CHAPTER 15

UNIVERSITY OF MASSACHUSETTS AT LOWELL

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INTRODUCTION
The client for whom this project was designed is a non-verbal 11-year-old girl with learning disabilities. These include poor auditory comprehension, as well as trouble understanding words and concepts represented by pictures. The teacher has been teaching the client to point to small picture squares as a form of communication. Often, the client points to a picture conveying a message, such as the need to use the bathroom or desire to use the computer. It took the teacher one year to help the client understand the connection between a picture of a computer and the computer workstation itself.

The teacher requested a device linking the pictures that the client already uses to corresponding audio messages. The device consists of nine square
buttons intended for the display of the client’s picture cards, each button triggering a separate re-recordable audio message.

**SUMMARY OF IMPACT**
The Talking Box (Figure 15.1) serves as a learning tool to reinforce associations among pictures, concepts and words and also serves as an augmentative communication device. The teacher commented that the simplicity of the device is helpful; there are only the nine buttons, one power switch, a volume knob and a recessed play/record switch. Additionally, after only two hours, the client had already begun to understand that this device was hers only, and that the pictures were meant for her to communicate ideas. The teacher then presented new concepts to teach the client, and commands or comments she could express using the device. The teacher anticipates that the client will become more independent as she becomes more proficient with her Talking Box.

**TECHNICAL DESCRIPTION**
The device consists of nine large 1.75” square arcade buttons (with the back-lighting capability disabled) on the front face of a rectangular box. On one side of the device is a three-position volume control, chosen over a variable volume control to prevent accidental alteration of the setting. On this side also lays a recessed play/record switch and a battery compartment containing four AA batteries. On the opposite side are speaker holes and a microphone for recording. Attached to the rear, flat side of the device are two Velcro straps, for strapping the device to the user’s waist.

Only three ICs were needed to implement the audio capabilities. Winbond Electronic Corp.'s ISD2560 provided 60 seconds of addressable audio recording and playback. To control the playback of audio, Parallax Inc.'s Basic Stamp (model BSII) provided 16 I/O pins able to be programmed with a variant of the BASIC language. An LM386 Power Amplifier was used to boost the output volume to a two-inch speaker. The buttons were simple three-terminal momentary pushbuttons, typical in arcade machines.

The cost of parts and material was approximately $160.
INTRODUCTION
The Drop Foot Sock (DFS) (Figure 15.2) was designed for a client who has a neuromuscular disorder known as drop foot, which affects his ability to raise his foot at the ankle. He wears a brace that pivots his ankle for him so that his heel always plants first before his toes. If the heel is not planted first, a stumble or fall is likely. The purpose of the design is to alert the user if his foot is not bent back enough to make a proper heel plant to take a step. The device is simply a sensor attached to an ACE bandage. As the foot drops more and more, a vibrating motor intensifies, alerting the user to concentrate more on pivoting the foot so that the heel plants first. Upon completion, the DFS was presented to the client.

SUMMARY OF IMPACT
The client has some control over his compromised foot, but does not have much feeling in it. The DFS was designed to replace the brace and let the client work on getting full control over his left foot. The DFS is a feedback device that alerts the client if his foot is not in a proper position to take a step. If the client feels an intensifying vibration, he knows to concentrate more on pivoting his ankle to plant his heel first.

TECHNICAL DESCRIPTION
The DFS has two parts: a traditional sock with Velcro on the bottom to secure the pressure mat, and
an Ace bandage that goes over the sock and secures the flex resistor (drop sensor) tight to the user’s foot. On either side, the bandage holds the battery pack and project enclosure that stores the circuitry with plastic fasteners. Four cords extend out from the box: one goes to the battery pack, another to the flex resistor (drop sensor), and another to the pressure mat. The last cord is small and is connected to the DC motor. This motor gets tucked into the bandage when the user puts on the sock, which allows the user to get the full effect of the vibration.

A schematic diagram is provided in Figure 15.3. The device is powered by four AA rechargeable Ni-MH batteries. This 6-volt supply must be regulated to 5 volts for the logic circuitry. The voltage regulator is made of a zener diode and a series resistance of 110 ohms. The device draws less than a 200 milliamps and should run at full load for approximately 10 hours.

The pressure switch is made with a cut-out section of a footpad with two thin metal discs as contacts. The two discs are set on either side of the footpad; when the footpad is compressed the two pieces of metal make contact. Wires were soldered to each disc to serve as the two leads of the switch. The contacts are covered on either side using a clothing patch. The pressure mat opens and closes a ground path for input 1 of a Quad 2-input XOR (7486) logic chip. Input 2 was tied directly to the 5-volt from the regulator. In order for the system to be on when the switch is open and off when the switch is closed, an inverter (7404) was used. The output of the inverter goes to the resistor bridge. The bridge was designed so that when variable resistance (flex resistor) is increased the output voltage decreases. The bridge is made up of three 750-ohm resistors and the flex resistor that varies from 12.3k to 34k ohms. When the flex resistor is completely straight (the lowest varied resistance), the bridge outputs 110 mV, which is then amplified. Because the output of the bridge was only 110 mV, it had to be amplified to activate the DC motor. An LM 358 was used in conjunction with a 1k ohm input resistor and a 22k ohm feedback resistor to give the 2.5 V needed to operate the motor. This dual low-power operational amplifier was chosen due to the 6V supply.

The cost of parts and material was approximately $75.

Figure 15.3. Design Schematic of Drop Foot Sock
INTRODUCTION
The Snoezelen Switch was designed to create interactive sensory experiences for a child with physical and cognitive disabilities. The child is legally blind, has limited motor skills, and cannot speak. The device contains a series of four pull switches, adapted from the child’s environment, that hang approximately 12 inches above the child when he is lying on an activity mat. Three of the pull switches activate music of different types. Each of these three switches is recordable. The fourth switch activates a vibrating motor, which runs through a DC plug on the base of the unit (as shown in Figure 15.4). Upon completion, the project was presented to the client’s school.

SUMMARY OF IMPACT
Left unattended, the child would simply lie on his back, pulling and chewing a tube attached to a key-chain coil. Utilizing the coil-tube, the client’s response to auditory stimulation, and his preferred physical position, the Snoezelen Switch allows for advancement in both his motor skills and his intellectual capacity while maintaining familiarity with his environment.

TECHNICAL DESCRIPTION
The outer housing of the Snoezelen Switch was
constructed of lightweight aluminum sheet metal, attached by plastic corner bracing. Aluminum provides a rigid frame resisting deformation when the child produces downward force on the body of the device. This was essential due to the length required for spacing of pull switches. The plastic bracing provides the level of safety required given the environment in which the device is to be operated. The housing was mounted using three L-shaped brackets without cross braces. This was done so that no part of the mount would be accessible to the child.

The pull switches were designed to mimic the child’s existing toy. A keychain-style plastic coil was attached to semi-rigid plastic tubing mounted through a grommet-fitted ½” hole in the housing (see Figure 15.5). Each coil was spaced 10” apart, accommodating the client’s visual impairment and his motor skills. The tube and coils are removable from the exterior of the housing for cleaning or replacement.

The internal electronics of the device consist of a BS2 micro-controller, ISD 2560 Voice Record Chip, LM386 Audio Driver, and all necessary switches and wiring. Audio for the device was stored on the modified ISD 2560 Voice record chip. By altering the cutoff frequency of the chip, it was able to record music with minimal distortion. Additionally, the chip has the ability to store several segments of audio on one source, without A/D conversion or memory, while still having audio that is addressable and re-recordable. The chip also had differential speaker outputs, which improve noise rejection. A BS2 Micro-controller was used to accept the switch inputs, and control the ISD 2560 and vibrating motor circuit. In order to drive the vibrating motor, an IRF510 Power Mosfet was used for switching. The mosfet was used due to the inability of the BS2 to provide sufficient current to the DC vibrating motor. The BS2 sends logic one to the gate of the mosfet, allowing 10 Volts DC to pass through the motor. This was wired to a DC power jack to provide modularity.

The cost of parts and material was approximately $150.
INTRODUCTION
The Head-Activated Wheelchair (HAW) was designed to provide the client a means of improved control of his electric wheelchair. The client can move his head but has limited movement in his arms. He has difficulty using his electric wheelchair because it has three 10 mm proximity switches with only three sensors that are hard to use while also adjusting the direction of travel. As a result, the client’s parents were trying to find a better way for him to use his chair and provided the specifications for this project.

This device replaces expensive components of electric wheelchair systems with a system that is more affordable and easier to use. The device will allow any user to control a wheelchair with more accuracy and considerably less physical effort. The device is placed over the head of the user and connected to a digital box on the wheelchair. Once the wheelchair is turned on, it is ready for use. The client uses his head to control the direction that the chair travels (see Figure 15.6).

SUMMARY OF IMPACT
The newly designed system has a set of six sensors made of conductive and non-conductive fabrics that when pressed, behave as a sensitive switch. The client uses his head to control forward traveling motion and his right arm to reverse direction. As a result, he is able to use his wheelchair more efficiently, allowing him to be more involved in interactions with his environment.

TECHNICAL DESCRIPTION
The system consists of a head array and a digital interface that communicates with the original wheelchair’s digital box and controller. The head array is made of multiple pads located in a support bar around the user’s head. Each pad is made of multiple layers of fabric enclosed in six different 4” x 3” zipped bags. In total, eight layers of materials were used to construct the pads or sensors that are located inside the bags (see Figure 15.7). The outermost layers (the bottom and top layers) are composed of fabric. The next two layers are made of Peltex fabric, which does not conduct voltage and acts as insulation for the conductive inside layers. The next two layers consist of a highly conductive material, metallic silk organza, which distribute the voltages along one side and collect voltages on the other side. Next is a layer of Peltex fabric, which has a square concentric hole to insulate the wires coming out of the conductive layers so that they do not touch one another. The next layer is a resistive foam that, when pressed, will allow the current from one conductive layer, the input, to flow to the other conductive layer, the output. The input receives 5
volts coming from the LP interface and sends voltages in the range of 0 to 5 volts to the LP digital interface as outputs.

Once the signals from the head array arrive to the LP digital interface, the set of signals must be processed so that the correct instruction is given to the wheelchair’s controller. Enclosed in a 6” x 4” x 2” Project Enclosure, which is easily attached to the back of the wheelchair, is the circuitry that will process the DC signals (see Figure 15.8).

The circuit consists of a set of NPN transistors that work as digital switches, only allowing voltages to be sent when the pads are pressed hard enough to transmit 2.75 volts to the LP interface. From the transistors the signals go to a micro-controller, Basic Stamp 2 (BS2-IC), which sends the correct set of signals to the digital interface so that the wheelchair’s controller allows the chair to be moved in the proper direction.

Programming in the BS2-IC controls the logical low signals that are sent to the digital box of the wheelchair, which activates movement in a certain direction. When no voltages are transmitted from the head array to the LP interface, the BS2-IC sends all high signals to the wheelchair’s digital box, setting the HAW to its rest position. When a particular pad is pressed, the chair will travel in the direction that the pad is located, no matter how long it is pressed. If two pads are pressed at the same time, the wheelchair will travel on the most forward direction and the travel direction will not change until that particular pad is released and another pad is pressed.

The LP interface is powered by the wheelchair’s 24DC battery and has an integrated voltage regulator to produce the 5 DC volts required by the internal circuit. The LP digital interface has an on/off switch, an LED that indicates when it is being powered, and a fuse. The LP digital interface can be easily mounted in the back of the wheelchair by screwing it onto a platform with a bracket attached to the wheelchair structure.

Total cost for parts and materials was $236.
TRANSITIONAL TIMER

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INTRODUCTION
The Transitional Timer is designed to assist therapists in guiding children with autism and related developmental disabilities from one activity to another. It is a 60-minute timer designed to provide sensory feedback for timed activities. Once the timer is set, it provides visual cues corresponding to the amount of time left before activity completion (see Figure 15.9). The device was presented to a center for children with disabilities.

SUMMARY OF IMPACT
The occupational and physical therapists and the speech-language pathologist at the center have difficulty getting children to switch from a play activity to a work activity or vice-versa. They requested a timer to provide visual feedback regarding the amount of time left for a timed activity and a separate display for the therapists to track the amount of time left. They specified that the device should operate quietly, and they wished to be able to set, reset, start, and stop the timer. The therapists had been using a single egg timer in a large therapy room to help signal transition times. However, that timer was difficult to see and hear. The Transitional Timer is intended to provide greater control and offer greater visibility.

TECHNICAL DESCRIPTION
The Transitional Timer was mounted on a 2' x 2' section of plywood. The mount had to be large enough for easy view across a large room and strong enough to support its own weight. The circuit diagram is given in Figure 15.10. A Microchip PIC microcontroller maintained the timer and controlled a 12-volt stepper motor, 120 LEDs, a 4 by 4 matrix keypad, and a 16-character by 2-line LCD. Additional “glue” logic was used to provide an interface between the PIC and the LEDs. Darlington transistors were used as an interface between the low current PIC and the higher current stepper motor. Power was provided by a retail power supply offering two 5-volt sources at 2-½ amperes and one 12-volt source at 1 ampere.

The PIC microcontroller was selected for its ease of programming, versatility and packaging. It has three 8-bit ports, one 7-bit port, and one 3-bit port, most of which were used for digital input or output (see Figure 5.10). The PIC was programmed in C to trigger an interrupt every 10 milliseconds before determining if any attached devices required service. Lengthy service requests were separated into smaller tasks that were subsequently handled. This algorithm allowed the microcontroller to maintain rigid timing requirements within the system.

A stepper motor was selected for its ability to operate quieter than conventional quartz movements found in existing timers. The motor provided more than enough torque to actuate a large timer hand through its full range of motion. A 162-degree range of motion was selected to provide...
sufficient resolution of each minute as it expires and without the need for additional gearing.

The cost of parts and material was approximately $150.

Figure 15.10. Transitional Timer Circuit
INTRODUCTION
The No Touch Switch (Figures 15.11 and 15.12) was designed to upgrade a client’s Jelly Bean Talking Switches to a system that would be implemented under a table. This will help the client use table space more easily and comfortably. The system uses commercially available proximity sensors, which are triggered by hand motion.

SUMMARY OF IMPACT
The client and guardian both said that the new design will make things easier for them. Now that the jelly bean switches are replaced by the No Touch Switch system there will be no need for tape on the table and the client is not likely to accidentally knock objects off the table while reaching for switches.

TECHNICAL DESCRIPTION
A 12V DC power adapter is used to power the capacitive proximity sensors under a table. The sensors are triggered by hand motion, stimulating a voltage signal. Voltage dividers then decrease the
voltage and the logic 1 signal (5 volts) is obtained. Logic 1 signal is then sent to Basic Stamp 2, which recognizes this voltage and analyzes it through a program. After running through the program this signal is sent to an input pin of the ISD 2560 chip, which then determines whether the system is in the recording or play mode. The signal is then amplified using an LM–386 Driver Amplifier, which goes out through a speaker so that an audio output is received.

When the system is in the record mode, a stereo microphone is used to record audible data. To record, the sensor must be triggered by hand and the above cycle of signal going through the Basic Stamp and the ISD 2560 chip is followed.

The cost of parts and materials was approximately $100.
WIRELESS BASE SIGNAL FOR BEEP BASEBALL

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INTRODUCTION
This product was designed to be used in “Beep Baseball” games. It consists of one transmitter and two receivers. The transmitter can be used to select either one of the two receivers at one time. When a signal is sent to a receiver, a loud buzzer is sounded. The two receivers are kept inside the first and third bases. The transmitter is typically kept behind home plate. A buzzer is sounded at first or third base whenever a ball is hit. This tells an individual who is blind which base to run to. The custom product was soldered directly to PC Board and enclosed in standard plastic enclosures. While many wireless switching products are already readily available, none were found to have the correct combination of range, size, volume, and durability.

SUMMARY OF IMPACT
The sport of beep baseball is a great way for individuals who are blind to participate in baseball. This product will change the way that beep baseball games are set up. Usually there are wires running along the ground from home plate to the bases. The wires are cumbersome and can be dangerous tripping hazards. Having a wireless system in place of the cable system is an improvement that will enhance safety and aesthetics.

TECHNICAL DESCRIPTION
This product is enclosed in three standard plastic project enclosures. The transmitter enclosure is significantly smaller than the two receiver enclosures due to the nature of the electronics. The electronics were soldered directly onto three standard PC boards. The batteries and electronics are completely enclosed and protected. Only the switches and buzzers are mounted on the exterior of the enclosures. Generic standoffs, screws and nuts were used in mounting and securing the project. Necessary holes were made in the plastic enclosure with a simple drill and standard bits.

Both the receivers and the transmitter are each powered by a single 9V battery. The transmitter accepts an input range of 5-12 Volts. For this reason, voltage regulation was not necessary and the battery was connected directly to the electronics and ICs.
Given that the receivers are sensitive to voltage, a voltage regulator was used. The buzzers were connected directly to the battery while the voltage regulator provided +5Vdc to the sensitive electronics. Voltage regulators like the LM7805 introduce large amounts of power loss. This usually means that standard 9V batteries will not last very long. In this situation however, very little current is needed from the regulator, and it is only fully operational for very short periods of time.

The device operates at a frequency of 433 MHz. The outdoor range is approximately 400 feet. This is more than double what is needed in this application.

Wire antennas of approximately 13.8” were attached and loosely wound within each enclosure. The only difference between receivers was the grounding of the address pin ‘A0’ in the second receiver. Simple schematics of the electrical design are shown in Figure 15.13. The power circuit is shown in Figure 15.14.

The cost of parts and material was approximately $135.

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**Figure 15.14. Power Circuit for Wireless Base Signal**

![Power Circuit Diagram](image-url)
INTRODUCTION
The Voice Activated Alarm Clock System (VAACS) was designed to help a child with physical disabilities control an alarm clock independently and in the dark. To operate the VAACS, the user simply makes sound, such as a hand clap or vocalization, near the microphone. The signal output can activate the relay which can turn on the projector of the alarm clock (see Figure 15.15).

SUMMARY OF IMPACT
The design criteria were defined according to the user’s capabilities. The child wants to see the time at night, but she has difficulty turning on the light. Now she will be able to see the time without need for extra lighting. The device is safe and portable. Voice activated technology can be a fun motivational tool for practicing environmental control and learning cause and effect relationships.

TECHNICAL DESCRIPTION
The system has an on/off switch. The electret microphone is ready to pick up the signal from the user. One red LED is designed to confirm the working system. The relay activates the alarm clock about three seconds after the sound is received. All additional electronic components of the VAACS are soldered in one prototype board and secured to the frame with bolts.

Figure 15.16 shows the complete circuit board installed inside the box. The system has a sound sensitivity control with a Koa 200k adjustable...
trimpot. The voice activated switch entails a combined analog and digital circuit. The LM358 is a National Semiconductor inverting negative feedback operational amplifier. The IC will capture the voice signal and amplify the amplitude. The input signal is doubled by two diode signal rectifiers. It is then compared with a comparator amplifier to determine whether the digital signal is high (logic 1) or low (logic 0). This controls the relay that turns the alarm clock on and off.

First, the microphone will pick an input signal from any audio signal. That is amplified by IC LM358 as a non-inverting amplifier. One capacitor is coupled with frequencies above 10 kHz to avoid noises from the microphone. The voltage at the negative feedback resistor is calculated by a voltage divider. Another resistor is used for the DC supply to the electret microphone with a built-in amplifier. It serves as a load resistor for the amplifier. The output at pin 1 of the op-amp feeds two diodes, which function as a half-wave voltage doubled by using a signal diode. Additionally, a capacitor and diode serve as a DC restorer (clamped capacitor). Because of the polarity with which the diode is connected, the capacitor charges to a voltage equal to the magnitude of the most negative peak of the signal. This rectifies the audio signal to produce a DC voltage across the capacitor with value of 2.2 microfarad. Two resistors are connected to adjust the off delay time. The DC signal is fed to a second stage op amp. This amplifier is constructed as a comparator. A resistive voltage is set to about 2V at pin 6. When the DC voltage is greater than about 2V, this turns on transistor Q1, which activates the relay and turns on the LED.

The cost of parts and materials was approximately $50.
INTRODUCTION
The client for whom this project was completed has severe lack of motor control and unintelligible speech due to complications of cerebral palsy. For the past several years he has made use of a system consisting of an Apple computer and a single pushbutton switch to form text messages so that others may read and hear them. He must wait for the cursor to reach his desired option before he may make that selection. Although the basic requirement of message formation is met with this system, it is extremely slow and lacks several basic features found in basic word processing applications. The objective of this project was to create an entirely new system that would solve the deficiencies the client currently faces with the old method of text processing.

SUMMARY OF IMPACT
The Foot-Controllable Text Processor (Figure 15.17) greatly enhances the client’s communication experience. The most significant benefits are that words and sentences may be formed more quickly, messages tend to have a more sophisticated structure, and records may be kept of any text created. The client’s father, who has for decades volunteered in the care of many adults with disabilities, firmly believes that using the new system will be an enjoyable and enriching experience for his son as well as for others with severely limited mobility.

TECHNICAL DESCRIPTION
The system is composed of a specially developed program and a controller to perform program operation. It is easy for the client to use. The most significant difference from the old system is that it allows the client to move the cursor in any direction and at his own pace. The controller casing is a durable plastic box with dimensions 8” L × 6 3/16” W × 2 1/2” H. Mounted onto the front of this box (8” × 2 1/2” side) are the pushbutton, horizontal toggle, and vertical toggle switches from left to right. The controller box is mounted securely to the footrest of the client’s wheelchair using a 1/2” thick piece of wood and a metal bracket. The interior of the controller houses the circuit board for switch debouncing and the USB interface module. Switches are debounced with series RC circuits with time constant equal to approximately 0.1 seconds. The DeVaSys USBI2C/10 interface board provides connectivity between the controller and host computer. Any standard USB cable with A and B connectors may be used. Included with the module are a device driver, firmware, and application programming interface (API) for interfacing with the hardware in C-based applications.

The custom designed “TextMaker” program (Figure 15.18) was coded and built with the Microsoft Visual C++ 6.0 integrated development environment. While there are some graphical improvements to the user interface, its structure has been kept essentially the same. In the top left pane of the program window is the main menu, and to its right is the sub-menu for the current operation being performed. The bottom half of the window displays the text. When the program is started, the stored vocabulary is loaded into memory from a set of files, one for
each letter of the alphabet and another for multi-word phrases. Each file is loaded into a binary tree structure for faster searching. All program objects are based on the Microsoft Foundation Classes (MFC), a library of classes that encapsulates many portions of the Windows API. Moving the toggle switches in a certain direction will change the position of the cursor within the current menu. Pressing the large pushbutton switch will execute the exact same code as if the item were clicked (if a button) or double-clicked (if a list box item).

Many features have been included in the TextMaker program to provide the client with a more streamlined and sophisticated text processing system. He may enter words and phrases much in the same way as before, and he may now insert numeric and punctuation characters, including all numbers for writing dates. Another option made available is the addition of new words by spelling them letter by letter from an array of characters. When the user finishes spelling a word, it is automatically added into its corresponding word tree and saved to the appropriate vocabulary file. Any word in the stored vocabulary may be removed by selecting it in the same way as it is selected for insertion into the text window. To perform audio output, the application passes the text window contents to an instance of the Microsoft Speech API’s ISpVoice class. The client then has the option of restarting, pausing, or stopping audio output of the text.

Another newly available feature is file input and output. The client may save his work into a text file with a name of his choosing and open it at a later time. File input and output is accomplished with the C++ ifstream and ofstream objects, respectively. Clear options include erasing only the last word entered, or the entire contents of the text window. If the user wishes to quit the program, he has the option of saving his work before exiting.

The total cost of all components was approximately $540.

Figure 15.18. TextMaker Program User Interface
INTRODUCTION
The Keylessboard was designed to give active audio feedback to children with reduced motor skills. It functions as a normal musical keyboard, but the keys have been removed and replaced with sensors (see Figure 15.19). When an object is placed over the sensors, notes sound.

SUMMARY OF IMPACT
Some students at a school for children with disabilities had motor control problems that made it impossible for them to control keys on a typical musical keyboard. They now have a way to enjoy making music.
TECHNICAL DESCRIPTION

The Keylessboard is simply a modified keyboard. The keys were removed from it and replaced with a sheet of high-pressure laminate dry erase board. Holes were drilled into the board and cut to the appropriate size and shape using a jigsaw. Sensors were inserted into these holes and hot glued in place. The circuit was mounted inside the keyboard by using existing screw holes and by using wire to securely fasten the board to the cover of the keyboard.

The circuit itself starts with the sensors. The sensors utilize an IR LED. When an obstruction gets in its path the IR light is reflected back and turns on a phototransistor. The amount of current drawn by the phototransistor is dependent on how close the obstruction is to the sensor. This output voltage is then sent to a comparator.

The comparator compares the input voltage from the sensor with a voltage from a trimpot. The trimpot is used to adjust how close the user’s hand must be to the sensor in order to sound the key. The comparator is set up in such a way that a low signal is output when the two voltages compare. Otherwise it is always outputting a high signal.

The output signal from the comparator is attached to the enable pin of the buffer. The buffer’s enable pin is active low, hence the reason for the comparator outputting low voltage when the two compare. Once the buffer is active a Vcc signal is able to go through the buffer to the relay.

The relay receives the signal from the buffer and turns on. When the relay turns on, it connects the two ends of the key circuit on the keyboard. A schematic of the circuit is shown in Figure 15.20.

The total cost of this project is approximately $65.
INTRODUCTION
The Circle Time Apparatus is a device to enhance the environmental awareness and independence of children in a special needs classroom. “Circle time” is when four children, with limited mobility and under the supervision of an instructor, come together and perform tasks, such as preparing a meal. The Circle Time Apparatus, shown in Figure 15.21 is a wireless system that senses when jellybean switches are pushed, and then broadcasts sensory data. Subsequently, the broadcast data are used to control any electronic device plugged into the system.

SUMMARY OF IMPACT
The client coordinator stated that, “any device that gives the children a cause and effect and allows them to do things on their own increases their self-esteem and confidence in a tremendous way.” An instructor, with the aid of the administrative control system shown in Figure 15.22, has the children push a sequence of buttons that control kitchen appliances to prepare a meal. As a result they accomplish tasks that previously required the assistance of others.

TECHNICAL DESCRIPTION
The device utilizes the HT-12E encoder, HT-12D decoder, TWS 434A RF transmitter, RWS 434 RF receiver, Basic Stamp 2 and solid state relays. The data inputs D0-D3 of the HT-12E encoder receive on/off voltage signals from the four jellybean switches mounted on the circle time desks. The binary signals are encoded based on the HT-12E preprogrammed settings, which are assimilated by the address settings A0-A9. After the data are amalgamated in the encoder, they are communicated to the data input of the TWS 434A RF transmitter by means of a square wave. The square wave is then interpreted by the TWS 434A RF transmitter, and converted to an amplitude modulated radio frequency, operating at 433.92MHz. Subsequently, the radio wave is broadcasted to the RWS 434 RF receiver via antennas. The RWS 434 RF receiver translates the radio wave into a square wave and sends the wave from its digital data output to the serial data input of the HT-12D Decoder. However, the information is not processed until the decoder receives a transmission validation by way of a valid transmit circuit.

The valid transmit circuit is comprised of a light emitting diode, a transistor and two resistors. When a current is dispatched from the linear output of the RWS-434 receiver it passes through a 470 resistor. The current passes through the light emitting diode and enters the collector of the transistor. The emitter of the transistor is grounded; hence the current emerges from the base of the transistor into the 10k resistor and commences the transmission validation. After obtaining validation, the square wave is deciphered by the HT-12D decoder and converted to binary impulses, which are transmitted to the administrative control system. There are two essential selection knobs in the administrative control system; these are used to ascertain which
data setting will drive the system. The first knob gives a student authorization to control a selected appliance. This means that the students obtain the ability to control the appliances only when the instructor sanctions the task by turning the knob on the number associated with that particular student. The second knob selects which appliance is to be controlled. The selection knobs perform these tasks by incorporating rotary switches. When the knobs are positioned at a number, the terminal associated with that number on the rotary switch becomes Vcc; otherwise the terminal is ground. The administrative control system is mainly comprised in the Basic Stamp 2 microcontroller. The components of the administrative control system are connected to the Basic Stamp 2 as follows: the first selection knob is connected at pins 1 through 4, the outputs of the HT 12D decoder are connected at pins 5 through 8, the teacher lockout switch is connected at pin 9, and the second selection knob is connected at pins 10 through 12. These inputs are processed by the Basic Stamp 2, and accordingly send 5V to the solid state relay circuitry.

The Basic Stamp 2 program operates under three pivotal principles. The first principle is that Basic Stamp 2 will only conduct a task when the teacher lock switch input is Vcc; otherwise it will remain dormant. This principle was implemented to ensure that instructors are not injured when students accidentally push a switch. The second principle is that the voltage output to the solid state relay circuitry replicates the voltage input from the selected HT 12D Decoder outputs. The third principle is that the parameters instantaneously transfer when the settings of the selection knobs are changed.

The solid state relay circuitry consists of a 2N3904 transistor, a 10k resistor and an ECE solid state relay. The solid state relays have four nodes. The first node was connected to the high wire of a power line that supplies 120V, and the second node was attached to a socket. The third node was directly wired to 5V Vcc, and the fourth node was connected to the collector side of a transistor. The emitters of the transistors were grounded and the base was connected to 10k resistors. When the Basic Stamp 2 determines to power an appliance, it dispatches 5V to the 10k resistor coupled with the solid state relay via a transistor. When the 5V is placed at the 10k resistor connected to the base, the transistor grounds its collector, which in return sets the fourth node of the solid state relay to 0V. Once the fourth node has been set to 0V, the circuit is completed. Therefore, nodes three and four are connected, 120V is sent to the socket, and power is supplied to the appliance.
WIRELESSLY CONTROLLED HEATED GLOVES AND SOCKS

Designer: John P. Garvin
Supervising Professor: Walter McGuire and Alan Rux
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INTRODUCTION
The heated gloves and socks were designed for a client with Charcot-Marie-Tooth (CMT), a form of muscular dystrophy. CMT is a neurological disease that causes muscular degeneration of the extremities, namely the hands and feet. The lack of muscle mass in the hands and feet leave them extremely prone to cold weather. When the hands of a CMT patient become cold, they lose mobility and all existing strength. When the client’s feet get cold it becomes incredibly difficult to walk. Heated gloves and socks provide an active source of heat to prevent his hands and feet from becoming cold, and also can warm them if they are cold to begin with.

SUMMARY OF IMPACT
The extremities of a CMT patient are very sensitive to heat as well as cold. Battery heated socks or gloves that are already on the market can become uncomfortably hot. At other times they are not warm enough. These socks and gloves provide the ability to adjust the heat level of each unit separately. They also obviate the need to run wires throughout the client’s clothes. Given that the client has difficulty with mechanical knobs, this project uses easy pushbuttons for heat control. This project allows the client to enjoy outdoor winter leisure activities in comfort.

TECHNICAL DESCRIPTION
The components of the device are shown in Figure 15.23. The project consists of five casings; each is 2” by 3”, and 1.5” deep. One of the casings is the transmitter and control box. This box contains a Basic Stamp 2 microcontroller, with four momentary switches as inputs. There are two red switches and two black switches. One red switch is to increase the heat of the gloves, the black one to decrease the heat. The other red and black switches control the heat level for the socks. The Basic Stamp controls the inputs to the Holtek HT-12E encoder. This chip
encodes a 4-bit parallel input to a serial stream output. The inputs of the encoder are pulled high by the Stamp chip, and the Stamp controller sends a specific number of active low pulses to the encoder. The encoder continuously sends the data to the LINX TXM transmitter modules. The 315 MHz modules control the gloves’ heat, while the 433 MHz transmitter controls the socks’ heat.

The heat-controlling device is a pulse width modulation circuit. The pulse width is adjusted by the DS1669 digital potentiometer. The digital pot adjusts the pulse width of the square wave generated by op-amps, which is sent to the gate of the IRF510 power MOSFET. This MOSFET turns on the nickel-chromium heating wire based on the setting of the digital pot. The DS1669 has two active low controls for increasing or decreasing the resistance. These inputs are connected to the Holtek HT-12D decoder. The LINX RXM receiver modules accept the serial stream sent by the transmitter, and send it to the HT-12D decoder. These data are decoded into a four-bit parallel output. The first two pins are used for the gloves, and the bottom two pins are used for the socks. As a stamp output pin goes low, the corresponding output pin on the receivers go low, and adjusts the digital potentiometer accordingly.

The two enclosures for the gloves fit directly inside prefabricated Velcro pouches sewn onto the wrist area of the glove. The existing wires were prototyped to a DC power plug, with the corresponding socket on one end of the enclosure. The battery packs have a pouch with Velcro straps sewn on to secure to the forearm area.

The two enclosures for the socks have specially made pouches that are sewn onto the top of the socks. The battery packs also have their own pouches made with Velcro straps to secure to the calf area.

The cost of parts and materials was approximately $443.
INTRODUCTION
A computer workstation was designed for patients with a variety of physical disabilities in a hospital. The hospital had available only simple computer systems that are difficult for some patients to use because of problems with mouse or keyboard control. The new workstation incorporates voice recognition software paired with a wireless Bluetooth microphone. This allows users to move around without getting caught on any wires. It is ergonomically designed to be used for long periods of time.

SUMMARY OF IMPACT
The device, shown in Figure 15.24, will allow patients to use the computer without help from others, at the same level of functioning as anyone who has the capability of using a keyboard and mouse. Checking email will be as easy as saying a few words.

TECHNICAL DESCRIPTION
This project consists of three major parts: the software, the wireless microphone and the hardware system. The software that was selected is Dragon Naturally Speaking 8.0. This software was chosen because of its ease of use and how well it will work for someone who is unable to use a keyboard and mouse.

The second part of the project is the microphone. The software came with a microphone but it was insufficient for the application because it had a wire and could possibly fall off if the person using it moved around too much. To fix this problem a Bluetooth microphone was used instead of the wired one. This microphone has a range of over 30 feet, so moving around is easy. The implementation of this software requires a system with a Pentium 3 of 700 MHz or greater and at least 512 MB of RAM. This is actually not sufficient; it ran slowly when the software was tested on a Pentium 4 system with 512 MB of RAM. To solve this problem, a dual AMD MP Processor machine running at 1.4 GHz each and 768 MB of RAM was used instead. This configuration allowed the software to run at an almost real time speed which is imperative to using this software properly. The final hardware configuration used for this system started with a Tyan Thunder K7 motherboard. This board supports two processors so it is equipped with AMD 1600+ MP processors. The memory is PC2100 DDR RAM and has a GeForce 3 Video card to meet the needs of any graphic configuration. The other important part of this system is the power supply, which requires an ATX-GES standard. These power supplies are difficult to find, so an EPS12V 550 watt supply with an adapter was used instead. This design was used in case the power supply broke so that the hospital staff would have an easier time replacing it and it would be less expensive to replace. The rest of the computer is fairly standard, including the case, sound card, hard drive and CD writer.

The cost of parts and materials was approximately $2370.
Figure 15.24. Perfect Workstation
WHEELCHAIR SCALE

Designer: Edward Avery
Client Coordinator: Walter Farrington, Bedford, NH
Supervising Professor: Walter McGuire
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INTRODUCTION
The wheelchair scale (shown in Figure 15.25) was designed so that a user can get onto a scale in a wheelchair and determine his or her body weight. The user approaches the scale and turns it on. The digital output produced by the scale is entered into a computer program. The user can see the total weight minus the weight of the wheelchair.

SUMMARY OF IMPACT
This scale will enable a wheelchair user the freedom to weigh himself or herself.
TECHNICAL DESCRIPTION

The scale's operation is based on a very simple concept: the more weight that is put on the scale, the more the aluminum platform bends toward the ground. As this aluminum is strained, the resistance of the strain gages changes slightly. The gages are arranged such that the amount of weight on the scale correlates to an amount of voltage drop across the gages. An amplifier amplifies that voltage so that it can be accurately measured by a voltmeter. This value is then entered into a Visual Basic program, where the voltmeter reading is converted into a weight.

The circuitry is simple. The four strain gages are placed on the lower piece of metal and their lead wires enter the circuit to form a Wheatstone bridge. The voltage drop across the bridge is sent to an amplifier so that the signal can be read. The voltage across a load resistor of 1 kΩ is read by the digital voltmeter. Both the voltmeter and the strain gage circuit are turned on and off by the DPST switch. All of the resistors, connections to strain gages, and the op-amp are placed into sockets on the circuit board.

The strain gages are placed, two on the top, and two on the bottom, on the lower piece of aluminum. In order to place the strain gages on the metal, the surface had to be thoroughly cleaned and the gages had to be handled with tweezers to avoid damage. A thin coat of the SG401 adhesive was placed on the back of each gage and each gage was pressed into place as smoothly as possible. Their efficiency is determined by how well they are attached to the aluminum. They are all 350 Ω resistors at rest. When the scale has no load upon it the voltage drop across the bridge should be close to zero. As the metal begins to bend the top and bottom gages have an opposite change in resistance. This causes the voltage drop to change linearly as the weight is applied. After this the voltage is amplified and the resulting value is displayed on a voltmeter for the user to see. This value is entered into a Visual Basic program where it is entered into a calculation to determine the weight of the client.

The cost of parts and material was approximately $310.
NUMBER ACTIVITY BOARD

Designer: Eduardo Vargas
Client Coordinator: Pam Fraser, Lawrence High School, Lawrence, MA
Supervising Professor: Walter McGuire and Alan Rux
Electrical and Computer Engineering Department
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INTRODUCTION
A learning board (see Figure 15.26) was designed to help children with learning disabilities learn about numbers. Light emitting diodes (LEDs) are connected to a stamp chip and programmed to generate numbers from one through eight randomly. To identify an answer, the child must press a number on the box. When the answer is correct, a chime rings and when incorrect a buzzer goes off.

SUMMARY OF IMPACT
The Number Activity Board will help children to use their senses to recognize numbers and build counting abilities.

TECHNICAL DESCRIPTION
The durable casing of the Number Activity Board was made out of wood 24 inches long and 9 inches wide. The pushbuttons are mounted in the bottom front of the box, and the LEDs are mounted on the top front of the box. On each side of each LED a hole was drilled for the buzzer and the chime.

The project operates in the following manner. First, the user turns on the Number Activity Board. The Stamp chip then begins to randomize between zero and 64k. Each of eight cases signifies a number to be displayed by LEDs. Using the random function syntax of the Basic language for the BS2p40-IC, the cases are randomized.

Once the Stamp chip selects a case, the corresponding LEDs turn on. The user is to count how many LEDs are on and then press the button that corresponds to the correct answer. If the user selects a correct answer, then the Stamp Chip goes through an "if-then" loop through eight cases to select the desirable case. This algorithm selects the right answer by going through each of the cases. The right answer sends a "1" to the Stamp chip, causing six volts to be sent to the pin to which the chime is connected to denote a correct answer. A wrong sends a "0" to the Stamp chip. As a result, six volts are sent to the pin associated with the buzzer.

The buzzer and the chime are connected from the output of the Stamp chip to the positive side of the device and respectively, its negative sides are connected directly to the ground. The Stamp chip itself is being powered up by a 6-volt power supply provided by Radio Shack. The circuit diagram is shown in Figure 15.27.

The cost of parts and material was approximately $96.
Figure 15.27. LED and Pushbutton Circuit
INTRODUCTION
The Snoozellen Device was designed to appeal to multiple senses of students with a variety of physical and cognitive disabilities. It plays three 20-second segments of music and also vibrates as the music plays. The device has one large jellybean switch mounted on the center for easy access for students with limited motor skills (see Figure 15.28). The jellybean switch is connected to a three-pole switch that controls each one of the segments. On all three settings the vibrating motors run for the length of each song.

SUMMARY OF IMPACT
The completed device was presented to the special education department of an elementary school. This project helps this wide range of students understand cause and effect. The recordable aspect of the design enables the teacher to personalize the device to the likings of each student.

TECHNICAL DESCRIPTION
Given that the special education teacher travels among different school buildings, it was important to make the device as compact and portable as possible. The casing of the Snoozellen Device was a preformed plastic box approximately 8 inches wide by 10 inches long. The reason for choosing a preformed box was the strength from the internal supports and the size constraints. The button is mounted in the center of the box, and there needed to be enough support to withstand the weight of the children pressing on it. The box has a depth of approximately 3 inches with removable aluminum sides to prevent it from collapsing. The controls on the side panel are a volume control, the three-pole switch, the power button, the playback/record button, and the microphone jack. The reason that these are all mounted on the side is so that the entire device can be put inside a foam pillow to protect the
device from the students and to protect the students from the edges. This also gives the teacher the ability to control the volume and the content of the recordings.

The ICs in this device consist of the Basic Stamp 2 micro-controller, the ISD 2560 audio chip, the Lm386 audio driver, and IRF 510 power mosfet. The audio is recorded onto the ISD2560. This chip can hold up to 60 seconds of audio at an 8.4 KHz sample rate, or can hold a number of shorter segments using the controls of the address pins. This is the main purpose for using the micro-controller. Using a series of inputs and outputs, the stamp controls the addresses and the amount of time it plays back if the entire 20-second segment is not used. The entire circuit runs off a 9.6-volt rechargeable battery, so an important aspect of the design was conserving power. For this reason the Stamp was used to control the power down pin of the ISD as well as the IRF 510 power mosfet controlling the two motors. The stamp sends a logic one to the gate of the mosfet allowing the 9.6 volts to run directly to the motor when the ISD is in playback mode.

The cost of parts and material was approximately $180.
VOCAL TRAINER

Designer: Chung Chan
Client Coordinator: Ms. Webster, Lowell High School, Lowell, MA
Supervising Professor: Jay Fu
Department of Computer and Electrical Engineering
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INTRODUCTION
The Vocal Trainer (Figure 15.30) was designed for a special needs student in a high school. Its purpose is to provide encouragement and promote self confidence when the client says a word. When the user speaks the device plays back his words to him. An LED display provides visual feedback corresponding to his loudness. The louder his voice, the more light he sees. If the client vocalizes at a mid-range volume, music plays.

SUMMARY OF IMPACT
The device helps the user to develop his speaking skills while engaging in something that is fun. Also, it encourages the user to speak more loudly.

TECHNICAL DESCRIPTION
The headset-microphone combination filters out much of the background noise so that the voice of the user is isolated. The microphone had to be directional and take in only voice signals. The input from the microphone goes to the audio amplifier. The analog sign goes directly to the LED drivers. The LEDs depend on the amplitude of the sign to light up. Also, music will play as the LED lights up to a particular point. A 9 V DC adaptor is incorporated.

The cost of parts and material was approximately $50.
Figure 15.30. Vocal Trainer
LIGHT, MUSIC AND TOY BOX

Designer: Chun-Tung Woo
Client Coordinator: Ms. Webster, Lowell High School, Lowell, MA
Supervising Professor: Jay Fu
Department of Computer and Electrical Engineering
State University of Massachusetts
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INTRODUCTION
The Light, Music and Toy Box (Figure 15.31) was designed to promote physical and intellectual stimulation. It uses a remote radio frequency device to control light, music and a toy. Inside the toy box is a series of light tracks with lights that light up to follow a foam ball as it rolls down the light tracks. At the bottom of the light track, a motorized swing projects the ball back up to the top of the light track.

SUMMARY OF IMPACT
The device is entertaining and promotes learning of cause and effect and use of the hands to manipulate button controls. Soft music and soft blinking lights may be soothing to some users.

TECHNICAL DESCRIPTION
The size of the plastic rectangular transmitter box is 6” x 9” x 3”. The receiver device is 14” x 11” x 1”. The front side of the box is covered with a transparent plastic sheet, and rest of the sides are covered with a plastic sheet painted black. All sides are held together with a hot glue gun. Five 5” x 1” transparent strip tracks were glued inside the box. The back of the box has 16 drilled holes for the LEDs.

The main components of this RF device are the transmitter, receiver, encoder, and decoder. Data input into the encoder are transferred to the transmitter, via a radio frequency signal. The signal received by the receiver is transferred to the decoder for output. The output is on when active high and off when active low.

For the blinking light effect, four LM555 timers were used. To change the timing of the blinking, each of the timers has a different value capacitor. The values of the capacitors range from 10F to 1F. These allow each of the timers to have a different frequency, and, therefore, to blink differently.

The music is sent from a preprogrammed microprocessor chip. The microprocessor was built into a circuit such that it only had to connect to the 5-volt relay to operate. A motor was connected to the 5-volt relay because additional voltage was needed. The wiring is shown in Figure 15.32.

The cost of parts and material was approximately $80.
Figure 15.31. Light, Music and Toy Box

Figure 15.32. Wiring for Light, Music and Toy Box
INTRODUCTION
The joystick-controlled tilting mirror (JCTM) is an educational device that provides children with many tools to enhance their visual and motor skills. It is intended to allow children to interact easily with it and to encourage their visual and cause-and-effect exploration. This device is well suited for children with sensory processing, perceptual, and physical disabilities and is also intended to be an attractive and enjoyable educational toy.

SUMMARY OF IMPACT
The JCTM, shown in Figure 15.33, provides visual and motor learning opportunities as well as entertainment. It also encourages curiosity, as the user can see the entire device, including its internal mechanisms and circuits. Also, users are challenged to enhance self-image and discovery, as they visualize different perspectives in the room, including their own reflections. The device will serve as part of a classroom-learning device for students in a special needs classroom. The product was designed for a group of approximately 80 students with ages ranging from 3 to 21 years, with varying cognitive, speech, language, mobility, and visual disabilities.

The JCTM reinforces visual-motor perception as the user observes the mirror’s movements in all directions. The mirror moves up, down, right, and left as well as in combinations of those movements. In addition, moving colored lights turn on in correspondence with the direction of the device’s rotation. This feature allows the children to associate the direction of the lights with that of the mirror. Cause and effect associations are promoted as students control the mirror and observe that it moves in any direction.

TECHNICAL DESCRIPTION
The JCTM is a solid structure that contains a moving frame holding a polycarbonate-based mirror. The
the vertical rotation simulating the up-down direction.

A bipolar stepper motor powers the device’s moving frame. This is joined to a speed-reduction mechanism by a ribbed belt. The system will be controlled by a logic control circuit, which receives signals from the joystick as well as from two switches called limit-of-travel sensors. These sensors are intended to provide a limited range of movement along the horizontal axis. These sensors are used because there are cables connected from the main circuit to the moving frame, preventing a 360° rotation. The logic control circuit generates signals to control the vertical and horizontal motor drivers (UCN 5804), which provide the power output for the stepper motors. Stepper motors were chosen because they offer high resolution, high torque, and more control flexibility. The control logic circuit will also be responsible for generating signals to control the LEDs arrays depending on the direction of the device’s movement.

The JCTM was designed to be a robust and safe device. Its main component is a transparent enclosure containing the circuitry, wiring, moving parts, and joystick. These parts are fully enclosed and protected so that the user will not have any contact with any parts that may be hazardous. The material selected for the enclosure is clear acrylic because of its aesthetics as well as the fact that it also offers durability, flexibility, and is relatively low cost. The enclosure’s corners are protected by aluminum angles to keep the acrylic from breaking or shattering if the device accidentally falls.

Another important component of the device is the moving frame. This is an aluminum-based structure that holds a geared stepper motor that moves the mirror in the up-down direction. The geared stepper motor is attached to a shaft that holds a light and flexible 8”x10” polycarbonate mirror. The polycarbonate mirror was selected over any other material because of its safety, durability, and elasticity. This type of mirror is safe and virtually indestructible under normal use.

A stepper motor attached to a speed reduction assembly is used to drive the moving frame. This configuration provides higher resolution and sufficient torque to move the entire structure without any problems. A block diagram of the components is shown in Figure 15.35. The approximate cost of the project was $250.

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Figure 15.35. Block Diagram of Joystick-Controlled Tilting Mirror
MOTION-ACTIVATED CD PLAYER

Designer: Amir T. Tabrizi
Client Coordinator: Marie Haggerty, Shore Educational Collaborative, Chelsea, MA
Supervising Professor: Alan Rux
Electrical Engineering Department
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INTRODUCTION:
The Motion-Activated CD Player (MACDP) was designed as part of a Snoezelen room at a school for children with special needs. It was intended for students with physical disabilities that prevent them from using their fingers, hands or feet to activate switches and press buttons.

SUMMARY OF IMPACT
The MACDP enables the users to listen to music without having a parent, guardian, or a teacher assist them in controlling the CD player.

TECHNICAL DESCRIPTION
The core of this product was the GP2D15 motion sensor chip manufactured by Sharp. The way the GP2D15 operates is that it has two lenses mounted on it: one is the transmitter and the other is the receiver. The transmitter is constantly sending IR beams out, and if the receiver doesn't receive any IR beam, it means that there is no object in front of the device; therefore there is no reflection. A relay was used to act as a switch for the play/pause button of the CD player. The signal from the motion sensor is sent to the play/pause button, and the CD player plays music.

The cost of this product was approximately $65.
Figure 15.36. Motion-Activated CD Player
INTRODUCTION
The Interactive Bubble Tube was designed to provide sensory stimulation for children with multiple disabilities. The device (as seen in the concept drawings in Figures 15.37 and 15.38) is basically a tube of water with an air pump that sends whirling bubbles rising up the tube and lights that illuminate the entire tube in vibrant color. When turned on, the bubble tube rotates through combinations of red, blue, green, and yellow light, creating soothing visual stimulation. The tube also includes a control unit with colored buttons that, when pressed, stop the patterned display and illuminate the tube with the corresponding color. The ability to control the color of the tube is intended to give children the opportunity to control their sensory stimulation. Ultimately the bubble tube serves a dual purpose as a relaxation aid as well as a learning activity device. Upon completion of the final design, three bubble tubes were fabricated for three different classrooms.

SUMMARY OF IMPACT
The design criteria for the bubble tube were defined by the capabilities and needs of the children who will use it. Teachers requested a device that would be portable, entertaining and educational. The tube is fully self-contained and requires only an available electrical socket. Also, the tube weighs less than 20 lbs when filled with approximately 2 gallons of water. The tube’s control unit is removable so it can function as a stand-alone relaxation aid. When the control is connected, a single user can play with the buttons, which promotes learning of cause and effect and experience with colors and color mixing.

The control unit has ports to plug in additional remote switches so that multiple children may use the tube together and learn sharing and teamwork.

When the tube was presented, the children in the classroom immediately turned their attention to the device and appeared mesmerized and excited by it. The children’s aides commented how the bubble tube’s presentation “made their day.”

TECHNICAL DESCRIPTION
The Interactive Bubble Tube consists of two separate devices: the bubble tube, and the control unit, as seen in the block diagram in Figure 15.37. The bubble tube houses the primary circuitry, including the air pump, microcontroller, and LEDs. The control unit is connected to the tube via a standard PS/2 keyboard or mouse cable, and houses the buttons and jacks for external switches. These are wired in parallel so that either the button on the unit or a remote switch will work to send a signal to the bubble tube when activated.

As can be seen in the block diagram, the Basic Stamp 2 state machine is at the heart of the bubble tube’s operation. The state machine has two states, an idle state and an interactive state. When idling, the microcontroller counts through a series of LED bit-patterns stored in memory and outputs that pattern to the LEDs. There are 20 patterns stored, with each subsequent pattern only changing one bit to create a gradient of changing color in the tube. While displaying the light pattern, the microcontroller constantly monitors the inputs from the buttons. If any of the buttons are pressed, the system immediately jumps into the interactive state and transfers control of the LEDs to the control unit and doesn’t return to the idle state until after a few seconds of inactivity on the control lines.

The cost of the three interactive bubble tubes totaled around $400, which is approximately $100 less than a single commercially available comparably featured device.
Figure 15.37. Interactive Bubble Tube Block Diagram

Figure 15.38. Detail of Interactive Bubble Tube State Machine
INTRODUCTION
The Smart Pillbox (Figure 15.39) is a box with timed alerts corresponding to multiple compartments. It is meant to help people who take many medications keep track of their intake. The Smart Pillbox combines features of existing products to provide prescription medication users with an organized and reliable medication tracking method. At the beginning of the day, the patient sets times for each compartment of the device using buttons and a display screen. When it is time to take a particular medication, a light corresponding to the medication’s compartment goes on, and stays on until the patient pushes a button to indicate that he or she has taken the medication.

SUMMARY OF IMPACT
The client for whom the Smart Pillbox was designed (shown in Figure 15.40) needs to manage medications for several conditions. In the past, she has had difficulty taking her pills in a timely fashion on a daily basis. Since receiving the device, the client reports that she has achieved almost flawless administration of her medications. She simply sets aside a few minutes in the morning to set the device. Then, she does not have to worry about her medications any further throughout the course of the day. In her own words, “I feel like a weight has been lifted from me, because I don’t spend half of my day worrying about whether or not I’ve taken my medications correctly. I would definitely recommend this to anyone who has to keep track of more than a couple of medications.” The client indicates that setting the device is fairly self-explanatory and user friendly, and she likes that she has the option of plugging the device in or using batteries and taking it with her. The client did note however, that the one improvement she would make on the device would be to make it smaller, and therefore less conspicuous and more portable.

TECHNICAL DESCRIPTION
There are five components to the Smart Pillbox device: 1) the microcontroller BS2-IC, 2) the time-keeping chip DS1302, 3) the LCD BPI-216, 4) four pushbuttons, and 5) six LEDs (see Figure 15.41). The project operates in the following manner. First, the user turns the device on and uses the pushbuttons to set the clock. The user then uses the buttons to select and set the time for each medication. The Basic Stamp program stores these times and compares them to the clock to check whether it is time for one of the medications. When it is time for one of the medications, the corresponding LED lights up. Once the medication has been taken, the
user pushes a button to turn off the LED. The user has the ability to reset the clock as well as check and reset the compartment times at any point. Also, the user may choose between plugging in the device and using a 9V battery.

The microcontroller communicates with and interprets data from the other components. The BS2-IC has 16 I/O pins and programs are written in PBASIC to the 2KB EEPROM. Other industrial versions of the Stamp chip are available with more I/O pins and extra memory, which could be used for adding more features and messages to make the operation of the device more user-friendly or to simply include additional compartments. Any such changes can be incorporated through some lines of code to the same program. The device could be constructed using a keypad instead of pushbuttons, except that a keypad connects to the microcontroller in parallel and takes up too many I/O pins. On the other hand, the pushbutton method uses program code to perform a specific function when the user pushes a button. For instance, the buttons allow the user to select, scroll, display, and reset. This method assigns various functionalities to each button at different stages of the program. This method requires lengthier program code, but conserves physical and electrical space.

Connecting the pushbuttons to a ground would conserve power, but a true ground is nearly impossible to achieve with all the interference from the rest of the circuit. By connecting the pushbuttons to +5V, the interference problem is solved. The time-keeping chip has the option of 24-hour time, but 12-hour time is used in the interest of shorter program code and will suffice for the client’s needs. The times set for each compartment are lost when power is turned off. Volatile memory is not a concern for this client because she prefers to set the time each day since her schedule and medications are changing regularly. The device packaging is bulky, but durable and safe. There is a flap door for the user to access and change the 9V battery without being exposed to the circuit.

The cost of parts and materials was approximately $300.

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Figure 15.41. Circuit Components
INTRODUCTION
The Program Timer is a wireless environmental control system to enable a client to turn on or off the appliances and lights in her home.

SUMMARY OF IMPACT
The design criteria for the Program Timer were defined by the capabilities of the client and her needs at home. The device enhances her independence and quality of life.

TECHNICAL DESCRIPTION
The project integrates the client’s appliances and lights via a hand-held device or through commands on a computer.

It incorporates a Visual Basic Program that runs by X-10 modules. X-10 is a language that allows devices to talk to one another using electrical wiring in the home. The transmission of a message occurs close to the zero crossing of a 60 Hz power line.

There is a binary one that is represented by a one millisecond burst of 120 kHz at the zero crossing point. There is a binary zero in the absence of a 120 kHz burst. The complete code transmission lasts for 11 cycles of the power line. The first two cycles represent a start code. The next four cycles represent the house code. The last five cycles represent the number code (1 through 16) or a function code (on or off). The appliances and lights accept the X-10 signal and decode it and the microcontroller decides whether to turn off or on.

The total cost, including labor, was $1006.
INTRODUCTION
Parents of a child with autism were finding it hard to keep constant watch over their child, especially at night when he should have been sleeping, but instead was often trying to sneak out of his room. Also, he was frequently falling out of bed without their knowing about it until they would find him on the floor the next morning. This project was devised to address both of these problems. An alarm system notifies the parents when their child has fallen out of bed or if he tries to leave his bedroom.

SUMMARY OF IMPACT
This project will provide the parents with the reassurance of their child’s safety while they sleep. If the child triggers the pressure sensitive mat by falling out of bed, or triggers the motion sensor by leaving the room, and the parents are notified through a receiver.

TECHNICAL DESCRIPTION
The device includes a mat to detect when the child has fallen out of bed and motion sensors to detect when he is leaving his room. When the mat is triggered it sends a signal to a Basic Stamp chip, which identifies that the mat was the object triggered. Then the Basic Stamp chip sends a signal to a transmitter, which sends a signal to a receiver, causing a buzzer to sound.

Motion sensors are mounted in the doorway of the child’s bedroom. Triggering these sensors also sends a signal to the Basic Stamp chip, which transmits the signal to the receiver and triggers a ringer. The ringer is distinct from the buzzer sound so that the parents will know which of the devices has been triggered. An ISD chip could be incorporated to provide the parents a voice recording to alert them as to which of the devices has been triggered.

The cost of parts and materials was approximately $217.