ALTERNATIVE DESIGN II

Monitor lift for Adjustment of Computer Display
&
Oil Paint Cap Removal Aid

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I. ALTERNATIVE DESIGN PROJECT 2

1.1 Introduction

Monitor Lift

Our client, the experimenter at the Neurolinguistics Laboratory at Ohio University, requested a lift that can lift the heavy monitor off the table surface. The purpose of this procedure is to measure the comprehension of neurological patients in response to auditory and visual stimuli from the monitor. The monitor lift will provide a means to deliver the auditory and visual stimuli to the patient as well as provide a platform for any medical devices used in tracking the response of the patient. At this time, the monitor used remains stationary on a desk, resulting in limited mobility of the unit. The inability of the monitor to move results in hardships on the patient due to the fact that the patient has to accommodate the position of the device opposed to the other way around. The lift will allow the patient to remain in a comfortable position while the movement requirements of the device for an effective means of studying the patient would rely solely on the device itself and not the patient. It will deliver the stimulus at the correct plane of sight of the patient as well as allow for the implementation of an eye tracking mechanism to record the patients eye responses to stimulus. The eye movement of the patient is one of the only means of communication between the tester and the patient with regards to their comprehension of various stimulus, thus it is of the utmost importance to move the eye movement tracker to the patient since the patient cannot align to the correct positioning of the eye sensor. The monitor lift will improve the handling of patients as well as the effectiveness of the tests being performed. There was recently an attempt at making such a device but it failed because of space constraints as well as the device being to distracting in nature to the patients.

In this paper, we will present the second alternative design of a monitor lift. To enhance the effectiveness of our design and to satisfy the needs of our client, we have made changes and implemented new ideas in this second design. It describes what the monitor lift will be able to do, how it will be implemented, the major components and how the design has been modified from the previous ones. The monitor lift will be capable of steadily lifting a large, heavy computer monitor (which weighs 80 pounds or more) from near surface height up 12+ inches through use of the strong spring and air pump. It will have a small footprint area so that equipment (namely an eye tracking device) can be stored underneath it when it is raised. It will be quiet and has many safety features such as a safety clamp, raised edges, guided bars, tie down accessories, and an internal spring. These features will make it suitable for use in a clinical environment. There was recently an attempt at making such a device but it failed because of space constraints as well as the device being to distracting in nature to the patients. Our design will be black, not have any unsightly wires and be quiet so that if used with patients they will not be distracted from the monitor.
The original design for the monitor lift used a hydraulic lift system. Feedback from teachers and peers brought to our attention that a hydraulic system may be too noisy for a clinical setting and can be very messy. There were also possible problems with bending moments and many parts meant there were many possible areas for defect in our first design. The second design relied on a completely different technology: spring force. This modification eliminated the noise and mess that would be encountered with the hydraulic system but the hinges on the V-arm and the ability of the monitor to stay level were questionable. This new design is modeled after the function of an adjustable chair. The main components of this design are the monitor platform, strong attachment of the platform to a cylinder underneath, 3 cylinders that fit in side each other and of which the sum of the heights of the two internal cylinder is no less than 12 inches, a heavy duty spring, air valve and safety clamp (see Figure 1 below). The monitor platform is welded with a piece of metal to the cylinder underneath it (rather than a hinge as in the last design) so that the monitor will always be level. The cylinders, air valve and spring make up the moving part of the lift. The sum of the height of the two inside cylinders will be at least 12 inches and the internal spring will be selected to have enough force to just almost lift the monitor itself. The spring has degrees of freedom in every direction by nature but the cylinders will eliminate all of those degrees except for the one in the vertical direction, which is an improvement upon the last design. When the air valve is opened, the lift can be raised by hand with little force thanks to the internal spring. The influx of air to the cylinders as it is raised will provide the necessary force to hold the lift where it has been raised to when the air valve is closed. To lower the lift, the air valve is opened and the air within the cylinders is slowly released. During this action the internal spring actually also acts as a safety device. If the valve were to fail, the lift would have some force still counteracting its fall to make it less severe. Tie down accessories, raised edges on the platform, a safety clamp and safety guide bars are all incorporated into the design to make it more stable and safe for use around patients. Simple technology and a relatively small number of parts compared to the first design reduce the number of ways the design could fail.
This paper presents an overview of the second alternative design for an oil paint cap remover that will be used by an artist with multiple sclerosis (MS) whose disease has made it difficult for him to remove the paint caps himself. It describes what the paint cap remover will be able to do, how it will be implemented, the major components and how the design has been modified from the previous ones.

The paint cap remover is tailored to remove the caps of 1.25 oz tubes of Grumbacher brand paint. The device is designed to be mostly automated so that little force or grip is needed to operate it and it will also work even as the tube changes shape (as paint is used). It is battery operated and small so that the user has more freedom to use it wherever is most convenient for themselves. This ultimately gives our users the ability to open paint containers with little strength or grip wherever they choose.

The oil paint cap remover will be implemented specifically for use by a painter who’s MS has deteriorated his dexterity and strength in his hands. Our client only has limited strength and grip in one hand and little to none in the other. The client’s disease has made him dependent on others for simple tasks such as removing the paint caps and this is having negative implications concerning his livelihood and independence. The paint cap remover will be implemented to help restore this painter’s livelihood and independence.

The last design for the paint cap remover had problems with the stability and the ability of the cap head to find the cap each time it is used. This problem has been fixed in this
design along with the location of the handle. The size has also been reduced in the second alternative design because the previous designs were too large and bulky. The second alternative design’s key components include a descending platform, a clamp for the paint tube, motor, springs and a sliding PVC guide-tube system (see Figure 2 below). The descending platform will house the DC motor and batteries and be suspended by an overhang support bar with springs. A key addition to this design is that the platform is extended and connected to a PVC tube-guide system. This system eliminates the multiple degrees of freedom from the springs and will ensure that the cap head hits the cap each time the platform is depressed. It uses PVC tubes around metal bars for a combination of strength and stability with easy gliding and little wear between components. The clamp is designed to hold the paint tube secure enough to remove the cap and yet still loosely enough that paint will not expel from it. The motor that is used to rotate the cap head is a DC motor that can be run on batteries and has a slow rotation speed (54 RPM). This is sufficient for our design’s purpose and is also safe for the application. Gears can be used to alter this speed if needed. This design is safe because all electrical components will be grounded and the user does not come into direct contact with them during use.

![Figure 1: Overall design of Cap Remover](image-url)
1.2 Subunits

Monitor Lift

1.2.1 An Overview

The second alternative design for the monitor lift relies again on the nature and function of springs. The design of how the spring is used is completely changed and offers a more stable and mechanically achievable function. The first alternative design relied too much on the constant weight of the monitor and relied too heavily on the precise measurements and weight calculations of the pivoting arm bar. The large moment created by the monitor in the previous design could result in unsafe use and the possibility of failure. The new design took into consideration the suggestions from teachers and peers and meshed the safe nature of the hydraulic design structure and the easy mechanical, less technical, operational functioning of the spring design. We were warned of the messiness and unreliable nature of hydraulics thus stuck with the spring as the focal point of the lifts functionality. The V arm of the second design and the complicated pivot joint that would have to be manufactured was replaced with a more stable and geometrically sound (box) frame. Figure 1 seen below will be broken down to each individual component and their function in the lifting of the monitor will be explained and justified.

Complete Assembled Monitor Lift

Figure 1- the complete monitor lift in the maximum and minimum height position. Attachment to fixture (table) in the laboratory is diagramed in this drawing and laboratory table is not to be included in the project.
1.2.2 The Monitor Platform

The subunit of the top platform took into consideration the nature of the monitor used as well as its attachment and secure fit to the middle assembly of the lift. The monitor being used is square in nature and can accommodate the monitor being used in the Ohio University laboratory. During the design of the monitor the center of gravity was taken into consideration and the environment of the monitor was studied. The engineers who designed the monitor did so in a way that it could be free standing and balanced when placed on a flat surface. Knowing that the monitor can free stand on a flat table the idea was to mimic this table like surface in the machining and designing of the top platform. The top platform will be constructed of high strength aluminum in which elevated borders will surround the solid floor panel of the base, also made of aluminum. The safety of the patient is of great concern to us in the designing of the lift and thus certain measures were taken to ensure their safety at the advice of others. The raised side bars are a safety measure to help keep the monitor from sliding and moving during operation. The top platform will be tailored to the dimensions specified in the project thus further increasing the safety of the device. Tie down accessories will be placed on either side of the platform allowing for a multitude of straps to be implemented in tying down the monitor, again further anchoring the monitor to the solid frame design. Previous designs of such a lift had a problem with unsightly wires. This was taken into consideration in that a hole will be machined in the rear of the top platform so as to allow the discrete exiting of the wired down the backside of the lift in a bundled fashion. Another concern with the previous alternative design was the hinge joint that attached the top platform to the middle functional unit. The levelness of the monitor during operation was a big problem with such a hinge and thus a solid flat fabricated attachment piece will serve as a constant non moving fixture between the top platform and lower unit, connecting the two (described in later section). Concerns of safety in regards to the falling of the monitor on the patient were taken into consideration as before and thus circular holes will be placed on the platform in all four corners allowing for safety guide bars to be implemented throughout the whole functioning of the lift. The safety bars ability to pass through the plate allow for the movement of the monitor as well as providing shear horizontal plane stability. Figure 2 shows the previously described structure.
Complete Top Platform

**Figure 2**- An aerial and side view of the complete schematic of the top platform that will house the monitor throughout its operation. All parts are labeled as they will be implemented in the functioning of the machine.

1.2.3 Attachment of Top Unit to Functional Middle Unit

The attachment of the monitor lift platform to the functional middle lift unit is important in that it must hold the two pieces together and accommodate the forces and weight that the monitor will impart on it. This is the sole connection between the two units and must be strong in nature so as to allow for any un-centered weight in the platform itself and due to the monitor. The desired connection is to weld a piece of high strength aluminum to the underside of the top platform. This piece will be of the same geometric shape as the point of attachment of the middle lift top piece (circle). The welded intermediate piece will be of slightly larger size than that of the top of the middle lift piece so as to assure that it can be welded to the lift part or in the case of an adhesive being used allow for greater surface area and thus a stronger connection between the two subunits. Figure 3 shows the attachment piece as well as highlighted parts of attachment. The shaded in areas represent the points of contact where the two pieces will join.
Attachment

Point of Attachment (middle subunit to monitor platform)

Figure 3- View of attachment. Aerial and side views are shown to get an idea of how attachment will occur. Highlighted regions are where adhesive or weld can be applied. Crucial attachment piece can be seen in side view just under the platform itself.

MIDDLE MOVING SUBUNIT

1.2.4 Middle Functional Unit of Lift

Design of this lift focuses on the use of a single heavy duty spring that is encased within three hollow cylinders that adapt within each other. The middle unit consists of three hollow cylinders in which the bottom cylinder remains attached to the lower unit and will house the collapsed other two cylinders when in the lowered phase. The circumference of the cylinders gradually goes down as one looks at the ascending units. These cylinders allow for easy movement in the vertical direction while supplying constant horizontal support from any shearing stresses that may be applied. Another key feature of this design is that the spring will be housed within the hollow cylinders, as a result will have limited, if any, flexural movement. The motion of the spring will be limited to the vertical direction and any flexural tendencies of the spring will be negated by the inner structure of the cylinders. A requirement of the top two cylinders is that their combined height is no less than 12 inches, due to the fact that all the motion of the lift depends on the maximum limits of the motion of the two top pieces. Another thing to consider is that the units, especially the lower unit, are able to accommodate each other so as to allow for complete movement of the machine. The nature of the lifts movement will be described in a later section accompanied by a force body diagram. The nature of the movement resembles the physics of an adjustable computer chair with some major modifications. Figure 4 shows the middle functioning piece in its maximum and minimum positions.
Middle Functional Subunit

Figure 4- The monitor lift middle functioning (moving) subunits are seen as described in the previous paragraph. The maximum and minimum positions are seen in the figure and show the wide range of motion of the lift in the vertical direction. Horizontal plane stability can be justified by this diagram.

1.2.5 Internal Workings of Middle Subunit

The internal workings of the middle subunit are simple in design and rely on the functionality of a single spring. The spring is anchored to the very base of the bottom subunit within the structure. The spring is then guided by the design of the middle unit up to the top of the peak cylinder. The two points of attachment within the middle subunit are the points of force on the mechanism and are the main reason for the lifting force of the machine. This chamber created by the three interlocking cylinders is air tight with the ability to release and take in air as desired through a simple air valve seen below.
The way the mechanism works is similar to that of an adjustable chair. The upward force of the spring within the mechanism will counter the weight of the upper unit. The force body diagram seen later will prove this fact. The force of the spring will be just below the equilibrium force to hold the monitor. With the air valve open the monitor will force the spring down slowly due to the constraints the spring is designed to be within. If the spring is just under the equilibrium force of the monitor as the air valve is open the pressure is released and the sole thing keeping up the upper unit is the spring which supplies a force just under that to hold the monitor (slow decent). To then raise the monitor the air valve is opened and the lift is physically raised up creating a larger volume in the middle unit resulting in the influx of air. Because the spring is almost in equilibrium with the monitors down force, the effort to raise the lift is minimal. Once the desired height of the monitor is achieved the air valve is then closed so as to create an air tight chamber within the middle unit. Since the air cannot escape the middle unit the lift is suspended and held at the desired height. The air pressure within the unit is capable of compensating for the slight downward force the spring cannot handle. Figure 5 below shows a cross section of the internal workings of the lift in a maximum and minimum position.
Cross Section Middle Subunit

Middle Functional Subunit Side View (cross section)

![Cross Section Middle Subunit Diagram](image)

Figure 5- Cross section of the middle subunit in the maximum and minimum position. Shows the nature of the spring in both instances. At no point is the spring in tension (always compression due to downward force created by monitor and upper unit).

1.2.6 Force Body Diagram

The nature of the design relies on some simple forces involved in the raising and lowering of the lift. There are no angular forces that are of significance thus the forces that have to be in balance are in the vertical longitudinal direction. Some simple weights have to be taken into consideration when calculating the downward force in Newtons. The platform is constructed of aluminum in the specified dimension 10in (25.4cm) X 19.5in (49.53cm) X .25in (.635cm). This gives the platform an area of 48.75 cubic inches or 798.689 cubic centimeters, and with the density of Al being .0027kg/cubic cm the mass of the platform is 2.15695 multiply by the acceleration of gravity 9.8m/sec.squared one gets a force of 21.1381 Newton’s. The weight of the monitor is 80 lbs converted to kg equals 36.29kg and multiplied by the acceleration of gravity 9.8m/sec. squared gives a downward force of 355.616 Newton’s. The combined total downward force is the sum of these two forces giving 376.755 Newton’s total downward force. This force is then taken into consideration when choosing a spring which will have to support this force. The equation for a spring is F=Kx in which the force is equal to the
spring constant $K$ multiplied by the distance the spring travels, $x$. If the spring is to travel 12 inches and match the 376.755 Newton’s downward force from the equation we get a spring constant of 1236.07. In order for the monitor to lower itself when the air pressure is released the spring constant must be slightly less so as to create a smaller upward force than that of the downward resulting in downward motion. The smaller the spring constant is the less force it will exert and the faster the monitor will come down when released from its top position. The force body diagram below shows the calculations and the point of application of the forces. Figure 6 seen below:

**Figure 6**- Force body diagram of the lift with the resultant spring constant needed.

### 1.2.7 Base Subunit

The base subunit is similar to that of the hydraulic lift we designed earlier. The shape mimics that of the top subunit and is of the same dimensions to provide the smallest footprint possible. The base of the middle lift mechanism will be welded to the solid bottom of the stand. The base will have the ability to clamp down to the table that it sits on to provide a safer operation of the monitor. The guide bars are mounted at their designated spots on the base unit. The simple nature of the base allows for easy placement on the desired table and provides a solid foundation for operation of the machine. Figure 7 below shows a side and aerial view of the base subunit.
1.2.8 Safety Clamp Mechanism

The final subunit of the device is solely for safety. Safety was a big issue with regards to the previous design, in particular the stability of the monitor off of the table. The catastrophic event of the monitor falling on the patient has been taken into great consideration and certain safety measures have been taken with regards to counterweight balancing as well as safety harnesses. These measures taken to secure the monitor to the lift itself are useless if the whole monitor lift and monitor fall over. This final means of protection against such an event anchors the whole mechanism, which up to this point is all securely anchored within its subunits, to the table or fixture it is being placed on. The idea is simple in that it relies on the use of a hinge as used before on the arms. This hinge will be welded to the end of the steel base unit. An L shaped steel piece will be machined and welded to the other end of the hinge (as seen below). This hinge will have a through bolt with a safety cable that when in the locked position will not be able to unhinge. The L shaped steel fabricated piece will butterfly out as its placed on the table and then secured under the table as shown in the locked position, with the through bolt through the hinge. At this point, once both L bars are secured under the table, the monitor lift/monitor are secured to the table which remains a relatively permanent fixture within the laboratory. The nature of this design relies on the use of a durable and relatively permanent/heavy table to be present within the laboratory. Figure 2.8 shows the device in the unlocked and locked position.
Safety Hinge Anchoring Mechanism

Figure 8- Here the device fabricated from scratch is seen on the left. The mounted assembly of the safety hinge is seen on the right in both the locked (safe mode) and unlocked (unsafe mode) position.
Oil Paint Cap Remover

1.2.1 An Overview

For our second alternate design for the paint cap remover, we have further modified our device which should directly affect the reliability and longevity of the system. Our changes were based on suggestions from teachers and classmates to try to improve the effectiveness of the removal system as well as fix problems with the first alternate design. Our new design is shown in its entirety in Figure 9, below. Alterations were made to how the cap-remover head is brought down onto the cap. A big concern was that the descending platform would be able to swing around freely. The springs were originally not restricted in any motion. To fix this we have implemented sliding PVC guide-tubes. All components will be described to explain their form and function as well as to give a visual diagram of how it will be incorporated into the final project.
Figure 9- Front View of Entire Paint Cap Removal Device
1.2.2 The Descending Platform

Most of the components of our device are housed on a descending platform. Our design capitalizes on the inherent weight of these components (motor, gears, and batteries) by creating a spring stabilized force equilibrium to support the weight. A free body diagram has been included in section 1.24. The beauty of the platform is that it uses the weight of the motor and electrical components to its advantage. Four springs are attached to the corners of the platform and are tethered from above to overhang support bars. A total of 8 support bars (4 horizontal support bars and 4 vertical support bars) make a box-like cage around the entire device and provide a structural scaffold for the descending platform. To reduce cost and overall bulkiness we have reduced the size of the entire device. The platform itself, which can be made out of aluminum, is 6" by 6" can be either ¼ or ½ an inch thick.

![Top View of Descending Platform](image)

Figure 10- Descending Platform
The platform houses everything essential to the actual removal of the paint cap, including: the DC motor, the motor circuit with batteries and switch, the motor gear, the cap-head gear, and the cap-remover head. The basic idea of the descending platform is as follows. The motor is in a very simple circuit with a battery, a switch and the motor itself. The user presses a switch in the motor circuit which begins operating the motor. This happens because the switch closes the circuit, allowing for the flow of current from the battery into the motor, driving the rotation of the motor head. The head of the motor is attached to a “motor gear”. When spinning, this vertical gear rotates a horizontal “cap-head gear”. The cap-head gear drives a rod which goes through a drilled hole in the platform. The rod ends at the cap-head itself, so therefore whenever the switch is depressed, the cap-head will continuously turn.

The user then applies a very small amount of force on the depression handle that is attached to the platform. We have altered the design so that the depression handle is now directly in the center of the platform. This eliminates any rotational moments that would have been created by pulling original the lever-like handle. The 4 corner-springs which rest at equilibrium are easily stretched when the handle is pulled downward. This allows the platform to be lowered toward the tube of paint which has been placed into the clamp. The spinning cap head approaches the cap of the paint tube. Our cap-head design is shown in Figure 11. There are small teeth in the head which will fit around the cap snugly. Since the type of paint is specific, we can design this cap head to fit our cap precisely. Upon request, we could also design multiple sized cap heads for different types of paint. The cap-head remover is a cross section of a small cylinder that can be made from plastic. We can make these easily by drilling a hole through the circle of plastic and then using a utility knife and a file to make the teeth. The final product is a specialized cap head with small grip-teeth that perfectly matches the cap of the paint tube. When the rotating, the cap-remover head is finally lowered onto the cap, and the grooves of the cap-head will lock into the cap, spinning both the cap and tube counterclockwise.

![Figure 11- Paint Cap Remover Head](image-url)
1.2.3 Sliding PVC Guide-Tube System

A new innovation we have added to the system is a sliding PVC guide-tube system. A problem with our alternate design 1 was that the springs allowed for full free motion. What would guide the cap remover to the cap? It would be too easy for the user to miss the tube entirely. To prevent this free range of motion we have implemented a guide system for the descending platform. Attached at the four corners of the platform are brackets. These brackets clamp onto a set of four small PVC pipe sections. The PVC pipes are large enough to fit over the vertical support bars, but are only a short section of pipe, approximately 2 inches long. Essentially this forms a cylinder inside of a hollow cylinder. They will be able to slide up and down on the bars with minimal friction. The main function of these guide-tubes is that they will eliminate all movement in the XY plane. This means that the only movement of the descending platform will be up and down in the Z axis. This easy innovation fixes the problem of the paint cap remover trying to align with the cap of the paint tube. Now it will come down directly on top of the cap, removing it easily and with precision.

Figure 12- The Sliding PVC Guide-Tube System

Figure 12 shows how the guide tube system will work. The PVC pipe (shown in grey) can slide over the guide bar both up and down with little friction.
1.2.4 The Clamp

If the tube were uninhibited, our device would not accomplish the goal of opening the paint tube, since the tube could simply rotate endlessly. Think about trying to unscrew a nut from a bolt. If the bolt is free to rotate, the nut will be nearly impossible to twist off since the bolt would spin too. The same is true for our paint cap and tube to prevent the tube from spinning along with the head, the tube must be restricted from spinning. Our original design used a tight clamp to secure the paint tube from spinning. One major drawback that we were asked to consider was that a tight clamp might put too much pressure on the paint tube. This could result in the tube expelling paint superfluously. Not only would this be a waste of paint but it would be very messy and would require unnecessary cleaning of all parts involved in the device. Our design is unique because it will secure the paint tube without expelling the paint. The key to our design is that it takes advantage of the ovular shape of the paint tube. If you look at the tube from a birds-eye angle you can see that its width is larger than its depth, resulting in an oval shaped tube. This can be seen in the figures below. Figure A shows a top view of a full paint tube after it has been placed into the box-shaped clamp. The clamp fits around the outside of tube without applying any pressure to the tube. These simple metal clamps are cheap and come in many sizes at local hardware stores or online stores.

Figure 13 (left) shows the front view of the paint tube inside of the clamp. Figure 14 (Below) shows the different stages of the paint tube in the process of cap removal.
Figure B shows what happens once the cap head remover comes into direct contact with the cap of the paint tube. When the cap head locks into place over the cap of the tube, both the tube and the cap begin to rotate counterclockwise. However, since the tube is wider than it is deep, it is prevented by the clamp from rotating fully. The clamp stands firm and holds the tube with minimal pressure, and this allows for the cap to be twisted counterclockwise. After several rotations the cap will be removed. At this point there is no pressure at all on the tube because nothing is twisting it. The user can now let go of the depression handle. This will allow the 4 corner-springs to retract the descending platform. The descending platform returns to its steady-state resting height, and the motor can be turned off. The final result leaves the paint tube sitting loosely in the square clamp with its cap removed. The tube can be easily picked up out of the device and the user is ready to use the paint.

Figure C shows a paint tube with less paint inside of it. One important concept to take into consideration is that the paint tubes change size as they expel more and more paint. The specific type of paint, Grumbacher Oil Based Paint, comes in small 1.25 OZ containers. These containers are shaped like a toothpaste tube, except the paint tube is made out of a thin metal. What is unique to the shape of the tube is that it is sealed at a flat line at the very bottom of the bottle. This means that no matter how much paint is already used, the width of the tube will never be less than its original width. Figure C shows this concept: that although the depth of the tube will decrease as the paint gets used up, the width will remain nearly the same.

Figure D shows the tube with less paint in it once the cap head remover comes into direct contact with the cap. Even though the tube has less paint in it and the depth has decreased, the width of the tube cannot change because it is sealed in a flat line at the bottom. The metal tube retains its rigidity and when the tube begins to rotate it comes into contact with the clamp. The clamp prevents the tube from rotating in a complete circle and therefore the cap is allowed to be unscrewed counterclockwise. After several rotations the cap will be removed. Just like with the full tube, at this point there is no pressure at all on the tube because nothing is twisting it. The user will once more let go of the depression handle enabling the springs to retract the descending platform. The descending platform returns to its steady-state resting height, and the motor can be turned off. The final result again leaves the paint tube sitting loosely in the square clamp with its cap removed. The tube can be picked up out of the device and the user is ready to use the paint.

The unique feature of this simple metal clamp is that it will work properly and efficiently for the paint tube no matter how much paint is remaining in it. Because of the distinctive sealing of the tube at the base of the bottle the width of the tube will not be variable. Therefore since the clamp is rectangular shaped it will prevent the tube from rotating no matter how full it is. Even if the tube is almost completely empty, it will still have relatively the same width as when it is brand new.

Another important fact to note about these simple metal square-shaped clamps is that they are cheap and easily found in a hardware store. If the user decides he wishes to
use larger tubes of paint he would only needs buy a larger clamp to fit those requirements. The clamps can be easily exchanged and replaced while leaving the rest of the device the same, accommodating different size tubes.

1.2.5 The DC Motor

To open the cap of the cap of the paint tube, the motor must have a low amount of rotations per minute. Most small DC motors spin at a high rate. Since we’re lowering a spinning head onto a stationary tube, we don’t want it to be spinning too fast. King Right Motor Co. Ltd provides a small 12 volt motor with a relatively low RPM.

Specs:

- RPM: 54
- Volt: 12.16V
- I: 0.98amp
- Input: 11.9
- Torque: 9.20kg-cm (7.985 lb/in.)
- Output: 5.1W
- Efficiency: 42.9%

If necessary, we can also reduce the speed of the cap remover by using a gear system. A pair of spur gears is mounted to the parallel shafts. The smaller gear is called pinion gear which is in contact with its mating bigger gear [2]. A pair of spur gear is used to transmit power between shafts rotating usually at different speeds [1]. The purpose of this gear system is to reduce the speed of the motor and also to increase the torque depending on the number of teeth on each gear. The higher the number of teeth, the faster the gears can rotate.
1.2.6 The Springs

The final component of this alternative design is the spring. As can be seen from figure 1 and 2, there are 4 springs on each of the corners of the descending platform. The spring system is the biggest change from the original design, and it makes use of the weight of the descending platform to help operate our device. Instead of trying to manipulate a heavy bending arm, the user is able to exert very little effort to move the platform.

The key to the whole design is based on the intrinsic nature of how springs perform. Generally, basic springs obey Hooke’s Law. See Equation 1 below:

\[ F = -kx \]

- **F** is the force applied to the spring
- **k** is a predetermined spring constant
- **x** is the distance the spring travels

Using Hooke’s Law for the springs involved in our design, it is possible to mathematically determine the type of spring needed for our system. Below, Figure 16 shows springs at different lengths during tensile stretching.

**Figure 16: Using Hooke’s Law**

Obeying Hooke’s Law, the springs will deform linearly. Part A shows a spring sustaining 1” deformation. If we assign an arbitrary value of \( k = 2.5 \text{ lbs/inch} \), we could calculate the force on the spring being 2.5 lbs. Next, we examine the spring in part B. The spring has deformed 2”. Using the same value of \( k = 2.5 \text{ lbs/inch} \), we can determine that a force of 5 lbs is being carried. Finally, in part C, the spring has stretched 4 inches. This would require 10 lbs of force.
Determining the amount of weight required to deform a spring a specific distance is useful in instances where the spring has already been purchased or placed into a device. Graph 1 shows the relative weights and distances a spring with a constant of \( k = 3 \text{ lbs/inch} \) would deform. The force vs. deformation forms a linear line for a linear spring.

A scenario that is more pertinent to our design rather than determining how much weight deforms a specific spring, would be to determine which type of spring we need to buy. To do this we would need to calculate the specific weight of the descending platform and the distance traveled. Optimally, our design would allow the sheer weight of the platform to stretch the springs a certain distance. I will refer to this distance as the equilibrium height, since the springs will come to rest at this point and will hang below the overhang support-bars at this level. The equilibrium height would ideally be about 4 inches above the clamp. This provides enough space in between the platform and the clamp and would allow the user to insert the paint tube.

The weight needed to pull the descending platform down to the paint tube would be additional force added to the preexisting force caused by the weight of the components and the platform. Table 1 estimates the weight of these separate elements. All together the components of the descending platform will weigh around 3.5 lbs. If we desire the springs to depress around 4 inches, we can use Hooke’s Law to find a spring with the appropriate spring constant. Solving for \( k \) in equation 1, we get

\[
\text{Equation 2: Solving for } k \quad k = -F/x
\]
<table>
<thead>
<tr>
<th>Component</th>
<th>Weight (lbs)</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC Motor</td>
<td>0.088</td>
<td><a href="http://www2.towerhobbies.com">http://www2.towerhobbies.com</a></td>
</tr>
<tr>
<td>2 D batteries</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>Depression Handle</td>
<td>1.0</td>
<td><a href="http://www.safehomeproducts.com">http://www.safehomeproducts.com</a></td>
</tr>
<tr>
<td>Gears and Cap Head</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>Misc. Wires and Fasteners</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td><strong>TOTALWEIGHT</strong></td>
<td><strong>3.488</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Table 1: Calculating Total Weight of Descending Platform**

If we plug in the desired length and weight into equation 2 we get \( k = 3.5 \text{ lbs/4 inches}, \) or \( k = 0.875 \text{ lbs/inch}. \) Since we are using 4 springs, we can divide this \( k \) by 4. So for each spring, \( k = 0.875/4 = 0.219. \) Graph 2 shows the deformation of 4 springs with each \( k = 0.219 \text{ lbs/inch}. \) We can see from this graph the equilibrium distance of 4 inches is 3.5 lbs, as calculated. As the user applies more force to the system, the springs can further depress and lower the platform to the paint tube. The user can easily depress the platform several inches with only a couple of lbs of additional force. Most importantly, the system requires very little grip strength and can be operated with one hand.

![Force vs Deformation of Spring, Total k = 0.875 lbs/inch](image-url)

**Graph 2. Force Versus Deformation**
A free body diagram has been included for the spring system. Free body diagrams are a crucial first step in considering how a system might react to inherent and applied forces. Figure 17 shows two free body diagrams of our system. The left diagram shows the springs resting in their equilibrium state. The only force on the system is the inherent weight of the platform and its components. With a weight of 3.5 lbs and four springs with each $k = .219$ inch/lbs, the platform will rest at an equilibrium stretching of 4 inches.

When the user wishes to lower the platform he can apply a small amount of force to the depression handle. If he applies a force of 2 lbs, the total downward force will be 5.5 lbs. Still using the same $k = .219$ for all 4 springs, the springs will stretch to a total of 6.28 inches, lowering the cap remover onto the cap.

One last important note to consider is the linearity of springs. A spring can only be stretched elastically to a certain length. After a certain length the linearity of springs no longer exists and a significant amount of extra force is required to deform the spring. While purchasing springs we must be careful to consider the manufacture’s maximum deformation of the spring. Exceeding this value will not only require an excess amount of force but can also damage the springs.
II. REALISTIC CONSTRAINTS

Monitor Lift

Engineering standards require that a product be reliable, durable, manufacturable, and most importantly the product must satisfy the customer and be safe. The monitor lift has been designed to be durable by use of a simple system using materials that should not wear or break easily. The metal guide bars, welded attachment of the platform to the cylinder, and the fact that the degrees of freedom of the spring have been limited by both the cylinders and the guide bars should make the lift durable and reliable. The simple technology and absence of electrical components will add to the reliability of the lift. The most likely place for possible failure over time would be the air valve or the seals in the cylinders, but it is unlikely that either will fail suddenly. Failure would be gradual and therefore the problem can be repaired before the lift became unsafe to use. Replacement of the parts is also rather cheap and easy. Failure will hopefully be avoided by designing the lift and selecting the parts to be able to handle loads much greater than anticipated. We will design the lift to be able to manage loads two or three times what is expected so that there is a sufficient factor of safety. The small number and the simplicity of all of the parts make this design easily manufacturable. The dimensions and properties of each component has been designed or selected to meet the needs of the client. The cylinder will leave a small footprint on the desk and the air valve and spring are being selected to accommodate the weight of the monitor which is 80 pounds. The monitor platform is slightly larger than the dimensions of the monitor itself and many additional safety components such as the safety clamp, raised edges, and tie down accessories have been incorporated. Before this device is used in an actual clinical setting, it will be rigorously tested by our own team and then will probably have to be approved for use by the FDA to double check that all safety standards have been sufficiently met.

The manufacturability of the parts of the monitor lift faces some constraints. It should be relatively simple. Parts cannot be custom made by an outside company since we are working on a timeline and they would probably take too long to receive. If a custom part is needed, it must be thoroughly planned out, absolutely necessary, and ordered far in advance from when it is needed. Any pieces we order that are not already welded or put together should be materials that are easy enough to assemble that we can do it ourselves. The tools available to us in the machine shops and labs constrain which pieces we will and will not be able to assemble ourselves. Another manufacturability constraint is that the parts ordered must meet specifications calculated (i.e. springs must have proper force constants). Time is a major manufacturability constraint on the project.

An economical constraint for the monitor lift is our budget. The sum of all of the parts needed to build the lift must not exceed the preset budget. Shipping and handling and tax must also be considered in the budget.
An ethical constraint regards the use of budget money. The budget money should not be spent “just because it is there”. Materials should be researched and shopped around for before purchasing to make sure that the money provided by the sponsor is not wasted on overpriced goods. If there is a sale, or a different company can provide the same quality part at a lower price, the lower priced piece should be purchased. Concern for safety is another ethical constraint. It would be unethical to design a lift that could support only 80 lbs. The monitor lift is going to be used in a clinical setting. An object weighing 80 lbs could seriously harm somebody if it fell on them for instance. If the lift failed while it was raised, it would most likely also crush the eye tracking device (which is most likely very expensive) underneath it. It would be unethical and reckless to not incorporate a variety of safety measures.

The monitor lift has no set constraints when it comes to sustainability. Wear is impossible to avoid forever but, keeping safety in mind, it should not be made of a material or in a fashion that would increase its likelihood of breaking suddenly. The springs may wear and need to be replaced every so often, and the joint may need to be oiled sometimes. It will probably not be used or moved too often, so we hope the device sustains for at least 5-10 years.

Health and safety constraints for the monitor lift include the safety of the patients and users. There are no electrical devices to pose a threat. The balance of the monitor and the risk of it falling or the joint failing are the only real potential problems. Safety measures (clamp, strap, raised edges on the platform) have been taken to meet these. The failure of the spring in the design is improbable since it is housed inside of the cylinders. The most likely way the design could fail would be through the air valve breaking. If this happened the lift would not stay up and it would fall. The fall would be broken somewhat though by the heavy duty internal spring and the direction on the fall would be managed by the guide bars and cylinders.

There are no political constraints for the monitor lift but the social constraints include the status of the patients and the environment. The lift must not disturb the patients while they are being tested. This means that the lift cannot be aesthetically distracting (it will be all black and is designed to house the wires for the computer in a tube) and it cannot be noisy. It needs to make looking at the screen comfortable for the patients. It will also make testing the patients easier for the technicians. The implementation of the monitor lift will help make the patients more comfortable while being tested, and will also make the test results more accurate/easier to obtain. These test results may help uncover solutions to a variety of neurolinguistic problems.

The monitor lift is going to be used in a laboratory or clinical setting. It needs to be quiet so it will not disturb the patients. It cannot emit any kind of pollution or mess that may harm those around it (this is not a problem for this design since it is not powered). It must be able to stand on a desk and be compact. When it is raised, it must leave the smallest possible footprint on the desk so that a tracking device may be stored underneath it. Temperature of the room should not affect this design, though it may have an impact on the functionality if hydraulics were still being used.
Oil Paint Cap Remover

Engineering standards require that the oil paint cap remover be reliable, durable, manufacturable, and most importantly the product must satisfy the customer and be safe. The paint cap remover design has the PVC guide-tube system to ensure that it finds the paint cap each time and is reliable. The selection of the materials makes our design durable. Metal rods provide stability and undoubted durability to the guide system while the PVC tubes around the metal rods makes movement along them easy. PVC has been selected because it is also very resistant to wear so the constant use of the device will not be a problem. There are no rare, complicated or expensive parts in this design so it should be easily manufactured. Also, the paint cap remover device requires that the user only be able to apply a small amount of force to the top of the depression platform. Dexterity and grip are not needed at all for operation. This is important because if dexterity, grip or any significant amount of strength was needed to operate it, our client would not be satisfied. It is also battery operated and small so that our client will have the freedom to keep the device wherever they choose. This is important because the device is needed to restore some of the client’s independence. Safety has been addressed in the design through the housing of electrical components in a box. All electrical components will be grounded and the user will not come into contact with them during regular use (only when changing batteries, but those will still be separated from the rest of the electrical components. The wires used will meet engineering standards. Since the output current is relatively small, the thickness of all electrical wires that will be used in our application is small within a range of 0.254 – 0.28702 mm of diameter. These wires can also be enclosed in PVC electric conduits that are light-weight and have high impact resistance, safe and low flammability, and long lifespan. The motor will be powered by 12VDC batteries which are relatively low in power input and output and are safe and easy to use. The motor only runs when the switch is turned on. The switch must be held down. When it is released, the motor stops, which is an additional safety factor of our design.

The main manufacturability constraint on the paint cap remover is the timeframe given to build it. The oil paint cap remover has a wide variety of parts; it has electrical components, structural components, and springs. Not all of these parts will be easy to find at one company. This may increase the amount of time spent waiting for parts to arrive since sometimes companies take longer to ship smaller orders.

An economical constraint for the paint cap remover device is the cost to run it. Especially since it is a device for personal use that will be used often, the cost to power the machine should not be excessively high. The budget is the main economical constraint on the paint cap remover device design.

The same sorts of ethical constraints apply to the paint cap remover. The budget money cannot be used recklessly or for anything other than the development of the project. The safety of the client is also an ethical constraint since it would be entirely unethical to develop a product for a client that might harm them in any way. Thorough testing and planning will be done to make sure the device is safe for constant use.
The paint cap remover has no set constraints on sustainability. It is battery operated and it would not be ideal for the client to have to change the batteries all of the time. Therefore, we will either use long lasting batteries and/or try to make it not consume much power per use. We expect the device to be used often so it we hope it sustains for at least 1-3 years.

The paint cap remover has more health and safety constraints because it has more types of parts. The electrical components must be grounded at all times. The client/user should not ever come into direct contact with any live wires or components. They will all be housed in a box. The motor and the cap head are moving parts. They should not be easy to get things such as hair tangled in, or fingers caught in. The device should be sturdy so that it will not fall over or wobble when it is being operated. The client may not have the strength, dexterity, or reflexes left to be able to react accordingly in such a situation.

The paint cap remover does not have any political constraints but it has more social constraints. The client has multiple sclerosis and as a result can only use one hand, and with little force or grip. The paint cap remover must be simply operable with only one hand. It must be mostly automatic. The objective of the paint cap remover is to give the client back his independence.

Since the paint cap remover is being designed with the goal to give back a sense of independence to a person, it should not be confined to a certain space. It must be not only easily operable but also easily accessible even in a wheelchair. By having the paint cap remover run on batteries, the client has the freedom to keep the device wherever he chooses; he will not be limited by where the power outlets are in a room. Since the device will probably be stored in an art room, the probability that it will get messy is a constraint. The device will either have to function when it is dirty (maybe has paint from the client’s hands built up on it), or be easy to clean.
III. SAFETY ISSUES

The first and most important consideration all engineers must revolve is safety issues. Overlook in identifying any mechanical, electrical, or other failures might lead to many downfalls associated with financial, social and economic problems, and possible lawsuit. In medical system, patient safety is the primary concern, and it is extremely substantial to understand fully all the known risks of any device that will be used both in vitro and vivo. All medical devices must be approved by the Food and Drug Administration (FDA) before expose it to the market. For any new medical products, FDA will goes through processes that evaluating the safety, efficacy, and use of medical products [8].

Errors and device failures are unavoidable. It takes numerous trials of testing in order to successfully remove all the possible hazards from the device. It is essential to pay a very close attention to every small detail as much as possible to limit the severe damage to both designers and users.

Monitor Lift

The environment is very important in this design. The monitor lift will be placed on top of the laboratory table and is in the front of the patient. The monitor being lifted is a big monitor with the dimension of 19.25 inch tall x 10 inches wide and 80 pounds. Failure of the lift might cause severe injury to the patient and possibly persons who are performing an experiment. There are several methods being implemented to prevent unnecessary risks. On each corner of the bottom platform, there will be four safety guided bars that are made of aluminum. These bars will go through the top platform that supports the monitor. This will prevent the monitor from sliding horizontally on the top platform. We will also secure the monitor from falling off the top platform while being raised by tie its base leg down with firm straps. The bottom platform is anchored to the laboratory table by the L shape steel bars that attached to the simple hinge. This durable and sturdy clamp will secure the platform to the table and hinder it from sliding in case of failures of the middle subunit.

The spring design is safe in this design because it is housed within the three hollow cylinders. The spring will have limited flexural movement and in case of its breakage, the cylinders will still be able to hold the monitor upward. The mechanism being used in this design for lifting and lowering the monitor is the seized air pressure inside the cylinders. The cylinders are made of aluminum, which is relatively durable and long life. Air cannot escape out of the chamber easily due to the special welding and enclosing of the three cylinders. In case of air leakage, disaster can also be minimized because the strong spring can uphold the monitor together with the aid of the four guided bars. For the worse condition where the spring might be broken, the monitor will not fall off the table toward the patient’s direction; instead it will just collapse downward due to the cylinders and guided bars constraints.
Lastly, this design does not involve power source, therefore it is free of electrical risk. A minimum amount of force needed to either raise or lower the monitor. The number of possible mechanical failure is limited because this device does not involve much of surface contact and wearing can be minimized.

**Oil Paint Cap Remover**

For any device that is connected to a battery or AC power supply, electrical hazard might happen at any time during or after operation. Our device, the oil paint cap remover, is considered a simple electrical application that does not involve complicated electrical component and wire network. Our system encompasses a DC motor that can be operated using 12VDC batteries. The 12VDC batteries are relatively low in power input and output that will reduce the high risk of electrocution. The output current from the DC motor is 0.98Amp, which is critically safe. In addition, choosing the right size of the electrical wire and cable is crucial in reducing the heating up and causing fire during the performance [2]. Since the output current is relatively small, the thickness of all electrical wires that will be used in our application is small within a range of 0.254 – 0.28702 mm of diameter. Because all the electrical components are hold in the descending platform which is constantly moving up and downward, all the wires should be held in place firmly. These wires can be enclosed in PVC electric conduits that are light-weight and have high impact resistance, safe and low flammability, and long lifespan [11]. Because all the electrical components are kept inside the aluminum descending platform, the user is safe from being in contact with wires and all other electrical components.

PVC Electrical Conduits

[11]

For mechanical safety in our application, we implement the switch which can be turn on or off by the user. The switch allows the motor and the head to spin only when it is depressed by the user. The new non-compressive clamp which holds the paint tube will not squeeze out the paint when its cap is being opened by the device. Because the descending platform is controlled by the spring which can possibly swing in many directions, we added another feature called the PVC guide-tubes. The PVC guide-tubes are attached to the bottom of the descending platform and sliding down together with the platform when the user applies the force downward. These sliding tubes will keep the platform in place and its attached cap head will
lower downward right onto the paint’s cap. Another advantage of having these tubes is it provides safety for the user in case of breakage of spring. Because the descending platform is attached to the whole device through these tubes, it will not fall off and cause any electrical or mechanical harm to the user.

IV. IMPACT OF ENGINEERING SOLUTIONS

Monitor Lift

Our device has shown a great improvement in the dimension of the whole system. This has a great environmental impact for our client. We are trying to create a compact device which does not take up space on the laboratory table. Our client wishes to have a device that does not produce a lot of noises. In our design, the use of the spring and air pump has its advantage in which noise is limited. Other features such as wires, shape, and color will be developed based on our clients’ desires. The patients being tested have neurological disorders; therefore our goal is to create a device that is simple enough to prevent any distraction to the patients.

In the neurological laboratories, many benefits will be gained through the use of our device. Upon achieving all the requirements, our device will help in bring more accurate and effective discoveries or solutions to the laboratorial experiments. Once the results are obtained from successful experiments, new solutions such as drugs, devices, or methods will be given to patients, helping them to recover their illness and complications. There are a large number of populations who are suffering from neurological disorders, new discoveries and findings will have such a great social impact on mankind. It will reduce many burdens for families and friends. Life will be much easier than it always is.

Globally, there are a large number of companies producing monitors/television lift. Those include LCD lift from ActiveDesign [13], monitor lift from Flex-Y-Plan [14], monitor lift from Starfield Group [6], LCD lifter from ChuangGD in China [15], monitor lift from Fox Bay Sit – Solutions for Human [7], and many more. These companies’ purpose is to provide people easy access to the monitor. Our device, with a similar purpose, can be successfully deliverable in the near future. With our additional safety straps and clamps, we will add more benefits, also success, to the monitor devices in general.

Economically, our device is cost effective in a way that it can be manufacture in bulk with cheap budgets. Many people, not necessary industries, hospitals, or laboratories only can afford one.
Oil Paint Cap Remover

Approximately 250,000 to 350,000 people in the United States have been diagnosed with MS [12]. MS can occur between the ages of 20 and 40 and causes many sorrows for those young people. Among these are the young and ambitious painters who are struggling with their careers due to the limitations of physical abilities. Our design, which is the paint cap remover, has the great impact in improving both career and social life of many painters. This device will provide him with more confidence in achieving his career goal since he will not worry about such a small task. The users can be independent whereas he will not need any help from an assistant. They will feel much comfortable in a sense that they can use it any time without asking anyone for help. According to psychologists, humans tend to feel much confident in their work when they have a full control over it. The painters will gain back his confidence and positive determination in achieving their ultimate life and career goals. Socially, upon the full control of his painting tasks, the painters can raise his self-confidence and self-esteem. This behavior will lead to many positive impacts such as communication, social involvement, and human relationship and partnership.

The lifespan for people with MS is nearly the same as for those who do not have MS. Because of this fact, expense of diagnose, treatment, and daily health care is a big problem; billions of dollars are spent annually. Economically, the price of our device is reasonable for it can last for a long period of time. Our future implementation of the device will bring down the cost. Nevertheless, the painter is able to save a good amount of money since he does not need human assistant or any other aids.

Our ultimate goal is to be able to provide the client the maximal convenience and comfort in his working environment: less strength and easy-to-operate, compact device. There are numerous devices in the industry that allow users to open bottle, can, or lid that our client might possibly use. However, those devices do not give him a maximal comfort and minimal use of hand grip. Our device’s impact is that we satisfy every request our client asked for and it is specific made to accommodate the needs of our client.
The differences:

This is an electric bottle or jar lid opener which was patented in 1998. A base member supports a vertical travel arm, which in turn supports an electric motor. The travel arm has height adjustment knobs allowing the user to position the opener on various sized bottles [9]. This device is much similar to our device, however, the travel arm is needed to be adjusted manually by the user. In this case, our client does not have a dexterity to turn the knob. Our device is made specifically for oil paint cap, which has a clamp that holds the oil paint tip in place. This device seems to be large in size compared to our compact paint cap opener.

This powered jar lid opener was patented back in 1994. The advantage of our device over this device is that the user to manually adjust the lever to accommodate with the jar's height. We not to have the user apply any force during his task. [10]
This bottle closure opener was issued in 1990. This device can raise the bottle using the drive shaft provided with a drive shaft gear integrated with a lower clutch member having a clutch lining at its lower end and drivingly connected to a reversible motor. This device is considerable; however, it is too big and bulky. [11]

Out of these three examples, our device is better off for its small in size and easy-to-operate features.

If many positive feedbacks are given by our client, we might be able to expand the use of our device to the greater extend. Since our device is very unique and specific for one application, we might be able to produce in mass amount and deliver to all MS patients all over the nation, possibly the world. This device can be used by any other people who have the same or similar complication. The device is very easy to operate; therefore people with any age will not find any problem to use it.

The MS is not only a burden in United States, many other countries in other continents such as Europe, Asia, African, and more are suffering through the disease. Many devices are invented with the purpose to aid MS patients in various tasks such as wheel chair, electrical syringe, and many others. So far, there is no published work of any cap or specifically oil paint cap removal device particularly for MS painters. We hope that our device will help our client and all other MS painters all over the world. In addition, upon our new design and ideas, we are looking forward for other designers who wish to design a similar device that can help many MS patients nationally and internationally.
V. LIFE-LONG LEARNING

Our projects have expanded our knowledge much further in engineering discipline. Every part of our designing process allows us to gain much valuable experience that we will use in our future career. The purposes of the projects are incredibly relevant to our career that is being able to improve health and life of mankind using technological aids.

So far, we have learned different types of mechanical systems that could be used in our monitor lift. The systems included hydraulic, pneumatic, spring, and air. Through some investigation of each system, we are able to discover the advantages and disadvantages of each system regarding our unique application. For our first alternative design, we have decided on using the spring and pivot system for our device for many reasons. The advantages of this system are flexible and adjustable vertical height adjustment, avoidable unnecessary sound, compact, reliable, and simple design and manufacture. The bar integration of spring mechanism and the integration of arm bar and pivot joint allow a very smooth and substantial lowering and raising manipulation. Most devices in the world today use spring in their applications. With this knowledge about spring, we will be able to understand how other devices work and learn from it.

As mentioned, because we have used spring in our monitor life project, we are able to proceed through our second project easily. The cap removal device also uses spring system to descend the cap head to be fitted directly on top of the oil paint cap. The spring and the weight of our motor compartment together create advantages in which reduce the amount of work the user has to apply to push the head downward. This project has developed the basic knowledge of motor among the team members. Acquiring a right motor is not such an easy task as it sounds, thus it requires a good amount of knowledge about gears, rotation speed in relation with voltage supply, current in relation with the torque, size, and many other important factors. Almost all technologies operated by motors, therefore motor comprehension will serve a very important and beneficial foundation in our career lives.

This is a design project that based on the need of the client. In the past months, we have learned the skills and steps in achieving the needs of our client. As engineers, it is very important to provide all of the engineering standards and specific needs that are required from the clients. It is useless to produce a device that does not encompass all the basic specifications requested. Therefore, we have learned step by step in approaching and solving problems that are given. For instance, our oil paint cap remover project's requirements are non-manual labor, compact, and easy to operate. At first, we did not fulfill all the conditions because it was difficult to put together a perfect device in the first try. However, through the help of our client, professors, advisor, and classmates, we are able to identify and solve the problems. As of right now, we are able to have a control over our projects because we have spent a good amount of time researching and solving for any issue that come along with the design process. We have learned that for any design, it is necessary to obtain all the
information, to identify all the possible problems, and to collect feedbacks from all the surrounding sources.

Learning will never end. We acknowledge that we will have to learn more in depth about every part in our designs. Learning is not only through successful trial, also through failures in both hardware and software designs. Our projects might fail, but failure does not mean the termination of our goals. With the goals set in mind, we will accept any failure, learn, implement, and improve from it. In the future, besides our ultimate goals of which producing a working device, we also look forward to acquiring important education and expertise related to engineering.

Besides academics, we have learned a lot about team work. Our team is incorporated of four members and we are responsible for two projects. It was challenging when there are more members in a group. Initially, we struggled in dividing the tasks equally among the members of the group, setting up meetings, and putting together ideas. However, as we go along with the projects, we are able to communicate and compromise on everything that we are doing. We hope in the future, with our hard work, we will be able to deliver products that will fully satisfy our customers.
VI. REFERENCES


   URL[http://www.powerstream.com/Wire_Size.htm]


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    URL[http://www.google.com/patents?vid=USPAT5370019&id=LvQhAAAAEBAJ]


