

# CHAPTER 12

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# LIFT N' GO - ASSISTIVE MEDICAL WALKER

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## INTRODUCTION

The purpose of this design is to create a device to assist people with limited leg strength in moving from a seated to a standing position and subsequently function as a stabilizing device for walking. Existing products for lifting a person into a standing position are generally heavy, cannot fit through standard doorways, require assistance from other people, and/or cannot be used as a standard walker. To address these problems, an assistive device combining the lift and walking functions, named as "Lift N' Go" was created in this project. Designed in a compact way, the device mainly consists of two six-bar linkages driven by two synchronized linear actuators and supported by a wheeled frame; which lifts the user from the seated to the standing position, and then allows the user to use it as a walker. Tests with perspective clients, up to 250 pounds, show that the prototype provides stable and comfortable lift-up support.

## SUMMARY OF IMPACT

The Lift N' Go can be used by a wide range of people, including those with lower-body debilitating ailments and elderly patients with weakness in legs. Many of these people are able to walk with the assistance of a standard medical walker once in a standing position, but the process of standing can be an arduous task requiring assistance from others. In the most severe cases, this can completely immobilize a person who does not have assistance. People who require assistance to stand up or sit down will find that our device makes their life easier and increases independence because they will no longer need assistance standing or sitting. Its compact size allows the Lift N' Go device to be used effectively in residential homes as well as in hospitals and rehabilitation clinics to help patients regain strength in their legs.



Fig. 12.1. Prototype and CAD drawing of Lift N' Go.

## TECHNICAL DESCRIPTION

The Lift N' Go consists of two six-bar linkages driven by two synchronized linear actuators and a supporting aluminum frame.

The innovative six-bar linkage is designed such that the output link, which supports the user at the armpit, replicates the shoulder joint motion path of the natural human standing and sitting process, and moves in curvilinear translation to maintain stable support to the human body. Our intention is to maximize user comfort through an ergonomic design that promotes natural motion. The six-bar design allows for a more compact and capable mechanism with less design constraints, compared with an equivalent four-bar linkage. By allowing an input-to-output distance magnification, an 8-inch stroke linear actuator is able to provide the necessary 19-inch vertical displacement of the output link.

The Lift N' Go utilizes two linear actuators running in parallel with position sensors for closed-loop synchronization control, which avoids unbalanced loading of the actuators. They are triggered by a wired controller operated by the user in the "switch until released" mode, and each actuator has a limit switch that stops the actuator once it is fully retracted or extended. This type of logic allows the user to easily abort the actuation process when he or she deems necessary. The actuators are powered by a small 24 VDC rechargeable battery pack that provides enough energy for use during an entire day. The actuators are rated at 2500 N (~560 lbs.) and are selected based on the dynamic analysis for a 300 pound individual. They move at a speed of ~0.4 inch/second when fully loaded, and the entire lifting process takes approximately 20 seconds.

The frame is constructed of 1-inch square 6061-T6 aluminum alloy tubing with 1/16-inch walls. It is designed to contain the linkages and to be lightweight without sacrificing strength and



Fig. 12.2. Demonstration of Lift N' Go.

stability. Total locking casters (swivel and rolling lock) are adopted to maintain the mobility of the device and the stability when in the locked position. In addition, forearm and underarm supports are designed to be adjustable for a wide range of users and for increased stability and comfort. A hip harness and sling support are adopted to decrease the requirement of upper body strength input and to enhance the safety features, allowing the user to rest the entire body weight during the lift process or in the standing posture.

The cost of parts and supplies for this project is \$1983.

# ASSISTIVE HANDCYCLE

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## INTRODUCTION

A special handcycle is custom-designed and constructed for a child with a complete left-side weakness. Due to the weakness in left side, the child tends to use his right arm and hand whenever possible, which prevents him from regaining the strength in his left side. No existing commercial assistive device is available for solving his problem, which was the motivation for this mobility and rehabilitation device. A tricycle is modified to provide an effective solution for improving the control of the client's left arm and leg. A sprocket-chain system is created to enable the user to ride the tricycle by hand. A disc brake is incorporated as an engaging mechanism to ensure that the left hand and left arm are actively involved in riding the tricycle. Corresponding to the hand-driving design, the steering of the handcycle is designed to use the feet. After finalization, the prototype assistive handcycle will be delivered to the client.

## SUMMARY OF IMPACT

The custom-designed assistive handcycle provides an effective solution to the client, which is not available from existing assistive products. With this device, the client can steer with his feet and pedal with his hands, and in particular, engage his left hand more than usual, which will assist him to rehabilitate his left side while providing him with more mobility. Moreover, the handcycle design can be easily extended to fit the needs of different children and adults with other levels of left or right arm weakness.

## TECHNICAL DESCRIPTION

A Schwinn Meridian Adult Tricycle is used, considering the cost of prototyping and the size to accommodate the individual.

To transform the tricycle into the handcycle, the frame is extended with an additional support on which the hand pedals and engaging mechanism are attached. The foot pedals are removed. A lower sprocket is placed on their shaft, which receives the force and motion delivered by a chain from the upper sprocket engaged to the hand pedals. A chain guard is added to cover the chain for enhanced safety.

The engaging mechanism is particularly designed to force the client to use his left side. The core is a standard bicycle disc brake. The disc is connected to the right side of the upper bracket along with the hand pedal. The caliper of the break is attached to the frame such that the bottom bracket fits properly over the disc. A spring in the brake caliper is connected to one end of a rotating link so that the pads clamp down on the disc when the user releases the left brake lever. The disk break ensures that the left break lever is held down in order for the child to rotate the pedals. When the brake lever of the engaging mechanism is released, the spring locks the brakes and the crank cannot be turned. When the break lever is held down, it stretches the spring and thus releases the brakes.

The steering system includes a set of links that connect the front fork to a foot-controlled pedal. The foot pedal is attached to the frame from below such that it can rotate left or right. When the foot rest is parallel to the ground, the front wheel is straight forward. When the user pushes down his right foot, the links connecting the foot pedal and the front fork pull the front fork and wheel to the right, causing the handcycle to turn right. When the user pushes down with his left foot, the steering links pull the front fork and wheel to the left, causing the handcycle to turn left.

The cost of parts and supplies for this project is \$680.

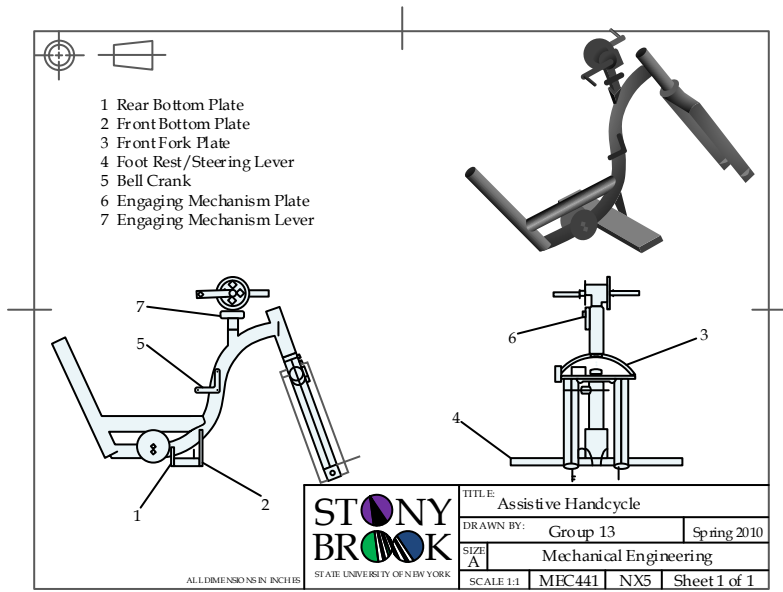


Fig. 12.3. Assistive Handcycle CAD drawing



Fig. 12.4. Assistive Handcycle Prototype.

# THE BOUNCE-N-WALK - MODIFIED BABY WALKER

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## INTRODUCTION

In this design project, a special baby walker is custom-designed to assist a five-year-old girl. She has been diagnosed with multiple syndromes, including Seckel syndrome, Dandy-Walker syndrome, and hypertonicity, and is unable to walk or crawl. She also tends to lose her breath when extending her neck backwards. There is no existing commercial product to assist our client. Our device design uses the child's weight to propel the walker by bouncing and moving her legs up and down. Extra support is also provided to prevent her from arching her neck backward and which inhibits her breathing.

## SUMMARY OF IMPACT

Our device allows the client to sit or stand while using her own movement to move the device forward when desired. Such a lightweight mobile device meets the present needs of both the child and her caregivers. The additional benefits include providing a learning tool for walking and enabling the child to play with other children, helping to develop her social skills as well. The client's quality of life will be improved in a variety of areas. Our client and her family were very happy to see the prototype, and the client wanted to use it immediately. The prototype will be delivered to the client after finalization.

## TECHNICAL DESCRIPTION

The user will control the device through the use of a pedal. A curved bar from under the pedal connects to the cable and pulls it when the pedal is rotated downward. A pulley directs the cable from the pedal to a spring-loaded drum. The purpose of using such a component is that the shaft will transmit the rotation in one direction and allows the cable to retract to its start position. On every down-stroke of the pedal, a cog-set turns the front wheel to



Fig. 12.5. Front View of the Bounce-n-Walk.



Fig. 12.6. Side View of the Bounce-n-Walk.

move the walker. The pedal then returns to its start position such that the next down stroke can be made. Square tubes are welded to the mechanism to provide extra support. The above assembly is designed as an attachment to a standard baby walker. With two bent steel plates, it can be clamped onto the plastic frame of the walker near the caster wheels. The pedal and its pivots are made of metal plate, but a soft rubber is used to cover the pedal to soften the impact of the client's feet.

As its base, a baby walker is implemented such that it does not obstruct attachment of the device from

behind. A head support is also added to the seat. It is made of insulation material that is soft and pliable. Underneath this material is a coil spring that allows the client's head to move forward but not backward.

Our design converts a baby walker into a walker trainer on which the client can lean in a standing position and bounce on the pedal.

The cost of parts and supplies for this project is \$520.

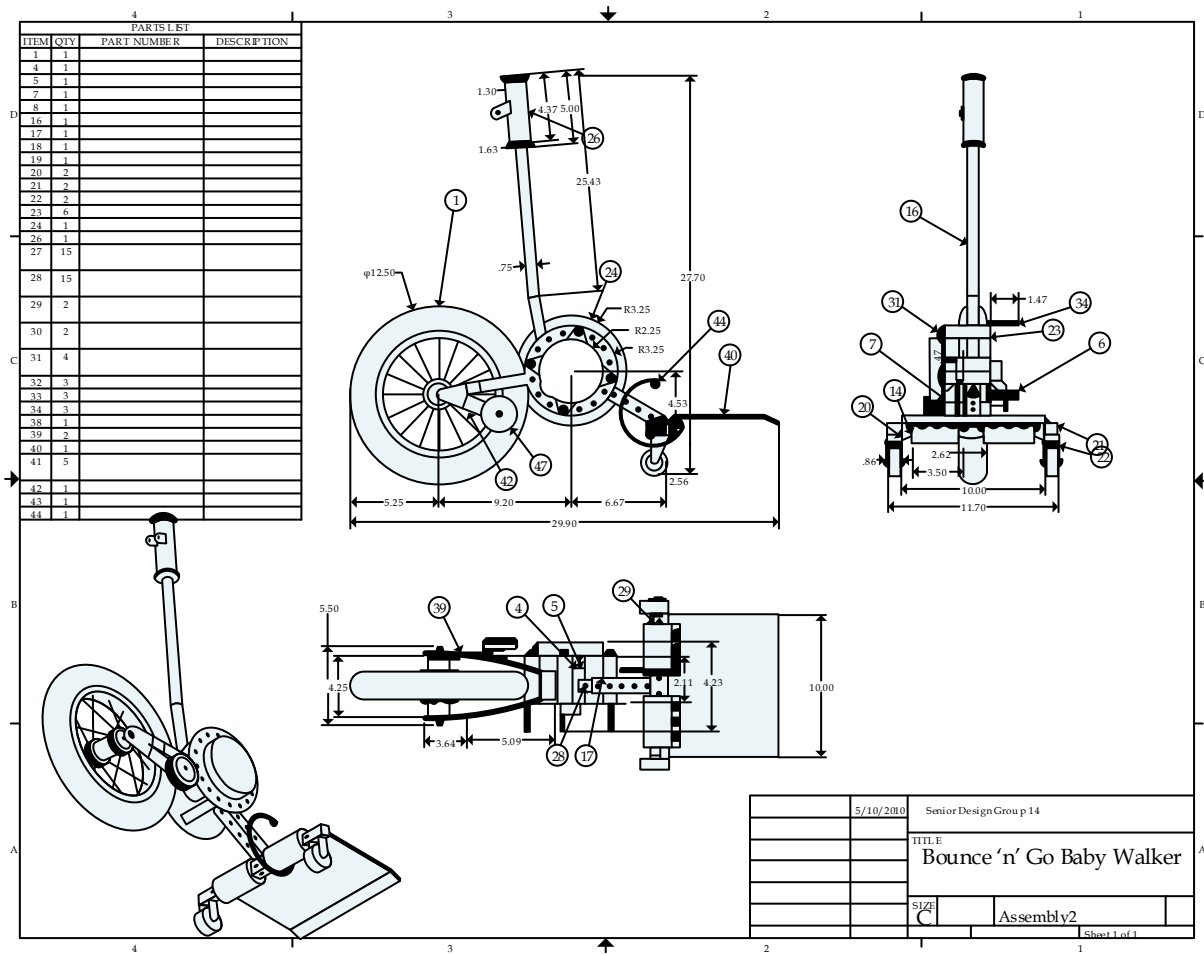


Fig. 12.7. CAD Drawing of the Bounce-n-Walk.

# THE TECS DEVICE: TECHNOLOGICALLY ENHANCED CIRCULATORY SYSTEM DEVICE

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## INTRODUCTION

Maintaining comfort is important for people with disabilities who have to sit for extended periods of time in wheelchairs or lie on beds. Lack of comfort often means muscle fatigue and skin conditions that can result in pain and even more serious medical situations. A common solution is to move the patient once a while, which requires the assistance of caretakers who can lift the patient. This is a task that can sometimes be overlooked as well. This project introduces a solution by designing a device that can be mounted into various types of seats to make users more comfortable during extended periods of sitting or lying down. By rotating an array of steel coils cushioned underneath the seat cover, this device alters the pressure points that the user experiences at a controllable time interval. It promotes the circulation of blood and oxygen to reduce skin irritation and muscle fatigue.

## SUMMARY OF IMPACT

Bedsore and Decubitus ulcers are serious problems for those who develop discomfort from extended periods of sitting in wheelchairs or lying down on beds. Our design provides an effective and economic mechanical solution to offer users comfort and relief, and achieves a higher weight capacity than existing air-pressure based products. Besides wheelchairs and beds, we also envision that this device can serve a broader population in offices, schools, vehicles and much more.

## TECHNICAL DESCRIPTION

This device functions by alternating the pressure points that the user experiences at a user identified time interval. To accomplish that goal, an array of flexible steel coils which are fixed to three horizontal shafts rotate underneath the seat. A DC motor drives the coils through a transmission train consisting of a gearbox, two chains and several sprockets which are attached to the output of the gearbox and the input



Fig. 12.8. TECS Prototype.

of the shafts. The transmission train is designed to provide the desired high torque and low speed. A tensioner using two sprocket idlers is added to eliminate any slack in the chains. The pressure points that the user experiences are determined by the position of each winding of the coils. The coils are vertically flexible so that they can contour to the seated user to increase the surface contact area. They were covered with a soft foam cushion to avoid hard contact. Rotating the coils will give the user a "massage" which facilitates the release of tension in the muscles and the skin.



A motor controller, which can work in two modes including automatic and manual, is included in the design. The automatic mode is controlled by a cyclical timer circuit. With this circuit, one can control how long the motor runs by setting the corresponding time intervals. The manual mode is controlled using a switch circuit to turn on and off the motor which allows the motor to spin forward or backward. A relay circuit is added to supply enough power to the motor.

The cost of parts and supplies for this project is \$896.



Fig. 12.9. Opened TECS Prototype.

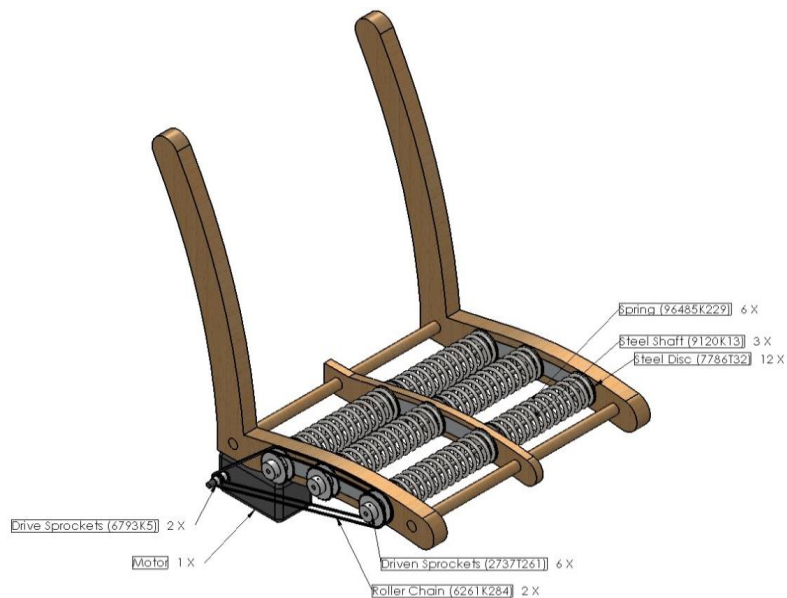


Fig. 12.10. CAD Drawing of TECS Assembly [Isometric View].

# AUTOMATED WHEELCHAIR DESK

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## INTRODUCTION

An automated wheelchair desk is designed to provide convenience for students using wheelchairs to move a desk and book bag to the seating area. Students in wheelchairs tend to have difficulty in accessing books and other school supplies. Similar products on the market are not automated and require assistance from another person to bring forward the desk or book bag. This project provides a solution that enables a wheelchair-bound student to control the desk from his or her seated position using a simple toggle switch.

## SUMMARY OF IMPACT

This device will benefit the large population of students that use wheelchairs, allowing them to do their schoolwork in wheelchairs at their convenience. Users will have the control to bring the desk to their laps with minimal effort from a comfortable seated position. The use of this device will give them more independence in daily activities. The same idea can be easily extended to benefit other wheelchair users by providing them the convenience of carrying and easily accessing their belongings.

## TECHNICAL DESCRIPTION

The input of the entire system involves a DC gear motor that supplies rotational motion to the vertical drive-shaft which rotates the desk assembly from the back of the wheelchair to the front. The vertical drive shaft is fixed onto the wheelchair back through rod ends. The desk is supported by a horizontal support arm which is connected to the top of the vertical drive shaft via a shim. The transmission is designed to rotate the desk from its initial to final upright position (270 degrees of rotation) in three seconds.

The user controls the rotation of the desk using a switch. In the forward mode, the desk is rotated from its home position to its final upright position. The wheelchair user can detach the backpack from the assembly and place it on a hook, and then bring

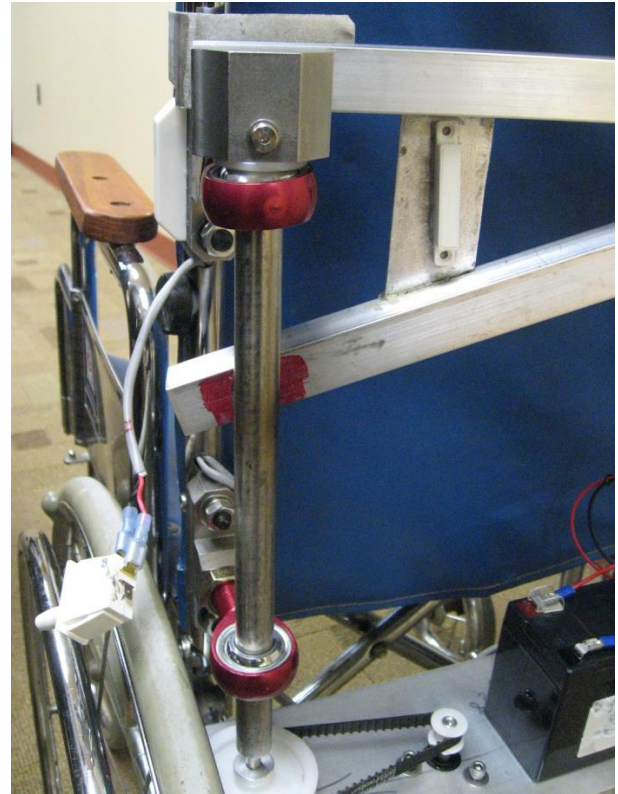


Fig. 12.11. Vertical End Rod Assembly.



Fig. 12.12. Desk in the folded position.



# SOLAR-POWERED AUTOMATIC WINDOW

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## INTRODUCTION

The solar-powered automatic window is designed for people with disabilities and the elderly who are unable of opening a window due to diminished arm strength or other physical detriments. This window operates on battery power which is charged through a solar panel, and slides horizontally upon being triggered with a remote control. This design targets various facilities for people with disabilities, such as the Premm Learning Center, and is also suitable for personal use in residential houses.

## SUMMARY OF IMPACT

This project aims to help any person that has difficult opening standard windows. The solar-powered automatic window is easy to operate (with a remote control), which offers clients the convenience to control air flow at home, school or workplace. It gives them more freedom and independence in their daily lives at home and at work, and allows them to enjoy fresh air and desirable room temperature at their leisure. Powered by harvesting solar energy, the system is self-sustained, and can be incorporated into any green technology-based facility.

## TECHNICAL DESCRIPTION

The mechanical body of the solar-powered automatic window is a 36" x 36" vinyl window that opens and closes through horizontal sliding. The driving power from a DC motor is transmitted through a pulley-belt set. One pulley is fixed to the drive shaft of the motor, while the other is fixed to a 2" steel shaft that is fixed between two flanged mount bearings in the wall. The window is fixed to the belt with a high strength epoxy. To overcome the friction force involved in sliding a vinyl window, several rollers are placed along the bottom edge of the window panel. This reduces the friction force and allows the use of a low torque, low power-consumption motor to automate the sliding process. The motor is controlled through the use of a remote



Fig. 12.14. Prototype of the Solar-Powered Automated Window.

control and can move the sliding window pane to the desired position. Careful consideration is taken to ensure that the overall size of the mechanical components is easily retrofitted into a standard house wall without protruding from it.

To power the motor, a 5000mAh battery is used, which is constantly charged by a 15W solar panel. The output power of the solar panel is regulated to prevent the battery pack from overcharging. A remote control is designed using a radio frequency transmitter, which has two buttons to toggle individual relays to trigger the corresponding modes of the onboard motor controller. The onboard motor controller then sends the appropriate signal to the motor which controls the forward or backward rotation to open or close the window.

The cost of parts and supplies for this project is \$759.21.

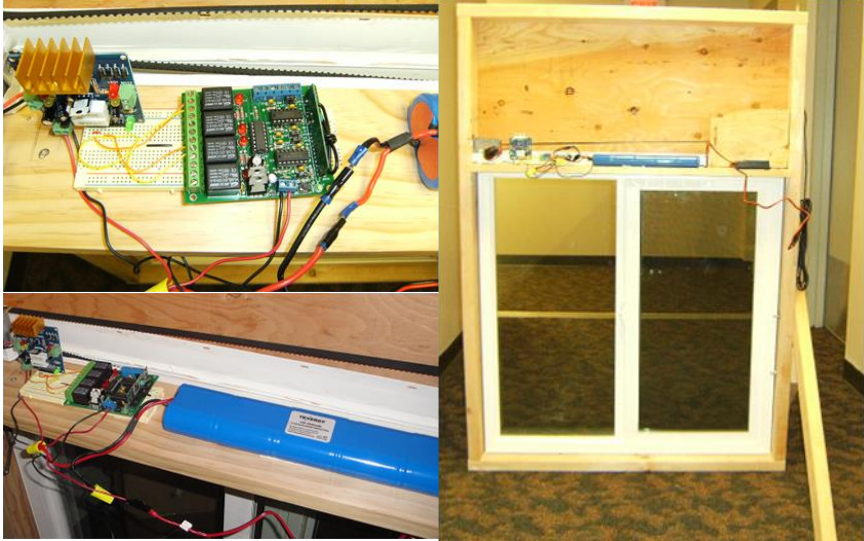


Fig. 12.15. Circuitry and Installation.

# NATURAL GAIT GUIDANCE MECHANISM

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## INTRODUCTION

In this project, a device is custom designed for a child who is nearly paralyzed on the left side of his body and is capable of limited movement on the right side. Though he can stand and walk using a gait trainer powered by his stronger leg, the other leg is not able to assist him in locomotion. To provide a solution, this design involves an assistive mechanism attachable to an existing gait trainer, such that the child can propel it himself. Once his stronger leg makes a step, it will propel the gait trainer to move him forward. The other leg will be attached to the device. As he moves forward, the device will subsequently move his weaker leg forward in a natural gait.

## SUMMARY OF IMPACT

This gait guidance mechanism is designed to address the needs of a specific client due to an unbalanced strength in his legs, enabling him to use a standard gait trainer and guiding him through a proper walking technique. It will encourage him to use a gait trainer to rehabilitate the leg muscles in his weaker leg and promote natural gait motion. For individuals with muscular dystrophy and other serious leg disabilities, it is very challenging to stand and especially difficult to walk. With improvements in medicine and medical procedures, there is much hope for those with debilitating conditions to experience significant recovery. Rehabilitation is of great importance for them to regain muscle strength and walking capability. The design idea of this project can be extended to match the needs of different patients, by studying and encouraging the natural gaits of different individuals.

## TECHNICAL DESCRIPTION

The assembly of the gait guidance mechanism is fixed onto a main aluminum plate which is attached to a gait trainer along the longitudinal direction. When the client takes a step with his dominant leg, he will propel the gait trainer and himself forward.

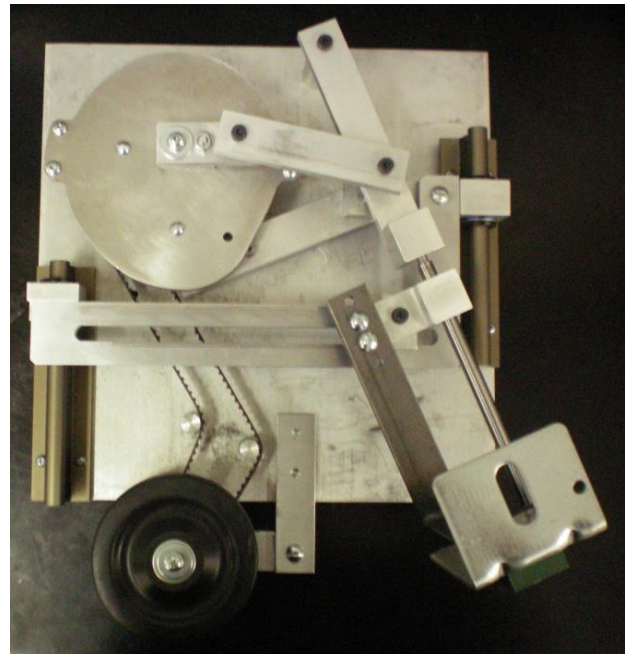


Fig. 12.16. Prototype of the Gait Guidance Mechanism.

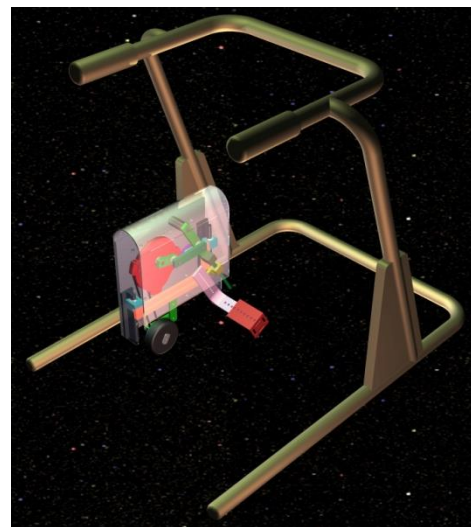


Fig. 12.17. The Mechanism Attached to the Gait Trainer.

As he moves forward, the device will subsequently move his weaker leg forward in a similar walking motion. The gait length and orientation is fixed, and is determined by measuring the ideal step that the client should take.

The driving power of the mechanism comes from a wheel that is kept in contact with the ground. As the gait trainer moves forward, by either the user's own power or the supervisor's assistance, the friction between the ground and the wheel drives the mechanism. The input power from the wheel is transferred to other moving components of the gait guidance mechanism through a pulley set consisting of two pulleys connected by a flat belt. One pulley is attached to the axle of the driving wheel, while the other is attached to the axle of a cam. The cam is specifically designed to deliver the vertical

component of the natural gait motion, with the cam contour determined by analyzing the client's ideal gait. The cam drives a four-bar linkage which governs the horizontal position of the weaker leg. The ankle of the client's weaker leg will be held by a brace at the output of the linkage. As the cam rotates, the four-bar linkage will move the client's ankle forward and backward to repeat the ideal gait.

The gait guidance mechanism has a compact design, with all components fitted onto a one square foot back plate. Being attached to and supported by the frame of a gait trainer, it does not add extra load to the user.

The cost of parts and supplies for this project is \$667.

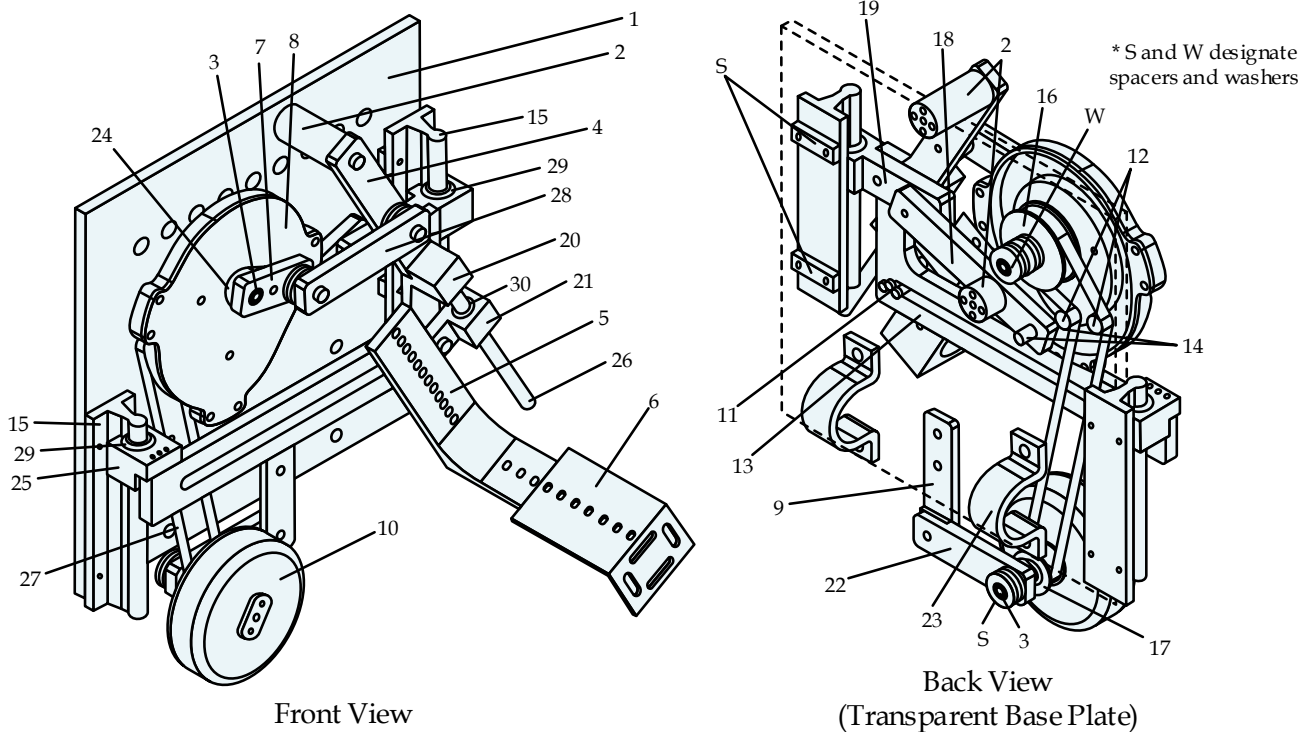


Fig. 12.18. CAD Drawing of the Assembly of the Gait Guidance Mechanism

# THE RUMBLE AIDE

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## INTRODUCTION

The goal of this design is to create a travel aid device for visually impaired people. The Rumble Aide consists of two ultrasonic sensors to detect frontal and overhead obstacles and provide comprehensive assessment of the user's surroundings. Depending on the proximity of a frontal obstacle, the device will provide haptic feedback or vibrate; and if there is an overhead obstacle, the device will provide auditory feedback or a "buzz". It is designed to improve the range of awareness provided by existing solutions such as traditional canes and guide dogs.

## SUMMARY OF IMPACT

The Rumble Aide design is a compact, light-weight and user-friendly obstacle detection device. It is capable of both overhead and frontal detection of objects, each with a distinct feedback mode for easy differentiation. Comparing with other aide systems such as canes and dogs, our device provides a much broader obstacle detection range, has a comparable or even longer lifespan of usage, and requires little maintenance. This device is able to improve the quality of life for visually impaired people by helping them move around independently with wider object detection capability.

## TECHNICAL DESCRIPTION

The Rumble Aide consists of two ultrasonic sensors, four motors and a buzzer controlled by a BASIC Stamp 2e Module microcontroller with a 9 V battery as a power source. Additional components include N-Channel MOSFETs and voltage regulators.

The 9V battery power source is transformed to proper voltage inputs for the vibration motors

(which run on 3V) and the ultrasonic sensors (which run on 5V). The 3V for the vibration motors is obtained by passing the 9V through an adjustable voltage regulator (which has been set to provide a maximum of 3V). The 5V for the ultrasonic sensors is obtained by passing the 9V through a constant 5V voltage regulator.

The microcontroller controls the two ultrasonic sensors (which are capable of sensing from 2cm to 3m). Each ultrasonic sensor has two components: a transmitter and a receiver. The transmitter sends short ultrasonic signals, and the receiver collects the signals reflected back by nearby objects. The P-BASIC programming in the BASIC Stamp converts the signal traveling time into distances. Then the microcontroller triggers the motors or the buzzer depending on the location of the obstacle. If the obstacle is frontal, the motors will vibrate. The intensity of the vibration depends on the proximity of the obstacle, with all motors vibrating when an obstacle is within two feet of the user and one motor vibrating if the obstacle is four to seven feet from the user. If the obstacle is overhead (close to the head), the buzzer will ring.

The electronic components are enclosed in a homemade PMMA casing. A handle protrudes from the back, made of an aluminum rod covered with PE foam, and a strap is designed to provide extra support to the user.

The cost of parts and supplies for this project is \$965.



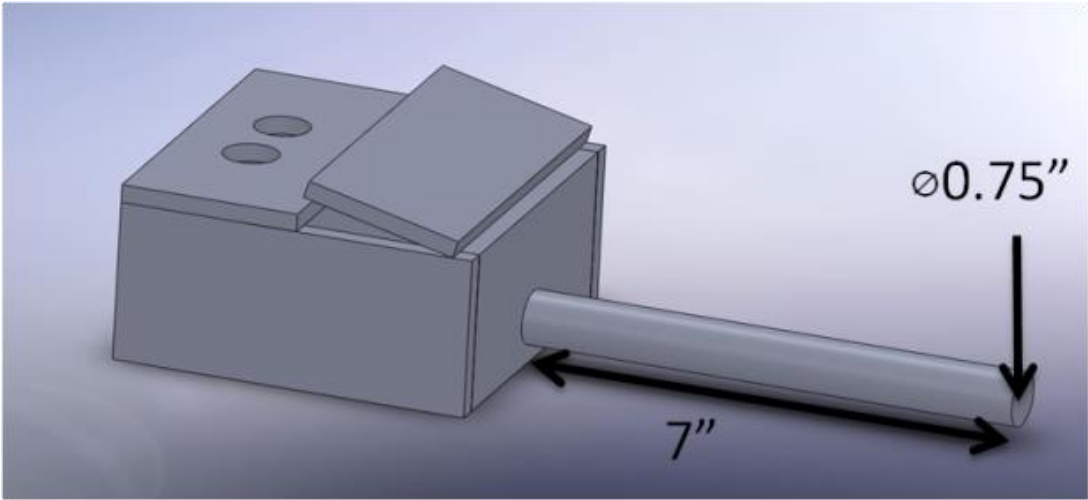
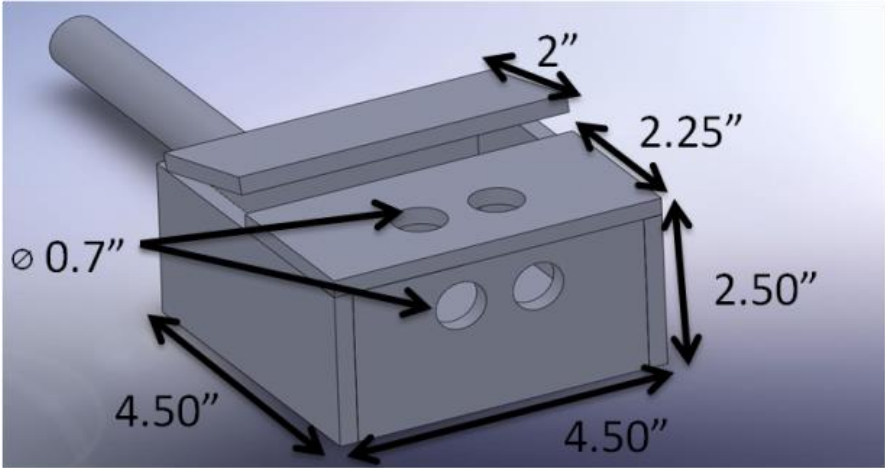


Fig. 12.19. Casing of the Rumble Aide.

