CHAPTER 10
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INTRODUCTION
The goal of the Chain-Driven Seven-Speed Wheelchair, shown in Fig. 10.1, was to provide its user with greater mobility than a traditional wheelchair. Traditional wheelchairs, although intended to increase mobility, often create restrictions. Their speed is limited by the user’s arm strength and range of motion. The range of inclines that users are able to navigate is similarly restricted. This device addresses both of these issues. It adds an adjustable amount of mechanical advantage to the user’s input (arm motion), thus allowing him or her to travel at a faster rate of speed, or with greater output torque, than would be possible in a typical wheelchair. The mechanics of the device are such that they can be controlled by the user as they are traveling. Different “gears” can be chosen depending on the ground characteristics or the user’s desire (see Fig. 10.2).

SUMMARY OF IMPACT
This device can expand the range of recreational activities in which a person who uses a wheelchair can participate. By enabling people who use wheelchairs to move at a faster pace, they can more easily accompany others while they participate in activities requiring such movement. The increased ability to take part in activities and keep up with those not using wheelchairs can provide greater independence and confidence.

The gearing system in place on this new device allows a range of different outputs for the same input, thus making a more efficient use of the energy input. Brakes on a traditional wheelchair are generally four-bar locking mechanisms. They are either ‘on’ or ‘off’. While this is good for keeping a wheelchair stationary once it is in a desired position, it does not work well for slowing the wheelchair to a gradual stop. This new device makes use of pressure sensitive brakes, which are actuated from a convenient location for the user. In addition to allowing the user to decrease speed safely, these also can be helpful while navigating steep inclines. By squeezing the brake controls a user may pause on an incline. To continue he or she needs only to release these controls.

While the prototype only retains a small amount of the wheelchair’s collapsibility (due to fabrication limitations), in actual production the modified wheelchair would fold as well as a traditional wheelchair. The benefits of this feature will be the same as a normal wheelchair; however, more significance will be placed on the ability to pack up this new wheelchair to take it to parks and on trips.
An operator of this new device will have a wheelchair which is easier to use, is more capable, and has a greater range of motion than a typical wheelchair. This device will allow him or her greater freedom. Use of this wheelchair could help accelerate rehabilitation or, in the case of permanent use, lead to a more active and healthy lifestyle.

**TECHNICAL DESCRIPTION**

The device is designed around an alternative propulsion method. Instead of the traditional wheelchair input, which is tangential force on the outer edges of the large wheels, this device has input levers in a more ergonomic location. They are positioned right where a user’s hands comfortably rest, past the ends of the armrests (see Fig. 10.3).

There is one lever on each side of the device, each controlling the motion of the corresponding wheel. These levers each rotate a driving sprocket, which is linked by chain to a sprocket cassette located axially on the large (driving) wheel. This cassette contains seven sprockets of varying size (see Fig. 10.2). Although the gear settings are controlled independently on the prototype to retain maximum flexibility during testing, their incorporation into a single control could be easily accomplished in production if the current system were determined to be overly complicated for a typical user. Furthermore, a second set of gear sprockets could be utilized to add additional versatility to the wheelchair by providing more gear ratios similar to that found in a bike. In the prototype, the driving sprocket is a set selection. If the gear sets were codependent and controlled from a single controller, utilization of the second set of selectable sprockets would become possible, resulting in even greater adaptability.

Through the use of a derailer, the chain can be moved to each of the seven sprockets. This gives the device selectable mechanical advantage. For a given input, the user can select an output that can offer a high torque and low speed, or a low torque and high speed, depending on his or her current needs. The controls for these derailers are located right on the input levers, allowing the user to change the sprocket ratios during travel. Each sprocket can be selected by making use of the gear shifter mounted on the control lever (Fig. 10.4). These shifters change the tension on a cable leading to the derailer. They are calibrated so that a detent in the shifting mechanism corresponds to the proper tension required for the selected gear.

The input levers do not make full revolutions. They are pushed forward through a partial revolution (varying from 100 to 150 degrees, depending on the user) and then pulled back to their initial position before being pushed forward again. The chain is only engaged when the controls are being pushed forward. When they are being pulled back, a ratcheting mechanism prevents the driving sprocket from turning, thus keeping the chain stationary with respect to the sprocket cassette. This is necessary because the derailer requires that these sprockets go through a ¾ revolution in order to change gears. This means the chain cannot travel backward, as that would undo any progress it has made switching
between gears. One of the disadvantages of this particular driving mechanism is that the mechanism cannot power the chair backward. The wheels must be gripped and moved like a traditional wheelchair to accomplish this. This limitation results from the bicycle mechanism itself, which does not allow for a powered “reverse” mode. Time constraints prevented the pursuit and incorporation of a selectable “reverse” gear; however its inclusion would make the gear system more complete.

The wheels are spaced slightly farther apart than they would be on a traditional wheelchair. This provides greater stability, as does the use of wider rubber air-filled tires. These tires also allow the chair to travel more easily over rougher terrain than could a traditional wheelchair by taking advantage of deep traction grooves. For instance, the user could easily transition from a paved surface to a grassy field with minimal additional effort. These tires also provide increased traction which contributes to its overall safety. The tires resist sliding on slippery surfaces and by gripping the ground better when braking fast, contribute to a quicker, more controlled stop.

In many cases it will become necessary for the user to decrease speed. Pressure controlled brakes allow this to occur in a smooth controlled manner. On each wheel rim there is a clamp that, when actuated, presses rubber against the wheel and causes the device to slow down. The controls for the brakes consist of levers which put increasing tension on a cable. The cable leads to the aforementioned brake clamps, causing them to close together and press against the wheel rim with a force proportional to the applied tension (see Fig. 10.4).

The wheelchair steering is accomplished through the use of independent control levers. For gentle turns, one control can be operated while the other one remains motionless, or moves at a slower speed. This device is also capable of completing tight, fast turns. Instead of leaving one wheel free one can apply the pressure sensitive brakes on the control to lock it in place. This causes the wheelchair to pivot around the stationary wheel which means that the turning radius is limited only by the width of the device.

Since the goals of this device are comparable to those of creating a bicycle, there are many safety considerations. Armrests were created to keep the operator’s hands and arms away from the sprockets and chains. These armrests function as guards but are also cushioned for comfort, as can be seen in Fig. 10.5. A seat belt was included to keep the operator safe and secure. Although not illustrated, a helmet should also be worn at all times when using this device. The device is shown in Fig. 10.6.

The total cost of this device was $381, not including the wheelchair, which was donated.
Fig. 10.6. User Operating the Device.
WHEELCHAIR POUCH

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INTRODUCTION
The Wheelchair Pouch is a device to be used on a wheelchair to store personal items such that persons with limited hand function are able to access them with ease. This personal foldable pouch, shown on a wheelchair in Fig. 10.7 and alone in Fig. 10.8, is designed to fit on either arm of a wheelchair to accommodate all users. The goals for the pouch were that it be easy to use, convenient, durable, inexpensive, and aesthetically pleasing.

SUMMARY OF IMPACT
The convenience of this device will benefit anyone who uses a wheelchair and has limited use of his or her hands. The pouch increases user independence by providing storage and quick, easy access to personal items. It is simple, durable, lightweight, and easier to use than a pocketbook. The handle is placed strategically and Velcro is used as the closure mechanism so that any user can independently access his or her belongings.

TECHNICAL DESCRIPTION
The design of the pouch was based on a discussion with a person with paraplegia and a physical therapist. Weatherproof vinyl was used to manufacture the pouch because it is durable. Cardboard and a flexible fiber material were added to provide stiffness and form.

The device is shown alone in Fig. 10.8, partially folded. The dimensions of the pouch are 7 by 19 inches unfolded and 6 by 7 by 1 ½ inches folded. In the folded position, the pouch can hang on the arm of a wheelchair via two small loops. It is kept closed using hook and loop fasteners. A large loop handle is attached near the inner side of the wheelchair arm. This allows for the user to slide a hand into and pull the fasteners apart, opening the pouch. The pouch then unfolds onto the person’s lap like a book, as in Fig. 10.9. There, a cell phone, a mirror, or any small item may be stored and tucked away for later access. The pouch has three sections, two of which are for personal storage.

A standard sewing machine with a leather needle and black thread were used to stitch the pouch. The vinyl and reinforcement were stitched together along with the two small hanging loops. The large handle loop was then stitched, followed by the hook and loop fasteners. Fabric glue was also used to secure the fasteners to the storage compartments.

The design was tested using a cell phone as a personal item stored in the pouch. The final assembled pouch is simple and sleek. The completed pouch weighs approximately one pound.

The total cost of this project was $25.
Fig. 10.8. Wheelchair Pouch Partially Folded.

Fig. 10.9. Wheelchair Pouch in Use.
WHEELCHAIR ACCESSIBLE EXERCISE STATION

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INTRODUCTION
Most exercise stations on the market today are designed to target a particular muscle group; thus, to work on various muscle groups one has to move from one machine to another. The Wheelchair Accessible Exercise Station, shown in Fig. 10.10 can assist anyone who uses a wheelchair to take advantage of multiple exercises on one machine.

SUMMARY OF IMPACT
The Wheelchair Accessible Exercise Station allows individuals who use wheelchairs to perform varied exercises. They can target the upper and lower body, without the hassle of moving from one machine to another. By incorporating various exercises into a single station, this device helps the user stay in shape and maintain overall health.

TECHNICAL DESCRIPTION
This device is comprised of two main components: the exercise unit (frame) and the base. The frame is the upright section where the pulleys, cables, and weights are located, while the base is the part into which the user rolls his or her wheelchair (see Fig. 10.11). Both the frame and the base are constructed of 1 ¾-inch square 18-gauge steel tubing. Steel tubing was selected because the device has to be strong enough to withstand heavy and repeated loading. The frame measures 73 inches high by 31 ¾ inches long and the base measures 70 inches long by 31 ¾ inches wide. These dimensions were chosen so that the device can accommodate a wide range of users.

To use the device, the user wheels into the base and secures the wheelchair in place with the help of a rod located on the base. The user can choose to perform exercises such as cable pull-down, as shown in Fig. 10.11, or cable pull-back, shown in Fig. 10.12.

Fig. 10.10. Wheelchair Accessible Exercise Station.

A cable and pulley system is used to help pull the weights up. In addition the user can engage muscles of the lower body by using the stair-stepper that is attached to the base. The stepper can be easily detached from the base when not in use to provide more leg room.

For ease of shipment, the exercise station is designed to be easily disassembled.

The total cost of the project was $191.
Fig. 10.11. Cable Pull-Down Exercise.

Fig. 10.12. Cable Pull-Back Exercise.
COLLAPSIBLE WHEELCHAIR LIFTING SEAT

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INTRODUCTION
The objective of this project was to design and build a seat to lift a person who uses a wheelchair for transfer to or from a bed. Currently straps are often used to lift a person from bed. Caretakers as well as people who use wheelchairs can become injured from moving and placing these straps into position. A solution to this problem, shown in Fig. 10.13, is a collapsible seat for transfer to and from a wheelchair. Design requirements include a collapsible seat that can remain beneath the user while sitting in a chair or lying in bed.

SUMMARY OF IMPACT
The collapsible lifting wheelchair seat provides assistance to people who use wheelchairs and their caregivers, and in addition provides comfort. Straps can be removed and adjusted, which permits a person with no or reduced abdominal strength or fractured vertebrae to be lifted. This is achieved by allowing the person to recline into the seat.

TECHNICAL DESCRIPTION
The seat consists of a nylon waterproof canvas with military brass grommets. The canvas distributes the load evenly across the seat. It also allows for reliability and compactness.

Carabineers are used to attach the seat hoist. The carabineers are load rated for 600 pounds and can easily be attached or detached from the seat. Polyester webbing load rated at 1200 pounds is attached to the carabineers with industrial strength stitching to serve as adjustable arms to lift the seat.

Two stainless steel O-rings loaded for 2500 pounds are located where the seat is attached to the lift, as shown in Fig. 10.14. These rings have an inner diameter of 2 inches and a material diameter of 5/16 inches and can be easily attached to a series of lifts.

A double-fold cushion covers the seat and can be easily removed by pulling apart the hook and loop fasteners that attach it. Also, the cushion can be washed by removing the inner cushions from the cover through a series of zippers.

Six arms and a chest strap ensure stability of the seat on the hoist and the safety of the user. Each of the arms is attachable and detachable and a series of color-coordinated markers allows the user to connect the correct strap with its position on the seat.

The total cost of the project was $124.

Fig. 10.13. Collapsible Wheelchair Lifting Seat.
Fig. 10.14. Lifting Seat Loaded onto Hoist.
SHOULDER STEERABLE TRICYCLE

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INTRODUCTION
The Shoulder Steerable Tricycle, shown in Fig. 10.15, was designed to provide a means of transportation for people who do not have full use of their arms. Traditional bicycles are steered by moving the handlebars; this tricycle can be maneuvered through shoulder movement. The rider simply fits his or her shoulder into the specially made shoulder clam to control the direction of the tricycle. Also, activation of the brakes is incorporated into the pedals, rather than at the handlebars.

SUMMARY OF IMPACT
This project eliminates standard hand-operated bicycle braking and steering systems and substitutes foot braking and shoulder handling mechanisms. The result is increased independence and mobility for those who otherwise would not be able to use a bicycle.

TECHNICAL DESCRIPTION
The Shoulder Steerable Tricycle consists of a pedaling and braking mechanism, and a shoulder handling mechanism. The tricycle is driven by two front wheels and direction is changed by steering its rear wheel. A gear chain located at the center of the double wheels is used to drive the shaft of the two front wheels. The gear chain is linked to a coaster brake hub installed at the front of the tricycle. The coaster brake hub allows single direction pedaling. The rider pedals forward to move the tricycle, and backward to engage the brakes.

The shoulder mechanism is comprised of a differential and a shoulder harness. The differential component, shown in Fig. 10.16, is important to avoid confusion of the turning state; without it, the actual direction of this rear-wheel-steered tricycle would be opposite the movement of the body. The differential was installed with the function of reversing the steering direction so that shoulder movement to the left results in a left turn, and vice versa. This makes steering more intuitive to the user.

The shoulder harness, shown in Fig. 10.17, is attached directly to the differential, which allows the rider to be secured to the steering device.
The prototype works in accordance with the design specifications. The only major problem of this design is the small turning angle of the tricycle. The maximum turning angle for this tricycle is 20°, but the intended turning angle was 45°. Observation and analysis of this problem lead to a solution of installing a two-to-one gear transmission to increase the turning angle.

The total cost of the tricycle was $239.
INTRODUCTION
The objective of the One-Handed X-Box Control Joystick was to enable a person who has limited or no mobility in his or her arm to interact with X-Box video games. The standard X-Box controller requires two hands to play a game while this new design implements every function on the paddle in a configuration that can be operated with one hand. The final product, shown in Fig. 10.18, was constructed by modifying a store-bought joystick to include all of the features and functions of the standard X-Box controller. The controller may be built for use with the right or left hand. With its square base, it can be placed on an arm of a chair, a desk, a coffee table, etc., without slipping. It is a mobile unit and can be used on any X-Box system.

SUMMARY OF IMPACT
Playing video games is a popular activity among people of all ages. It is typically a two-handed procedure, leaving out those who do not have full functionality of both hands. With this design a person who has the use of only one hand due to amputation, birth defect, or injury is able to play a video game. This device allows individuals with a lost or non-functioning hand to enjoy video games alone or in a social setting. Fig. 10.18 shows the hand placement on the joystick.

TECHNICAL DESCRIPTION
The prototype of this design was constructed from a joystick and an X-Box control paddle, purchased off the shelf. The control joystick has two parts: the handle and the base. First, the joystick handle was modified to allow more wires to run through it. Next, different sized holes were tapped in the handle to accommodate the additional buttons needed to emulate the X-Box controller functions. A metal housing was bolted onto the top of the handle for a 360° switch, shown in Fig. 10.19. Finally, electrical tape was used to cover the wires running down the handle.

The purpose of the base is to store all of the wires used in the handle and throughout the control joystick. It also houses the main circuit panel of the unit. The base was designed for stand-alone stability and it was fabricated from a high strength, low weight polymer. Several 90° metal braces were bolted to the base to add strength and durability. Once the user interface and casing was complete, the circuit board from the X-Box control paddle was soldered into place to connect to the new controls. A low wattage soldering gun was used to prevent against heat damage to the waffle board.
The device was tested by a 14-year-old boy, who was able to enjoy playing many different video games for several hours. As all of the control buttons were proven to be functional, the design is a success. The cost of this device was $80.
LIGHT EMITTING SLIPPER TO ASSIST PEOPLE WITH VISION IMPAIRMENT

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INTRODUCTION
People who have limited vision often experience more difficulty seeing objects in low-light environments. The Light Emitting Slipper, shown in Fig. 10.20, was designed to provide illumination to help these individuals see better while walking around the house at night. The sources of illumination are lights mounted in the front of the slipper. Although this product was designed to assist individuals with vision impairments, it could be used to increase visual perception for anyone while walking in the dark.

SUMMARY OF IMPACT
The concept of nighttime illumination applied to slippers has already been developed and produced. This product will impact the users in a more positive way due to advantages it has over others. They include: 1) more light sources; 2) a focusing function to ensure optimum light beam distribution; and 3) a power management system. These slippers combine user comfort with the proper light displacement necessary to increase visual perception at night.

TECHNICAL DESCRIPTION
There are three technical aspects of this product that distinguish it from similar products:

• A multi-source lighting system;

• A light-focusing function for each slipper; and

• A power-management system using a tilt sensor and phototransistor.

Each slipper provides three separate light sources to ensure that the maximum amount of light is provided. Most of the similar products researched provide only one light source in the form of an LED. The lights used in this design are small light bulbs surrounded by reflectors to project a solid beam of light, expanding outward as it extends further from the slipper. The light sources are located at the front of the slipper’s sole to concentrate all of the light in front of the user. These lights are also connected to the circuit in a series configuration. The inner electrical components can be seen in Fig. 10.21.
The light bulbs are secured into a male bulb housing, which is threaded to mate with a female housing that protects the bulb and also contains the light reflector. This assembly is similar to that of a flashlight. This approach was taken in order to allow light to be focused to the optimum beam projection before the slipper is fully assembled. Adjustments are made by twisting the female housing tighter or looser onto the male bulb housing, which changes the bulb position with respect to the reflector. The greater amount of light provided to the reflector, the more concentrated the light beam will be and the further it will be directed from the slipper.

Three AAA batteries provide 4.5 volts of power to the circuit. They are secured in a battery pack in the heel of the slipper sole (See Fig. 10.22). Wires are directed to a circuit board through wire channels built into the sole. The circuit that powers the light sources was designed to act as a power management system, to ensure that power is used only when necessary. The circuit uses NAND gates and inverters to interpret the signals sent from each sensor. When motion is detected, a tilt sensor sends a signal of one to an inverter, converting it to a zero. This signal proceeds to a NAND gate.

If a zero and anything else is detected, a one is distributed to the next NAND gate which is connected to a phototransistor. If this detects darkness, the NAND gate receives a one, which recognizes a one and a one, producing a zero, and charges a capacitor so the lights stay on. The lights will stay on eight seconds after no motion is detected, and distributes a zero to another inverter. This is converted to a one again, which trips the Darlington transistor and the lights turn on.

If at any time the phototransistor, located in the back of the slipper sole (See Fig. 10.23), detects light, then a signal of zero is sent through the circuit, tripping the NAND gate, cutting off power to the circuit.

The total cost of this project was $85.
INTRODUCTION
For people with knee or back pain, moving a heavy item into or out of an oven can be a challenging task. Additionally, leaning over a hot oven door can be quite dangerous. The goal of this project was to create a device to assist in lifting or lowering items into an oven. This device is also intended to allow the oven rack to be held in place at stovetop level.

SUMMARY OF IMPACT
The Lift-Up Oven Rack, shown in Fig. 10.24, allows users to place food items on or take them off the oven rack without having to bend over. With its elevated handle, people who are only able to use one hand can also benefit from the Lift-Up Oven Rack. An additional advantage of the device is its ability to be installed into existing ovens.

TECHNICAL DESCRIPTION
The Lift-Up Oven Rack was designed to be installed in existing ovens; however, as ovens vary in size, it should be noted that the device described here was designed specifically to fit the following inner oven dimensions: 15¾-inch height, 22¾-inch width, 18-inch depth.

A working prototype was not created for this project due to the need of high temperate roller bearings for the slider. A mostly wooden prototype was therefore created to demonstrate the general concept of the design.

The foundation of the design is a parallelogram mechanism with four-bar linkage. The parallelogram design, which guides the path of the rack, ensures that the rack remains level. The mounting shelf made of sheet metal (See Fig. 10.25) allows the device to slide into the existing oven on its top rack level.

Wooden triangles are attached to each side of the mounting shelf, providing the stationary axes of rotation for the parallelogram mechanism. Two 18-inch steel bars pivot freely in two holes drilled in each triangle. The bars extend down from each triangle and connect to two identical triangles below (See Fig. 10.26). Thus, there are four triangles and four bars in all, making up the four-bar mechanism.

Because of space limitations and oven rack height requirements, a slider was needed to slide the rack out of the oven before lifting up. A set of 16-inch full extension ball bearing slides were mounted on the lower two triangles. A wooden rack was then

Fig. 10.24. Lift-Up Oven Rack.

Fig. 10.25. Mounting Shelf Pulled out of Oven with the Rack in Lowermost Position.
mounted to the sliding mechanisms on both sides, connecting the four-bar mechanism. Although adding the rack did increase the stability of the mechanism, a rod was installed beneath the rack, connecting the two lower triangles for additional support. A metal handle was then added to the rack to aid lifting. Fig. 10.27 shows the rack fully extended from the oven, in the lowermost position.

To hold the rack in the uppermost position, as shown in Fig. 10.28, a ledge was added to the underside of the mounting shelf. When in its uppermost position, the rack slides back slightly so that it rests on the ledge.

Although changes in material selection would have been made if it were being designed for production, proof of concept was shown.

The total cost for this project was $16.
REDESIGN OF A PORTABLE, COLLAPSIBLE WHEELCHAIR-TO-VEHICLE TRANSFER SYSTEM

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INTRODUCTION
Entering and exiting a vehicle is a common task that can be difficult for those who use a wheelchair. To alleviate this difficulty many lifting systems have been developed to lift safely the user out of his or her wheelchair and place him or her safely into the passenger or rear seat of a vehicle. Current lifting systems are not portable and are designed for exclusive use with large vehicles that have a considerable amount of interior space, such as a van or mini-van. Most often these units must be permanently installed on vehicles, thereby altering the vehicle from its original condition. The innovative design presented here and shown in Fig. 10.29 maintains the structural integrity and functionality of existing lifting systems, plus it is easily transportable, may be stored in the user’s trunk, and may be used with a wide range of standard wheelchairs and vehicles.

SUMMARY OF IMPACT
As of 1997, the National Highway Traffic Safety Administration estimated that approximately 100,000 vehicles on the road had been modified by adding a wheelchair lift. These numbers demonstrate the need for a portable, more user-friendly device that accomplishes the same function as the permanent wheelchair lifts. The strong, lightweight materials used here and the collapsibility of this new design allow users to easily transport the device itself and then use it to transfer a person from his or her wheelchair to a vehicle. The key advantages of this device over existing lifting devices are that it is portable and that it does not require permanent modification of the wheelchair or vehicle.

TECHNICAL DESCRIPTION
The system consists of the main lifting section, telescoping legs, and a customized seat harness (See Fig. 10.30). This lifting device utilizes a modified lightweight aluminum racecar jack. The lifting point for this jack incorporates both vertical and horizontal movement. The horizontal component, along with the tendency of the unit to lean forward, was addressed by designing a linkage that connects to the rigid portion of the lifting section and the upper part of the moving tower.

The lifting tower, rigidly connected to the aluminum jack, consists of a slot to insert the fork-lift bars, which then attach to the seat harness. These bars, made from a high strength alloy steel, are easily...
attached and secured by using quick-release push pins. All of the components that can be disconnected from the main unit can be placed inside a slot within the main unit when it is in its collapsed position, as shown in Fig. 10.31. This allows for easy storage, preventing the misplacement of pieces.

Two telescoping legs connect to the main lifting section with quick release pins. These pins are also used to lock the legs in the fully extended position. The length of the fully extended legs must be longer than the lifting point (location of the seat harness). Attached to the end of each leg are hard rubberized casters, which provide ease of movement.

The third assembly component is the seat assembly. The seat is constructed of heavy-duty canvas material which covers a wood base and composite wood board backing. It has a hinged back, which allows for easy storage. The seat assembly is intended to be placed into the wheelchair prior to the user entering the wheelchair. Once the user is placed into the wheelchair, the seat assembly latches onto the fork-bar and hoists the person into the passenger seat of the vehicle.

Although the total weight of the system is approximately 82 pounds, the weight of all of the separate detachable pieces totals around 30 pounds. The unit could be made lighter by removing sections of the outer housing that were built around the aluminum jack, replacing the ¼-inch aluminum that was used to ensure a high factor of safety to 1/8-inch, or changing the material of the legs to aluminum square tubing instead of galvanized steel.

The cost of this device was $300.
TREADMILL GUARDIAN ANGEL

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INTRODUCTION
The goal of this project was to devise an affordable support and harness system that would fit over any existing treadmill. This unit was made to be capable of being taken down and stored out of the way. The harness of the system is shown in Fig. 10.32.

SUMMARY OF IMPACT
The Treadmill Guardian Angel is strong and sturdy enough to prevent individuals on treadmills from falling and potentially injuring themselves. This apparatus will allow individuals to rehabilitate from injuries at their convenience in their own homes. Persons living with disabilities will be more confident in increasing the intensity of their therapeutic exercise on their own knowing that they have a safety net should a leg give out or light-headedness occur. This product will enable those who are not able to attend physical therapy outside the home to help themselves gain strength and flexibility through exercise.

TECHNICAL DESCRIPTION
The Treadmill Guardian Angel, shown in Fig. 10.33, is a supplement to any treadmill. It consists of five pieces of cold drawn steel tubing of 1 7/8-inch diameter, two nylon ropes, and a harness. The tubing and rope selected are rated to withstand in excess of 300 pounds. The harness and D-Clips are rated to withstand a 10 kilos Newton load. The harness height is adjustable as is the harness itself, allowing for a snug, comfortable fit for people of various heights and sizes. The overall dimensions of the Treadmill Guardian Angel are 84 inches wide, 82 inches deep and 90 inches tall, which allows it to accommodate a wide variety of existing treadmills. The Treadmill Guardian Angel was weight tested up to 250 pounds dynamically loaded and 270 pounds statically loaded. The four legs have smooth 6-inch-diameter circular plates mounted to their base to help distribute the user’s weight.

Fig. 10.32. Treadmill Guardian Angel Harness.

The steel tubing of the Treadmill Guardian Angel must first be assembled. The ropes must be installed on the top tube crossbeam. The structure is then centered over a treadmill. The individual must put on the harness and tighten it to a snug fit. Next, the user simply attaches the harness to the rest of the structure with two simple D-clips. The ropes are then adjusted to eliminate any slack.

The cost of this project was $340.
Fig. 10.33. Complete Treadmill Guardian Angel System in Use.
CARPET CLEANER ATTACHMENT FOR A WHEELCHAIR

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INTRODUCTION
The Carpet Cleaner Attachment for a Wheelchair, shown in Fig. 10.34, is a device that allows persons who use wheelchairs to easily vacuum a carpet. This device can be installed on a standard wheelchair without any modification and can be easily detached. The attachment is adjustable so that the user can lower the cleaner to the floor to clean an area of carpet and raise it when it is not in use.

SUMMARY OF IMPACT
This device enables people who use wheelchairs to clean a carpeted area by themselves. The user can easily attach and detach this device without help from others. It increases the user’s independence, and it may even help him or her to take advantage of employment opportunities in the housekeeping field.

TECHNICAL DESCRIPTION
There are six main components in the design: a modified hand winch, plastic clippers, a 17½ x 9½-inch piece of three-layered wood, a 2-inch spring, a cylinder, and ‘L’ brackets. Most of the components are made of aluminum, wood, or plastic. The dimensions of this device without attaching the carpet cleaner are 17 ¾ inches wide by 13 ½ inches high by 9 ¼ inches long. When the carpet cleaner is attached to the device, the dimensions are 17 ¾ inches wide by 15 inches high by 9 ¼ inches long.

Four plastic clippers, shown in Fig. 10.35, were installed on both sides of the wheelchair to ensure a firm attachment of the device to the wheelchair. The clippers also facilitate easy detachment.

The device is adjustable up to 1 ½ inches through a modified hand winch, a spring, and a cylinder. The details of this system are shown in Fig. 10.36. Using the ergonomic design of the handle, the user can turn the hand winch easily. A steel rope was used to connect the hand winch to the cylinder. Two pulleys were installed to allow the steel rope to move smoothly. Therefore, when the user desires to clean the floor the device is easily accessible, and when its use is no longer needed, the cleaner is secured 1 ½ inches above the floor.

The cost of this project was $112.
Fig. 10.35. Attachment Clips.

Fig. 10.36. Details of Cleaner Lifting System.
SIMULTANEOUS MULTIPLE KEYSTROKE SUPPLEMENT FOR KEYBOARDS

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INTRODUCTION
The Simultaneous Multiple Keystroke Supplement for Keyboards, shown in Fig. 10.37, assists individuals who have had an amputation of a finger or arm in completing keyboard commands involving simultaneous keystrokes on a PC. For maximum functionality of the device at minimal cost the following four commands have been addressed: 1) Ctrl-Alt-Delete, 2) Shift-Delete, 3) Alt-Escape, and 4) GUI-E.

SUMMARY OF IMPACT
Several common computer functions require the simultaneous depression of multiple keys. Using the current standard keyboard design, it is challenging, if not impossible, for people who have had an amputation of one or more fingers or an arm to perform these simultaneous keystroke operations. The Keyboard Supplement enables such individuals...
to complete the multi-key functions necessary for many computer related jobs and activities. The result is increased quality of life through greater computing capabilities.

**TECHNICAL DESCRIPTION**

The Simultaneous Multiple Keystroke Supplement for Keyboards is a 6 x 6 x 2½-inch box with four buttons on top and two six-pin mini DIN female receptacles on the back. One of the receptacles is for data input from the regular keyboard and one is for the data output (See Fig. 10.38). The top and back of the box are fastened with screws and therefore can be removed in order to access the logic board. Inside the box is a CME11E9-EVBU development board which has been wired and programmed to assign the appropriate PS/2 Set 2 scan codes to each button and send these codes to the PC via a six-pin mini DIN cable.

The standard keyboard plugs into this device so that all of the keyboard data, regardless of origin, arrives at the PC via the same cable. As a result, the PC will not detect a difference between a standard keyboard and the supplemental keyboard. Because of the way the device is wired, the logic board can easily be programmed to reassign the scan codes of any key on the standard keyboard as it passes through the device. For example, the device can be programmed to output the print screen scan codes when the F12 key is pressed on the regular keyboard. This is possible because all of the data are passing through the device already, and a simple line of computer code calls for the replacement of a specific scan code should it pass through. This will allow effortless personalization of this device to each user’s specific needs.

The cost of this project was $138.
MANUAL WHEELCHAIR WITH PNEUMATIC HEIGHT ADJUSTABLE SEAT

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INTRODUCTION
The device shown in Fig. 10.39 was designed for use with a wheelchair. The goal was to provide easy access to high tables and countertops, cupboards, shelves on demand, while allowing the usual lower ride height associated with unmodified wheelchairs. The product was designed to be lightweight and collapsible and to allow for transport and storage.

SUMMARY OF IMPACT
People who use wheelchairs may experience limited reach or sight due to the fixed height of their wheelchairs. This device addresses these limitations by providing convenient height control anywhere inside or outside the home. This device increases the independence of the user by extending ranges of reach and sight.

TECHNICAL DESCRIPTION
The base for the additive hardware is a standard collapsible wheelchair made by Everest and Jennings. U-brackets were made to fit over the upper bars on the chair. Holes were drilled to match the pattern on the foot mounts provided with the cylinders. The foot mounts and cylinders were purchased from McMaster Carr. The air cylinders are aluminum and double-acting, which provide 90 pounds of force at 100 psi each. Standard pneumatic lines and fittings were used to control the inflow and outflow and from the cylinders. Fig. 10.40 provides a detailed view of the lifting system.

With air pressure supplied by an outside source, the cylinders raise the seat to a maximum increase of eight inches (See Fig. 10.41). The air can then be bled out of the cylinders to the atmosphere, comfortably returning the user to regular ride height.

The seat was taken from an office chair with similar dimensions to the unfolded stock seat. Rectangular
The wheelchair, pneumatic lines and fittings, and office chair seat were donated for this project.

The total cost of the project was approximately $150, not including a controller and pressure supply source that would be needed for operation.

Fig. 10.40. Lifting System Components.

Fig. 10.41. Adjustable Seat at Maximum Height.
ADJUSTABLE SEAT HEIGHT ATTACHMENT FOR WHEELCHAIRS

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INTRODUCTION
The Adjustable Seat Height Attachment for Wheelchairs, shown in Fig. 10.42, provides vertical mobility to people who use wheelchairs. The device is portable and can be used with any wheelchair. It allows users to sit at a standard wheelchair height during normal activities and to adjust their position as needed to reach or work at a higher surface such as a table or countertop.

SUMMARY OF IMPACT
This device provides safe assistance to wheelchair users to elevate vertically to a desired sitting height while in their wheelchairs. It minimizes users’ dependence on other people to reach things at a higher level and allows them to work on higher surfaces without moving to a different chair. Ultimately, it improves the quality of life of people who use wheelchairs by making everyday tasks easier.

TECHNICAL DESCRIPTION
This device is constructed of top and bottom plates that are Poly-Carbon, a material similar to Plexiglas but lighter weight. This material was selected because of its strength and ability to support the weight of an average person, as well as its clarity, which allows easy inspection of the inner parts. The top part of the upper plate has a cushion for user comfort (See Fig. 10.43). The cushion seat is attached to the device using hook and loop fasteners so that it can be easily removed for cleaning or substitution of a different cushion.

The bottom part of the upper plate is connected to an air spring bellow, which provides the force to vertically move the plate. The two sides of the upper plate are connected to the lower plate by scissors beams and a ratcheting device for stability. The two scissors beams, 1½ x 1½ -inch aluminum, are angled to provide support and stability while the height varies and vertical force is applied to the connecting plates. Aluminum was chosen as the beam material for its strength and light weight. At the connecting points of beam and plate, a ratcheting device was designed for additional stability at any desired height.

There are three levels of desired height, each allowing the user’s weight to be uniform to prevent any form of tilt. The desired height levels can also be changed easily from level to level using the
unlocking ratchet device and the valve to release the air from the bellow, as shown in Fig. 10.44.

The device at its maximum height is shown in Fig. 10.45.

The total cost of this project was $123.
HUMAN POWERED OFF-ROAD WHEELCHAIR

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INTRODUCTION
The Human Powered Off-Road Wheelchair, shown in Fig. 10.46, can go almost anywhere a bicycle can be ridden. The device is powered and steered solely through movement of the user’s arms. A natural rowing-style motion exerted on handlebars, which are set on a slider, generates power. These same handlebars provide steering capability by simply turning them as one would turn the steering wheel of a car. The handlebars also contain a shifter to change gears and bicycle-style brakes to slow or stop the wheelchair. The design requirements for this device include ease of entry and exit, ability to accommodate users of all sizes, and intuitive operation.

SUMMARY OF IMPACT
This device allows people who use a wheelchair to experience the outdoors without needing smooth paved pathways. It provides an exciting new way to be independently active.

TECHNICAL DESCRIPTION
The wheelchair consists of four main components: the frame, drive system, steering mechanism, and wheel assemblies. The frame is comprised of welded aluminum tubing. The main components of the frame are 1 1/2 inches in diameter with a 1/8-inch wall and the roll bars are made from one-inch diameter, 1/16-inch wall tubing. The frame provides structural stability to the entire vehicle and locations to mount other components. Two roller bars on either side of the vehicle protect the rider in the event of a rollover. They also aid in entering and exiting the vehicle by providing a stable place for an individual to hold while lifting into the seat.

The drive system is the most complex and significant aspect of the vehicle. It is comprised of several individual components including the slider body, drive links, drive shaft, front sprocket, Nexus hub, rear sprocket, and drive axle. The individual systems work together to provide power to move the vehicle forward.

The slider body is an aluminum box with a cylindrical rod protruding from it. Polyurethane rods were placed into holes that were cut in the square body. Handlebars were attached to the cylindrical rod on the slider body, which the rider holds to pump the slider body back and forth along a square tube. This square-profile length of aluminum was rounded and pressed into bearings on each end, allowing it to rotate. A bearing was pressed on the cylindrical piece so that when the slider body is rotated, the links attached to the outer race of the bearings do not rotate. These links, which are connected to the outer race of the bearing, are the drive links, which consist of two sets of two bars. The slider body along with the drive links creates a typical slider-crank four-bar mechanism.

The slider-crank converts transitional motion into rotational motion to spin the drive shaft. The slider-crank linkages were configured so that the free wheel mechanisms in the second links allow for one set of links to power the shaft in each stroke direction. A sprocket on the drive shaft spins and transfers power to the Nexus hub via a chain. The Nexus hub is a contained unit of planetary gears...
used on some bikes, which replaces the standard set of front and back sprockets. It enables a range of seven speeds and transfers the input to the rear axle via a second chain. The specific advantage of the Nexus hub is that it allows gears to be shifted at very low speeds or at a complete stop, a capability that is essential for an off-road vehicle.

The steering mechanism in Fig. 10.47 is comprised of two links, the first of which is connected to the slider shaft, and the second of which connects to the aforementioned link to the steering rods on the front wheel fork. A connecting rod in turn links the two forks together to ensure that they turn in unison.

The last major components of the vehicle are the four wheels and their associated assemblies. The rear wheels, shown in Fig. 10.48, came as a pre-assembled wheel and axle unit used to convert a two-wheeled bicycle into a tricycle. This component was ideal for the purposes of this project as it provides a way to power the vehicle effectively. All that was necessary was to connect the assembly to the frame and run a chain to the already-installed sprocket on the axle. The front wheels are two bicycle tires, which were attached to the frame with their respective forks.

The total cost of this project was $560.
INTRODUCTION
This project addresses the needs of individuals who require a cane or some other form of walking aid. The purpose of this project was to expand on the concept of a conventional cane so that it can be of greater assistance. Canes have a fixed length based on the standing height of the user. When a person is moving from a sitting position to a standing position, however, a normal cane often cannot provide the necessary leverage to help him or her stand. The modified cane shown in Fig. 10.49 is able to assist the user as a standard walking cane, but it also provides superior assistance as the user stands from a sitting position.

SUMMARY OF IMPACT
In many cases, individuals who use canes require another person to help them stand up from a chair. The modified cane is a portable device that can help anyone who uses a cane rise from any chair, anywhere. People who take advantage of these two canes-in-one will have more independence.

TECHNICAL DESCRIPTION
The cane consists of three major parts: a prefabricated ratcheting device, a slide rod, and a pair of telescoping rods. The ratcheting device, shown in Fig. 10.50, was taken from a caulk gun. It uses springs and small plates to form a trigger and a locking mechanism. The locking mechanism prevents the rod from sliding when it is not desired. The rod from the caulk gun was removed and replaced by a 40-inch-long slide rod. A set of two telescoping rods was attached to form the body of the cane. One of the telescoping rods was attached to the ratcheting device from the caulk gun using a caulk adhesive. The other telescoping rod was attached to the bottom of the slide rod with a pin.

The cane can be set to its minimum height, shown in Fig. 10.49, by first pushing down on the locking mechanism to unlock it. The ratcheting device can then be moved down the slide rod so that the telescoping rods are completely overlapping. At this height individuals can use the cane to help themselves stand up from a sitting position. Once a person is standing, the trigger can be pulled repeatedly, until the cane is at the maximum height, shown in Fig. 10.51. At the maximum height, the cane can function as a normal walking cane. The total weight of the cane is two pounds, which is comparable to the weight of other common canes.

The total cost of the project was $15.
Fig. 10.50. Ratcheting Device and Handle of the Cane.

Fig. 10.51. Cane at Maximum Height.
INTRODUCTION
Fitness centers often do not provide exercise equipment that is appropriate for use by people who use wheelchairs, which makes working out difficult. If people who use wheelchairs want to exercise they often have to find a facility that has equipment designed specifically for them. The Wheelchair Exercise Station, shown in Fig. 10.52, addresses this need by enabling people who use wheelchairs to get a full upper body workout in the privacy of their own homes. With the exception of initial assembly, the user can operate the station independently. Several different exercises can be done with this one device.

SUMMARY OF IMPACT
Exercise is essential to everyone’s health and well-being. For example, people that exercise regularly have a reduced risk of developing heart disease, high blood pressure, depression, and anxiety, just to name a few. The wheelchair exercise station allows people who use wheelchairs to do exercises such as butterflies, arm curls, tricep extensions, rows, and shoulder presses. The user can control the amount of weight that is being used in order to get the most effective workout without requiring the assistance of others.

TECHNICAL DESCRIPTION
The exercise station consists of a frame, two cables, two sets of wooden weights, six hooks with threaded ends (three on each side), four pulleys, and a grip on one end of each cable. The frame was built out of two-inch inner diameter PVC piping. Six hooks with threaded ends were attached to the PVC piping (three for each set of wooden weights) with the purpose of holding the pulleys in place. By using hooks to attach the pulleys to the frame, it is easy for the user to take the pulley off of one hook and place it on another in order to do different exercises. Only four hooks and four pulleys are used at one time (two for each set of weights) leaving one hook on each side unused. One hook is attached straight above the weights on the top pipe of the frame. One pulley is always attached to this hook. One of the two other hooks is used in collaboration with the hook that is always attached. The pulleys fit onto the hooks such that they are tight enough to stay on the hook but at the same time have a bit of freedom to move. The moving capability of the pulleys ensures that the user can perform a variety of movements. For example, two exercises that use the same hooks (such as arm curls and butterflies) work different muscle groups due to different motions. Arm curls involve a back and forth motion with the cables and
butterflies take the cables across the body. This variation is possible because of the freedom that the hooks have to move around.

Rope was used as the cable in this project. One end of the rope has a rubber covering that serves as the grip, shown in Fig. 10.53. The other end of the rope is attached to the inside of a ¾-inch inner diameter PVC pipe. The PVC pipe extends vertically through the middle of a stack of wooden weights. There are two stacks of wooden weights, one on each side. Holes were drilled horizontally through the middle of the wooden weights and through the PVC pipe to allow the user to change the amount of weight used for each exercise. The weights each have semicircles drilled vertically through both ends. The weights were placed between two 2½-inch PVC pipes that run vertically. This makes it possible for the weights to travel in a straight line up and back down when an exercise is being performed, as shown in Fig. 10.54.

The cost of this project was $90.
STAIR TO RAMP CONVERSION KIT

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INTRODUCTION
The purpose of this device is to increase the mobility and freedom of people who use wheelchairs. Stairs often inhibit the movement of wheelchair users; however, having a compact set of stairs can be beneficial to save space. The Stair to Ramp Conversion Kit, shown in Fig. 10.55, allows the conversion of a set of stairs into a wheelchair ramp with the flip of a switch. The ramp can be custom built to the dimensions of any size stair.

SUMMARY OF IMPACT
The main impact of this project is the increased accessibility that results from having a wheelchair ramp. This ramp is designed to convert two or three average size stairs into a fully locking and retractable wheelchair ramp. It also enables those who do not want a large permanent ramp in their home to have a set of stairs as well. The design allows anyone who can operate a light switch to deploy or retract the ramp.

TECHNICAL DESCRIPTION
The system includes the ramp, stairs, motor, connecting rods, hinges, and electric switches operating as one unit. Flipping one of the three-way switches activates a reversible motor. The motor is connected to a threaded rod that begins to rotate. While the threaded rod spins, a nut travels along the length of the rod. Welded onto this nut are two metal strips with holes in them. This makes a traveling bracket. A universal rod end was aligned with the holes of the traveling bracket and secured together using a machine screw and nut. The other end of the universal rod end is connected to the ramp. As the nut travels across the threaded rod, the rod that connects the nut to the ramp is forced to raise or lower the ramp depending on which direction the motor is rotating. The universal rod end is important to allow a slight pivot in the connection since the angle between the connecting rod and threaded rod will vary. Fig. 10.56 is a close-up view of the mechanical components.

When the ramp reaches the desired position, the switch is flipped in the opposite direction to stop the motor. Either switch can cause clockwise or counterclockwise rotation of the motor since they are three-way switches connected to a reversible AC motor. A standard 120 Volt AC outlet supplies power.

When the nut reaches a bracket or the stairs block the ramp movement, the AC motor will be overloaded and will stall for a split second. After the
motor stalls, the rotational direction is reversed automatically. This eliminates the need for a complicated wiring system. Flipping either switch will reverse the motion of the ramp to either stair (see Fig. 10.55) or ramp mode (see Fig. 10.57), depending on the previous position.

The total cost of this project was $30.

Fig. 10.56. Mechanical Components.

Fig. 10.57. Ramp Mode.
AUTOMATIC TELESCOPING REACH EXTENDER

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INTRODUCTION
For people with limited mobility or for those who use a wheelchair, accessing an object that is out of reach from the sitting position can be difficult. The aim of this project was to provide a device that allows a person to reach and grab objects that are out of reach and bring them close with minimal effort. The Automatic Telescoping Reach Extender in Fig. 10.58 can easily extend to a desired object with the use of a trigger. It then grips the object with the use of a switch and retracts back to the user with the use of the trigger in another position. The entire device is compact for optimal portability and storage.

SUMMARY OF IMPACT
The Automatic Telescoping Reach Extender allows people who would normally be dependent on others for tasks such as picking something up or reaching for something out of range, to have the ability to complete these tasks by themselves. This device can be of help to people who use wheelchairs and those with back problems that limit their ability to bend down.

TECHNICAL DESCRIPTION
The project is based around the telescoping characteristics of three round thin-walled aluminum tubes. These tubular sections were taken from an extending pole that is normally used for reaching areas in houses for dusting or painting. The three sections are each of different diameters so that they can slide within the next larger diameter tube, extending or retracting a total of 14 inches. Fig. 10.58 shows the device in full retraction, while Fig. 10.59 demonstrates full extension.

The extension and retraction of the aluminum sections is achieved with the use of a DC servo. The servo is a small motor that is geared down in order to decrease the speed and increase the torque. A setup of 50-pound test fishing line is used to extend and retract the two smaller tubes. Extension is obtained by pulling one line that is directed by a series of pulleys through the smaller diameters. Retraction is achieved by a straight line attached to the end of the smallest tube. The power to pull the two lines is provided by a modified Futaba S3004 servo. The servo has been modified to allow the output shaft to rotate continuously without restriction when the trigger is pulled. A multi-diameter plastic spool was manufactured and

Fig. 10.58. Automatic Telescoping Reach Extender in Full Retraction.

Fig. 10.59. Full Extension.
attached to the output shaft of the servo to reel the line as it is pulled. The special design allows for smooth extension and retraction of the arm when the trigger is toggled.

The diameters of the notches in the spool are critical because as one notch in the spool fills up with line, the other notch is feeding line back into the tube assembly, and slack must be minimized. This reduction of slack allows the user to stop the arm at any distance within the maximum reach and have the arm rigid and resistant to compression or strain. High tensile strength wire could be used to improve this performance.

The servo mentioned above is the main servo and is powered by a nine-volt battery. The direction of the servo is controlled by a double pull double throw (DPDT) momentary switch used for the trigger. The extension and retraction of the tubular assembly is limited by two mini lever switches. These switches stop the extension and retraction slightly before the maximum is reached in order to prevent stress on the servo and fishing line.

The rotation of these tubes is stopped using a pin and slot setup. The two smaller tubes have slots machined into them, and the two larger diameters each have a rivet that runs into these slots. The tube assembly is held into a plastic case from a cordless drill with the use of an aluminum collar. This drill case houses the main servo, spool, two DPDT momentary switches, a nine-volt battery, and wiring (See Fig. 10.60).

The other automated portion of the automatic telescoping reach extender is the gripper that is mounted at the end of the tubular assembly, shown in Fig. 10.61. The gripper is powered by a modified HiTec HS-65MG servo. This servo drives a threaded rod that goes to a coupler that is mounted in the gripper. The movement pushes or pulls one jaw of the gripper closed or open respectively. The location of the coupler dictates the speed with which the gripper closes as well as the force with which it grips. If manufactured, this location could be adjusted for various applications and performance requirements.

The gripper is mounted by use of an L-bracket, which allows a plastic part at the end of the tubular assembly to thread into it. The power for the gripper servo is provided by wires running through the tubes and down in the handle.

The total cost of the project was $228.
INTRODUCTION
The Radio Controlled Bracelet for Opening Doors is a device worn around the wrist of a person to remotely activate motorized handicapped-access doors. By wearing the bracelet around the wrist, as shown in Fig. 10.62, it is readily available to the user. A simple push of a button on the bracelet opens doors that would otherwise be activated by pressing a wall mounted button. The device is mated with an existing handicapped door button to allow the current functionality to remain.

This device fits inside the electrical box so that, on the exterior, there would be no change to the door button design. The device was aimed to have a plug-n-play feature that would allow the person installing the button to simply swap out existing buttons with those equipped with the radio receiver device. The device utilizes the existing wiring and power supply that the current buttons use.

SUMMARY OF IMPACT
This device allows a person to easily activate automatic doors by pressing the button on the bracelet or by using the remote that can easily be attached to a key chain. With this device, powered doors can be opened much more quickly as the user approaches them. This way the wearer does not have to reach out to the mounted button or lose momentum while they wait for the doors to open.

TECHNICAL DESCRIPTION
This design uses a radio remote and receiver set from a remote car starter. The receiver is placed inside the existing button housing typically found mounted on the wall near the door it controls. Connection to the existing handicapped door button circuitry allows the door to be operated by remote control or by pressing the wall mounted button. This configuration allows general use of the door system so that users that do not have a remote are still able to operate the door.

Fig. 10.62 features designs of both a keychain and bracelet. The adjustable wristband also allows this device to be fastened directly to a crutch or wheelchair arm. The bracelet itself is made of ABS plastic for durability. The process used to make the bracelet was stereolithography (SLA), or rapid prototyping.
First, an Audiovox AS9055T remote control car starter was stripped of all unnecessary parts to minimize size. Such parts included wires used to install the device on a car and excess length of the antenna wire. This insured that the starter would fit inside a standard MS Sedco square automatic door control box (Fig. 10.63).

The red light mounted on the top of the device serves the purpose of demonstrating that the button or the remote control device can close the circuit, and thus activate the handicapped-access door.

One problem addressed in the design was the proper supply of power to the device. The remote car starter runs on a 12 Volt DC setup, while the handicapped-access door button and the motor that operates the door itself run on 110 Volts AC. The best choice was to use an AC adapter with 12 volts of DC output by plugging into a 110 volt AC power outlet. To make the device easy to plug in, an old telephone power jack plug that matched in size was wired into the circuitry of the remote car starter.

Another design challenge was programming the remote car starter itself. The Audiovox AS9055T remote car starter required the calibration of the unit itself by reading a tachometer signal (engine speed) of the automobile telling the device that the car is running. The remote car starter is not being used in a car and there is no tachometer signal. A square wave generator and amplifier running an electrical signal at a frequency of 16 Hz, which is equivalent to 960 revolutions per minute, were used. This is an acceptable engine speed for the remote starter to understand, and allowed for proper programming. Once this programming step was complete, the remote starter worked correctly and gave the proper signal to close the electrical circuit and allow the door to activate.

The approximate cost of this device is $320.

Fig. 10.63. Inner Components.
INTRODUCTION
If a person who has limited mobility needs to escape from the first, second or third floor of a residence, there are few options currently available. Fire escape ladders are currently on the market and attach easily to any window. To successfully escape using a fire escape ladder, however, one must be in good physical condition and have unrestricted mobility. Thus, ladder devices are not beneficial to individuals with impaired mobility and limited strength.

The Multi-Story Window Fire Escape enables individuals with limited mobility to safely descend from a multi-story living arrangement to the ground in the event of an emergency. The device, shown in Fig. 10.64, attaches to a window and provides a secure place from which the occupant can descend. The device is electrically powered and can carry one person at a time. The occupant simply pushes a button and the platform is lowered safely to the ground. The platform can then be returned to the window and can be used by another occupant, if needed.

SUMMARY OF IMPACT
Since the device is powered, it can be used multiple times to save other people or even pets. The Multi-Story Window Fire Escape is unobtrusive and requires no modification to a building. To install, the unit is simply set in the window. Operation of this device is effortless and could potentially save lives.

TECHNICAL DESCRIPTION
The Multi-Story Window Fire Escape consists of three main components: the frame, platform and hoist setup. The frame is constructed of mild steel hollow 2-inch square cross-section tubing with a wall thickness of 1/4 inch.

The vertical support is 10 feet long and is welded to the horizontal support, which extends four feet at a 90° angle. To reduce the stress on this joint, a diagonal support spans from the end of the horizontal support to the middle of the vertical support. The window sill clip is constructed of the sill and wall support, which are both two feet in length. They are welded together at a 90° angle to each other and then welded to the vertical support, creating a clip. This forms one of the legs of the frame. The complete frame consists of two legs, which are held together by 34-inch leg spacers. There are six leg spacers between the vertical supports, one at each of the following locations: at the bottom, five feet from the bottom, at the end of window clip’s horizontal and vertical components, at the top of the vertical support, and at the end of the horizontal support.
The frame of the plate is constructed of the same material as the main frame. The platform is a four-foot square made of the mild steel hollow square tubing described above. The platform is covered in perforated 3/8-inch plate steel. The perforation serves to reduce weight and to prevent accumulation of rain or snow. Each corner is connected to a high test cable used to raise and lower the platform.

The final component of the Multi-Story Window Fire Escape is the hoist setup. The hoist setup is powered by a low-speed reversible high torque electric motor. The motor is mounted perpendicularly to the horizontal support. The spool shafts are 1-inch cold rolled steel with a 2-inch diameter at the cable spool. The shafts are held in place with completely sealed roller bearings to prevent the need for any future maintenance. The spool shafts are connected to the motor via a #60 roller chain and corresponding gears. The spool shafts are fitted with a 4-inch gear while the motor uses a 2-inch gear to provide an increase in torque. The hoist setup, shown in detail in Fig. 10.65, is sealed from the environment in a tin enclosure.

Proof of concept was demonstrated using a scale model. The mild steel was replaced with ¾-inch square aluminum tubing with a wall thickness of 1/8 inch. All dimensions were reduced to 3/8 scale. The hoist was powered by a 14.4 volt drill motor and bike chain was used to drive the spool shafts. The high test cable was replaced with 30-pound fishing line. The model in the lowered position is shown in Fig. 10.66.

The total cost of this project was approximately $300.
PORTABLE AUTOMATED MULTI-PILL DISTRIBUTOR AND MEDICAL NEEDS KIT

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INTRODUCTION
The goal of this device was to properly dispense medication over the course of one week. Similar existing products only provide stationary automation or portable pill trays. This design is a unique, low-tech approach that meets the need for portable automated medication dispensers. The Portable Automated Multi-Pill Distributor and Medical Needs Kit (see Fig. 10.67) was designed to be usable in travel situations so that people who require the assistance of pill distribution devices can maintain an effective, healthy medication regime. The pill dispensary is intended for one week worth of dosages, which could include 20 or more pills per day. This amount of medication could lead to confusion at any time, especially when traveling. A secondary function of this device is storage for other medical supplies an individual may require during travel. Such items might include diabetic testing supplies, general first aid supplies, epinephrine shots, and medical ointments.

SUMMARY OF IMPACT
A consistent medication regime is important to the continued health of any patient. This device was designed to provide portable automated multi-pill distribution for individuals that use many medications and medical products daily. This device can increase the patient’s independence by ensuring that the correct medications are distributed at the appropriate times without frequent visits from a caretaker. It also helps to ensure the safety of a
patient by protecting them from missed medication and incorrect dosages.

**TECHNICAL DESCRIPTION**

The prototype is made of wooden components due to this material’s ease of machining. If this product were mass produced, all of the parts could easily be converted to highly durable plastics.

The process of operating this device begins with assembling all of the pills needed for each day of the week. To load the machine with pills, the mechanism must be advanced by pressing the momentary switch located on the lid of the box, as seen in Fig. 10.67. Once the alignment of the slot and the pill void are in view, one day’s worth of pills can be deposited into the void. This process is continued until the user returns to the starting position. Then, the box is closed and the clock and alarm are set for the intended medication administration times.

When the alarm sounds, the user will need to turn off the alarm and press the momentary switch on the lid. The mechanism will advance to the next slot, and the pills will be dispensed into a cup located inside the box, shown in Fig. 10.68. The user will then open the box and retrieve the newly dispensed medication. At this point, the box is ready for the next medication distribution time.

The total cost of this project was $95.
WHEELCHAIR DIP STAND

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INTRODUCTION
The Wheelchair Dip Stand, shown in Fig. 10.69, is designed for use by individuals who use wheelchairs. The user sits in the device, then raises and lowers his or her body in a dipping manner to strengthen the arms and chest. It is safe and lightweight. It can be adjusted to target the chest and triceps. This device is ergonomically designed to fit a wide range of users, male and female, 12 years of age and up. It is relatively small and conveniently folds flat for easy storage.

SUMMARY OF IMPACT
This device is exceptional as a means of exercise for people who use wheelchairs. This specially designed dip stand could be especially beneficial to people who are beginning to use a wheelchair, helping build the upper-body strength required for mobility and daily activity.

TECHNICAL DESCRIPTION
Various ergonomic requirements were taken into consideration for the detailed design of the device. The primary restraints were dip height, dip width, grip diameter, and total weight. These criteria were modeled to the United States population of males and females aged 12 to 74 using the program People Size++. Users from the fifth to 95th percentile can be comfortably accommodated. Two critical design elements that allow this device to accommodate such a wide range of user body-types are the adjustability of all four legs by four inches each (See Fig. 10.70) and the pivoting arms.

The original design called for an aluminum frame; however it was decided that PVC would be a good alternative material, satisfying all design criteria, providing sufficient strength at a low cost, and weighing only 14 pounds. The frame of the device is composed of 1 ½-inch outside diameter, 1/8-inch wall PVC tubing, which includes eight joints and 86 inches of straight tube. Each of the four adjustable legs is made from 1 ¼-inch-diameter tubing, 6 inches in length with four drilled holes to provide an additional 4 inches of height range. Each leg is fit with a black rubber butt cap to provide stability on most surfaces. At its lowest setting the stand provides a dip height of 11 inches and a dip width of 16 inches, while at its highest setting it provides a dip height of 17 inches and dip width of 30 inches or more. Various combinations of height and width provide for a variety of exercises for a wide range of body types. Fig. 10.71 shows the device collapsed for easy storage.

An alternative version of this device may be constructed from 1-inch-diameter anodized...
aluminum with 1½-inch outside diameter rubber grips. This design would be less bulky while maintaining the appropriate gripping diameter where necessary. With this material selection, based on weight, strength, and cost, the device could provide sufficient strength for a user weighing up to 300 pounds, would weigh approximately 10 pounds, and would be relatively inexpensive to produce.

The total cost of this project was approximately $25.

** People Size Version 1.40, Licensed to Colin Drury, Copyright Friendly Systems Ltd. 1994,1995

Fig. 10.70. Adjustable Leg.

Fig. 10.71. Dip Stand in Collapsed Position.
INTRODUCTION
The Therapeutic Injury Massage device, shown in Fig. 10.72, was developed to allow patients to self-administer massage treatment.

SUMMARY OF IMPACT
The Therapeutic Injury Massage provides the convenience of independent massage treatment. This device could be used by athletes to provide stimulation of specific muscles or by any individual to administer a general massage for relaxation.

TECHNICAL DESCRIPTION
The Therapeutic Injury Massage uses pneumatic flow to fill two vesicles that have a known control volume. The filling rate and final volume are precisely controlled electronically with a programmed micro-controller. The device consists of: 1) one pump; 2) one microcontroller; 3) one pressure transducer; 4) three X-valves; 5) one six volt DC power supply; and 6) two vesicles (blood pressure cuffs). The normally-open ports of valve one and valve two are connected to control volumes one and two respectively, while the port of valve three vents to the atmosphere. The common port of valves one and two is connected to the pressure transducer while that of valve three is connected to the intake of the pump. The pressure transducer is connected to the exhaust of the pump. All three valves are connected to the same normally-closed port for venting. The pump and the transducer are connected to a battery-powered micro-controller.

The pump, which is powered by a six-volt DC power supply, inflates the control to a pressure of approximately 1.8 kips. This pressure corresponds to a voltage programmed in the micro-controller of 4.5 Volts DC. Once this voltage is reached, a series of pump and vent scenarios programmed in the micro-controller are activated. This throttles the vesicles and creates a pulsation effect, which is used to massage the area. There are eight scenarios because three valves are used. The pressure transducer measures the gauge pressure of the control volumes. It is programmed to accept a maximum gauge pressure of 2.4 kips; if this pressure is exceeded, the bladder will vent. As an auxiliary safety feature, the vinyl tube used for plumbing also dislocates from valve two to interrupt the air supply when maximum pressure is surpassed. Fig. 10.73 shows some of the inner components of this device.

Below is the software sequencing applied to run the pump continuously when power is supplied to the pump, x-valve, and processor.

1. Valve 3 (on) - Air supply to pump blocked and vent line open.
   
   Valve 2 (on) - Bag 2 to vent line.
   
   Valve 1 (on) - Bag 1 to vent line.

2. Sample pressure sensor for output < 1.0V DC.

3. Valve 1 (off) - Bag 1 to air fill line.
   
   Valve 3 (off) - Air supply to pump and vent line closed.
   
   Valve 2 (on) - Bag 2 to vent line.
4. Sample pressure sensor for output > 4.5V DC.

5. Valve 3 (on) - Air supply to pump blocked and vent line open.
   - Valve 1(on) - Bag 1 to vent line.
   - Valve 2 (on) - Bag 2 to vent line.

6. Sample pressure sensor for output < 1.0V DC.

7. Valve 1 (on) - Bag 1 to vent line.
   - Valve 2 (off) - Bag 2 to air fill line.

8. Sample pressure sensor for output > 4.5V DC.

9. Valve 3 (on) - Air supply to pump blocked and vent line open.
   - Valve 2 (on) - Bag 2 to vent line.
   - Valve 1 (on) - Bag 1 to vent line.

10. Go to 2.

The total cost of this project was $524.

Fig. 10.73. Close-Up of Inner Components.
DEVICE FOR DETERMINING DIRECTIONALITY OF SOUND

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INTRODUCTION
The Device for Determining Directionality of Sound, shown in Fig. 10.74, is worn on the head. It receives sound input from the environment and converts it to visual representations that can be seen by the wearer. Two LED lights are mounted on the hat such that they can be seen in the wearer’s peripheral vision. The LED lights begin to blink in response to sound detected by the device. The blinking lights alert the user to the source of sound.

SUMMARY OF IMPACT
This device will allow people that have partial or complete hearing loss to be more aware of their environment. Since sound is often used as a means of warning, such as a car horn or emergency vehicle siren, it is especially important for a person’s safety that he or she be made aware of a sound source as quickly as possible. Such a device could save the life of a person with hearing loss. Additionally, this device has social benefits in that users can become immediately aware of someone speaking to them and where that person is.

TECHNICAL DESCRIPTION
The device has two circuits: one for each side of the wearer. (See Fig. 10.75) Each circuit contains an amplifying circuit that converts sound waves into light emitted by an LED. The LED was chosen because of its immediate and variable response to sound. The LED is able to emit high and low levels of light for the different levels of sound.

The sound is received by omni-directional microphones, shown in Fig. 10.76, so that sound can be picked up in a 180-degree cross-section. The gain of the circuit is controlled by a potentiometer. This potentiometer is important when adjusting the device for indoor or outdoor use. This is necessary because of the effect of sound waves bouncing off walls.

The two halves of the device oppose each other and when properly tuned, effectively pick up the sounds that are coming from their own direction as well as the other direction; however, the sound coming from their direction has a far greater amplitude and is thus displayed this way as the LED emits light.
Fig. 10.77 shows the batteries and electrical components that are housed in the utility belt connected to the hat. Fig. 10.78 shows the device in use.

The total cost of the prototype was $100.

Fig. 10.76. Directional Microphone.

Fig. 10.77. Circuit Board and Battery Storage.

Fig. 10.78. Device in Use.