td>
<td></td>
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<td>94</td>
<td></td>
<td>Wires</td>
<td>1 day</td>
<td>Fri 12/17/10</td>
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### Figure 6. Project Timeline

<table>
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<th>ID</th>
<th>Task Mode</th>
<th>Task Name</th>
<th>Duration</th>
<th>Start</th>
<th>Finish</th>
<th>Predecessors</th>
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<tr>
<td>55</td>
<td></td>
<td>Screws/Plages</td>
<td>1 day</td>
<td>Fri 12/17/10</td>
<td>Fri 12/17/10</td>
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<tr>
<td>56</td>
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<td>Limit Switch</td>
<td>1 day</td>
<td>Fri 12/17/10</td>
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<tr>
<td>57</td>
<td></td>
<td>Relay</td>
<td>1 day</td>
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8. Team Members Contributions to the Project

8.1 Team Member 1 (Joe Yi)

The work accomplished the previous week involves two different tasks. These were the purchase requisition form and the optimal design report. For the purchase requisition form, I had researched online the best prices for the materials we needed for our go kart. These included a five point safety harness, a bucket seat, an electric dune buggy go kart, universal joystick with a microswitch, and a killswitch remote. These were the major parts needed to begin assembly and modification of the electric dune buggy go kart. Upon determining the necessary parts for the purchase requisition form, I began work on the optimal design. I took charge of particular sections that dealt with the go kart. These parts included the introduction, realistic constraints, safety issues, impact of engineering solutions, and lifelong learning. The introduction section dealt with the overall objective of the project. This was to design and assemble a particular vehicle for our client that will take into account his disabilities and allow him to have greater ease while trying to operate this vehicle. Different products were listed in addition that will be used to assemble the vehicle. Realistic constraints predicted the restraints we would most likely encounter throughout our project. These prediction included budget constraints, safety constraints, environmental constraints, and weather constraints. Safety issues were also addressed. This section discussed various ways to increase the safety of the operator of the vehicle. Impact of engineering solutions and lifelong learning discussed the potential impact that our devices could have upon the world and what we have and will potentially learn from this design project. This week will conclude with a list of 100 tasks that is specific to what each teammate will be accomplishing in the upcoming
weeks. A power point presentation will also be created to supplement our 10 minute presentation.

8.2 Team Member 2 (Savio Chris)

When beginning this project, I, Savio, met with my team members to arrange a general plan to commence with. I then obtained the contact information of our client, June Macary, and got in touch with her. Ms. Macary’s son, Steven, has cerebral palsy (CP) and so we spent some time talking about his strengths, weaknesses, and limitations in order to get a basic idea of Steven’s situation so our team could best aid him. Upon concluding the first conversation with our client, I had the approval of the mother and an appointment to meet Steven and his teacher, Karen Burnham, in his school. A couple of days later, Judy and I then went to meet Mrs. Burnham and observe Steven and his interaction with his surroundings at school. We spent about an hour with Mrs. Burnham talking about Steven and his ability as a student. In the process we were able to understand the extent to which Steven is affected by CP – his inability to use speech to communicate, the communication devices and methods he uses, his apprehension to walk without any support, and so on. I took plenty of notes and so did Judy, which would later help us to brainstorm ideas for the project we could pursue to best help Steven. Later that same day, Judy, Joe and I went to Steven’s house to meet with Ms. Macary and get a better idea of Steven’s living area and also to take a look at his ATV that his mother said may need some adaptations.

With the notes and information gathered, we were able to come up with three different ideas that could be presented to the client – A button operated door knob opener, a portable electronic communication device, and modified ATV or gokart. While
working on the project statement, specifications, proposal, and the proposal presentations, I focused my attention on the portable electronic communication device, while Joe and Judy worked on the ATV and door knob opener, respectively. Once we put together the statement and specifications, I approached the client with the ideas we had. She was extremely impressed with all of our work, however, she felt that although she was most interested in the portable communication device, she no longer felt it might be a worthwhile project as Steven’s school was already purchasing a communication device for his own personal use. That being said, we dropped the idea for that project and I began sharing the workload with Judy and Joe on the button operated doorknob opener as well as the ATV while putting together the optimal design report and the budget requests.

All along, I have taken up the responsibility of mediating between the team and the client and taking our ideas to the client every week or so. I was also able to obtain contact information for Steven’s speech, physical, and occupational therapists. We will be contacting them to get a better idea before we begin the finalized design for either of our projects. As of now, my responsibilities are focused on following through with the therapists to meet with them as a team and discuss, in further detail, our designs and what might best help and suit Steven, particularly with the ATV or go kart. Also, I have assumed the responsibility of focusing in more depth on the button operated doorknob opener, while Judy and Joe spend more time on the ATV or go kart. We will be putting together more part order forms, particularly for the button operated door knob opener by the end of next week, so as to get started on that project no later than the beginning of winter break.

8.3 Team Member 3 (Judy Kachittavong)
In the semester of BME 4900, the beginning semester was spent doing background research in order to prepare and develop a product design. I did research on cerebral palsy and potential devices that correspond to this disorder. Along with the background research, the team met with the family. Also, in order to learn more about Steven’s condition, I was able to meet with his teacher. This helped us have a better understanding of the extension of Steven’s capability due to the cerebral palsy, which is important to design features and specifications. In the early weeks of BME 4900, each member was responsible for coming up with design ideas.

For each of the reports, the team split up the writing sections and amount of work for each group member. For the project statement and specifications, I was responsible for all the sections that involved the button-operated doorknob opener. Prior to writing the project statement, we had our first meeting with our client and client’s teacher on September 3, 2010. We were able to get to know our client and find out exactly what the client wanted our product to do for Steven. For the project proposal, I was responsible for the following sections, executive summary, introduction, purpose of the project, and previous work done by others. For the proposal presentation, each team member created slides corresponding to the assigned sections. During the proposal presentation, each member was responsible for presenting each device (at the time we came up three devices for our project). For alternative designs, the team was informed that the client no longer wanted one of the devices anymore, which lead to the elimination of the portable communication device. I was responsible for the alternative designs for the button-operated doorknob opener. For the optimal design report, I was responsible for all the sections related to the button-operated doorknob opener. Although, the entire team
contributed to creating the finalized budget, I was responsible for researching and coming up with the budget for the button-operated doorknob opener. Also, I was responsible for putting together the website, using Dreamweaver and to upload all files onto the website. Currently, the group is working to produce a final report for BME 4900. The majority of our efforts will be focused on this throughout the next couple of weeks.

9. Conclusion

Steven Macary’s struggle with cerebral palsy presents him with many physical and psychological challenges. The physical and communicative limitations that are thrust upon Steven due to this disorder are cause for frustration for Steven himself as well as for his family members. His inability to comfortably walk from place to place without continuous hesitation, his inability to enjoy his ATV without the presence of a parent or guardian to support him and guide him, his inability to navigate easily from room to room within his own house without the aid of someone to open the doors, are all only a few key examples of Steven’s lack of access to a life that is common to most children. The underlying theme that is visible in the given examples is that of a lack of independence. The purpose of this project, then, was to provide Steven a greater sense of independence than he currently possesses. And in the attempt to do that, the goal is to improve his accessibility to a far more normal childhood and a greater sense of peace and joy to his family.

The approach to achieving the mentioned goal was to pursue two projects: 1) a button-operated doorknob opener and 2) modifications made to his current quad. To help Steven gain a sense of freedom and independence within his own house, the issue of
easier navigation within his house must be addressed. Steven’s condition makes it
difficult for him to exercise sufficient muscle control and accuracy to twist a doorknob in
order to open a door. This prevents Steven from entering or leaving a room with a closed
door, unless someone opens the door for him. And so, the button-operated doorknob
opener was an idea that was brainstormed and found to be a great way of bringing more
independence into Steven’s life.

Furthermore, Steven has a quad and enjoys riding it around in his backyard.
However, several problems arise every time Steven chooses to enjoy the use of his quad.
The quad is designed for a normal child and Steven’s several physical ailments act
against him in his enjoyment of the quad. Steven lacks the sufficient lumbar support to sit
in a normal seat and hold himself up and so a parent or guardian must be present with
Steven to hold him up and provide support to keep him on the quad while he rides it.
Steven’s condition also drastically reduces his muscle control and accuracy in his arms as
well as his legs, thereby making it close to impossible to steer the quad with the steering
system it currently has or to press down the pedal to propel the quad. This means that
once again, a parent or guardian must be around while Steven rides his quad to help him
steer and propel the vehicle. Essentially, Steven cannot enjoy his quad by himself. This is
also a terrible inconvenience for his parents or guardians. In attending to these issues,
modifications such as a seat with sufficient lumbar support and a five-point safety
harness will be implemented. Furthermore, a joystick will be installed for simpler
steering and propelling controls that Steven can easily use. Such modifications allow
Steven the ability to enjoy his quad with far more independence than he currently has. In
addition to these modifications, a remote control system will also be implemented so as to provide Steven’s parents or guardians an extra measure of safety to prevent any potential accidents that Steven might be heading towards in the case that he fails to sufficiently control the vehicle by himself.

In designing these products for Steven the budget must not be taken out of sight. While such a project might be suspected to be very expensive, the proposed budget for the modified quad is approximated at about $1300 and the button-operated doorknob opener is approximated at about $560. When considering the costs of most unmodified quads and ATVs on the market, they generally exceed the $1300 cost level. With that in mind, this may very well be a great investment towards a more independent enjoyment of childhood for Steven. While looking at the doorknob opener, there aren’t exactly any such devices on the market and so it is difficult to compare its cost to anything. However, $560 may be a great investment not only towards Steven’s independence within his house, but also towards a possibly new marketable product for others of similar needs as Steven.

While Steven’s independence and accessibility to a more normal childhood remains our focus throughout the design and implementation of these products, his safety will not be sacrificed and remains our highest priority. Keeping that in mind, many safety measures will be implemented in our designs, particularly in the modifications for the quad. A safety harness for the seat, leg restraints, the remote control with kill switch for the parent or guardian, are all safety measures that are to be implemented to prevent
Steven from encountering any dangerous situation. It is our eager hope that through this project, Steven will be able to enjoy his life to a greater extent due to his exercisable independence and freedom.

10. References

<http://www.cpsc.gov/businfo/frnotices/fr06/066703.html>


11. Acknowledgements

We would like to thank our sponsor, Dr. John Enderle for his efforts in making our design project possible. Also, we would like to take our client, June Macary, Steven’s mother, for her support and without her we wouldn’t have a project. Along with special thanks to Mary Macary, Steven’s grandmother, Mrs. Karen Burnham, Steven’s teacher, and Ms. Molly Grabowski, Steven’s physical therapist.

12. Appendix

12.1 Updated Specifications

12.1.1 Button-Operated Doorknob Opener

Operational Specifications:

Power will be supplied to the device from a rechargeable battery, since it is remote-operated. Exchanging a rotational motion into a linear translation of the door latch will
allow the door latch to be pull back. A motor will turn the threaded rod on which a bar is mounted. This bar will move forward and backward as the rod spins to pull the latch open and closed. A little piece of aluminum will be attached to the latch apparatus for the bar to hold onto and pull the latch back. Each end of the rod a bearing mounted to the case will present a smooth rotational motion. There is a circuit is required for the design to achieve the desired rotation of the motor that is charged for 20 volts. The circuit includes a 12-volt battery, the remote control transceiver, two relays, two limit switches, and the motor. Once the remote control or push button is activated, the motor will start to rotate. When the latch is fully open, the bar goes along the threaded rod and hits a limit switch. This triggers a relay to switch the direction of the motor and close the latch. When the bar returns to its original position, another limit switch is pushed, causing the other relay to turn off the circuit.

**Technical Specifications**

**Physical:**
- Type of material: Wood outer covering, Plastic outer covering for push button

**Mechanical:**
- Size:
  - Outer box: 15x 7x 3 inches (L x W x T)
  - 5x 4-x 2 inches (L x W x T)
- Push button: 2-3 lbs
- Weight:
- Electrical:
  - Current: 10-20 Amps
  - Voltage Range: 12-20 Volts DC
  - Battery Life: 40 hours

**Environmental:**
- Operating Environment: On an indoor or outdoor door
- Maintenance: Suitable use of the device
- Software: Not included
12.1.2 Modified All Terrain Vehicle

Operational Specifications:

The ATV in question will operate on battery that can be recharged through a standard 120-volt outlet. The factory seat will be replaced with a bucket seat for better cushioning as well as better seating. This will allow for safer driving and will be coupled with a restraint belt so that he does not fall off. At the base of the ATV where Steven places his feet there will be indents that match the size and shape of both his feet on each side. This will serve as placements for his feet to minimize his involuntary movements. We will be eliminating the need for the pedal for accelerating, as this will be implemented in the joystick. This joystick will integrate steering, reversing and braking all into one mechanism and will require the use of only one hand rather than two hands needed for conventional steering. This will enable our client to more effectively maneuver his ATV given his disabilities. On a completely aesthetic level, the ATV will be repainted to represent the colors of the character Barney so that it will encourage Steven to want to ride it.

Technical Specifications

Physical:
Type of Material: - Exterior will be composed of primarily (ABS plastic)
- Plastic tires with rubber traction strip
- Cloth seat with neck and core support
- Wooden foot placements

Mechanical:
Size: 44x30x31 inches (L x W x H)
Weight: 40 lbs

Electrical:
Voltage Range: 7 to 15 Volts DC
<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery Life:</td>
<td>4 hours</td>
</tr>
<tr>
<td>Electric Motor:</td>
<td>2 x 6 Volt 25 Watt</td>
</tr>
<tr>
<td>Environmental:</td>
<td></td>
</tr>
<tr>
<td>Storage Temperature:</td>
<td>-20 to 60 degrees Celsius</td>
</tr>
<tr>
<td>Operating Temperature:</td>
<td>0 to 100 degrees Fahrenheit</td>
</tr>
<tr>
<td>Operating Environment:</td>
<td>Outdoors</td>
</tr>
<tr>
<td>Controls:</td>
<td>Joystick must be weather tight</td>
</tr>
<tr>
<td>Software:</td>
<td>Microprocessor Chip</td>
</tr>
<tr>
<td>Maintenance:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Battery recharge</td>
</tr>
<tr>
<td></td>
<td>-Clean battery terminals regularly to ensure good operation and connection.</td>
</tr>
<tr>
<td></td>
<td>-Clean regularly to avoid dust particles and so on from affecting the device</td>
</tr>
</tbody>
</table>
### 12.1.3 Purchase Requisitions and Price Quotes

**PURCHASE ORDER REQUISITION - UCONN BME SENIOR DESIGN LAB**

**Instructions:** Students are to fill out boxed areas with white background

Each Vendor will require a different purchase requisition

<table>
<thead>
<tr>
<th>Date:</th>
<th>Team #</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Student Name:</th>
<th>Total Expenses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Student Initial Budget</th>
<th>Student Current Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FRS #</th>
<th>Project Sponsor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Ship to:** University of Connecticut
Biomedical Engineering
U-2247, 260 Glenbrook Road
Storrs, CT 06269-2247

<table>
<thead>
<tr>
<th>Attn:</th>
<th>Lab Admin only:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Project Name:**

**ONLY ONE COMPANY PER REQUISITION**

<table>
<thead>
<tr>
<th>Catalog #</th>
<th>Description</th>
<th>Unit</th>
<th>QTY</th>
<th>Unit Price</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAM124105</td>
<td>Rampage Bucket Seat</td>
<td>###</td>
<td>1</td>
<td>$200.00</td>
<td>$200.00</td>
</tr>
<tr>
<td>RTD2355</td>
<td>Joystick Control</td>
<td>###</td>
<td>1</td>
<td>$30.00</td>
<td>$30.00</td>
</tr>
<tr>
<td>smaMR939555</td>
<td>Five Point Safety Harness</td>
<td>###</td>
<td>1</td>
<td>$170.00</td>
<td>$170.00</td>
</tr>
</tbody>
</table>

|                          |                          |      |      | $0.00     |       |
|                          |                          |      |      | $0.00     |       |
|                          |                          |      |      | $0.00     |       |
|                          |                          |      |      | $0.00     |       |
|                          |                          |      |      | $0.00     |       |
|                          |                          |      |      | $0.00     |       |
|                          |                          |      |      | $0.00     |       |
|                          |                          |      |      | $0.00     |       |
|                          |                          |      |      | $0.00     |       |

**Comments**

**Price Quote File Name:**

**Vendor Accepts Purchase Orders?**

<table>
<thead>
<tr>
<th>Price Quote File Name</th>
<th>Vendor Accepts Purchase Orders?</th>
<th>Shipping</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$0.00</td>
<td>$400.00</td>
</tr>
</tbody>
</table>

**Vendor:**

**Address:**

**Phone:**

**Contact Name:**

**Authorization:**

---

*Figure 7. Purchase Requisition Form for ATV*
### PURCHASE ORDER REQUISITION - UCONN BME SENIOR DESIGN LAB

**Instructions:** Students are to fill out boxed areas with white background. Each Vendor will require a different purchase requisition.

**Date:** December 10, 2010  
**Student Name:** Team 22  
**Ship to:** University of Connecticut Biomedical Engineering  
**Storrs, CT 06269-2247**  
**Attn:**  

**Project Name:** Steven Macary Project  

<table>
<thead>
<tr>
<th>Catalog #</th>
<th>Description</th>
<th>Unit</th>
<th>QTY</th>
<th>Unit Price</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>GC-217</td>
<td>12V 18Ah Sealed Lead Acid Battery</td>
<td>2</td>
<td>$53.00</td>
<td>$106.00</td>
<td></td>
</tr>
<tr>
<td>LPS-32</td>
<td>12V Lighted Push Button 2&quot;</td>
<td>4</td>
<td>$4.75</td>
<td>$19.00</td>
<td></td>
</tr>
<tr>
<td>BC-212</td>
<td>12V DC 500MA 2 Stage Charger for lead acid batteries</td>
<td>1</td>
<td>$12.75</td>
<td>$12.75</td>
<td></td>
</tr>
<tr>
<td>DCM-251</td>
<td>12 VDC Motor</td>
<td>2</td>
<td>$3.75</td>
<td>$7.50</td>
<td></td>
</tr>
<tr>
<td>Wires</td>
<td>1</td>
<td>$10.00</td>
<td>$10.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROC-30050151</td>
<td>Slotted Oral Head, Stainless Steel, 3/4&quot;</td>
<td>20</td>
<td>$0.25</td>
<td>$5.00</td>
<td></td>
</tr>
<tr>
<td>ELH-923</td>
<td>Stainless Steel Hinges (Pair)</td>
<td>2</td>
<td>$15.89</td>
<td>$31.78</td>
<td></td>
</tr>
<tr>
<td>Relay</td>
<td>4</td>
<td>$11.99</td>
<td>$47.96</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limit Switches, Prewired</td>
<td>4</td>
<td>$81.00</td>
<td>$324.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Comments**

**Price Quote:**  
**File Name:** Vendor Accepts Purchase Orders?  
**Vendor:** all.electronics.com, reidsupply.com  
**Address:**  
**Phone:**  
**Contact Name:**  

**Shipping**  

**Total:** $564.19

**Authorization:**

---

**Figure 8. Purchase Requisition Form for ADO**