ARC Slide
Optimal Design

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1. Optimal Design

1.1 Introduction

The Automated Retracting Coaster (ARC) Slide is an adaptable recreational slide created for people with motor control disabilities. Specifically, the ARC Slide is designed for a 6 year old male, Joey Toce. Joey Toce suffers from cerebral palsy, a condition which inhibits his capability to fully control his posture or limbs. Because of his condition, Joey has trouble sitting upright, controlling spastic movement of his arms and legs, and making small gestures at will. Like any six year old, Joey enjoys playing outdoors, and is in need of custom recreational equipment to accommodate his activities.

In the past, Joey has played on a slide called the Extreme Coaster by Step2. This children’s coaster has two components: a small car and a descending track. This coaster provided some necessary components for Joey, but missed certain key features necessary for his safety and enjoyment. Due to a lack of harnesses and supports in the car, Joey’s guardians had to hold him in place as he descended down the hill. Also, his guardian has to physically push him back to the top of the hill every time he wanted to slide down – a strenuous task that will continue to get harder as Joey gets bigger.

Similar to the Extreme Coaster by Step2, the ARC slide will have two components, a car and descending track. However, this design will be equipped with all necessary mechanisms to give Joey more independence. The modified car will have comfortable seating with side supports to maintain his posture. Because Joey often squirms his way out of seats when he gets excited, the car will also contain a harness and leg supports to keep him safely and comfortably in place. To limit the strenuous task of pushing Joey back to the top of the slide, a winch mechanism will be installed so that Joey can be automatically be pulled back to the top after descending. Lastly, the slide will have a powered lifting mechanism at the top of the slide to tilt the platform downward on command. This optional mechanism will act to “push” Joey and the car down the slide.

Although the ARC slide is initially designed to contour to Joey’s needs, it is easily adaptable to any child with motor control disorders. Currently, there are no other similar designs on the market. Thus, the ARC slide is a groundbreaking device in the area of modified recreational equipment for people with disabilities.

1.1a Track

The first of the two main components of the ARC Slide is the track. The components of the track include of the descent ramp, the upper platform, winch motor, lift platform, and electrical housing unit. A depiction of the track can be seen in fig. 1.
1.1b Car

The second component of the ARC Slide is the adaptable car. The car used on the track will safely move the user during descent and retraction. The car will be equipped with nylon chest and hip harnesses to keep the user from slouching and sliding forward into an unsafe position in the seat. The seat as a whole will have adjustability from 10 to 20 degrees to allow for optimum user comfort. Also, the partially reclined seat will promote resistance of the car to tip or travel in an unintended manner. The seat will include an adjustable head rest to support the head and neck during travel. This head rest is necessary to prevent harm in the case of whiplash or sudden stopping.

The seat and leg areas will be equipped with foam padding covered in nylon fabric. As seen in fig. 2, the seat padding will be rounded at the edges to provide additional support to hold the user’s trunk and limbs in place. The leg supports will allow for a bend in the knee for comfort. Velcro straps will be employed to hold down the user’s lower limbs during activity.
1.2 Subunits

1.2.1 Winch Motor

A winch motor will be installed to pull the car back to the top of the slide. The 1/2 horse power winch motor will be powered by a motor control unit with a 12V DC supply voltage. The motor will have the ability to turn on and by two means: a wireless remote control and a push button on the side of the slide. Furthermore, a photoelectric sensor will be installed at the top of the slide. As a safety measure, the motor will be programmed to turn off when this sensor is triggered for more than 3 seconds.
The winch motor to be used is manufactured by TRAC, an outdoor trailing company. This motor was chosen because it fit all criteria necessary, is inexpensive, and as has the convenience of being designed for outdoor use. Its maximum pulling capacity is 2000 lb, a value far beyond our scope. Thus, the input voltage of the motor must be regulated in the motor control unit. Figure 2 is an example of a DC motor switch control circuit. A similar circuit will be used to power the winch motor, where the terminal labeled Input On/Off will be linked to the microcontroller and triggered by the wireless receiver. When the on button to turn on the winch mechanism on the remote is pushed, the receiver will send a signal to begin powering the motor. To regulate the amount of voltage going into the motor, a voltage divider circuit will be used. See figure 3 for a Multisym schematic of a voltage limiting circuit. This initially was a temperature controlling fan circuit design, but was modified in Multisym to meet the DC motor controlling needs. In this configuration, the voltage powering the motor was limited from 12V to 6.2 V DC. (3)

![Diagram of a DC motor switch control circuit](image-url)

*Figure 2: 12V DC motor switch control circuit (2)*
Figure 3: Voltage regulating circuit for motor. In this configuration, the voltage powering the motor is limited to 6.2V DC

1.2.2 Lift Motor

A piston motor will be used to slightly tilt the top of the slide to a 15 degree angle as a means to push the cart down the slide. This ½ horse power motor will also be operated using 12V DC input. The motor will be turned on by a wireless remote control, operated through the microcontroller. Furthermore, it will be programmed to turn on only when the cart has reached the top of the hill, or when photoelectric sensor is triggered. Once turned on, the motor will remain elevated for 10 seconds before reversing back to its starting position. Figure 5 is a circuit which controls the direction of a motor, using inputs from two signals, A and B. A similar circuit will be used to control the lift motor, with inputs A and B sent from a microcontroller.
1.2.3 Tower Light

A tower light will be installed on the top of the slide. The 12V powered tower light will have four color indicators: Red, yellow, green and blue. The red indicator will illuminate when the motor is in use. If the motor is turned off before the photoelectric sensor is triggered, the light will remain red. The green light will turn on when the cart reaches the top of the hill and the motor is turned off. The yellow light will take place over the green if the car reaches the top of the hill and the 12V battery to the motor is low. This light will be used as a warning mechanism to indicate that the battery needs to be charged. Lastly, the blue light will illuminate when the lifting device is in motion. If the motor is turned off for more than 10 seconds and no other signals are sent to the controller, the tower light will turn off.
Figure 5: LED Stack tower light. Left figure is the 4 color stacked light to be used for the ARC system

1.2.4 Photoelectric Sensor

Photoelectric sensors consist of electric eyes mounted in a parallel configuration. When the path of the electric eye is blocked, an output signal is sent. In this application, a retro-reflective photoelectric sensor will be installed at the top of the hill where the car sits before descending. The sensor will be powered using a 12V DC power supply, and will send a signal when the infrared light beam is blocked by the car. Using microcontroller technology, the signal sent by the photoelectric sensor will trigger the motor to stop.

Figure 4: Photoelectric Sensor and infrared reflector (5)
1.2.5 Microcontroller

The microcontrollers used in this system will be the 40 pin, 8 bit Microchip PIC16F877. This microcontroller was chosen because while it is capable of a wide range of tasks, it is also relatively easy to program and use. This software for the PIC is written in embedded C code. For the ARC slide, one PIC will be used per motor.

1.2.5.1 Control Overview

Truth tables 1 and 2 describe the basic control mechanism of the system. There will be two microcontrollers in the ARC slide – A and B. Microcontroller A will be the first unit in the relay of signals. An output from microcontroller A must be sent to microcontroller B to operate the lift. Initially, the system must be turned by flicking the safety switch on the back of the winch motor. This safety switch will enable unit A to begin receiving and sending signals. Once on, the microcontroller will respond to the two inputs: the RF remote winch control and photo eye at the top of the slide, and three outputs: The red LED light, the signal to the winch motor control unit, and signal to enable unit B. When the switch to the winch motor is pushed, the motor will turn on. A switch that latches only when pushed will be used, so when the button is released the power supply to the motor will automatically turn off. When the motor is on, the microcontroller will send a signal to illuminate the red LED light on the tower, signaling the winch is in use. As soon as the photoelectric sensor is triggered, the power supply to the motor will turn off, regardless of the input from the controller. At this point, a signal will be sent to enable microcontroller B.

Figure 5: I/O pins of 8-bit PIC16F877 (6)
When the enable signal is sent to microcontroller B, the system will begin to respond to the RF lift hill remote and battery low signals. Similar to the winch user control, the lift hill remote will have one push button as well. However rather than stopping when released, the lift will continue its operation. Once the switch is pressed, the lift motor will slowly ascend until the platform reaches a downward position set at 15 degrees. From there, a delay of 3 seconds will be programmed before the motor automatically descends back to its starting position. When the lift is in use, the blue LED stack light will illuminate, and remain on until the motor resumes back to its original position. When the car is at the top of the slide and the lift push button is not in use, the green LED light will illuminate. Furthermore, when the lift push button is not pressed and less than 20% of the battery remains, the yellow LED light will illuminate in replace of the green. Once the car descends down the hill, the photoelectric sensors will stop triggering, causing the enable B signal to shut off. Thus, after the car descends down the hill, the lift motor will lose its ability to operate and the yellow, green, or blue lights will turn off.

Table 1: Truth table of microcontroller A

<table>
<thead>
<tr>
<th>Safety Switch (enable)</th>
<th>Motor Up</th>
<th>Sensor</th>
<th>Winch</th>
<th>Enable B</th>
<th>Red</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>Winch Motor is on, Red light is illuminated</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Winch Motor is off</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>Sensor is triggered, second microcontroller is enabled</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>Sensor is triggered, winch motor no longer can run. Second microcontroller is enabled</td>
</tr>
<tr>
<td>0</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>system disabled</td>
</tr>
</tbody>
</table>

Table 1: Truth table of microcontroller A
1.2.5 Safety Rails

The hand rails used will have to be ADA (Americans with Disability Act) compliant. Due to this compliancy, the rails are required to have a smooth finish. The metal of choice is aluminum for its strength, durability and corrosion resistance. The safety rails will be anchored horizontally into the wood beams rising above the platform from the corners (see fig.6). The rails will be slip-on fittings enabling them to be easily installed or removed. They will be put together as a 4 piece component for each of the 3 sides of the platform. The fourth side is the track. There will be a total of 6 horizontal hand rails (see fig. 8) measuring 14inches and 2.5inches in diameter with a thickness of .125inches and a total of 3 vertical support bars (see fig.9) for the hand rails measuring 13.6inches in length, 3inches in diameter and 0.125inches thick. The three rails will be held together with a 6inch long mid-joint (see fig.7) with two 2.51inch openings on front and back and a 3.01 inch opening on the bottom for the vertical support.

<table>
<thead>
<tr>
<th>Enable (B)</th>
<th>Battery Low</th>
<th>Lift on</th>
<th>Lift</th>
<th>Yellow</th>
<th>Green</th>
<th>Blue</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>Green light illuminates signaling lift can begin</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>Yellow light illuminates signal battery is low and lift can begin</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>Lift is on, blue light is illuminated</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>lift is on, blue light is illuminated</td>
</tr>
<tr>
<td>0</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>system disabled</td>
</tr>
</tbody>
</table>

*Table 2: Truth table of microcontroller B*
Figure 6: Mid connecting joint and Horizontal Hand rail

Figure 7: Mid Connecting Joint
The rails will be padded to provide both comfort and safety. The material used for rail paddings will be semi-rigid molded polyurethane. This material has an approximate density of 300 kg/m3 and will be about 1 inch thick.
1.2.6 Track

The track will be made of wolmanized wood; a pressure treated wood with a copper azole for resistance to rain and other harsh conditions. Because of its strength and durability outdoors, this wood is a perfect choice for the ARC slide. The track will be approximately 26” wide and 141” long. The top of the track will be 35” high, and the bottom will be 136” from the platform.

To keep the car from steering off the track, two 2” barriers will be installed on the side of the slide. The walls will be bolted on to the edge of the ramp and will follow the track from the platform to the bottom of the hill. There will be a 26” clearance between the walls, which will leave a comfortable yet secure spacing for the 24” wide car.

In order for the car to be brought back to the top of the hill, it must first be pushed to the foot of the slide. Because the car width of the car is very close to the width of the track, there is risk that the winch may pull the car sideways off of the track if misalignment occurs. To alleviate this possibility, the end of the slide will be flaired outward. This will limit the amount of precision needed in the alignment of the car before being pulled to the top of the hill. For a smooth transition from the platform to the slide, and from the slide to the ground, the track will be tempered and curved at both ends.

4”x4” wooden posts will be used to stabilize the base of the slide. The top platform of the slide will consist of an upper and lower component. The lower component will made of 2” thick wood, and secured by bolts and 2”x4” brackets. The lower platform will have a hole drilled in the back center to accommodate a space for the piston lift. An upper platform will be installed over this lower base. The upper platform will be approximately 1” thick, and sit on a hinge secured at the front of the hill. Upon movement of the piston motor, the upper component will move radially up and down. This component will be positioned 35” off of the ground. See figures 10 and 11 below.

Figure 10: side view of the ARC track
The winch motor will be installed behind the central platform. It will sit on the bottom component of the top platform, and will be secured using bolted connections. Below the upper platform will be a lower platform. Here the electrical components and lift motor will be stored. Figure 10 illustrates both platforms on the slide base. Lastly, safety rails will be placed on the top of the slide. These rails will be approximately 12” tall, and will prevent the car from traveling any other direction other than forward.

1.2.7 Car Frame

The car frame will be constructed of one inch square tubing at ¼” thickness. The steel used for the frame will be 304 grade. The dimensions of the base are 20” x 30”. The mounting beams for the foot support and seat will also be made of the same square tubing and are welded to the car frame as seen below in fig. 10. The underside of the frame will be covered with 1/8” thick stainless steel sheeting to provide the mounting area for the release mechanism for the winch hook. The wheel mounts provides 1.15” clearance between the wheel shafts and the underside of the frame. The wheels will have a 6” hub diameter made of polypropylene plastic. The tires are 1.00” inch thick with a diamond tread. The tire width is 1.50”. With a 3/8” steel shaft at 23.5” long, the clearance between the wheel hub and car frame is 0.25”. The wheels are held in place using cotter pins and 3/8” stainless steel washers. Figure 12 below depicts the car frame with wheels mounted.
Fig. 12. ARC Slide car frame with wheel assembly.

The underside of the car is depicted below in fig. 13.

Fig. 13. Underside of car (release mechanism not shown).
1.2.8 Car Restraints

The car must have a high level safety measures to ensure the user’s optimum safety during operation. Due to Joey Toce’s inability to hold his trunk upright, hip and trunk restraints will be incorporated to hold him safely in position. The trunk harness will be made of seatbelt grade nylon and steel seat buckles. The trunk restraint will form an “X” pattern on the front of the trunk and will buckle at mid-chest level. The lengths of the restraints are adjustable to meet the growth of the user and user variability.

A hip restraint and buckle similar to those found in airplane seats will hold the anterior portion of the pelvis in place and does not permit the hips to move forward in the seat. This will deter an unsafe and uncomfortable position. The restraint will buckle and the mid-sagittal region of the hips.

The headrest incorporated into the seat back also provides another safety measure. The headrest is comprised of high density foam and a nylon fabric cover that will absorb impact of the head in the case of whiplash from sudden movements. In order to account for the growth of the user, the headrest level is adaptable. The headrest pins are notched every one inch to gain up to four inches in headrest elevation.

1.2.9 Car Seating

While the seat of the ARC Slide is designed based on the limb and trunk dimensions of Joey Toce, the car seat is large enough to accommodate children approximately five to ten years old. The top back of seat is equipped with foam padding with raised edges to keep the user from drifting from side to side during movement. The seat bottom also posses this characteristic. In addition to the restraints, the seat is also designed to hold the user in place.
The leg rests are also made of foam padding with a nylon fabric cover. The limb area of
the seat is rounded inward to keep the legs in place. Velco leg straps are sewn into the distal
portion of the leg cover to secure the user’s lower limbs during the use of the ARC Slide. Figure
13 depicts the seating complete with padding and headrest (seating restraints not depicted).

The chair also has arm rests for user comfort. They also serve has an extra mechanism to
keep the user from sliding out of the chair and into an unsafe position. Maintaining the user’s
position is necessary to stop a shift in the center of gravity from tipping the car over. The
dimensions in inches of the car are depicted in fig. 15 below. The armrests have a length of
10.812”, seat back padding, 10.750”, seat bottom padding, 7.150”, and leg rest padding, 10.124”.

Figure 15. Car seat with supports.
The car will be covered with covered polypropylene sheets to give a playground and recreational toy appearance. The sheets will be 1/8” thick and will be securely screwed into the frame and the car seat for the finished design. A depiction of the car will is depicted below in fig. 17.

Fig. 16. Car seat dimensions.

Fig. 17. Depiction of the ARC Slide Car without harnesses and polypropylene coverings.
1.2.10 Car Retraction and Release

For the safety of the user, it is necessary that the cable hook disengages only when the car is on top of the platform. To cut costs, the release mechanism is designed as simple as possible and without using complex electrical equipment. This mechanism is completely mechanical with moveable parts that will allow the release of the hook without any input from the parents.

The first component of this mechanism is a 1 x 1 inch square, ‘block’, protruding upwards from the platform. Then a series of moveable parts, labeled A through E in the figure below, will be installed on the undercarriage of the car. The parts are solid one piece parts that have holes drilled in them where the hinges will be placed.

As the car reaches the top of the hill, it will move over a ‘block’ centered in the middle of the platform. Part A is positioned such that the block will apply a force on its upper side, causing it to rotate about a fixed hinge. This rotation will cause the lower end of part A to hit the rear end of part B which will then cause part B to rotate counter-clockwise about the fixed hinge. As part B rotates counter-clockwise, it will apply force on the rear end of part C, causing it to rotate clockwise about its hinge. Finally part C will apply force from the bottom on the rear end of part D, the end component of the mechanism, causing it to move away and separate from part E in a downward counter-clockwise rotation. This domino effect will allow the hook to be disengaged.

The figure 18 below shows a view from the top of the car with the base being “invisible”.

![Release Mechanism for the winch hook](image)

*Figure 18: Release Mechanism for the winch hook*
The hinges are planned to be spring loaded to enable the parts to move back to their original. As the car goes down the incline and proceeds ahead, the gate will close automatically. Once the ride is over, the car will be pushed back to the bottom edge of the ramp and the winch cable, which will unspool freely, will then be attached on to the gate. The winch will then be turned ON for the retraction to begin. This is where the ‘stopper’ comes in. The stopper acts as a barrier or as a cancelling force applied by part D due to the retraction. As the hook is pulling the car backwards, there is horizontal force applied on part D in the left direction, which will cause it to spin counter clockwise unless stopped. The stopper will prevent part D from rotating and opening the gate. The only time the gate can be opened allowing the hook to disengage is when the block applies force on the top portion of the stopper, pushing it backwards and rotating it about its hinge. So the stopper out of the way, the rest of the parts will move as described above and thus completing the mechanism and releasing the hook.

The movement of the parts and the block is represented by the arrows in figure 18.

1.2.11 RF Controls

The winch motor and platform lift motor will be controlled remotely using radio frequency (RF) controlling. A Colpitts circuit will be used for the high frequency oscillation portion of the circuit. Figure 19 below depicts the Colpitts circuit.

![Colpitts circuit for high frequency oscillation](image)

The oscillation of the circuit will be approximately 83 MHz which will not overlap with the frequencies of FM broadcasting. The transmitter emits an electric wave from the antenna (ANT). The control code used with the PIC16F877 turns the electric wave on or off. For the ports, +5 V will equal a high or on level and 0V will be equivalent to a low or off level. The operation of the transmitter circuit only occurs with the constant push of the control switches (SW1 and SW2, fig 17). When the switch is not pushed, the circuit is not powered, suppressing the consumption of the supply battery. In the case of control code malfunctions, the diode will be used to prevent voltages and currents that would damage the rest of the transmitter circuit. A final printed control board (PCB) layout is depicted below in fig. 20.
The receiver is comprised of a high frequency amplification circuit, a detection circuit, a voltage comparator, a clock oscillation circuit for the microcontroller, a relay drive circuit, and a power circuit for the microcontroller. A total circuit diagram for the receiver portion of the RF controls is depicted below in fig. 21.
The high frequency amplification circuit is a two stage FET amplification circuit. It will only amplify the received voltage signal and apply it at the gate (G, fig19). The resonance portion of the circuit will be constructed to pick up the resonant frequency of the transmitter, approximately 83 MHz. The detection circuit rectifies the output of the high-frequency amplifier with a diode to make a DC voltage from the high frequency voltage. The DC voltage then reaches the voltage comparator, an LM358N op amp. The output of the voltage comparator is either at a high level if the circuit is receiving a signal or at a low level if the circuit is not receiving. By using a Zener diode connected to the output (D3/RD5A fig19), the voltage at the output level will not exceed the permissible level that could damage the microcontroller. The clock oscillation circuit provides a 4 MHz oscillation frequency for the microcontroller. The relay drive circuit makes an LED light up to signal when the relays are in operation. A resistor in series with the LED limits the current to 10 mA. The relays are then connected to start the on/off operation of the winch and lift motors on the track platform. The PCB layout for the receiver can be seen below in fig. 23. Example source code that will be used to program the microcontrollers is listed in appendices A and B.
1.2.12 Electrical Housing Unit

The electrical housing unit (EHU) will be constructed to house all of the circuit components, shield them from noise, and protect the circuitry from the outdoor weather. The unit will be made of aluminum sheeting and attached to the base of the track platform. In order to shield the circuits from interference, the aluminum EHU will be covered in electromagnetic interference shielding resin. The receiver will also be stored here, with the antenna extending out of the unit to receive the signals from the remote transmitter. A depiction of the front control panel of the remote control is depicted below in Fig. 24. The transmitter circuit will be housed inside the remote control. This remote control will be made of impact resistant plastic in the case that the unit is dropped. The transmitter circuit will be powered by an on-board 9V battery.
In a separate compartment of the electrical housing unit, a 12V DC battery will be installed. The housing unit will supply a grounding connection for the battery and will have an easily removable cover to allow the battery to be removed, replaced and/or recharged. The EHU circuit portion will be completely sealed from the weather and elements, however, the battery portion will allow for the drainage of moisture through the bottom face of the unit. The dimensions of the battery compartment will be 8x12x8 (HxWxD) inches.

2. Realistic Constraints

The electrical components, such as the photoelectric sensors, motors, and tower light, compromise the most expensive portion of the ARC slide. Although these units are a great percentage of our budget, they are necessary for the functionality and safety of the system, and are thus required expenses. To counter these costs, the material of the slide itself will be durable but cheap. The wolmanized support beams and coverings are robust and provide longevity, while at the same time are less expensive than aluminum or stainless steel. Overall, the ARC slide will maintain affordability without compromising safety and performance.

Environmental durability is another constraint. The ARC slide will be assembled and used outdoors. The terrain of the yard is flat, which eliminates the concern of the car traveling far distances. However, the material must maintain its strength in rainy conditions, extreme heat (~105 degrees F in summer) and extreme cold (~5 degrees F in winter). Furthermore, the electrical components must be encased and sealed in housings that will shield the circuits from precipitation. In order to address these constraints, the material chosen for the arc slide, wolmanized wood, is known to be strong and durable in extreme weather. Furthermore, an outdoor winch motor will be purchased, and all circuits will be covered and shielded using resin.

Comfort is another constraint that needs to be addressed. The cart must have an equal balance of strength, comfort, and safety. To maintain comfort, the seat will be purchased from NeatMarket, a second hand store located in Hartford. This Market sells used seats and harnesses designed for people with disabilities. Joey will attend the trip to Neat Market and will try out multiple options for seating units. After assessing multiple seats, the one that gives him the most comfort and support will be purchased. Furthermore, after the base of the car is built, the positions of harness and leg supports will be tried out on Joey to ensure that all components are placed in a way that will provide maximum comfort and support.
3. Safety Issues

The ARC slide has both electrical and mechanical systems that must be periodically inspected to ensure the proper operation of the slide. As with any outdoor equipment, mechanisms are prone to rust and failure if not properly maintained. The car wheels should be lubricated regularly. Also, the seat restraints should be visually inspected to ensure that the nylon has not ripped and that the user has maximum safety during use.

As with any device using electricity, the proper ground connections must be made to reduce the chance of hazardous shock. The electrical housing unit must have a ground connection. The chance of shock is quite low as materials for the ARC Slide are mostly wood, plastic, and rubber. This significantly lowers the chance of harm to the user.

While the ARC Slide car can be stored away while not in use, the track will remain outdoors and exposed to sunlight, rain, snow, and other elements. With wood and changes in temperature, cracks can begin to form along the components and weaken the structure’s strength and stability. The slide will be covered with a weather-proofing coating however, the slide should be periodically checked for cracks in the support beams and platform to ensure user safety.

Commercial winch motors are design to have a high lifting capacity. While the car and the user are way below the weight limit, the speed of the motor will be under constant control such that the car retraction is at a safe speed and will not harm the user. The winch cable is also prone to corrosion when exposed to the outdoor elements. Rubbing and abrasions that may occur will also weaken the cable. The cable must not have any cuts or nicks or it may break and result in dangerous situations.

The winch motor disengage system ensures that the car is not pulled beyond the top platform retraction point. The photoelectric sensors will signal that the car is back in place and ready for descent; it will not be pulled further than necessary. The cable disengage system between the car and the top platform ensures that the cable is still not attached to the car when the lift motor is activated to begin descent. The logic table as seen earlier ascertains that the retraction and release mechanisms do not malfunction even if one of the components fail. The fail safe circuitry keeps the user from harm when using the ARC Slide.

The materials used are biocompatible with the user in mind. Joey Toce is not allergic to nylon material, so it will be a safe for him to come in contact with. Nylon allergy occurrences are very low. With a hypo-allergenic coating material, there will be a lower chance of a harmful reaction for any multiple of users that will utilize this device.

The user safety is the main priority of the design such that the car is equipped with the necessary restraints to keep the user in place and keep the car’s center of gravity from moving and possibly tipping the car over. The user not only has a safe place to sit but is in a comfortable position as well. The ergonomic design for the device produces a fun piece of recreational equipment that can be safely utilized by a disabled child with motor control problems.
4. Impact of Engineering Solutions

This device has never been seen before in the world of modified recreational equipment for the disabled. While most of the equipment is for walking or biking, there is very little in the realm of playground equipment. With this device, disabled persons can have another alternative way to safely be involved in outdoor recreation. The wireless control given to the operator removes the constant contact a guardian has to give when supervising a disabled child. This device can give a perceived sense of individuality because the operator will not be in much contact during the ARC Slide use.

This device is built from medium strength, yet less expensive materials. The manufacturing of the ARC Slide would not be as expensive as recreational equipment that relies on many motorized and metal components for operation. By using the materials selected in this optimal design, the device can be built at and sold at a moderate price, yet will still be affordable for many families that have to find means of providing mobility to their disabled children.

If this optimal design be produced and marketed on a global scale, it would provide thousands of children with the ability to experience the same recreation that non-disabled children can. The ARC Slide provides many new opportunities and experiences to the disabled that may have seemed unlikely before this device.

The ARC Slide is environmentally friendly in that it does not have any toxic emissions and uses a 12 V car battery for the motors and a 9 V battery for the remote control. The slide does not consume a large amount of power and the batteries can be recharged until they reach their recharge limit. The ARC Slide does not need to be near a 120 V outlet so it has a greater degree of freedom when placing the track in a yard or playground.

5. Life-Long Learning

The ARC Slide design requires strong skills in electric circuits, mechanics, biomaterials, and computer programming. Through the design process, this team has acquired new knowledge of radio frequency transmission and wireless control. To control these components, we have developed an in-depth knowledge of microcontrollers and PIC programming in order to control the winch motor, lift motor, photoelectric sensor, and tower light in order to create a safe and reliable recreational device for disabled persons.

To depict and dimension our design, this team has learned multiple CAD software programs including AutoDesk, Microsoft Visio, and SolidWorks. The CAD designs in SolidWorks allowed for a complete assembly of the components to provide a working design that will successfully meet the needs of the client. We have also learned to effectively use MPLab and Multisim to create and test circuit theory and apply it to the ARC Slide design.

Working as a team in a design project has given us insight into developing effective communication skills with each other and also the client. Without these skills, it is nearly
impossible to effectively create a device, such as the ARC Slide. The design would fail to meet the objectives set in the early design phase of the project.
6. References


