# CHAPTER 10
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# FLOTATION DEVICE FOR A CHILD WITH CEREBRAL PALSY

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## INTRODUCTION

The family of a three-year-old boy with cerebral palsy noted the child's enjoyment of being in the water. Due to limited motor control, the child has great difficulty swimming independently. Since being in the water benefits this child so much, the family requested a floatation device that meets the child's special needs. The goal was to design a safe device that would keep him afloat, support his neck, and not restrict his movements.

## SUMMARY OF IMPACT

There are many physical and emotional benefits for a child who can play in the water. The effect of weightlessness allows the child to take pressure off of the muscles and joints, which often become tight due to constant fixed positioning in a wheelchair.

## TECHNICAL DESCRIPTION

The design for this device was centered on the specific client and his older brother. The older brother's current physique was used to project an approximation of the client's future size and weight so that the device can be used for more than just one season. The device was designed after a typical wet suit used for scuba diving. Neoprene, the material in wet suit manufacturing, has a buoyant property that can float the user. A 6.5mm neoprene sheath makes up the bulk of the device, while a neck rest makes up the rest. Danmar Products manufactures a product known the Hensinger neck support that is incorporated into the design. The neck support is made of a thick circular-shaped foam band and covered in a vinyl coat. This allows the neck support to be waterproof and contribute some of the necessary buoyant force. To provide the force required to float each of the young boys two layers of the neoprene are used. Webbing is used, along with ladder lock buckles and adjustable nylon strap pieces, to give the device form and to hold it in place next to the body while in use. The Hensinger neck support is mounted to the device by means of the same style of webbing and buckles. A heavy-duty sewing machine was used to sew the two sheets of neoprene and the webbing together. A local upholsterer was contracted to do this sewing.

After production of the prototype, two children were served as test subjects for the device (Figure 10.1). The selected children are of the same age group but are slightly heavier than the client and his brother. Both of the test children were successfully supported in the water by the device and were floated with their chins, necks, and heads above water. The weight limit for this device is set at 55 lbs.

The cost of manufacturing this product is $197.53.

Figure 10.1. Flotation Device.

# GO-CART FOR AN ABLE-BODIED DRIVER AND A PASSENGER WITH A PHYSICAL DISABILITY

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## INTRODUCTION

A five-year-old boy, who has spastic quadriplegia due to cerebral palsy, is limited in the movements of his entire body. He wanted to be able to ride in a go-cart like other children his age. A go-cart was purchased and modified to accommodate this child's needs. The existing go-cart seat offered little, if any support or protection for a child with this condition. A new seat was designed and fabricated that incorporated a four-point harness system in addition to head, body, and side supports. The harness and support systems are fully adjustable in order to allow for the client's growth. In addition to the seat, an additional steering wheel is incorporated into the passenger side. The steering wheel has a soft connection to give the passenger the feeling of driving while not causing safety problems. The additional steering wheel is adjustable to allow for growth.

## SUMMARY OF IMPACT

A go-cart that is capable of supporting children with physical impairments can bring great joy to their play. This particular child is now able to enjoy the freedom and thrill of riding around in his very own go-cart, and because the go-cart is so adjustable, he will be able to enjoy the thrill for years to come. In addition, the high adjustability of the go-cart could allow for other children of all ages and sizes to enjoy a ride.

## TECHNICAL DESCRIPTION

The most important design goal was to ensure that the go-cart is safe. The harness system uses webbing and buckles that stand up to automotive safety standards. The seat belt anchors are made from 1/4" steel flat. The go-cart chosen has a full roll cage. Side supports are built in to protect the passenger from a side collision, and a DOT approved helmet is included with the go-cart as an added precaution. The steering wheel is adjustable to prevent injury from a head-on collision. The seat and all supports are well padded for both comfort and safety.

Another design goal was adjustability. The seat and harness system need to be adjustable so that the client can ride comfortably and safely up to the age of at least 18. This was accomplished by using anchors that can be moved between cut attachment holes. The slots are cut into the back of the seat, and they are smaller than the anchor pieces so that the anchor pieces must be rotated 90 degrees in two different planes in order to slide through the slot. Under any sort of force, the seat belt will orient the anchor so that the largest plane is parallel with the seat back, barring it from coming through the slot. The side, body, and head supports are composed of bent metal tubing covered in pads. These are bolted to the seat and can be adjusted with a wrench. The steering wheel is adjusted via a push button system similar to that found on modern crutches. It has a travel of 24 inches.

The soft connection on the steering wheel is achieved through the use of a pulley system. A pulley from the functioning steering wheel turns a belt that turns a pulley located on the passenger side steering wheel. This belt will cause the false wheel to turn with the go-cart, but will not allow the passenger to override the driver's steering.

The cost of the finished product is about $580.

Figure 10.2. Client and his Brother in the Go-Cart.

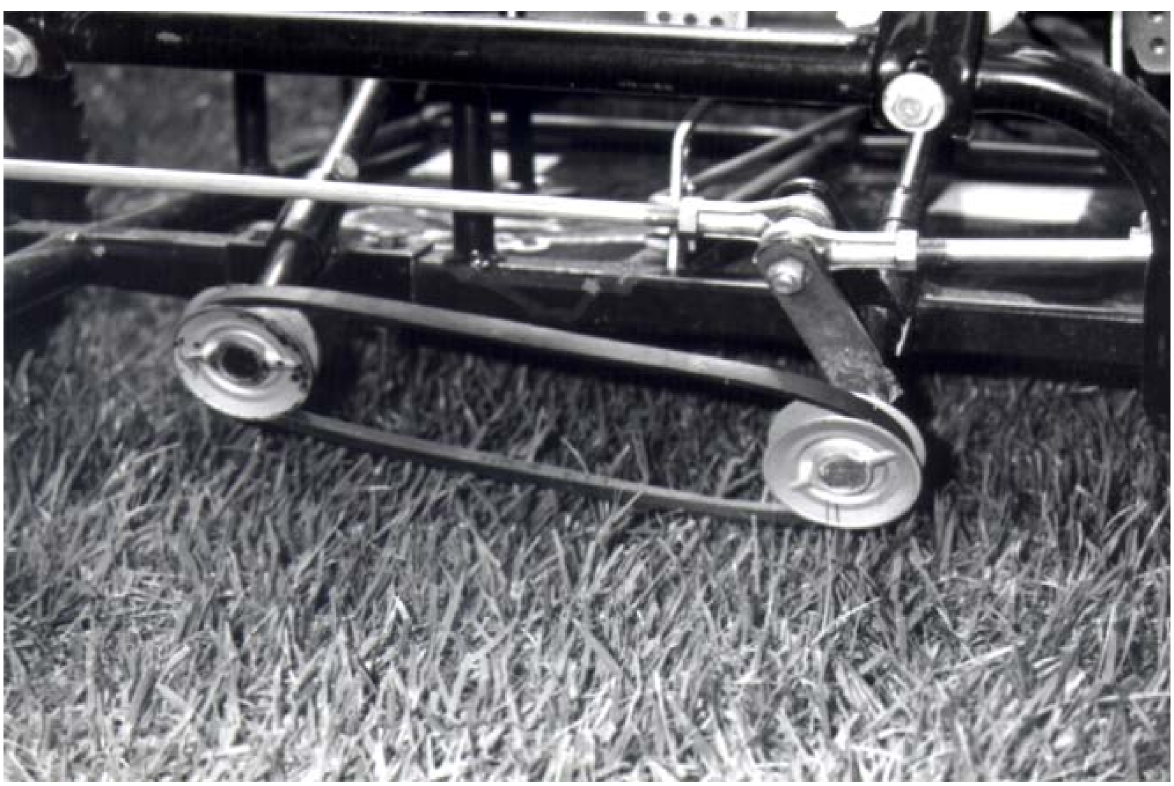

Figure 10.3. Soft Connection to Passenger-Side Steering Wheel.

# HOIST TO FACILITATE INDEPENDENT TRANSFER FROM WHEELCHAIR TO BED

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## INTRODUCTION

A man who has had lower-level paraplegia for 22 years employs a female caregiver for assistance in activities of daily living, including wheelchair to bed transfers. He desired an economical solution for independent transfer from his wheelchair to his bed and vice-versa. A lift consisting of a dual hand crank winch is attached to a trolley that runs on an I-beam track mounted perpendicular to his hospital bed. The I-beam is supported by two steel frames on opposing walls. The client manually transverses himself along the horizontal track using a wall-mounted aluminum bar.

## SUMMARY OF IMPACT

The client can now independently transfer himself to his bed. The lift also provides him with upper body exercise during the winch-cranking process, and pressure is relieved from his spine as his trunk weight is displaced somewhat from the lumbar and coccyx regions of the spine.

The client was not previously able to achieve independent transfers. His caregiver needed assistance in lifting him into bed, as the method previously used (manual lifting of the client) placed stresses on her spine that exceeded the U.S. Department Health and Human Services' limits by more than 200 percent. Commercial products are available to remedy this type of situation, but all require more than one person for operation or cost over $5000.

## TECHNICAL DESCRIPTION

The hoist's lifting mechanism is a dual hand crank worm gear puller rated at a 1500 lbf capacity with a 30:1 lift ratio. It is attached to a 1500 lbf capacity universal I beam mounted trolley. The trolley runs on an 11 foot track of I beam mounted perpendicular to the client's hospital bed, giving it a clearance of 2 in below the 8 ft ceiling and 1 in clearance with each side wall. The I beam is supported by two 3-sided squared frames on opposing walls, each standing 85.5 inches tall and made of C4 steel channel. The frames are bolted into the floor (3/4″ oak hardwood flooring, 1/2″ composite underlayment) with 3/16″ x 1-1/2″ wood screws.

The client can roll his wheelchair under the winch where a three piece Quick sling (commercially available, OSHA approved) is attached to a specially made hook (cold-rolled steel, 7/16″ diameter), put himself in it, and crank himself up for clearance over the side of his wheelchair using 2.25 lbf operating force per arm (Barrier-Free Lifts Inc. 1998). He can then manually transverse himself along the horizontal I beam track using a padded bar. It consists of six 1 in diameter aluminum tubing protrusions, each 4 in long, welded 10 in apart from the far end of the wall over a span of 6 feet. There is room at the end of the bar where he will not go since the bed is not flush to the wall. The "pull bar" for horizontal traversing is hinged on the wall closest to his bed. When parallel with the floor, the pull bar rests 28 inches below the I beam, which has a 2.5 in clearance under the room ceiling. The pull bar is also attached by 1/4″ nylon rope to two pulleys mounted on the ceiling so that the client can raise the pull bar and leave it at the higher height, effectively moving it out of the way of the caregiver.

ProMechanica in ProEngineer was used to analyze the most probable areas of failure: the I beam, horizontal steel channel on the supporting frame, and the hook for sling attachment. In addition to the weights of the lift itself, loads of 150 lbf were used to simulate the client's weight (currently 135 lbf). The S4 I-beam, A36 steel, 4.4 in X 7.7 lbf/ft has a maximum beam bending stress of 268 psi located at 58.5 in from one side of the I beam (halfway between supporting frames at each end), a maximum deformation of 0.025 in at 58.5 in from one end, and a maximum point rotation about the z axis of

0.00758 degrees/ft, resulting in a 0.037 degree rotation at the center of the I beam. The C4 Channel, A36 steel used for the frames, has a maximum beam bending stress of 810 psi where the center of the I-beam rests on the piece of channel parallel to the floor and a maximum displacement of .002 inches at the same point. The hook for sling attachment has a maximum hook displacement of 0.002 inches on the end of the hook. The stress in the bend of the hook exceeded 50,000 psi, but the area was almost negligible relative to the rest of the hook, which showed acceptable stress levels. The winch (nylon web strap worm gear puller) has a lift capacity of 1500 lbf, randomly tested at 3000 lbf, and a lift ratio of 30:1, requiring The client to place 2.25 lbf on each handle. The universal I beam trolley is rated at 1500 lbf also. While neither is man-rated, the client consented to use them due to their design, efficiency, and inexpensive costs relative to man-rated products.

The final cost of the project was $551.84. The most expensive parts were the web strap worm gear puller ($125), the trolley ($115), and the 3-piece Quick sling from Barrier-Free Inc. ($112). Other costs are due to steel, hardware, and labor ($35 for welding). Donations were made in the form of smaller pieces of steel and labor for installation.

Figure 10.4. View of Designer Testing Hoist in Client's Bedroom.

# BICYCLE TRAILER FOR A CHILD WITH DISABILITIES

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## INTRODUCTION

A ten-year-old girl with a severe physical disability and a cognitive disorder was unable to ride a bicycle. She was also too big to use any of the bicycle seats or trailers on the market. To overcome these problems a special bicycle trailer to drag behind a bike was designed. The trailer includes a frame, cover, seat, hitch, and tires. The frame consists of several pieces of tubing welded together to form a single unit. The other materials, such as the hitch, tires, and seat, are attached to the frame by bolts. The trailer connects to an adult size bicycle by a hitch that involves an assembly of two pieces (rod-end-joint and clevis). This design has been made to accommodate the young girl's size and special conditions.

## SUMMARY OF IMPACT

The bicycle trailer was designed to allow the user to enjoy the pleasures of riding a bicycle without having to operate or pedal it. The trailer device was sized to fit the patient's dimensions and made to easily attach and detach from a standard adult bicycle via a hitch device. The trailer gives the young girl the opportunity to experience bicycle rides with her family.

## TECHNICAL DESCRIPTION

The major design objectives were that the device:

- Weigh less than 45 pounds,
- Be fairly easy to attach to and detach from the bicycle,
- Be safe for the passenger and the bike rider,
- Not interfere with the person who is driving the bicycle, and
- Be able to hold the passenger's weight.

The trailer frame (Fig. 10.5) is made of 1" aluminum tubing with a wall thickness of .065". The frame is 34" wide, 45" long, and has a maximum height of 39". The trailer also has a tongue made of the same 1" aluminum tubing and is equipped with a clevis, which attaches to the hitch assembly at the rear axle on the left side of the towing bicycle. There is also a fiberglass seat attached to two 1.75"x1.75"x3/16" aluminum angles with four 5/16" carriage bolts. The seat has a seat belt for safety.

The trailer includes a foot platform lowered about 6" below the seat. The platform is made of 1" aluminum tubing and contains six 2" x 3/8" aluminum flats spaced apart by 1". The cart is covered with a yellow weatherproof awning material that adds a nice appearance and increases safety by keeping the child's fingers out of the wheels. Other features of the bike trailer include two 20" wheels attached to the frame by dropouts. There are two dropouts per wheel and they are attached to the frame by 5/16" bolts.

The total cost of parts and materials was $684.22.

Figure 10.5. Bicycle Trailer for a Child with Disabilities.