Alternative Design 2 Report

MEDSsense: A Portable Pill Dispensing Device

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1.1 Introduction

Today, modern pharmacological establishments spend billions of dollars each year on advertising due to the exponentially growing supply of competing prescription medications. Patients now find themselves in a world where dangerous conditions and diseases are easily managed by relatively affordable medications. Although a remarkable increase in life expectancy of the American population over the past fifty years could additionally be attributed to an increased awareness of daily health issues, it could easily be argued that the primary culprit is the ubiquity of pharmaceutical products. As the number of available medications increases, however, patients are finding themselves reliant on a growing number of daily medications. Ultimately, many individuals accumulate an unmanageable number of medications, a problem that could potentially lead to unintentional neglect of prescribed schedules and dosages.

This proposal outlines the development and production of a pill cap designed to dispense and cut medication for persons with disabilities. This project is being done for the Rehabilitation Engineering Research Center on Accessible Medical Instrumentation (RERC on AMI) competition headed by Dr. John Enderle. The driving goal in designing this device is to provide a means for persons with disabilities to access vital medication when traditional pill caps prove to be increasingly difficult. Certain difficulties associated with the prospective clients’ disabilities will be discussed later in the proposal. Also, more specific requirements relating to the programming and mechanical performance of the project will be outlined.

This product is an accessible pill cap that dispenses the correct amount of medication at a set time for elderly patients or patients with disabilities. It is difficult for some patients to remember when to take their medication, as well as how much medication to take. It may also be a problem for the patient to cut a pill in half if a half dosage is prescribed. The diverse disabilities of the patients for whom we are designing this pill cap include vision loss due to macular degeneration, hearing loss, loss of or decreased strength and motion in one hand or arm, memory loss and Dementia. Some minor problems that affect these patients that must be kept in mind while designing this pill cap are being in a wheelchair,
loss of legs, neuropathy in the hands, hand tremors, having small children and being easily intimidated by high-tech machines.

The main features of this product are designed to aid the patients in their medication routine. The multi-modal alert system lets patients know when it is time to take their medication with both visual and auditory alarms for patients with hearing loss or vision loss. The automated cutting mechanism accurately cuts pills in half if a half dose is required for patients with macular degeneration or a missing limb. The reminder to order a new prescription when the old prescription runs out is designed for elderly patients, patients with Dementia or memory loss, or busy patients who don’t have a lot of time to think about their medication. The offsite alert system, which notifies a family member, nurse or doctor offsite if a dose is missed by the patient, is a built in safety device so a responsible party is notified if something happens to the patient and they miss their dose. An easy-to-use interface is needed since many elderly persons are intimidated by technology and so the device is simple and user-friendly.

Other features that are not required but that will add to the accessibility of the product will be implemented. Patient safety is a huge concern for the project plan, so the designers of the device will put the patient’s safety as their number one priority while designing the pill dispenser. A security device should be installed to ensure that third-party members do not tamper with the schedules or amount of dosage programmed into the pill dispenser since this could seriously harm the patient if an incorrect dose is taken. This device should also be waterproof since many medications are taken with water. Water can cause electrical damage and malfunctioning of electrical equipment. A major safety concern for this product is that it is childproof. Children often mistake medicine pills as candy and will unknowingly consume pills that are left lying in a tray. Therefore, it is important that this design ensures the safety not only of the user, but also of any unsuspecting third party members.

This design aims to rectify the problems associated with the first design submitted. Problems such as pill stabilization and dispensing a single pill are solved with a rotating disc specific to each size and shape of a pill. This design also allows for the remaining half pill to stay within the main component of the device which eliminates a need to have a separate storage space. Another advantage of this design is that the distance the pill moves throughout the device is greatly reduced. Reducing the travel distance will decrease the overall size of the device which is a major goal of the project. The materials have also been changed with this device to make the device more lightweight which will increase portability. Changes to the pharmacist interface include fewer steps for the pharmacist and a different connection when the device is programmed by the pharmacist. The offsite alert has also been modified from a wireless alert system to a computer connection. The device will be connected to a computer which will then send an alert. Finally the device will become completely disposable which allows for more devices to be sold within the marketplace. The group believes these changes will improve the final performance of the device.
1.2 Subunits

1.2.1 Dimensions

The second design concept for the device is to use a cylindrical shape for the unit. The ergonomic design of this unit will ease the user when gripping the device. The base will include all of the necessary equipment to cut, dispense and to notify the user. The medication bottle will be placed on top of the device. The use of a cylindrical shape will insure that the user has a firm grip on the device while in operation. It is critical that the device be placed on a hard surface with good support so that the mechanisms that are cutting the pill do not cut a different size. The size of the device will have a maximum dimension of 12.2 cm by 7 cm by 7 cm to insure easy portability and to act as a bottle cap. An average medication bottle is about 6.35 cm in height by 2.5 cm in width with a diameter no larger than 2.54 cm. To make the device aesthetically pleasing, these size constraints were implemented.

Figure 2. Medication bottle [1]

Figure 3. Overview of Design 2
The ability to dispose of this device greatly increases the convenience of this device. This also alleviates the pharmacist error because each device will be designed for each separate medication. To cut the pill in half there will be a motor with a linear actuator; this motor will be no larger than 22 mm. Within the center of every linear actuator there will be a blade that will accurately slice the pill in half. The blade will be non-toxic, non-corrosive, and inert to all forms of medication. Single-edge blades are 0.023 cm thick and are 2.54 cm in height by 1.27 cm in width [2]. For the blade itself, stainless steel has been chosen because of its great mechanical properties; these include large tensile and compressive forces and good hardness properties. Also stainless steel is a very bioinert material thus not reacting to any of the medication.

Figure 4. Razor which will be used for cutting the medication

Once the pill bottle has been attached to the device, the pills will then travel through a cone shape into the rotating plate and cutting apparatus. The dimensions of this section can not exceed 7 cm in radius. In this section, pills will fall into one of the funnels, and then the apparatus will rotate to the cutting side where the pill will be cut into two halves. From there the correct amount of medication will be dispensed. The rotating device can be seen in Fig. 7 and will not exceed 8 mm in diameter. A full layout of this device can be seen in Fig. 5. This device needs to have compartments just large enough to hold a single pill so that no other pills will be able to fall into the compartment. By having compartments just big enough to fit one pill in presents a problem of jamming. To alleviate this problem there will be an angled piece that will funnel the pills down towards an opening that will then place one pill at a time into the rotating plate; this piece will not exceed 2.54 cm. The material used for the funnel and the inside rotating plate will be the polyether plastic that is the same material used for the outside casing. While the material used for the two plates that line the top of the rotating plate will be aluminum. This allows for support throughout the device and when the device is under duress the pills will not become jammed.

For the exterior of the device, a plastic casing will be used. Plastic will be a lightweight comparison to some other materials such as aluminum. Because this device will contain important materials, the casing needs to be durable and waterproof. Both of these requirements are satisfied by using a plastic casing. A Polyether Polyol and Polymeric plastic mixture will be used because of its low cost, high strength and resistance to heat [2]. Plastic can be molded into many shapes and sizes, so this also helps with design an efficient and cost effective device. On the exterior of the device there will be, an activating button which will be large enough of the user to see, an exit window for when
the pills are dispensed, and an opening to place the cap-less medicine bottle. The exterior will have a port where the medicine bottle will be placed. The operation of the device for the pharmacist will be as follows: 1. removing the cap of the user’s medicine bottle, 2. inverting the entire device and placing it over the bottle and securing it as one would with a regular medicine bottle cap, 3. invert the now connected bottle and set the device upright on a hard surface (note: the original medicine bottle will be upside down), 4. pushing the “button” to activate the system.

![Diagram of pill cutter](image)

**Figure 5. Specific View of Design 2**
1.2.2 Cutting Mechanism

The MEDSense Pill Dispenser is a pill cap that is capable of automatically cutting a pill in half. The device should be compatible with a number of pill sizes and shapes since there are a great variety of pill sizes available on the market. The following table, Table 1, shows the variety of pill sizes and shapes. [3]

Table 1. Tablet Sizes and Shapes.

The only kind of medication that is prescribed in the half-dose is the tablet. A tablet is a carefully measured dosage of powdered drug that is tightly compressed into tablets. Tablets are usually coated by press-coating, sugar-coating or film-coating to make them smoother and easier to swallow. Some tablets, such as extended release tablets, have layers of different drugs. The outer drugs will dissolve faster and release the medication into the body, while the inner layers remain inert until they are dissolved in the stomach. However, it is very rare that extended release tablets be cut. A halved tablet’s center is exposed to the stomach, therefore causing the center layers to be dissolved at the same time as the outer layers. Cutting a time-release tablet “short-circuits” the medicine, and is undesirable. Therefore, the only kind of tablet we will be focusing on is the homogeneous tablet, which may or may not have a coating.

In order to design an accurate cutting device that will split these tablets, the mechanical properties of the materials used in the tablets should be known. The strength of a compressed tablet depends on many different factors, including compression force and particle size. The following figure, Figure 6, shows the relationship between compression force, fracture resistance and hardness. [4]
The Strong Cobb reading is a measurement of the hardness of a tablet, which is really the compression strength of a tablet. Strong Cobb measurements are used to test the compression strength since compressed tablets are usually brittle materials, and a regular hardness test used for other materials, such as the Vickers Hardness Test, are not suitable for measuring the hardness of a compressed tablet. [5] This figure shows that as the compression forces of the tablet increase, the hardness and fracture resistance of the tablet also increase.

Another way to test for compressibility in tablets is using the Gurnham equation. This equation calculates the compressibility of pharmaceutical powders. The more compressed a powder is into a tablet, the denser it is, which, in most cases, increases its shear strength. The Gurnham equation is:

\[ \varepsilon = -c \ln(P) + d \]  

Equation 1

In this case, \( \varepsilon \) is porosity, \( P \) is pressure and \( c \) and \( d \) are constants. The porosity is related to density by this equation:

\[ \varepsilon = 1 - \left( \frac{D}{D_{true}} \right) \]  

Equation 2

In this equation, \( D \) is density and \( D_{true} \) is the true density of the powder. [6] The true densities of many solids commonly used in pharmacy can be seen in Table 2 below. [4]
The main mechanical property that affects the cutting of a tablet in half is the shear stress. Shear stress is a stress that is parallel to the face of the material and would be exerted on the tablet by the blade cutting it in half. Shear stress can be measured by the following equation:

\[ \tau = \frac{VQ}{It} \]  

Equation 3

In the above equation, \( \tau \) is the shear stress, \( V \) is the shear force, \( Q \) is the first moment of area, \( I \) is the second moment of area of the cross section and \( t \) is the thickness of the material perpendicular to shear. The force required to cause a tablet to shear will be tested using a Tinius Olsen machine.

In order to have the MEDSense device cut the tablet as accurately as possible, the stress put on the tablet should be almost all shear stress. If any other stresses are present, the tablet could fracture in other places and crumble. In order to do this, the blade will have to be very sharp and be made of an appropriate material, such as steel, to ensure that it can cut through the tablets.

A thin steel blade will be strong enough to provide the correct amount of force required to cut the tablets in half. The tablet will be held in a compartment and a steel blade will be used to cut the tablet. A linear actuator motor will provide the force necessary to accurately cut the pill in half. Stainless steel is chosen for the material because it is a strong metal and non-corrosive. The properties of stainless steel can be seen in Table 3 below. [7]
Table 3. Properties of Stainless Steel [7]

<table>
<thead>
<tr>
<th>Material</th>
<th>Density kg/m³</th>
<th>Ultimate Strength, Tension MPa</th>
<th>Yield Strength, Tension MPa</th>
<th>Yield Strength, Shear MPa</th>
<th>Modulus of Elasticity GPa</th>
<th>Modulus of Rigidity GPa</th>
<th>Ductility, Percent Elongation in 50 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless Steel, AISI 302, Annealed</td>
<td>7920</td>
<td>655</td>
<td>260</td>
<td>150</td>
<td>190</td>
<td>75</td>
<td>50</td>
</tr>
</tbody>
</table>

It can be seen from table 3 above that stainless steel is a very strong material and would be appropriate to use for cutting the tablet since it will be able to transfer enough force to cut the tablet in half.

The MEDSense pill dispenser will use a rotating wheel surrounded on the top and bottom by two stationary plates to transport, stabilize, cut and release the tablets to the user. When the multi modal alerts go off informing the patient that it is time to take their medicine, the user will invert the system so the pill cap is on the bottom and gravity can be used to move the pills. The pills will flow through a funnel, allowing only one to drop into the pill compartment in the rotating wheel at a time. The compartment itself will be funnel-shaped, with the funnel ending in the exact size and shape of the tablet, ensuring that the tablet falls with the correct orientation. The depth of the compartment will be exactly equal to the width of the pill, so only one tablet can fit in the compartment at a time. A depiction of the wheel and pill compartment can be seen below in Figures 7 and 8.

![Figure 7. Rotating plate](image-url)
This wheel will only have two compartments for the pills to fall into, with three different positions to rotate to. Position 1 is the original position of the wheel, where it is under the pill bottle. Only one pill falls into the compartment since it is the exact size and shape of the tablet. Different wheels will be used for different pill sizes and shapes.

Where the wheel rotates to next depends on whether a half pill or whole pill is needed. If a half pill is needed, the wheel will rotate to position 2. Position 2 is halfway over a sliding door that opens to a chute which leads to the pill output. This position is only halfway over the door so only one half of a pill can be released at a time. This position is where the tablet gets cut. In order for the pill to be cut in half, a force must be applied directly to it through a blade. This force will be provided by a rod attached to a small linear actuator motor. A linear actuator converts rotational motion into linear force, which is needed to cut the tablet. A small electrical motor will be attached to a threaded shaft. When the motor provides rotational movement, the shaft will move up or down due to the helical thread. The blade will come down and cut the pill, which is stabilized by the compartment. A diagram of this can be seen in Figure 9.
After the tablet is cut in half, the blade remains stationary in the compartment. The sliding door, which is positioned directly under one half of the tablet, will open, allowing half of a tablet to fall through a chute to the pill output.

When another half pill is needed at the next medication time, the blade will retract from the compartment. The wheel moves to position 3, which is directly over the sliding door. The sliding door will open and the other half pill will be dispensed. If one and a half pills need to be dispensed with each dose, the blade will again retract, but the second compartment, with a whole pill in it, will move to position 3. The sliding door will again open and the whole tablet will fall to the output. The other half pill will remain in the system and be dispensed at the next medication time. If only whole pills are needed for the dose, the wheel will rotate to position 3 all the time, since cutting and dispensing half a pill is not necessary. A diagram of these positions can be seen below in Figure 10.

A flowchart of the movement of pills in 1, 2, ½ and 1 ½ pill doses can be seen in the following figure, Figure 11.
Three motors will be used in this pill cap. The motors all need to be very small and compact. The only motor that needs to be able to provide a lot of force is the linear actuator motor that controls the blade and cuts the tablet in half. A small but powerful linear actuator motor like the Danaher Motion Digital Linear Actuator 42DBL10C1B-K provides 22.5 lb (100.0 N) of force, which will be a sufficient amount to cut a tablet in half. The motor is 22 mm wide and consumes 10 Watts of power. An image of this motor can be seen in Figure 12. [8]
In order to control the sliding door that opens so the tablets fall to the output, a small linear actuator motor like the Nanomotion ST Motor will be used. This motor is a piezoelectric motor and is very compact, which is ideal for this device. The dimensions of the motor can be seen in the following figure, Figure 13. All the dimensions are in millimeters with a tolerance of +/- 0.3. [9]

![Figure 13. Dimensions of the Nanomotion ST Motor](image)

The rotation of the wheel will be controlled by a rotational motor. This motor does not need to be able to provide a lot of force since it will just be rotating the wheel. A rotational motor like the Danaher Motion Slotted BLDC Motor can be used. This motor has static winding attached to motor housing to improve heat dissipation and provide overload capability and has feedback options so it can shut off in case of a jam. It can provide a torque up to 9.5 Nm. An image of the BLDC Motor can be seen below in Figure 14. [10]

![Figure 14. Danaher Motion Slotted BLDC Motor](image)
1.2.3 Notification System

It is necessary that the pill dispensing device has a mean of notifying users of various points of interest. To address the needs of a universal audience, the notification systems must stimulate multiple senses. MEDSense will feature visual alarm systems to accommodate users that are hard of hearing and auditory systems to accommodate users that are blind. Additionally, the device will vibrate when there is a notification to ensure that patience with both poor eyesight and hearing are clearly informed. Most importantly, the device will notify the user of when to take their medications. A microprocessor will be programmed with various command strings that remind the user to take their medications at certain time intervals. These strings will be input to a text to speech module that will verbalize the command. Selected times will be specific intervals before medication is dispensed, as selected by the user. The user can, for example, select that the device notify him/her every ten minutes before pills are dispensed to ensure that they are nearby and able to take their medications at that time. For a user with a busier schedule, selecting that the device notifies him/her half an hour before dispensing medications could be more convenient. Additionally, the user can select that the device notify him/her multiple times before dispensing pills. When the medications are dispensed, an alarm will sound and the “release” button will flash. Once the release button is pressed and pills are dispensed, a voice command will notify the user of consumption parameters specifying what medium to take with the pills (i.e. take with food, take with water, etc.). There will also be a volume control to ensure that all users are clearly notified.

In order to accomplish speech capabilities, the device will be installed with an IC2 text to speech synthesizer, a Devantech product distributed by Acroname Robotics. This compact module is 1.57 inches in length in 1.57 inches wide making it more than acceptable in size for the estimated design. The device runs on a 5V power source with a tolerance of approximately 10 percent. The standby current required is 20mA and the active speech current is 80mA. Additionally the device features an audio amplifier, an imbedded PIC processor, a Winbond WTS701 speech chip, and a 40mm speaker. The speech module has the ability to repeat 30 different text strings, each containing a maximum of 81 characters. A total of 1925 characters can be programmed. Although

![Figure 15. A look at the IC2 text to speech synthesizer. A) Schematic drawing B) Top view](image)
there are 30 predefined phrases available that are automatically programmed into the module, the user has the option of programming personalized text strings. This can be accomplished by programming the device SP03 module using the Brainstem Console Program, which is downloaded for free from acroname.com. Once the programming is established, the computer can communicate to the speech synthesizer using a standard RS232 serial port that will connect to the GND, RX and TX pins on the SP03 chip embedded on the device. Once the speech module is implemented into the pill dispensing device, it will be programmed to initiate specific text strings at programmed time intervals.

Visual notification systems will include a series of LEDs that will notify different occurrences. A static red LED will indicate that medications are not to be taken. When there is no action or response required (ie not prescribed medication time) the red LED will be constantly on. When there is a response required from the user a green blinking LED will be triggered and will continue to trigger until the user responds. At medication time, for example, the green LED will be blinking, notifying the user to press the pill release button on the side of the device. When the button is pressed, the blinking LED will no longer blink and the pill will be dispensed. The triggering of these LEDs will be programmed into the microprocessor.

Additional visual notifications will include a PC mount LED array that will act as a low battery indicator. A full battery charge will show all bars illuminated with one bar deactivating as the battery loses its charge. The LED array will feature a total of ten illuminating bars, thus, each bar will represent 10 percent of the total charge. As a device that relies heavily on the ability to keep time, a loss of power by depleted battery charge could lead to a loss of exact regulation of prescription times. A battery level indicator will clearly notify users of when to change the batteries in their MEDSense unit.

The trigger switch that will ultimately release pills will also feature a visual notification. By using an LED pushbutton switch from Honeywell, the user will be clearly notified of what action to take when it is time to dispense pills. The switch will feature pushbuttons,
paddles, rockers, solid state indicators as well as electronic key locks with LED, incandescent and neon illumination.

While creating the auditory and visual notification systems are relatively straightforward, notifying the user through their sense of touch proves to be a more difficult task. Similar to the E-Pill Vibrating device, the MEDSense will feature a vibrational device that will trigger at programmed medication times. Although there are many vibration sensing devices available on the market, there are no readily available devices that cause a device to vibrate. As a result, the MEDSense will feature a homemade vibration system.

A simple rotational dc motor will be stabilized in a sturdy plastic container. Attached orthogonally to the rotational end of the motor will be a small plastic gear that will rotate clockwise when the motor is activated. Attached parallel on the perimeter of the plastic gear will be a small weight. Due to the rapid rotation (100 to 150 RPM) of the system, the rotating weight will rapidly change the center of mass of the system causing a “wobbling” motion. As the speed of the motor increases, the wobbling will increase until it is a quick vibrating response. The homemade vibration device will undoubtedly require a significant amount of trial and error and trouble shooting. As a result, precise values have not yet been determined. However, the basic design has been clearly conceptualized.
1.2.4 Offsite Alert

With the popular onset of the Internet around 1995, rapid communication across limitless distances became available in homes all over the United States. As a result, modern medical devices can be connected to the internet to transfer vital healthcare information with incredible speed and accuracy. The MEDSense dispenser will attach to an external USB port that will automatically take information from the device and send it to the user’s computer. Information being transferred will include but is not limited to a log of dispensing times, precise dosage weights, and the time it took to dispense each pill in a given time frame. Once data is transferred, the computer will in turn send a text message via the internet to a pre-programmed cell phone number of the assigned caretaker. This cell phone number will be programmed into the MEDSense dispenser by the pharmacist before the device is distributed to the user. Alternatively, the device could be programmed to send an email to the health care professional rather than a text message, depending on the user’s discretion. It will be assumed that although most prescription medications require a strict dosage schedule, missing no more than 24 hours worth of medication is not detrimental to the user’s health. With this in mind, it is important that the user connect their MEDSense device to the USB connection every night so that it can transfer the data for that day to the third party member. If a user does, in fact, miss a dosage or the device malfunctions and a dosage is not dispensed, that data will be recorded and sent to the emergency offsite party member who will take the appropriate actions. From the pharmacist interface any phone number can be programmed into the device allowing a wide variety of users to take advantage of the offsite alert feature. While elderly individuals might choose to have the device call their doctor or pharmacist, a busy mother could have the system call her own cell phone as a double reminder in case the notification systems do not successfully catch her attention. Additionally, rehabilitation patients using the MEDSense device as a means of strictly regulating their medication intake to avoid a relapse of chemical dependencies could program their rehab officer’s contact information into the device to notify them of when medications are not taken correctly or if the device is tampered with. It is crucial for the safety of the patient to take their medication on time, and the offsite alert is a failsafe system to maximize the safety and health of the patient. If they miss a dose, the third party member is alerted and can respond however they feel fit.

The external USB dock will be specially made to fit the design of the MEDSense device. By shaping it to perfectly fit the pill dispenser, the USB dock will act as a cradle that will support the device in the vertical position. Most USB cables have 4 main wire components. Two of the cables (generally yellow and blue) are capable of transferring data from the device to the computer where it will be compiled and sent offsite. The other two cables (generally red and brown) are capable of supplying a +5V power source and ground, respectively. Although this particular design features an entirely disposable pill dispenser, other designs that are not disposable could further use the power supply of a USB port to automatically charge internal batteries. The advantages of a USB port include its ability to “plug and play,” allowing the user to plug the pill dispenser into the dock and have it automatically load data into a designated folder on the computer’s hard drive.
The overall design will feature a female port connected directly to the communication pcb board that will process the pill dispensing data each day. When the pill dispenser is sitting in the dock, the female port will connect directly to a male serial USB port that will transfer data through to the computer which is connected by another male/female connection. Additionally, two LEDs on the dock will signal when the device is transferring data and when it is charging.

It should also be noted that transferring confidential medical data over the internet requires a strict level of security features. To fully accomplish a sufficient level of security, an automatic email encryption program will be implemented into the USB device. The data transferring wires within the USB cable are additionally capable of automatically initiating software onto the computer or interface that it is connected to. Many USB flash drives, for example, feature U3 technology that uploads software onto the connected computer that efficiently manages information and files on the drive. Similarly, the connection of the dock USB device will automatically upload the encryption software onto the computer to ensure that all data that is compiled and sent via email is secure. While there are many encryption programs that provide identical features, this design will use CenturionMail, runner up winner of the MSExchange.org Readers’ Choice Awards.

### 1.2.5 Pharmacist assist

The original idea once the group received the product description was to have the user program the device. The user interface would have been easy to use and clear to those persons who have disabilities. Upon further review, the group realized this idea was impractical. Those persons with vision or motor loss would have difficulty programming any device regardless of the simplicity seen by the designers. Furthermore, these users would have to learn new technology which could be very intimidating. Also, from a design standpoint, many safeguards against incorrect programming would have to be instituted. The process of instituting numerous safeguards would be cumbersome and add complexity to the programming of the device. Even if these safeguards were a part of the device, there would still be a substantial risk that the device would be programmed incorrectly. This could cause either too much or too little medication to be dispensed which could have grave consequences. Another factor to take into account with the user programming method is that people could become discouraged. If the programming proved to be too difficult or the device too complicated people would not use the device and thus the device would not provide a service. All of these problems could easily be
solved if the user was taken completely out of the programming aspect of the design. This particular design reflects this ideal.

Instead of the user programming the device, the pharmacist will program this device. There are many reasons for this. The first reason is that the product would be sold to the pharmacist instead of the user. The pharmacist would then give the device to the user along with the medication which allows for preprogramming. More products could be sold if the device were sold to a pharmacy instead of the actual users. Another reason is that the pharmacist, in theory, would better be able to program a device than a person with various disabilities. If the device were to be sold on the market a company could send representatives to the pharmacist for extensive training which would ensure that the pharmacist was comfortable with the program. After this training, the pharmacist would be able to correctly program the device with ease. The final reason for the pharmacist to program the device is that the pharmacist would know the correct dosages for the medication. This eliminates the possibility that the user could enter the wrong amounts of medication due to vision impairment or simply misreading the label.

Though having the pharmacist program the device is better than the user programming method, it is not without limitations. Most pharmacists would not have extensive experience in computer programming. If the interface was too difficult to understand for the pharmacist, the pharmacist would not use the product. The legal ramifications for programming the device incorrectly would be too great for the pharmacist to undertake. In some instances the pharmacist could be held liable if a person took the wrong amount of medication due to incorrect programming. Therefore, the first element of the pharmacist interface must be clear and easy to use. The second limitation of having the pharmacist program the device is the lack of resources in a pharmacy. A pharmacy is unlikely to have complex equipment to program microprocessors. Due to this fact, the device must be able to be programmed by a personal computer. This design aims to solve both of these potential problems.

Figure 20 shows the design of the pharmacist interface. The group chose National Instruments LabVIEW to create the pharmacist interface. LabVIEW has the capability to create clear interfaces as well as program microprocessors which will be used in this device. Note the clarity of the design as well as instructions above the fields. A detailed explanation of these fields will follow within this section.
Figure 20. Pharmacist Interface Design

The first field to be discussed is the “# of pills per dose.” This field is a numeric control which allows for the user to input the desired amount of medication. The default amount for the field is zero. A default amount of zero requires the pharmacist to actively implement the dosage which reduces mistakes. Numeric controls allow the user to easily input the desired amount by simply typing in the amount or using the up or down arrows to either increase or decrease the value. Within this numeric control the pharmacist will
enter the dosage amount. The value in this field will tell the device the correct amount of medication to be dispensed at the determined times. Numeric controls allow for the input of fractional amounts. Fractional amounts will alert the device to dispense half pills after being cut by the mechanical elements. In the previous design a cut pills trigger was included. This was excluded from this design because it is redundant because the device could determine if the pills should be cut from the fractional amount entered. The cut pills button was entered as a safety factor but the function it would provide would not be worth an extra step for the pharmacist.

The field below the first field is the “# of dosages” field. This is another numeric control with the same properties as the “# of pills per dose” numeric control. Once a value is entered into this field it will allow the device to know exactly how much medication is in the device. After each medication is dispensed the device will update the amount of medication in the device. Once the medication is low, there will be an alert to the user that the medication needs to be refilled. This will allow the user to plan a trip to the pharmacy days in advance.

Below the “# of dosages” field is the expiration date. This is a time stamp that only includes the date instead of the time. Knowing the expiration date of the medication will allow the device to notify the pharmacy as to when the prescription needs to be refilled. This will allow the device to alert the pharmacy so that when the user goes to the pharmacy the prescription will be ready for them.

On the right side of the interface is a series of dosage time fields. To set times within a LabVIEW program time stamps are used. The default settings for the time stamp include the date as well. Note that the date is not seen in any of the time stamps in Fig. 20. Since programming the date of each dose is unnecessary it was removed so it would not confuse the pharmacist who may think the date is necessary. Within the properties of the time stamp the date can be removed. The default value of the time stamp is 00:00 PM. Pharmacists can change the value in these areas by either typing in a new time or by using the arrows to either increase or decrease the time within the field. It is the hope of the designers that the pharmacist could work in accordance with the user to program the times that would fit the user’s schedule. This provides the user some control over the times to take the medication without the potential hazards of programming. For display purposes, this interface was designed for a medication that needs to be taken four times per day. The final interface would allow for the pharmacist to input the number of dosage times needed. This increases the versatility of the program in accommodating many different medications.

Towards the bottom of the interface is the emergency contact information. This is one of the unique features of this device. One major element of the device is its ability to notify someone offsite if a person does not take their medication. A person offsite could check up on the user and make sure that there are no problems with either the person or the medication. This could be especially useful in elderly users who consistently have family members monitor them. Another usage of the offsite alert would be to allow living assistants or nurses to know what medication has not been taken. This design does not
have a tolerance feature for missed medication right now. The reason for this is that it would be difficult for a pharmacist or doctor to figure out the amount of medication that could be missed without effects due to the fact that medication affects people differently. While it could be unnecessary to notify if certain medications are missed once in awhile, it is better to err on the side of caution.

LabVIEW has the ability to send text messages to PDAs. This would allow instant contact to family, medical professionals or persons taking care of the user. Each cell phone acts as an e-mail address for receiving messages. Text messages can be sent from a computer to a phone or a phone to a computer. Knowing that cell phones in essence have e-mail addresses, the device will also send an e-mail. If a person does not have text receiving capability or is not with their phone, there will be a second level of notification. This second notification is by e-mail. The device will send a short message to an e-mail address saying that the person did not receive their medication. By inputting these values as strings, the pharmacist will provide information as to how to contact important people. The numbers and e-mail addresses will be provided by the user which again allows the user increased control over their health.

Verification is another important element of the pharmacist interface. The offsite notification will not work if the entries provided by the pharmacist were incorrect. By asking the pharmacist to input the values twice it decreases the risk since it unlikely the person would make the same mistake twice. The program would compare the two string values. If the string values are not the same in both the e-mail and phone number fields, an error message will be displayed. The only way the device can be programmed to have invalid offsite alert strings is that the pharmacist makes the same mistake in entering the values twice.

Directly above the program button is detailed instructions as to how to operate the pharmacists interface. This should greatly reduce any confusion as to how to program the device. Instructions are provided on the interface to ensure that everything is done correctly as well as to save time. It would take a lot of time to refer to a user’s manual to solve programming problems. Reducing the time it takes to program the device would make the device more attractive in the market.

The final element of the pharmacist interface is the “Program” button. Once the “Program” button is pushed, the program will check all fields for the correct information. This design has both a light and a text indicator of the result of the programming. If the device is programmed successfully the light will become green and a message reading “Program Successful!” will be displayed. If there are errors within the fields the device will not be programmed, the light will become red and a message reading “Program Unsuccessful” will be displayed. Adding text to the changing color provides another level of notification. This is much clearer than the previous design where only a color indicator was present.

If all values are inputted correctly, the computer will begin to program the device. This particular design calls for a DB9 serial (RS232) connection. Most pharmacies use
desktop computers which have this type of connection. The DB9 serial connection has a few distinct advantages. The first advantage is that the group has worked with using DB9 serial connectors in previous projects. This understanding of how this connection works would ease in designing a program for the device. If the group used a USB connection the group would have to learn a new connection method and new technology. Another advantage is that the pin out diagram for the DB9 serial connection is easily found. This will allow easy attachments during the production phase of the project. While a USB connection may be easier to use, the DB9 would not add a considerable amount of difficulty in attaching the device to a computer.

National Instruments LabVIEW has an application called VISA that can interact with a DB9 connector. This application would allow the group to use LabVIEW, the program on which the interface is written on, to also pass information to the device. In past projects the group has seen the interaction between the DB9 serial connector and a microprocessor so programming a microprocessor using LabVIEW and a DB9 serial connection will be possible.

1.3 Realistic Constraints

1.3.1 Engineering Standards

The FDA classifies medical devices into three categories. Class I devices pose little risk to the patient. If a device fails it will have a minimal adverse affect on the patient. Class II devices are more risky to the patient when failure occurs but are not used to sustain life. Class III devices are life sustaining devices. This design would be of a Class I device because if the device were to fail it would not directly affect the health of the person. It could potentially make the process of obtaining medication more difficult but it would not injure the person [17].

For production the manufacturer of the device would have to register with the FDA. This process is done by an online application. Following registration the manufacturer would have to list the devices produced with the FDA. Class I devices are exempt from the Premarket Notification and Premarket Approval sections because of the low risk involved. This device would be subjected to Good Manufacturing Practices (GMP) and Quality System (QS) Regulation. The GMP/QS regulations ensure that medical devices are safe to use by consumers. The higher the risk posed to patients by the device, the higher the scrutiny of the review. Table 1.1 shows the list of requirements by the GMP/QS [18]. Once all these requirements were satisfied to the FDA standards the device could be sold in the United States.
Table 4. GMP/QS requirements [18]

| 1. Obtaining information on GMP requirements |
| 2. Determining the appropriate quality system needed to control the design, production and distribution of the proposed device |
| 3. Designing products and processes |
| 4. Training employees |
| 5. Acquiring adequate facilities |
| 6. Purchasing and installing processing equipment |
| 7. Drafting the device master record |
| 8. Noting how to change the device master records |
| 9. Procuring components and materials |
| 10. Producing devices |
| 11. Labeling devices |
| 12. Evaluating finished devices |
| 13. Packaging devices |
| 14. Distributing devices |
| 15. Processing complaints and analyzing service and repair data |
| 16. Servicing devices |
| 17. Auditing and correcting deficiencies in the quality system |
| 18. Preparing for an FDA inspection |

### 1.3.2 Economics

One important aspect of this particular design is the fact that it is disposable. Disposable devices create both challenges and opportunities in the design of a device. The most pressing challenge of designing a disposable device is that the cost must be greatly reduced. Pharmacists would not want to spend a substantial amount of money on a device that will be used for one month at most. If pharmacists did buy the device, the cost would certainly be passed onto the user. The user would also not want to pay a large amount of money on a device that would aid their lives for only one month. The budget for the project is $2000.00. A rule in designing a prototype is that the final cost of a device, after manufacturing, would be 35% of the total cost of the prototype. If the full budget is used, the final cost of the device would be $700.00. It would be unreasonable to market a device that will be used for one month at $700.00. Though the budget for the project is large, the group must create a prototype for much less than $2000.00. Another challenge is choosing inexpensive components. The group must choose components that have a high quality but a low price. Decisions of decreased performance with decreased cost versus high cost, high performance will have to be made during the manufacturing stage. For the design process, components that will give the highest performance will be purchased.

While designing a low cost, disposable device presents challenges, it also presents opportunities. One major opportunity is that many devices will be needed. People will need a new device every time they refill their medication. In 1999, according to the most
recent census, approximately 2.974 billion prescriptions were sold in the United States [19]. Since both the population of the United States and the pharmaceutical industry have grown, this number is sure to be much higher today than that of only eight years ago. It can easily be seen that the market for this device is very large. Since the market is large, only a small profit needs to be turned on each individual device to make a large amount of money for the company. This allows the device to be sold at close to the cost of manufacturing which could make the device attractive in the market. This is a luxury that would not be available to a non-disposable design.

1.3.3 Environmental

With continued concerns about global warming becoming more important in mainstream society, the environmental impact of devices is becoming more relevant. More and more consumers are looking to the long term impact of devices on the environment as selling points for certain equipment. If the impact on the environment of this device could be minimized, it could become more attractive in the market and thus sell better.

All materials used in the product must not have an adverse reaction to the environment that would contaminate the surrounding area. Since the materials used in this device must be inert, due to the fact these materials have to be in contact with medication, the group does not expect there to be any environmental issues. The main components of the device will either be metal or plastic which would not pose environmental problems. This device will be completely disposable after use which presents more problems. First of all the device once discarded will take up space in a landfill. The device will be small however so the group does not believe that it will harm the environment more than any other discarded object. The group has investigated biodegradable materials but they do not have the desired strength or reactive properties needed by the design. Plastic will be used wherever possible due to its low weight and relative high durability.

One potential environmental issue seen with a disposable design is the disposal of the battery. The group will make the device battery powered so that it can be carried around by the users during their everyday activities. If possible the group would like to use a battery that would last for the duration of the prescription so that the user would not have to worry about recharging the battery. This may not be feasible since the device would have to power motors to cut the pills as well as many electronic components. A more feasible power source would be a rechargeable battery. In terms of environmental aspects, this may be preferable. Examples of these programs are in [16]. The group would include information on recycling batteries in the user’s manual hoping that the consumers take advantage of these programs. The group will make every effort to design the device so that the battery can easily be removed to facilitate proper disposal. If a company were to manufacture this device a program that would allow consumers to send back the batteries to the factory could be implemented to further reduce the device’s impact on the environment.
1.3.4 Sustainability

Sustainability long term is not an issue with a disposable device. Pharmacies will only dispense medication for at most one month. Since one prescription can only last one month the device would theoretically only have to work for one month. In actuality, the device will be designed to work much longer than one month to reduce the likelihood that the device will fail within one month. The mechanical components of the design will be chosen based on the thought that the device will work for much longer than one month. This will ensure that the best possible materials are chosen for this subunit since mechanical failure would result in the device being useless.

Sustainability of the power source will be a very important issue. Currently the group is looking for ways to reduce the amount of power consumed by the device. Reducing the power consumed will increase the battery life. This would, in turn, allow for more portability for the device. Ideally the device would come equipped with a single battery that would not have to be recharged or replaced. The group will test the device under maximum operating conditions to find the amount of power consumed by the device. If it is found that one battery or multiple batteries together can sustain the device longer than the required time, it would eliminate the need for the user to take action to keep the device running.

1.3.5 Manufacturability

Manufacturability is an issue in designing any device. The ultimate goal of the device is to be put on all prescription bottles. Since there are billions of prescriptions written every year the manufacturing process would have to be easy so many devices could be produced in a short period of time. Shape is one aspect of manufacturability that the group has considered. A shape that has many angles and details may be aesthetically pleasing but would be difficult to manufacture. The group has chosen easy to manufacture shapes since cost, not beauty, will be the main selling point of the design. Also the group plans to use parts from retailers. This would aid in the manufacturing because the company would not have to build its own parts. Finally, the group aims to design a device in which the assembly is easy. The electronics would be separated from the mechanical aspects of the device so that each could be assembled separately and then put together. This would reduce the time of manufacturing since people would not have to wait until the electronic components to be assembled to assemble the mechanical components.

1.3.6 Ethical

Profit versus quality is the major ethical question facing all companies. This question is easily answered because this is a medical device. Quality must be the first consideration. The group will design and build a device of the highest quality to greatly reduce the likelihood of failure. The device may cost more due to the increased quality but the potential consequences of building a low quality device are too great.
1.3.7 Health and Safety

This device will have many safety factors to ensure that the device aids a person’s health and does not hinder it. One safety factor is to only dispense medication at the desired time. This prevents people from overdosing on medication because they forgot how much medication to take. Another safety factor will be making the device childproof. The effects of medication on children are much more severe than adults. The portability of the device makes the device more childproof since the user can have the device close at hand at all times. Leaving the device at home with children while the user is away could result in the child taking the medication. People can bring this device with them and it won’t be too large as to hinder their daily activities. Also, the user would have to actively push a button to receive their medication. This would prevent medication from being released when the person is not around. Safety in all conditions is also a consideration. The device will be waterproof since many people take their medication in the bathroom where water is present. Other safety factors include material selection and the alert system. The materials used in the device will not react with the medication. This is especially important in the blade being used to cut the pills. Any reaction could reduce the effectiveness of the medication or even cause harm to the user. All materials throughout the device will be inert. The alert system aims to notify users that have many disabilities. The multi-modal alert system will alert three different senses. The device will have visual, audio and vibrating alerts. This will allow persons with hearing loss, vision loss or both to be notified to take their medication.

1.3.8 Social and Political

Many times persons with disabilities are not thought of in the design of devices. Countless devices cannot be used by persons with varying levels of disabilities because engineers did not take these individuals into account. This will not be an issue with this device. This device will allow persons with disabilities to have greater control over their lives which is what many of these people desire. Also it will allow these people to live healthier lives. The medications they are taking aim to increase the quality of their lives. This device aims to further increase that quality of life.

In the upcoming presidential election healthcare is undoubtedly going to be one of the most important issues each candidate will have to face. Some candidates have already proposed universal health care programs. This would provide health care to many more people in the United States. An increase in the amount of health care usually coincides with an increase in pharmaceuticals. As more people take medication, the impact of this device could greatly increase.
1.4 Safety Issues

Safety is one of the biggest concerns in the design process of the MEDSense pill dispenser. Since the patients will have contact with this device multiple times per day, it is absolutely necessary that the device be perfectly safe for them to use. However, the safety of the patient is not the only concern. The design team must also think about the safety of other parties, such as children, and the environment. Different safety concerns that should be addressed by the design team are electrical, mechanical, chemical and environmental safety issues.

Electrical safety is one of the biggest problems for this device. It is a battery-powered device with many electrical components, including a microchip and two motors. A safe and fail-proof electrical circuit should be designed so that there will be no chance of this device shorting or overheating and injuring the patient. Correct soldering techniques, approved components and sufficient insulation are also required to ensure the safety of the user. A major issue with electrical safety is making the device waterproof. Almost all medications are taken with water so it is essential that the pill dispenser be waterproof. If the device was not waterproof, the patient could be seriously injured through electrocution, since water is a conductor of electricity, and the device could fail. The failure of this medication dispenser could be very dangerous for a user. Many of the patients will rely solely on this pill dispenser to keep track of their medication doses and schedule. If the device fails and does not remind a user to take their medicine, the patient could become very ill because of their missed dose.

The next big safety concern with this product is mechanical safety. The pill dispenser has the ability to cut pills in half, so will contain a sharp blade in order to cut the pills. This blade should be fully protected inside the device so there is no chance the user could harm themselves on it. There should also be no sharp edges or other sharp components present on which the patient could cut themselves, and the device should not be too heavy or bulky so the patient can easily manage it and not injure themselves while trying to use it.

Safety from chemical hazards is a large concern for the design of the pill dispenser. This device must be designed for use with many different medications which contain a variety of chemicals. The device must be designed with materials that are non-reactive to any chemicals present in the pills. The metal cutting blade should be non-corrosive and non-reactive when coming into contact with the medication, as well as the rest of the device. All of the materials used in the pill dispenser should be non-toxic and biocompatible since the materials will come into contact with an orally digested pill.

Perhaps the largest safety concern having to do with the medication itself is the risk of overdose for the patient or other persons coming into contact with the device. This pill dispenser should be completely childproof. Children often mistake medicine for candy and will swallow many pills at once. The device will be fully childproof, with the pills sealed using a childproof lock on the pill dispenser. Overdosing on medication is a serious health concern that should be fully prevented by the pill dispensing device. It will
be designed so the patient will only have access to the pills at the pre-programmed dosage times. This way, the risk of overdose for the patient is removed.

The last main safety concern for the MEDSense pill dispenser is environmental safety. Since batteries will be used in this device, the user should be instructed on how to safely dispose of them. The other components should be safely disposed of by the user. All the materials used should not be harmful to the environment when decomposing.

1.5 Global Impact

Having discussed both the demand for a portable device that cuts and dispenses pills and how MEDSense, specifically, will address these demands, it is important to extenuate the inevitable impact of such a device on the global community. Although its impact may take time to diffuse through the many facets of society, accurate speculations on the ultimate impact of the MEDSense device can be made for each individual facet including global, economic, environmental and societal context.

The primary impact of the MEDSense device is to improve and optimize the health of a global community. Individuals are becoming more and more dependent on prescribed medications, resulting in an increased need to remain organized and strictly methodical when consuming multiple daily medications. As a device that will automatically dispense correct medication dosages at the correct times, the ultimate impact of the device will be to significantly lower the possibility of misusing prescription drugs. Often times it is difficult for elderly individuals to sufficiently keep track of the correct dosages of medications and when to take them. Additionally, busy parents are often too involved with other activities to remember to take their own or their children’s medications. Furthermore, parents with multiple children might find it difficult to organize and monitor multiple medications, dosages, and prescribed directions. As a solution, MEDSense will automatically notify the user of the medication times and dispense the correct dosage of pills, allowing the user to continue on with their regular busy schedules. By removing the human element, there is a much smaller margin of potential human error, resulting in an overall healthier global community.

Another global concern is whether or not some elderly individuals are capable of performing the required tasks to prepare each medication dosage and also take the pills in the correct prescribed manor. Not being able to correctly prepare dosages could lead to misuse or neglect of vital prescription medications. Many individuals, for example, are unable to divide single pills into halves for their correct dosages. Although the pills that need to be divided are often “perforated” at the break-point, many elderly men and women may be too weak or physically immobile to properly prepare their medications. In addition, they may be unable to remember or unable to read from the prescription label the proper way to take their medications. Some prescription drugs require that the user consume them with a specific fluid or perhaps with food. A simple antibiotic such as Tetracycline, for example, must not be consumed with milk because the active ingredients are deactivated by the Ca+ ions that are found in dairy products [1]. Not consuming the pills in the correct manor, therefore, could lead to unwanted and potentially fatal
repercussions. As a solution, MEDSense will output a series of voice commands that will instruct the user of how to properly consume the specific pill to ensure that all users are safely following the suggested directions. These reminders will, as a result, significantly reduce the likelihood that an individual will misuse the prescribed medications, thus, improving the general health and safety of the community.

As the presence of prescription medications available on the market increases, there is a concurrently increasing societal dependence on the consumption of pills. Many would argue that this increasing chemical dependency will ultimately have a negative effect on the overall health of the American public by artificially creating or altering chemical balances within the body. Medications like opioids, CNS depressants, and powerful stimulants, for example, all have long term negative effects such as seizure, irregular body temperatures, cardiovascular failure, and even death in extreme cases [2]. A long term side-effect that is paralleled in many prescription medications is the strong possibility of creating a chemical dependency or an addiction to one in particular. When particular portions of the brain are stimulated by prescription medications, they deplete the brain’s supply of dopamine, a chemical messenger that elicits feelings of “pleasure” throughout the day. With a lowered concentration of dopamine, patients will have reduced emotional reactions to daily activities. In order to reestablish a sense of feeling and enjoyment, the individual will turn to their prescription medication, which will force the excrement of dopamine. Without proper control of pill consumption regulation, many users of antidepressants and stimulants will deviate from their prescribed dosages, often consuming more pills than is necessary in order to feel good [3]. As a solution, the MEDSense pill dispensing device will be carefully programmed by a professional pharmacist to only dispense pills at the suggested times, eliminating the possibility of intentionally drug misuse. In fact, the MEDSense device could be specifically used on rehab patients that need strict regulation of their prescription medications. While assisted rehabilitation is an invaluable experience for those individuals in need of help with dangerous chemical dependencies, it is logistically impossible for there to always be a professional pharmacist or rehab officer sitting at their side to monitor their progress. MEDSense, however, could be used to automatically ensure the regulation of individual’s pill consumption. Furthermore, the offsite alert will immediately notify rehabilitation professionals if the individual’s medications are not taken on time or if the device is tampered with.

With a disposable instrument such as MEDSense, it is important to consider the potential environmental impact of the device. This design will feature inert, lightweight plastic materials for the majority of the parts. Inert materials will ensure that no detrimental environmental alterations will occur from the long term disposal of the device. Additionally, the possibility of using recyclable plastics is being researched, which would further minimize the environmental impact of the MEDSense pill dispenser. It should also be noted that it is important that users understand the proper disposal methods for used batteries. Properly disposing “empty” batteries will be clearly noted in the device instruction manual to ensure that there is a negligible amount of long term environmental impact.
One of the main deterrents of similar pill dispensing devices on the market is the incredibly high cost. Many devices cost anywhere between 800 and 1000 US dollars from retail outlets, a cost that most individuals cannot afford. The initial design of the MEDSense device, however, has an estimated budget of approximately 1000 dollars. Considering that the final product should cost about 35% of the prototype design, the final cost of the MEDSense pill dispenser will be a very manageable 300 dollars. This will allow individuals that are unable to afford other designs to purchase a pill dispensing device that will accurately manage their medications.

1.6 Life Long Learning

This design project allows for enhanced education in the engineering discipline. This project allows for the development of new skills including design, budgeting and planning. As we go into industry, these skills will excel us so we can develop new and innovative solutions.

For the second design, the use of a motor device for cutting the pill has been suggested. The advantages of using a motor device over a human mechanical device is that users with amputated arms, arthritis and other disabilities that limit human motor skills can use this device with ease. The previous design call for the pill to be dropped on to the tablet plate but this design was flawed. If the pill were to fall vertically and not horizontally, the pill would become lodged the wrong way, thus causing the device to become jammed. For this system, we will need to learn the properties of a linear motor, such as the amount of force the motor gives, so that the right amount of force will be used to cut the pill. The amount of energy that the motor needs to operate without exceeding certain restraints will need to be investigated. Also compression testing, on the medication itself, will need to be investigated; this will also help in determining the correct linear motor needed for this device. For the mechanical part of this design, many features will need to be investigated and thus life long learning will take place.

In order for this device to work properly, understanding the fundamentals of programming, timing, and design will be necessary. Because this design will have a turning sphere that will spin to dispense the pill, it is necessary to gain the knowledge of timing and programming. The use of a scheduling system will be employed to alert the user when the medication is needed to be taken. Using LabVIEW, a program will be constructed so that the user’s pharmacist will be able to set a correct schedule. For this it is necessary to learn the LabVIEW program and to develop a user interface that is easy for the pharmacist to use. Once understood this software will aid in the development of a scheduling system. Also, alerts will be used when the medication is needed to be taken and when the medication has not been taken. The software will help in the development of different alerts for the user.

For this second design, the skills that were learned are human mechanics and force needed to cut a pill in half, the LabVIEW software to build a scheduling system, and the alert system to notify the user when to take their medication. With all of these new skills,
life long learning was applied. From working as a team to developing a pill dispenser, life long learning does not stop and these skills will help as we go into industry.
1.7 References


