Automated Retracting Coaster Slide (ARC Slide)

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Executive Summary

The overall purpose of this project is to design and build a modified slide coaster for a 6 year old client, Joey. Joey is a child who suffers from cerebral palsy; a condition which inhibits his ability to fully control his posture and limbs. Like any 6 year old, Joey enjoys playing outdoors and is in need of custom recreational equipment for to accommodate his activities. In the past Joey has played on a slide called the Extreme Coaster by Step2. This marketed coaster has a small car to sit in while descending down the ramp. Although Joey enjoys playing on the extreme coaster, he does not have the posture to sit upright in the cart and cannot control the movement of his legs as he slides down. Furthermore, his supervisor must strain to push him back up the slide following descent.

The ARC slide will have a custom car for Joey to safely sit in; fully equipped with a harness and leg supports. The coaster will have a controllable winch mechanism to connect to the rear of the car to pull Joey back to the top of the slide. Once the cart is hooked to the winch, the motor will be turned on and off using a wireless remote, or by depressing a switch located near the motor. As the car reaches the top of the hill, the motor will turn off automatically once sensing feedback from a photoelectric sensor. From that point, the winch will disengage from the car and Joey will be allowed to safely slide down the coaster. Lastly, the top of the slide will have an automatic rear tilt, also controlled using a wireless remote. This feature will slightly tilt the top rear of the platform to a small angle such that the car can begin its decent without needing to be manually pushed. Currently, there are no slides similar to this design on the market. Thus, this project will give the client, Joey, a fun, unique, and safe recreational slide for him to play on.

1. Introduction

1.1 Background

Joey is a six year old male with Cerebral Palsy. For a reason undetermined, he has a damaged cerebellum- the portion of the brain responsible for motor function. Due to his condition, Joey does not have full control of the muscles in his torso and limbs. Although he has the muscular potential to sit upright, walk, or move his arms and legs for everyday tasks, the damaged neuromuscular path hinders his ability to control those muscles at will. Joey’s torso naturally slouches, and without supports or harnesses, he is unable to sit in an upward position. Furthermore, he cannot walk without an assisting device, and often kicks his legs when expressing emotion. Joey is small for his age and is not expected to grow a significant amount in the near future. Currently, he is 3 feet tall and weighs 35 pounds.

Despite his disability, Joey is an active and healthy 6 year old, and is in need of recreational equipment to allow him to safely play outdoors. In the past, Joey has played in a slide called the Extreme Coaster by step2. This slide consists of a small 30” high slope, as well as a reclining cart to sit in while sliding down the hill. Because this slide did not contour to his body, Joey’s mother had to hold him steady and run down the hill with him. Furthermore, she had to push him up the hill every time he wanted to go down – a strenuous activity that would continue to get harder as Joey grows.

1.2 Purpose
The purpose of this project is to build an automated slide for Joey to play with. This slide will be similar to the extreme coaster by way of having a cart for him to sit in while sliding down the hill. The customized cart will be designed to comfortably hold Joey in a secure reclined position. The inside of the cart will be fully padded and equipped with harnesses to maintain his upper body posture, as well as foot straps to hold his legs down. To alleviate the strain on his guardian, an automated winch mechanism will be installed on the slide to slowly pull Joey back up the hill. The winch motor will be controlled both by a push button on the slide itself and by a wireless remote.

1.3 Previous Work Done by Others

1.3.1 Products

After extensively researching the NSF, ABLEDATA, and company catalogs, we discovered that there is very little in the market for modified recreational equipment for disabled persons. Much of the recreational equipment is in the area of bikes and cycles and assisted walking devices. The “Step2” slide coaster on which this design is based is the only related product known at this time (see figure 1).

Fig 1. Step2 Extreme Coaster Model.

1.3.2 Patent Search Results

Upon review of the United States Patent database, we have discovered only two vaguely related devices for recreational purposes for the disabled. The first is US patent # 5,505,663 for a “self operable transfer system for the disabled”. This playground apparatus has a departure platform connected to a unidirectional conveyor belt to permit only upward movement. The conveyor has handrails extending along the conveyor for pushing or pulling upwardly. A slide is attached adjacent to the conveyor as a means for the participant to go down from the upper platform to the lower platform. This product was designed with the intention to remove the dependence of constant wheelchair transfer for the disabled participant.
Fig 2. US Patent #5,505,663: Self operable transfer system for the disabled.

A second device, US patent #4,865,312, relies on an extensive wooden access ramp for a wheelchair to reach an elevation coinciding with the top of a metal playground sliding board (figure 3). There are wheelchair transfer stations at the bottom and top ends of the slide. The access ramp is inclined slowly such that the participant can propel themselves up the ramp to the first transfer station, make the transfer to the slide platform, and subsequently travel down the slide. After descent, the user transfers to a wheelchair again at the landing platform. The participant then repeats the act of travelling up the ramp and down the slide.

Fig 3. US Patent #4,865,312. Recreational Device for Physically Disabled Children.

Both of these devices have the intention to help develop upper body strength of children having lower body disabilities. Such diseases may include cerebral palsy, spina bifida, and lower body paralysis. However, if the disability affects the core body muscles, then these devices are difficult to effectively utilize. The duration of the actual recreation period is quite short, as well. There is a substantial amount of time and effort to return the user to the top of the slide to repeat the activity.

2. Project Description

2.1 Objective

The main objective of this project is to successfully design an adaptable slide for a six year old male with cerebral palsy, Joey Toce. Cerebral Palsy is a disorder that affects motor functions, learning, seeing, hearing, and thinking due to complications with brain development.
Due to this, Joey cannot gain full control of his posture or limbs, thus making it very difficult to be an active child and hence requiring modified recreational equipment to provide the physical activity.

The slide being designed for Joey will be able to automatically retract, instead of his parents pushing him back up to top of the start. This will be accomplished using a DC motor winch. We also plan on wirelessly controlling the motor so the winch motor can be started or stopped from a distance away. There will also be start and stop push buttons for emergency purposes on the slide itself, which will cut off the power supply immediately. The modified slide will have the required seating equipment for Joey in order for him to experience a comfortable ride and less work and strain on the supervisors’ backs. The car seat will include adaptable size mechanisms so that it will accommodate Joey’s growing body. The seat will not be a snug fit but it will carry the necessary harnesses to secure his trunk and lower limbs in place. The retraction motor will stop upon reaching the top platform and the cable will disengage due to lack of tension. There will be push stop buttons on the platform which will engage when the rear wheels of the cart roll on top and will stop the retraction on the winch. We will also incorporate a mechanism to raise the platform approximately 15 degrees using a hydraulic pump. This will enable the cart to roll over and begin descent down the slide track.

2.2 Methods

**Car**

*Frame, wheels, shaft*

The car used on the slide track is a top priority throughout the duration of the design of this recreational device. The user must be securely strapped into the car for safe descent and retraction to the top of the slide coaster. The wheels on the car will be 6” run flat tires with a hub length of 1-3/8 inches, a ½ inch steel ball bearing and a diamond tread. The tire weight rating of 100 pounds will allow for the weight of the user, as well as the weight of the car. The shaft will be ¾ inch in diameter composed of stainless steel. The frame of the car will be made of 1/8” steel tubing. The leg area and backing will be covered with polyethylene to create a car look similar to that of a roller coaster. Any exposed metal components will be covered with rust-resistant paints to maintain the durability and longevity of the car.

*Seating and Restraints*

The seat will be a bucket seat with nylon cross chest harnesses to secure the users upper body. A hip harness will also be employed to keep the user from slouching and sliding forward into an unsafe position in the seat. The entire safety seat will be tilted back at approximately 10 degrees to allow comfort for the user upon descent and retraction. The partially reclined seat will promote the resistance of the car to tip or travel in an unintended manner. An adjustable head rest will be included to support the head and neck during descent
and retraction. It will also permit room for the growth of the user. The leg supports will allow for a slight bend in the knees for user comfort. Velco straps will be employed to hold down the lower limbs in the car during activity. The foot rests for the flat of the foot will have an adjustable length to accommodate the growth of the user.

**Track**

The entire slide will be built in 2 sections: the platform and the track. Upon looking at different materials for the slide it was decided that the frame of the slide will be made entirely out of steel. Steel is a more cost efficient choice compared to aluminum. Wood would also be feasible but would not provide the rigidity and sturdiness required. Four steel beams welded at the bottom end and the top. They will be cross linked for added support by steel rods. See the figures for illustration.

The next step in constructing the slide would be to weld together the track on which the cart will be rolling down on. Track must be able to support at least 200lbs. The incline will be supported by steel bars underneath which will provide the strength. The platform will be at about 40 inches height, 30 inches wide and 20 inches in length. The track will be about 9 feet in length. There will be two 2inch wide indents running the length of the track about 15inch apart and about half inch away from the edge of the slide. These will serve as the pathway for the cart to go down the slide and will prevent the cart from rolling out of the track and enable it to go in a straight line. The wheels being used are about 1 3/8 inch wide and will easily fit in the indents. These indents or “gutters” will be molded out of the plastic material, mainly polyethylene, which will also be used to serve as “housing” for the side walls and the bed of the slide. This is mainly for cosmetic purposes so that the skeleton of the slide is not visible and also will enable the cart to smoothly slide or roll down. Once the track is built, it will undergo testing to see if it is able to support the weight of the cart and if further support is needed underneath.
Fig 4. Right side view of upper platform.

Rear view of the platform

Fig. 5. Rear view of the platform.

Fig 6. Side view of full track and supports.

**Electrical**

All electrical components will be controlled through PIC microcontrollers with both DC and wireless inputs.

**RF Controls**

The slide needs to have a compatible wireless remote device to control the retraction winch motor and the hydraulic platform tilt lift. This is necessary to remove much of the
physical strain that an operator would have to endure in order to manually push and return both the car and user to the top platform of the slide. The RF controller must have the ability to control the retraction winch motor, the platform tilt motor, and the power to the automated system. The control unit will have status LEDs to communicate the status of the system to the operator. The DC motors will be controlled such that the rotation is bidirectional and the speed of the motor can be controlled by the operator. This will be accomplished through the use of IRFZ44 and IRF4905 MOSFETs.

The main component of the RF transmitter will be the PIC16F84A microcontroller while the main components of the RF receiver will be the PIC16F84A microcontroller and a low noise operational amplifier (LM358). Example circuits for the RF controls can be seen in figures (7) and (8).

![Fig. 7. Transmitter Circuit Diagram.](image)

![Fig. 8. Receiver Circuit Diagram.](image)

**Winch Lift**

A winch motor will be installed to pull the cart back to the top of the slide. The winch motor will be powered by a 12V DC battery with a pulling capacity greater than 150 pounds. 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 activated for more than 3 seconds.

*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 photoelectric sensor will be installed at the top of the hill where the car sits before descending. There will be a programmed delay in the signal sent to prevent other objects, such as falling leaves, from triggering the sensor. Using a microcontroller, the signal sent when the electric eye is blocked triggers the winch motor to cut off.

*Tower light*

A tower light will be installed on the top of the slide. The tower light will have three color indicators: red, yellow, and green. The red indicator will illuminate when the winch motor is in use. The green light will turn on when the car reaches the top of the hill and the motor is turned off. If the motor is turned off before the photoelectric sensor is triggered, the light will remain red. Lastly, the yellow light will illuminate in place of the green light if battery is low. This light will be used as a warning mechanism to indicate that the battery needs to be charged. 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.

*Incline 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 provide enough tilt to initiate descent of the car down the slide. This ½ horse power motor will also be operated using a 12V DC input. The motor will be turned on by a wireless RF remote control, operated through the microcontroller. Furthermore, it will be programmed to turn on only when the cart has reached the top platform, or when photoelectric sensor is triggered. Once turned on, the motor will remain elevated for ten seconds before reversing back to its starting position.

3. Budget

The component breakdown and estimate cost of each is depicted below. The total cost of building the ARC Slide is $1,526.96.

**ARC Slide Components**

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The result of including all these components not only produces a safe slide coaster product, but has the appearance and durability of secure outdoor playground equipment. The track must include visual signals to the operator such as status LEDs and a tower light to communicate the current operation and condition of the automated retraction coaster (ARC) system.

4. Conclusion

This product is a major progression in the development of safe recreational playground equipment for children with disabilities. The automated retraction system significantly reduces the physical strain placed on the operator during the user’s activity. The trunk and leg supports provide the necessary means to secure the user with a disability in a safe manner during descent and retraction on the track. The supports also account for the growth of the user or variability for the use of multiple users.

The wireless RF controls and panel controls used for enhanced automation give the supervisor full control and status of the ARC Slide. These controls, however, permit the user to be less dependent upon a supervisor to actively utilize the slide. The ARC slide will give the user a large degree of independence and freedom when utilizing the slide.
The lift motor for the upper platform also provides a means of automated descent to remove the possibility of back strain of the supervisor after repetitively pushing the car into motion to roll down the track. Overall, this device successfully meets the needs for safety issues with harnesses in order to provide a safe and fun recreational device.