Alternative Design #2 Report

Shampoo/Conditioner Identification Device
&
Backpack Lever Arm System

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1. ALTERNATIVE DESIGN PROJECT #1

1.1 Introduction

For individuals with physical and psychological limitations, innovative biomedical instruments can be used to aid them to independently perform certain tasks. The client’s specific symptoms have resulted in an inability to differentiate between certain items, and have led to greater dependency on others. Mrs. Smith wishes to be more self-reliant in terms of being able to differentiate between shampoo and conditioner bottles in the shower. Despite having mild cognitive impairment and reduced visual acuity, Mrs. Smith desires to remain independent in carrying out her daily routine.

This alternative design plans to incorporate ideas that were brought to the team’s attention during the first round of senior design presentations. Instead of designing a product that uses a mechanical stimulus from the client (for purposes of item identification), a device that dispenses the product upon voice activation may prove to be more convenient. This design would involve one terminal, which would be consist of the voice-recognition port, as well as separated containers that could be filled with the shampoo/conditioner of choice. The dispenser would be located at the bottom of the terminal, releasing the product based on a voice signal (auditory command) from the client.

The benefit of using this alternative is added convenience to the client. In comparison to the initial designs, there is no need to customize already available touch-pads to fit the size of a belt that will wrap around a bottle. The initial designs assume that Mrs. Smith will be able to lift a full shampoo bottle (to which the device is attached). Although this is what the client has asked for, it does not seem to be the most effective and user-friendly design. This has led the group to think of alternative methods by which the product can reach the hands of the client, without needing high visual perception or complex cognitive skills.

The product would eliminate the need for the client to physically carry any object in her hand. This is a major advantage, as reduced visual acuity may be a hazard, when trying to grip and carry a heavy shampoo/conditioner bottle. It is clear that the safety advantages that this design provides surpass those of any other design. A mere voice signal by the client would result in the product being dispensed from a spout at the bottom of the terminal. In designing this device, it would be imperative to account for the fact that noise
of the shower would exist in the background, and should not prevent the voice-signal from being recognized. In addition, vacant space of certain dimensions would have to be present in order to accommodate this device. The team is currently working with the client to ensure that these specifications can be met, and are practical for the environment in which the device will operate.

**Figure 1.** Flow Chart for device operation

1.2 Subunits

1.2.1 Voice Activation Kit

![Image of Flow Chart]

**Figure 2.** Voice Recognition Kit

This circuit planned for use will have three components the main circuit board, the display board, and the keypad board. The only component that will
actually be implemented into the final design is the main circuit board. The other two pieces will only be used during the programming phase. The board will work as follows.

The power delivery for this kit will provided for a 9V battery routed through a voltage regulator. The voltage regulator used will be a 7805 chip. This chip is ideal because it has a max voltage rating of 5.25 volts and a typical voltage of 5 volts. The current out of the voltage regulator is also set at 500mA. The chip is small and quit cheap to buy. A block diagram describing the voltage regulator is given bellow.

![Figure 3: Voltage Regulator](image)

The brain of the circuit is the HM2007 chip. This is the main voice recognition switch. The other component that is vital for the system is the 8K-byte SRAM chip. The HM2007 has two operating modes manual and CPU controlled. This project is interested in only the manual mode. In this mode the key pad is used to control the state of the HM2007 chip.

When power is first applied to the chip it initializes. If the WAIT pin is low then the chip will run through its memory check in order to check the state of the 8K SRAM. If the WAIT pin is high it will skip the memory check process and go into the recognition mode. When WAIT is high and RDY is low the chip is ready to read voice inputs to be recognized. Once an input is given the RDY will become high the chip will run through the recognition process. After this step is complete the result appears in the D-bus with the pin DEN activated. Figure 4 describes how the data is transferred through the data bus. A is the binary code range 0 to 4 and B is in the range 0 to 9.

When training the chip the first step is to use the key pad to select the word number. The number is inputted by entering the digits on the keypad one at a time. When the numbers are pressed on the key pad they same number is sent down the D-bus. After the word number is entered the function key is used to choose the operating function. If CLR is pressed the
corresponding word pattern is cleared from the SRAM and the HM2007 goes back to recognition mode. If the TRN function is activated the training process will be initialized. When the WAIT pin is high the chip will send a low signal to the RDY pin, which means the chip is ready to accept a voice input. Once the voice input is completed the RDY pin goes low indicating that it is ready to go through the recognition process.

<table>
<thead>
<tr>
<th>D7 D6 D5 D4</th>
<th>D3 D2 D1 D0</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 0 0 0 0</td>
<td>0 0 0 0</td>
<td>Power on</td>
</tr>
<tr>
<td>0 1 0 1 0</td>
<td>0 1 0 1</td>
<td>Word AB</td>
</tr>
<tr>
<td>0 1 1 0 0</td>
<td>0 1 1 0</td>
<td>Voice too long</td>
</tr>
<tr>
<td>0 1 1 1 0</td>
<td>0 1 1 1</td>
<td>Not Match</td>
</tr>
</tbody>
</table>

*Figure 5: D-bus transfer code*

![HM2007P Diagram]

*Figure 6: Voice Recognition Chip*

1.2.2 Microphone

The microphone is a very important component because it takes in the user voice input which is essential for operating the entire device. If the microphone fails, the device will not perform its tasks. Since the shower is a limited space, the device needs to be as compact as possible.

After exploring available products in the market, the team decided the Mini Microphone (Model Number: HX-0018-1) manufactured by Wellsun Industry(Shenzhen) Co.,Ltd is very suitable for shampoo/conditioner identification device. They are small in size and can rotate 180 to 360-degree, have a 50-60 Hz frequency response, and -39, +/- 3dB sensitivity. The
microphone is compatible with almost all the sound equipment, and can be directly plugged into the voice recognition circuit in the shampoo/conditioner identification device.

Water proof is another critical quality that the microphone used in this project has to possess. Although the Mini Microphones are made of water-proof material, they will be covered by the insulating material just like the rest of the device to ensure the safety of the user [4].

*Figure 7. For size comparison analysis [4]*
1.2.3 Outer Structure

The design for the voice-activated shampoo and conditioner will be based on a product called the ClearChoice\textsuperscript{TM} Dispenser, available through the ClearChoice Corporation. One of their products consists of two separated compartments, which can hold different products. Although features of this product suit the team’s requirements, some modifications are required to the structure. The client will input a voice signal, after which she will place her hand below the spout and wait for the product to be dispensed. The product shown below has two spouts, since it has been designed for the general public, and assumes that users will be able to differentiate between the products. In the current scenario, the team wishes to have one dispenser, connected to two the separate compartments. Based on the voice command, one of the two valves will open, dispensing the product into the client’s hands.
Some features that make the ClearChoice Dispenser an appropriate product to work with are that they come with wall brackets, and can fit into corners or flat walls. Each compartment holds approximately 15 oz, which is a substantial amount assuming that small amounts of shampoo/conditioner would be used every 2-3 days. In terms of the exact dimensions, the two-part reservoir system is 7.5 inches in height, 5.5 inches in width, and 3.125 inches in depth. The voice activation circuitry will be attached to the device, and will increase the height of the total device by approximately 2 inches. The weight of the empty container is .42 kg, making it easy to attach/detach to the wall in case of occasional maintenance needs.

The ClearChoice Dispenser is made out of a material called ABS, or Acrylonitrile butadiene styrene. This is a commonly used thermoplastic in the manufacturing of lightweight, rigid and customizable molding products. The benefit of using ABS is that it combines the high strength and rigid nature of acrylonitrile and styrene polymers with the toughness of the polybutadiene rubber. In addition, ABS is resistant to various aqueous environments (acidic and basic), making it a durable material and viable choice for this product. [2]

Figure 9. Product for base of design [3]

2. REALISTIC CONSTRAINTS

Engineering Standards must be taken into consideration when designing and developing new products. Some of organizations that specializing in
creating and monitoring engineering standards include American National Standards Institute (ANSI), American Society for Quality (ASQ), Association for Advancement of Medical Instrumentation (AAMI), International Organization of Standardization (ISO), and National Institute of Standards and Technology (NIST).

The Shampoo/Conditioner Identification device must meet or exceed the engineering standards and guidelines provided by the standard organizations because not only do they ensure the safety of the users, but they also enhance the quality of the product.

Several standards that are relevant to this project specifically are EN 1441:1997 Medical Devices (Risk Analysis), and EN 868-1:1997 (standardized packaging) [1].

In terms of economic constraints, the primary limitation is the allotted budget of $750. The device designed should be as affordable as possible, as it may hold potential to serving a larger population of senior citizens at some point. Families that require this device will vary in income levels. The solution will satisfy this fundamental condition.

The shampoo and conditioner identification device is essentially an adaptation of a voice activation dispenser. Striving for the highest quality; the device will be designed and assembled in manner with which it is economical to produce.

With reference to the environment, all measures will be taken to ensure that the device causes negligible or no harm to the surroundings. Specifically, this involves adequate disposal of batteries, and the waterproof nature of this system (to avoid leakage of toxic substances from the battery into the surrounding). Construction materials of the device will account for the client’s health and safety.

In terms of sustainability, the device will have to be capable of withstanding a variety of temperatures and a moist environment, which it will be constantly exposed to. Selection of appropriate materials for this device will be essential for corrosion resistant properties. In case of unintentional damage, the device must have accessible electrical test points for checking or repairing its operation.

Considering the properties of this device and its application, its manufacturing will involve a detailed consideration of each component. The safety measures will be central to the manufacturing decisions. Other factors
will be based upon ergonomics and client convenience. It is expected that the circuitry and design to be relatively easy to replicate, in case a larger market opens up for this type of product.

In addition to using insulating and airtight material in a wet surrounding (to make the device shock-proof), low-voltage power sources are used to make sure that all electrical components work according to the simulated model, we will ensure that the working life will be optimized. Materials with rough edges or sharp protrusions will not be incorporated to abide by the underlying values, which is to guarantee the safety of the client.

There is one social constraint, which is that the device must be refilled with shampoo and conditioner when it’s empty. This will require someone to periodically visit Mrs. Smith and do the needful. Therefore, a minute element of dependency on another individual still exists.

3. SAFETY ISSUES

The main safety concerns of the Shampoo/Conditioner Identification device are due to the unusual environment that it will be operated in – shower. The device includes electrical circuits which contain parts that will cause shock when exposed to water, therefore the entire device will be enclosed with insulating material to prevent water from entering. The security of the attachment of the device is another critical safety constraint because it will be placed on a relatively wet and slippery surface.

The shower has limited space, hence it is likely that the user could accidently run into the device. The device should have as few sharp edges as possible to avoid potential harm. Minimize the size of the device also increases the available space to the user in the shower, thus the device need to be very compact.

The device has a lot of electrical components, so the reliability of these parts will be very important. The batteries which act as the power source of the entire device will need to be small yet powerful enough to prevent operational failure, which consequently may result in inconvenience or even injuries to the user.

4. IMPACT OF ENGINEERING SOLUTIONS
Engineering solutions have the potential to fundamentally change the way humans live their lives. In addition to impacting lifestyle on multiple levels, they have the ability to advance knowledge and scientific methods of practice.

Based on an optimal design for the shampoo/conditioner device, it is obvious that a significant impact can be made at a global level, for clients with cognitive impairment, or reduced visual perception. Memory loss is a primary concern to patients with Alzheimer’s disease, a health condition that is common in individuals above the age of 65. At present, more than 5 million Americans are estimated to have Alzheimer’s disease. By the middle of the century, it is estimated that 14.3 million Americans will have the disease. Therefore, it is clear that a large market for this kind of device will develop over the course of the next few decades.

In addition, this device may be used for patients with low visual acuity, which may be caused by a disorder, or during healing time after ophthalmic surgical procedures. Patients (especially those that are single) may need temporary assistance in recognition of items within their household. Thus, a device such as the shampoo/conditioner voice-activated dispenser will provide assistance in doing so. The current project is catered to the dispensing of specific bottles of hair products for use in the shower. However, it is definitely possible to diversify applications using the same concept. A voice-activated dispensing device can be used in the kitchen for beverages or even food items.

Analyzing engineering solutions in an economic context requires examination of the market and customer base. In general, a conservative estimate is used, which it is projects that 10% of the customer base will be using this product within five years of release. However, this may change depending on company strategy and the method of marketing used. A voice-activated dispenser for a liquid item has the potential to make its way through other markets, in addition to a population that would require it for health reasons. A voice-activated beverage dispenser could be used in company cafeterias, or regular households, to avoid issues such as unnecessary spillage or waste. Loading this device into the refrigerator, and having it dispense a beverage of choice upon voice-activation would merely require refilling when supply in the container is depleted. It is clear that this device can be used for two purposes; one makes it a biomedical innovative, and may be used by healthcare institutions to aid their patients. The other application is that of a user-friendly, commercial device that can be used by the public for increased convenience. As a healthcare device, pricing would depend on costs of development, desired profit margin, and other factors such as insurance coverage. For use in a
technologically-savvy household, prices may differ. Thus, marketing and sales strategies would have to be tailored to each separate consumer base.

However, it is necessary to evaluate whether this type of product would be useful on a global scale (taking into account cultural practices). In developing countries, it would be hard to imagine this sort of device being successful. In populous Asian countries, it is customary to see elderly parents living under the same roof as their son and his family. It is also common to see domestic help around families that are middle to upper class. Therefore, even if this device was made affordable, the group feels that cultural norms would prevent it from being a financially lucrative product to produce in this type of market. If it was sold in a developing country market, it may be done as a ‘Giffen’ good, or one with snob value, which caters to an elite population.

In an environmental context, engineering solutions such as this one do not seem to pose much of a threat. To manufacture a device such as the shampoo/conditioner dispenser, the amount of pollution caused to the environment (land, air, water) is negligible in comparison to production of other products, in which harmful fumes or toxic wastes may be emitted. This will be operated by a dc power source (battery). Inadequate disposal of the batteries is the only other cause of concern to the environment. However, it is unlikely that this problem will be significant enough to threaten natural surroundings in any way.

5. LIFE-LONG LEARNING

For this alternative design, the majority of what the team learned came from comments based on the preliminary presentation. Through comments from the adviser, reviews from the client, and research, the group has learned about what constitutes an excellent design and what sort of features can lead to problems.

This served as a significant learning experience, as the team was provoked to think of ideas beyond the scope of a limited project description provided by the client and the NSF. This involved changing the fundamental mechanism of how the client’s needs were met. Instead of focusing on a design that involves a mechanical stimulus from the client (touch-sensitive pads, or buttons), which may prove voluminous for someone trying to grip and hold a full-shampoo bottle, the current design relies on a simple voice input. This seems to be more practical in terms of usage for elderly individuals, or those with disorders that considerably reduce muscle strength.
A device that wraps around each bottle, and emanates an auditory signal upon a mechanical stimulus from the client is what was expected. Proposals for this type of functional mechanisms were described in the previous two reports. However, the group realizes that a significant challenge lies in incorporating all necessary components on a single belt (speakers, circuitry, pressure-sensors) without making the device bulky or unmanageable in terms of weight. The design being currently proposed has noteworthy features to enhance the safety the client.

Particularly, Mrs. Smith faces reduced visual acuity and may find it difficult to place her hands on the exact location of the belt, where the pressure-sensors are located. The currently proposed design consists of one terminal, which is stationary at one location. The client has to simply command, and place her hands below the dispenser. This will be followed by release of the appropriate product. This way, the possibility of dropping a bulky item would be avoided, greatly reducing the chances of the injury.

In terms of satisfaction of needs, this fulfills the essential purpose, which is to get a desired product in the hands of the client and eliminating the need for visual acuity and highly developed cognitive abilities. This type of device may also be used for individuals that lack fine motor control (such as those with neuromuscular disorders). The device would eliminate the necessity for individuals to deal with items that are commercially packaged and may not be suited to their particular needs. However, it would be vital to ensure that users possessed adequate vocal abilities be able to input an auditory command.
6. REFERENCES

[1] Tech Street:
http://www.techstreet.com/cgi-bin/detail?product_id=24975

[2] Material Fact Sheet:
http://designinsite.dk/htmsider/m0007.htm

[3] ClearChoice:

http://wellsun.manufacturer.globalsources.com/si/6008821098541/pdtl/Com
puter-microphone/1004033558/Mini-Microphones.htm


Backpack Lever Arm System

1. ALTERNATIVE DESIGN PROJECT #1

1.1 Introduction

Innovative healthcare products can be used to aid individuals with debilitating physical conditions to carry out certain tasks. The client’s specific symptoms have resulted in an unavoidable dependency on others; he desires to be more self-reliant in terms of accessing his possessions without external assistance. Specifically, this refers to being able to place and remove objects from his back pack, which is usually attached to the wheelchair.

This design is unique in its ability to utilize space above the client, rather than relying on sufficient space on the sides. It is only similar to the previously proposed designs in that the final position of the backpack will be at the client’s midline. This design will differ in the mechanism through which the backpack is moved towards the client’s midline. This involves a different method of motion, and does not utilize some components of the initial design, such as the motorized wheel. In addition, the device does not move along the client’s side, but sufficiently above his head. In comparison to the initial designs, the current alternative has the potential to be more efficient in terms of space utility. Previously, vacant space of approximately four feet along the client’s periphery was necessary for proper function of the device. In a packed classroom setting, this requirement may be difficult to meet. In terms of safety, it is vital to note that the currently proposed foldable device uses vertical space, and poses less of a hazard to individuals within close proximity. Additionally, the device will be stored and folded (in entirety) at the back of the wheelchair.

The device will involve a motorized telescopic pole, attached to the back of the wheelchair. A rotational limb will be attached to the end of the pole. When it is not being used, the rotational limb will lie in the horizontal plane, and point to in the right-hand direction. For purposes of functionality, it will be capable of revolving ninety degrees in the clockwise and counter-clockwise direction. The rotational limb will be connected to one more limb (capable of parallel movement) via a hinge. The purpose of this is to allow sufficient horizontal distance between the client and backpack when the telescopic pole (raising the backpack) is lowered. This mechanism will bring the backpack close to the client’s midline (upper-abdominal – lower-thoracic level). It will be the final position of the device. From here, the client may remove or place belongings as he wishes.
To describe the functioning of the device in sequence, it starts with a user stimulus. When Mason wishes to obtain items from his backpack, he will turn Switch 1 located on a remote controller (which is attached by a Velcro strap to his right arm chair). The motorized telescopic pole (to which the limbs are attached) will slowly extend upwards, ending at a position that is 4 feet above the wheelchair’s height. Assuming a standard-sized school backpack that is less than 3 feet in length, sufficient space (6-12 inches) will remain between the client’s head and the base of the backpack.

Following this movement, the rotational limb (parallel to the floor and initially pointing in the right hand-direction) will move 90 degrees in the counter-clockwise direction. After this, the other limb (attached to the first limb via a hinge) will extend 180 degrees in a counter-clockwise direction. Finally,
the telescopic pole will move downwards, lowering the base of the extended backpack to his chest-line. At this point, the extended arm will be 6 inches above his head. As both limbs are equal in length (1 foot), their combined extension will provide 2 feet horizontal space between the client’s backrest and the backpack.

Once he has removed/replaced the desired items from his backpack, Mason will turn Switch 1 on the remote control. This will reverse the movement of the telescopic pole and limbs. A final, collapsible position will result, in which the device and backpack are conveniently located at the rear of the wheelchair.

![Flow Chart for device operation](image)

**Figure 1.** Flow Chart for device operation

### 1.2 Subunits

#### 1.2.1 Rotational Telescopic Pole

For the current design a telescopic pole will be implemented in order to raise a level arm system over the clients head. This lever arm portion will then extend out to a position that will place the backpack in at the client midsection. The telescopic pole will then lower the backpack so that it is in front of the client.

The telescopic pole that is planned for use in this project is the HTR dynamic telescoping actuator model T3B050. It has many features that will be useful for this project. This pole is made to raise objects weighing up to 110 pounds. It can also extend up to eight feet. This will allow ample space for the backpack to clear the clients head. The accuracy of this actuator is also roughly .008 inches, which means that the pole should consistently work in the manner proposed.
The pole is more than capable of meeting the needs of this project so the next step is how it will be used. The manufacturer offers different gears on the system so that it can be lowered and raised at different speeds. The weight of the unit is only 25 pounds so it is fairly light compared to the weight that it can lift. The extension is governed by sensors on the pole.

The telescopic pole will be bolted to the back of the wheelchair using by using one of the rails on the back. It will be mounted so that when the pole is retracted it will fit completely behind the back of the chair. This way it will not impede the client’s ability to move or be a danger to anyone walking around the wheelchair. Once the pole is completely extended the lever arm will activate.

1.2.2 Stepper motors

The stepper motor we are planning to use is the 10A-TTL-3SW-42 by Excitron. This motor is very versatile and will allow us to make precise movements without the need of an angle measuring device. This motor moves .9 degrees per step. The motors will be precisely controlled by the
microcontroller. A given number of pulses will be sent to the motor so as to ensure it only moves the proper amount. To operate our setup we will be using two motors, one for each hinge. These are idea for our setup because they provide the correct amount torque to ensure that the arm rotates out consistently and without complication such as overheating of gear shredding. These motors only require 12 volts to operate, however 24 volts is recommended. This should be easily provided by our client’s wheelchair. Since there will only be one motor working at a time there should be no extra strain on the wheelchair battery. The motor is also relatively light at 1 pound so it should not put any extra strain on the actual lever arm assembly.

![Figure 4. Stepper Motor (with controller)](image)

1.2.3 Lever Arms

The foldable arm will involve a single-hinge joint at an appropriate position on the arm to allow for horizontal planar motion. The arm will have one joint, connecting two limbs. It is attached to the end of the Rotational Telescopic Pole, parallel to the floor and pointing in the right hand direction at resting position. During the operation of the device, both Limbs will rotate about the hinges in order to bring the backpack to the front of the client. The backpack is attached to Limb Two via an attachment accessory, such as a clipper.

To describe the functioning of the arm in sequence, it starts after the Rotational Telescopic Pole rises and locks into place. Limb One will rotate 90 degrees counterclockwise about Hinge One. Limb Two will then rotate about Hinge Two 180 degrees in a counter-clockwise direction from the folding parallel position to directly in front of Limb One. Once the limb has reached its
final position and locked into place, Mason will turn switch one more time to have the Rotational Telescopic Pole lowers to 6 inches above his head.

Once he has removed/replaced the desired items from his backpack, Mason will turn switch on the wireless remote control to raise the Rotational Telescopic Pole, followed by the 180 degrees rotation of Limb Two in a clockwise direction to attain a folded position. Then both Limbs will rotate 90 degrees clockwise about Hinge One to bring the whole device behind the wheelchair. Once this has been achieved, the Rotational Telescopic Pole will lower to the original storage position.

The followings are visual representations of how the rotational arm part of the device is supposed to function. **Figure 5** illustrates the arm and its rotation mechanism. The upper block diagram indicates the movement to bring the backpack from its initial position at the back of the wheelchair to the front – to our client’s mid-body level. The lower block diagram shows how, upon stimulus, the backpack returns to its initial position behind the wheelchair, followed by folding of the arm into a convenient and ‘collapsed’ position.

![Diagram](image-url)
Figure 5. Rotation Mechanism of the Lever Arm System

1. After Rotational Telescopic Pole rises and locks into place
2. Both Limbs rotate 90 degrees counterclockwise about Hinge One
3. Limb Two rotates 180 degrees counterclockwise about Hinge Two
4. Rotational Telescopic Pole lowers to 6 inches above client’s head
In terms of exact location and of the device, dimensions of the client’s wheelchair, the Quickie-500, must be taken into account. The seat has an adjustable width of between 12’’-14’’; the depth of the seat is adjustable between 10’’-15’’. Taking these figures into account, it becomes easier to specify lengths of the individual arm components. In this design, both limb will be equal in length (1 foot), their combined extension will provide 2 feet horizontal space between the client's backrest and the backpack, and will not exceed the depth of the seat.

As far as determining the placement of the hook that will attach the backpack to Limb Two, torque must be taken into account. Client requested a device that will hold approximately 30 lbs, thus the torque will be calculated based on that weight. Torque is the measurement of the force acting on an object causing it to rotate. It is the cross product of distance vector and force vector.

\[ \tau = r \times F \]
As mentioned previously, the length of Limb Two is one foot or 0.3048 meters. Hinge Two acts as the pivot point, and weight of the backpack 30 lbs is the only force that will produce the torque. The following torque calculations were made based on the free body diagram.

**Figure 8. Free Body Diagram of Limb Two**
The backpack is hanging $\frac{3}{4}$ away from Hinge Two,
\[ \tau = r \times F \]
\[ \tau = \frac{3}{4} (0.3048) \times (13.64)(9.8) \]
\[ \tau = 30.56 \text{N} \cdot \text{m}. \]

The foldable arm itself will be made of low carbon steel because of it is light, malleable and inexpensive. These properties are extremely critical because the addition of the device should not affect the balance of the wheelchair. The project has a relatively low budget of $750, therefore the inexpensive nature of low carbon steel is also important.

1.2.3 Clipper

The H.B. Clipper Quickdraw will be used to hold the backpack in place. In addition to being capable of supporting a heavy load, this will enable convenient attachment/detachment of the backpack in case there is a need. In terms of materials, the clippers are made of stainless steel, which is corrosion-resistant. This will improve the safety and product life the device. The two clippers are connected by a strong, 13 cm nylon string. Since this device is meant to be used for climbing, it is capable of handling various degrees of strain, as well as different climatic conditions. This durability will prove to be a positive feature of the device. In addition, it is essential to realize that the H.B. Clipper Quickdraw is light in weight, and will not significantly add to the weight of the entire device. It is merely 4.8 oz, which is great when attention is directed to the amount of strength that it adds to the entire system.

In terms of the exact location on the backpack lever arm, the H.B. Clipper Quickdraw will be placed onto the limb which extends the furthest horizontal distance away from the client’s wheelchair. One clipper will be used to attach the backpack, whereas the other will be used to attach to the limb.
1.2.4 Supports, Attachment of Device to Wheelchair

The component used to attach the device to the wheelchair is a vital part of the system. It is absolutely necessary that it be placed at locations that provide maximum stability. In addition, materials that form the support must possess high mechanical strength (low-carbon steel). After careful analysis of the client’s wheelchair and the environment in which the device plans to operate (on the basis of pictures sent by the client’s family as well as a review of on-line information posted by the manufacturer), it seems appropriate to incorporate a horizontal bar support at the back of the client’s wheelchair. Since Quickie Z-500’s seat width is (12-14 in.), the horizontal support bar will be adjustable to accommodate sizes in between. This will be taken care of by inserting rods of varying lengths into the vertical adjustment holes, based on the client’s requirement. The bar will be locked on both sides to the vertical adjustment pieces, generally used to adjust the height of armrest clamps.

If the wheelchair needs to be adjusted, the support can be removed and placed at a height that the client feels is appropriate. The horizontal support will be the point from which the motorized telescopic pole originates and
extends upwards. Primarily, the vertical adjustment holes will bear the greatest force, which will be in the downwards direction. It is also essential that the rods inserted in the vertical adjustment holes have sufficient shear strength, since this is the type of force they will be experiencing. The team plans to use 304 stainless steel, as it will be more than sufficient in meeting strength requirements. The shear strength of 304 stainless steel has been noted to be 186 MPa. [2]

1.2.5 Microcontroller

The microcontroller that is ideal for application to this project is the PIC18F1230. This chip offers the ability to of customization and self programming based on the mode that it is put into. It also features pin break-out so that it is easy to use with a protoboard. There is also a built in potentiometer that is used to control a 10-bit analog-to-digital input channel. The microcontroller consists of two external clock modes and two external RC modes. However the two most pertinent aspects of this chip are the internal oscillator and the flash memory module.

The internal oscillator block can provide an 8 MHz clock as well as a range of six selectable frequencies between 125kHz to 4MHz. This feature will easily be utilized for providing the correct movement sequence to the stepper motors that are involved in the joint articulation. A specific interval of time can be programmed for each of the stepper motors to be active. This way there will be precise, repeatable movements of the lever arm.
3. REALISTIC CONSTRANTS

In today’s day and age it is not enough to just build an object, but we also must take into account the affect it has on its surrounding. Engineers are instructed to make sure that the products they design meet specific standards. Above all else their creations must do not harm. They must also be efficient and affective for the potential users. In order to ensure that new products on the market adhere to all of the requirements there are engineering standards that are predetermined.

These guidelines are setup up by the government and engineering organizations. Some of organizations that specializing in creating and monitoring engineering standards include American National Standards Institute (ANSI), American Society for Quality (ASQ), Association for Advancement of Medical Instrumentation (AAMI), International Organization of Standardization (ISO), and National Institute of Standards and Technology (NIST). The approval of these groups is vital in the potential market reaction to any new product.
For the Backpack Lever Arm System this means that it must meet all the standards of any product on sale today. Since this is not just a prototype that will be used for testing, but instead a device that will directly impact the life of another person it must meet or exceed the benchmark that consumers have come to expect. The most relevant standards that this project must meet are specifically the ISO 9001:2000 Quality Management Systems (Requirements which provides systematic methods for managing all aspects of manufacturing a device), EN 1441:1997 Medical Devices (Risk Analysis), and EN 868-1:1997 (standardized packaging). However, these are not the only constraints that have been put on or project.

In terms of economic restrictions, the primary limitation is our allotted budget of $750. The device that we plan to create must be affordable because it may hold potential to serve not only Mason, but other people living with cerebral palsy. The consumer market for a product such as ours will greatly vary in financial flexibility. So our charge is to design a device that is both effective and cost conscious. In this way we will ensure that the product will have a wide consumer base.

Our device is essentially an electrically operated mechanical limb, capable of moving Mason’s belongings to an accessible position. Given that we are combining two types of engineering into one device we must take care to ensure that these vastly different fields mesh together properly. This is not an easy task as there have been many instances where the outcomes of endeavors such as ours have been less than ideal.

Given our modern understanding of the impact humans have on the environment, all measures will be taken to ensure that the device causes negligible or no harm to the surroundings. For our device specifically, this involves adequate operation and disposal of batteries. It also means that materials used to build our device are recyclable and are safe for not only our client, but the environment he plans to use the device in. Since this device will be operational in a school surrounding, construction materials and design will account for our client’s health and safety as well as those around him.

In terms of sustainability, our device will have to be capable of withstanding a variety of mechanical loads and weather. This device will travel with our client everywhere, which means that it must operate without fail in any condition. Given that the intended family lives in Canada, withstanding different weather conditions will be vital for long-term functionality. The prevention of corrosion and weathering by selection of appropriate materials for this device will be essential. In case of unintentional
damage, the device must have easily replicable parts and must also go into a fail safe mode in which it can cause not harm anything it comes in contact with.

Considering the properties of this device and its application, its manufacturing will involve a detailed consideration of each component. The safety measures described in the previous paragraphs will be central to our manufacturing decisions. Other factors will be based upon ergonomics and client convenience. Although the circuitry may be easy to replicate, the actual design should have the ability to be customized to each client’s physical conditions.

In addition to using insulating material (to prevent shock in a wet surrounding), weight is also an important consideration in eliminating unnecessary strain on various components while the device is operating. This will not only reduce the wear but also go a long way in reducing the chance of injury. In addition, by utilizing low-voltage power sources or even the wheelchairs own battery we will ensure that the working life will be optimized. By making sure that all electrical components work according to our simulated model, we can safely recommend the use of our device. Materials with rough edges or sharp protrusions will not be incorporated to abide by our underlying values, which is to guarantee the safety of our client.

There is one social constraint, which is that our device will need to be lubricated periodically to ensure smooth functioning of incorporated joints. This will require someone to visit or client and carry out normal maintenance. However, we feel that this should not be much of an extra burden because any electric wheelchair typically requires this type of servicing. Therefore, only a minute additional element of dependency on another individual will have to exist.

3. SAFETY ISSUES

Ideas related to this design have been formed, taking into account the environment in which the device will operate. Primarily, this refers to the populated classroom/school setting, which will not only contain a higher density of individuals around the client, but other objects such as desks or learning materials. To avoid swinging metallic parts (lever arm) around the client’s periphery, the team has decided to propose another method which could be used to move a backpack from the rear of the wheelchair to the client’s midline (an accessible position to remove/replace personal belongings). This method involves a motorized telescopic pole and extension ligaments, which use space above the client’s head. It is assumes that ceilings will be high enough (higher than 10 feet from the floor) to accommodate this device. With
this mechanism of transfer, the chance of injury to others is considerably reduced.

However, it is vital to examine the actual components of the device, in relation to the external environment (not necessarily indoor), and what repercussions changes in weather would have on the device’s functioning. It is necessary to make sure that mechanical and electrical components are reliable. The device might be exposed to heavy rain or other harsh weather conditions; to protect electrical components and ensure a long product-life, Teflon tape will be used to insulate. In addition, Neoprene rubber will be used to cover the device from the outside, eliminating water contact with internal components of the device. Nylon may also be used to cover the rotational and extension arm, as its properties make it resistant to abrasion and chemicals. These protective measures will make sure that the client is safe from electric and any injury associated with corrosion of device parts.

4. IMPACT OF ENGINEERING SOLUTIONS

Obviously any engineering solution that has been developed throughout history impacts humanity in many ways. These solutions are used so frequently that we can forget how much of they affect our daily lives. In the modern age not only do new products have the ability to make life easier, but they also are a testament to the technological advances that have been made in our time.

The project discussed in this design paper is yet another indication of just how far engineering has come in the modern age. Creating a backpack transferring system that will assist the client in performing daily tasks will greatly improve his quality of life. Those around him may also begin to see the client in a different way. Without the need of others help the user will develop a sense of independence and accomplishment.

The impact can stretch much further to change the life of his family and potential many other individuals living with cerebral palsy. This global influence can even encompass persons with varying levels of cognitive impairment or physical limitation. There are close to 100 million people with disabilities living in America today. Of those roughly 500,000 have cerebral palsy.

Involuntary movements and poor motor skills are the typical symptoms of cerebral palsy. At present, about 2 out of 1000 children born in this country have some form of cerebral palsy. The trend is slowly decreasing, but the trend is still prevalent. Therefore the need for a device such as the one purposed in this text would bring great benefit to this community. However, this device is
not limited to only persons with cerebral pulsy. The system can be implemented by anyone who uses a wheelchair and has trouble with manipulation of heavy objects.

This device will bring independence to any client who wants it. Clients who live by themselves will benefit from the ability to transfer object to a position where they can use them. Our current project will be catered to or specific client and will be use to move a backpack to a comfortable position for him. However, it is definitely possible to diversify applications using the same basic concepts. A transfer device can be used in the home, office, workplace, or educational facility.

When discussing engineering solutions in an economic context, it is natural to analyze the market and customer base. Generally, a conservative estimate is taken, in which it is projected that 10% of the customer base will be using the product within five years of release. This means that the potential number of clients for our product will be somewhere in the range of 50,000 people. This number may vary depending on the way that our product is marketed. As stated before the customer bases for our device should be quite extensive because of the potential applications. Depending on factors such as total costs, and the profit margins desired, a price a proper marketing approach could be decided upon.

The next step in to look at when bringing a new product to consumers is the global potential. The main issue to consider is financial flexibility of people outside our own economy. This problem however, should not be too detrimental as the estimated cost for our project will certainly be less than $750 US. This is a price that should be relatively affordable for a majority of people outside the United States. The last impact that needs to be addressed is that of the environmental aspect.

In an environmental context, engineering solutions such as this do not seem to pose much of a threat. The materials planned for this device are all either made from recycled material are themselves recyclable. There is also no extra environmental concern about batteries since we plan on use the battery already implemented on the wheelchair. An optimal design plans to use a small voltage of 12 volts. Therefore, it is unlikely that this problem will be significant enough to threaten natural surroundings in any way.

5. LIFE-LONG LEARNING
Life-long learning can be described as a process, through which one modifies his or her views based on experiences. Based on further analysis of the system, the team decided to think beyond the traditional mechanism of design. For the first two proposals, the backpack was transferred to the client’s midline via different lever arm motions, and used space available at the right hand side of Mason’s wheelchair. In doing so, the assumption that ample room was existent, and no objects or individuals were present within four feet of the wheelchair (while the device was moving) was made.

In this alternative proposal, the team has decided to breach the limited view that the backpack can only be transferred from one of two sides of the client. Here, an attempt has been made to utilize space above the client, which is more likely to be vacant, except in the case of a low-ceiling room or another close-packed environment. By allowing the device to move the backpack above and over the client, the risk and possibility of injury to others in close proximity of the client is minimized.

In terms of the design advantages that were present previously, the group has managed to ensure that important features have remained. An ability to bring the backpack to the client’s midline, and a collapsible capability to form a compact structure are to main aspects that differentiates the current project from the ‘Backpack Transfer Device’ by students of Mississippi State University. By incorporating a motorized telescopic pole that extends upwards and retracts downwards, the collapsibility into a convenient storage position has been maintained. In addition, by having a rotational limb attached to another segment that extends in front of the client, the team has made sure that the backpack reaches the specified and desired position.

Based on input, questions, and suggestions after the first round of senior design presentations, the team decided to modify certain features of the backpack arm. Important feedback involved how to design the instrument to function according to the proposed sequence, from the controller to the final movement of the backpack.

The team also received input that having one switch control the device is better than two, so that the client does not have to work with separate components, or remember what specific switches correspond to. Although the team understood implications of this suggestion, the group wished to give the client greater control over the device. Rather than having a single switch and one complete motion through which the backpack moves from the rear of his wheelchair to the front, the group believes that the client should have the option of keeping his backpack in close proximity, but not all the way at his midline. This was practical for the first two design proposals.
However, in this design, it makes more sense to have a single switch control the entire movement and operation of the device. Here, separate functions would not be beneficial, as any position during the course of movement would involve the backpack being at a height level above the client, a position that is aesthetically awkward and inconvenient, in terms of being able to obtain belongings.
6. REFERENCES

[1] Climb High Outlet
http://www.climbhighoutlet.com/

http://www.ami.ac.uk/courses/topics/0123_mpm/index.html

[3] Tech Street:
http://www.techstreet.com/cgi-bin/detail?product_id=24975