Introduction

Cerebral palsy (CP) is a collection of motor problems and physical disorders related to a brain injury, and usually causes uncontrolled reflex and muscle tightness which can affect a part, side, or the whole body. CP can be linked to several other conditions, including mental retardation, seizures, vision and hearing problems, etc. The origin of CP can be linked to brain injuries occurring during fetal growth, birth, or during the first two to three years of life, however; the cause of the brain injury is usually not known.

Cerebral palsy is one of the most common causes of permanent disability in children and adults. CP occurs in approximately 1.4 to 2.4 of every 1000 people and its frequency of occurrence is equal for men and women. In the United States, there are currently more than 500,000 people with CP.

Since cerebral palsy affects motor control, CP patients have a difficult time with day-to-day activities. Tom Depugh, a CP patient located in Ohio, is an active member at the Passionworks art studio. Painting became one of Mr. Depugh’s favorite pastimes. A recent car accident coupled with CP has severely limited Mr. Depugh’s arm and hand movement and has left him unable to grasp. Also, when seated in a wheelchair, his head and shoulders tend to droop to the left. Providing Mr. Depugh a way to paint again is imperative for his identity, as he wants to contribute to the art studio in every way. Our three part solution is designed to allow Mr Depugh to resume painting.

I. Shoulder Support System

Objective:

The shoulder support system implements lateral wheelchair supports as well as a shoulder holder harness. The purpose of this system is to provide support and stability to the torso and upper extremities of the artist. These devices will increase the mobility of the arm of the artist and allow for longer periods of painting while minimizing fatigue and frustration. The overall goals of the shoulder support system are:

- Improve mobility, balance and posture
- Aid in torso and shoulder support and stability
- Provide the most functional positioning of the client
- Reduce the need for repositioning during the day

In order to provide an effective support system, these devices must be adjustable and versatile in order to optimize seating biomechanics. The lateral supports will consist of adjustable interlocking support members which use the interlocking devices to hold the support in the optimal position. Height is the most important consideration for lateral supports. If they are mounted too low they will be inefficient. If mounted too high, they will be uncomfortable and actually reduce mobility. Proper position is the most important consideration when providing optimal comfort and function. The later
supports will fulfill this by providing triaxial motion. This will maximize comfort and mobility for the user.

The end of the support members will have a polyurethane polymer cushioning system, which will help to contour the body. The advantage of contouring is that the forces applied by the supports are delivered over a maximal area. By increasing the area of application, the weight of the user is distributed, therefore reducing uncomfortable pressure and irritation.

Although the lateral supports stabilize the torso, the shoulder harness is necessary to further stabilize the shoulders. By providing posture correction, slumping will be reduced and arm, head, and neck movements will be encouraged. Biomechanical symmetry, balance, and dexterity are each important aspects which can be enhanced by shoulder positioning. By enhancing these aspects, the artistic experience will also be increased.

Durability and reliability are necessary for all aspects of this design. The repetitive use and cyclic loading of the supports necessitate durable support members which will not be affected by fatigue. The cushioning should have a memory feature in order to retain shape and strength. The housing for the cushioning should be tear resistant and have minimal abrasion properties in order to reduce skin and tissue irritation.

**Component Specifications:**

The lateral supports consist of 2 stainless steel rods, and two polyvinyl chloride rods. The polymeric rods are of a smaller size and fit into the steel rods. The two sizes will interconnect and allow for positioning adjustment of the entire system in two directions using a screw and flynut system to fasten the polymeric rods in their desired location. The latter of the PVC rods will connect to a cushioning mechanism which is encased in Pyrell Polyurethane. This polymeric cushioning system was chosen because it is capable of contouring to the body because of its deflection at small pressures (only .7 Psi yields a 25% deflection). The cushioning contours to the body for comfort purposes. It will dissipate the stress forces over the largest possible area.
### Table 1.1 Lateral Supports

<table>
<thead>
<tr>
<th>Components</th>
<th>Cost</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyrell Polyurethane Open Cell Foam Sheets (2sq ft.)</td>
<td>$9.49 per Sq. ft</td>
<td>Temperature Range: -40° - 225° F</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Density: 2 lbs/cu. ft.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Compression: 25% deflection at .7 Psi</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thickness: __ in.</td>
</tr>
<tr>
<td>Durable Cover Cloth (TBD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mounting Screws (TBD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stainless Steel Tubing 2ft (5/8 in.),</td>
<td></td>
<td>Size: 5/8 in.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Material: Stainless Steel – 304</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wall Thickness: .0350”</td>
</tr>
<tr>
<td>Stainless Steel Fittings (TBD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PVC piping 2ft (1/2 in.) (TBD)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 1.2 Shoulder Support Harness

<table>
<thead>
<tr>
<th>Components</th>
<th>Cost</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4in Polypropylene Webbing 10ft.</td>
<td>4.00 per 10ft</td>
<td>Strength: 450lbs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thickness: .040 in.</td>
</tr>
<tr>
<td>Pyrell Polyurethane Open Cell Foam Sheets (2sq ft.)</td>
<td>(See table 1.1)</td>
<td></td>
</tr>
<tr>
<td>DB Single Lock Double Bar Buckle (4)</td>
<td>3.96$</td>
<td>Material Acetal Nylon</td>
</tr>
<tr>
<td>Durable Cover Cloth (TBD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mounting Screws (TBD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSR Side Release Buckle</td>
<td>1.99$</td>
<td>Material Acetal Nylon</td>
</tr>
</tbody>
</table>
Technical Analysis

Since safety and reliability are the first and foremost design standards of the support system, a biomechanical static analysis has been performed to ensure that the system can sufficiently tolerate the forces imposed upon it by a user of up to 300lbs (136kg).

➢ *Lateral Supports*

These diagrams presumes the following

Assume:

- Shoulder height is approximate to the height of the back of the wheel chair
- The maximal angle which can be assumed by the torso of the user is a 180° degree bend at the waist induced by the extension of the *erector spinae* muscles of the lower back, which would invoke the largest force and can be used to estimate the maximum force that can be imposed on the shoulder harness.
- Assuming the largest user is 300lbs, an anthropometric data table yields a torso, arms, and head combined mass consisting of 67.8% of the total weight. The center of mass is 62.6% of the torso length from the greater trochanter

Fs= Force of Support
Wt=Weight of Torso
Fr=Net Force of Torso
Fc=Force of Wheel Chair
X=Joint formed at Greater Trochanter and Pelvis

Figure 1.1 – General Overview of Lateral Supports
Figure 1.2 - Static Model at Upright Position (0°)

\[ \text{Fs} = 0 \text{ lbs} \quad \text{Ft} = 0 \text{ lbs} \]

\[ \text{Wt} = 203.4 \text{ lbs} \]

\[ \text{Fc} = 203.4 \text{ lbs} \]

\[ \text{L} = 1.5 \text{ ft} \]

\[-M_x = 0, \text{ Fs} = 0\]

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Figure 1.3 - Static Model at Maximal Moment Position (45°)

\[ \text{Fs} = 245.7 \text{ lbs} \]

\[ \text{Wt} = 203.4 \text{ lbs} \]

\[ \text{Fc} = 203.4 \text{ lbs} \]

\[ \text{L} = 1.5 \text{ ft} \]

\[ \text{Length} = 3 \text{ ft} \]

\[ -M_x = (\text{Torso Weight} \times 0.678) (\text{Length} \times 0.626) (\cos 45) + (\text{Force of Support})(\text{L}) = 0 \]

\[ -M_x = (300 \text{ lbs} \times 0.678)(3 \text{ ft} \times 0.626)(\cos 45) + (\text{Fs})(1.5 \text{ ft}) = 0 \]

\[ \text{Fs} = 254.7 \text{ lbs} \]
These diagrams presumes the following

Assume:

- The maximal force invoked on the lateral supports is applied when the torso is bent to the side at a maximal angle approximate to 45° degrees.
- Assuming the largest user is 300lbs, an anthropometric data table yields a torso, arms, and head combined mass consisting of 67.8% of the total weight. The center of mass is 62.6% of the torso length from the greater trochanter

Fw=Force Webbing
Ft=Net Force of Torso
Wt=Weight of Torso
Fc=Force of Wheel Chair
L=length

Figure 1.1 General Overview of Shoulder Supporting Harness
Figure 1.2 - Static Model at Upright Position (0°)

\[ F_w = 0 \text{ lbs} \]
\[ F_t = 0 \text{ lbs} \]
\[ W_t = 203.4 \text{ lbs} \]
\[ F_c = 203.4 \text{ lbs} \]
\[ M_x = 0 \text{ ft} \text{ lbs} \]

\[ M_x = (L \times 0.678)(W_t \times 0.626)(\cos 45) + (F_w)(L)(\sin 45) = 0 \text{ ft lbs} \]

\[ F_w = 0 \text{ lbs} \]
\[ F_t = 0 \text{ lbs} \]
\[ W_t = 203.4 \text{ lbs} \]
\[ F_c = 203.4 \text{ lbs} \]
\[ M_x = 0 \text{ ft} \text{ lbs} \]

Figure 1.3 - Static Model at Bent Position (45°)

\[ F_w = 127.3 \text{ lbs} \]
\[ ? = 45° \]
\[ W_t = 203.4 \text{ lbs} \]
\[ ?M_x = 0 \]
\[ F_c = 203.4 \text{ lbs} \]

\[ M_x = (L \times 0.678)(W_t \times 0.626)(\cos 45) + (F_w)(L)(\sin 45) = 0 \text{ ft lbs} \]

\[ M_x = (3\text{ ft} \times 0.678)(300\text{ lbs} \times 0.626)(\cos 45) + (F_w)(3\text{ ft})(\sin 45) = 0 \text{ ft lbs} \]

\[ F_w = 127.3 \text{ lbs} \]
This data is used to determine the maximal forces that the user will apply to the supports. The shoulder support harness must consist of webbing that can support a maximal amount of 180.7lbs, while the lateral supports should be constructed to support 254lbs. These forces are not likely to occur, but could theoretically occur if the client adjusts his position to an extreme angle. By overestimating the maximal forces, safety can be improved and guaranteed. The components selected meet the specific force requirements to ensure safety while maximizing function.

**II. Paint Dispensing Brush**

**Objective:**

The design of a very specific paintbrush has been requested. It is imperative that there is ease of use for the client. In order to achieve this, the client’s needs were key factors in the brush design. The necessary features of the brush include:

- Gravity defying paint flow
- A wrist strap
- A standard voltage supply
- A switch that is operated with the forearm
A compact and safe overall design

The automatic paint dispensing brush (see figure 2.1) is designed to dispense acrylic paint onto a brush at the discretion of the client. The handle of the brush is essentially a syringe. The plunger is moved using a linear actuator screwed into the shaft of the syringe. The actuator will be operated with a switch. The switch is large and highly pressure sensitive to accommodate to the patients disability. This switch will be in series with a smaller three way toggle that will be controlled by the caretaker. The client uses acrylic paint which needs to be applied sparingly. Therefore the brush will dispense no more than 2.5 cc of paint per second the switch is on. Power will be supplied to the brush using a 9V battery. A circuit will regulate the voltage delivered to the linear actuator. The three-way switch leaves the brush on, off, or puts the motor into reverse. The reverse option allows the caretaker to refill the brush with paint by pulling the plunger up with the actuator. This mechanism is shown in Block Diagram 2.1. The brush, toggle switch, and batteries need to be mounted onto a comfortable but durable fabric backing. The backing will have Velcro straps that attach to the clients forearm and wrist. This allows the client to paint without the use of his hands which is a major requirement of this system. There will be one wire leaving the clients arm. This will be connecting the paint releasing switch that the client can operate with his other arm.

![Complete Automatic Paintbrush Design](image)

Figure # 1.1: Complete Automatic Paintbrush Design
Block Diagram #2.1: Paint Control Loop

Does the paintbrush contain paint?

- YES
  - Operate paint release switch
  - Paint flows to brush

- NO
  - Operate paint uptake switch
  - Motor reverses
  - Paintbrush is refilled
  - Switch to off
Technical Analysis:

The manufacturer specifies that the operating speed of the motor varies based on thrust. Various resolutions are available ranging from .003175 mm to .002 mm per step. The speed the size 11 actuator with a resolution of .003175 mm of linear travel/ step varies according to thrust. The operating speed of the actuator is between 200 and 1100 steps/ sec. With a 30 mm diameter syringe, the maximum paint flow rate was determined to be 2.47 cc /sec.

A 5 V power supply is required for the linear actuator. In order to use one 9 V battery the following circuit was designed to regulate voltage:

![Circuit Diagram]

Figure # 2.3: Complete Automatic Paintbrush Design

Components:

*Figures located below

1. The syringe should be made of polypropylene. This material was chosen because of its resistance to most acids. Acrylic paint contains acrylic acid which is corrosive to metals. Therefore a plastic was chosen instead. The diameter needs to be larger than 28 mm to accommodate the actuator.

2. The plunger of the syringe needs to be able to be screwed into the linear actuator. A rubber ring should be integrated for a tight seal.

3. The linear actuator is from Hayden Switch and instrument. It is a size 11 captive linear actuator. Its diameter is 28 mm which is the largest possible actuator that can be incorporated in order to be cost efficient. The actuator has a resolution of .003175 mm of linear travel/ step. This was decided based on calculations in the technical section. The linear actuator is rated for 2.1, 5, or 12 V DC. This actuator consumes 4.2 W of power.
4. The toggle switch is a special version of the single pole double throw switch. It has a third switching position in the center which is off. Momentary on-off-on versions are also available where the switch returns to the central off position when released. This would be incorporated as a safety measure for the reverse switch. One of the on positions would reroute control to the client controlled switch. The other on position would operate the motor in reverse.

5. A switch such as the Joggle switch will be used for several of its features. The switch is a large five inches ensuring ease of use. It can be operated at pressures ranging from 200 grams to 1.5 kilograms.

6. The actuator runs off a 9 V battery. A circuit will be incorporated to regulate the voltage down to 5 V. Design and parts are explained in the technical section.

7. The paintbrush is mounted on a heavy duty fabric. Velcro straps attaching the brush to the fabric at a variety of angles. Velcro straps also attach the whole apparatus to the client’s wrist and arm. Circuits will be boxed and contained in or on the fabric pending final size.

8. The brush is made of nylon or polyester filaments which are easy to clean.
III. Easel

Objective:

The adjustable art easel implements motion of the canvas area in four different planes. The purpose of this system is to provide simple adjustment of the canvas area so the artist can cover a wider area of canvas. The overall goals of the adjustable art easel are:

- Provide the most functional easel position for the artist
- Allow for canvas adjustments using simple controls
- Promote a safe, hazard free drawing atmosphere

In order to provide an effective adjustable art easel, the device first must be built with strength in mind. This permits the attachment of the heavy movement components. To achieve strength in the frame, steel is the material of choice. General purpose 1008/1015 low carbon steel provides the proper strength for the current application. With a well thickness of .06” and a width of 1-1/4” x 1-1/4”, the current application will never propose enough stress to even approach the yield strength of the material which is 686 Mpa. 1008/1015 low carbon steel was also the material of choice because it is easy for form, bend, braze, and weld. This supports our application because the frame of the adjustable easel will need to be welded together to provide maximum strength.

Attached to the stable, strong base will be components for motion. The easel must move in four different planes of motion, suggesting four separate components to provide that motion. The motion components of choice are DC linear actuators. DC linear actuators provide the proper push/pull force necessary to move the canvas about in the four directions, as well as providing the proper static force to maintain proper positioning when painting. A maximum push/pull force of 110 pounds and a maximum static force of 550 pounds is more than enough for the proper application. The actuators of choice have built in limit switches. These limit switches ensure that the actuator is never pushed beyond a specific point, making sure the canvas area is never forces past its maximum value of movement. Four DC linear actuators will be utilized in the design, one to control each plane of motion.

Since DC linear actuators run off direct current, a power supply must be incorporated into the design to transform the AC current from the well, to the DC current necessary to power the linear actuators. An AC/DC power supply incorporates a rectifier and a transformer. The transformer is the part of the power supply which converts the AC current to the necessary DC current. The rectifier ensures that once an AC current is converted in the transformer to a DC current, the DC current cannot travel backwards through the circuit. The power supply of choice accepts an input voltage of 115 VAC at 60 Hz and produces an output voltage of 12 VDC at 6 amps. The power supply is perfect for the current application because now we are able to power the adjustable easel from a wall circuit (115 VAC) and then convert the AC voltage form the wall to the necessary DC voltage (12 VDC) which is required to power the linear actuators.
The power supply converts the AC voltage to the vital DC voltage so that the actuators can have power. Once the actuators have power, they need some sort of control. A requirement for the adjustable easel was that it should be simply controlled. The simplest way to control the movement of the adjustable art easel is with one switch for each plane of motion. Each switch will be made up of a forward-off-reverse positioning system, with spring return to the off position. This ensures that once the desired location of the easel is reached and the switch is released, the linear actuator will immediately stop movement and remain static until the switch is activated again. The switches of choice are rated at a maximum of 15 amps, which is more than enough for the current design. The switches come with built in jumpers for a two wire in, two wires out connection, which minimizes that amount of wires required to hook up with system, and in turn minimizes any hazards created from access wires.

Another necessity for the adjustable art easel is some sort of glide or rail system so that the canvas top can effortlessly move to the desired location. Each rail system must tolerate precise linear motion so the actuators can alter the desired canvas location without any complications. Simple ball bearing rails are the preeminent selection of this application. Simple ball bearing rails can handle large dynamic loads, can be mounted at virtually any angle, and provide accurate linear motion without any difficulty. These ball bearing rails do not need any access attention in the form of maintenance (i.e. re-grease bearings periodically) because they are made up of a closed system; consequently, they make up the best glide system for the current application.

The final component of the adjustable art easel is the canvas drawing board. This board must be large enough to accommodate a variety of drawing sizes, however; its weight is an issue so that it does not put any unneeded stress on the actuators which moves it. The desired board size is 36” x 24” x 1”, which will accommodate the large variety of drawing sizes. The drawing board will be made up of a light weight cedar with a Formica laminate on top. Cedar is one of the lightest woods available, keeping the weight of the drawing board as small as possible. The Formica laminate serves multiple purposes. First, it proves a smooth drawing surface so the artwork isn’t affected in anyway by discontinuities of the drawing board. Second, the Formica laminate provides a drawing surface which can be cleaned easily following the completion of the drawing period. Lastly, the laminate allows the artist to secure the artwork to the board, using tape or other fasteners, without affecting the drawing board in the long run.

Component Specifications:

<table>
<thead>
<tr>
<th>Type</th>
<th>Thickness</th>
<th>Width</th>
<th>Tolerance</th>
<th>Yield Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>1008/1015 carbon steel</td>
<td>.06&quot;</td>
<td>1-1/4&quot; x 1-1/4&quot;</td>
<td>Standard</td>
<td>686 Mpa</td>
</tr>
</tbody>
</table>

This steel proves best for the current application. It provides more than enough strength with a yield strength of 686 Mpa, and also provides enough weight to create a heavy, sturdy base structure. The steel is easily welded, and strength isn’t sacrificed when welding this low carbon steel.
DC Linear Actuators

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Stroke</th>
<th>Push/Pull Force (max)</th>
<th>Static Force (max)</th>
<th>Current Draw</th>
<th>Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZYJ(s)-24</td>
<td>24&quot;</td>
<td>165 lbs.</td>
<td>550 lbs.</td>
<td>3 amps (max)</td>
<td>12 VDC</td>
</tr>
<tr>
<td>ZYJ(s)-18</td>
<td>18&quot;</td>
<td>165 lbs.</td>
<td>550 lbs.</td>
<td>3 amps (max)</td>
<td>12 VDC</td>
</tr>
</tbody>
</table>

These DC linear actuators are best for the current application. They provide the proper stroke (movement distance) for the current application. With a maximum push/pull force of 165 pounds, these provide more than enough force to move the drawing board. Once the drawing board is in the desired location, these DC linear actuators provide a maximum static force of 550 pounds, meaning it would take over 550 pounds to move the actuators. The actuators draw a maximum of 3 amps (current) which is half of the output current of the power supply.

Power Supply

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Input Voltage</th>
<th>Output Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS-1260</td>
<td>115 VAC (60 Hz)</td>
<td>12 VDC (6 amps)</td>
</tr>
</tbody>
</table>

The power supply is the best for the current design. With an input voltage of 115 VAC, the power to the adjustable easel can be controlled using a standard wall outlet. The output voltage is 12 VDC, therefore, the power supply will be able to power the linear actuators.

Switches

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Rating</th>
<th>Wiring</th>
</tr>
</thead>
<tbody>
<tr>
<td>EM534</td>
<td>15 amps (max)</td>
<td>2-in 2-out</td>
</tr>
</tbody>
</table>

These switches will simplistically control the linear actuators the best for the current application. They are rated at 15 amps max, which is more than necessary for this design. They are set up as reversing switches, therefore, when wired, they can be flipped forward to extend the actuator, or when flipped in the opposite direction, they reverse polarity, and retract the actuator.

Glides and Rails

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Dynamic Load Cap.</th>
</tr>
</thead>
<tbody>
<tr>
<td>6709K02</td>
<td>627 lbs.</td>
</tr>
</tbody>
</table>

These ball bearing rails are perfect for the current design. Their dynamic load capacity is 627 pounds, which is more than enough for the current application.
Technical Analysis

Again, safety and reliability are the first and foremost design standards of the adjustable easel. In order to ensure that the easel can sufficiently tolerate the forces imposed upon it, mechanical static analysis has been performed using maximum force values.

The adjustable easel is designed to overcome any forces put on it from outside sources (i.e. painting). The maximum moment created on the easel by the artist is produced when the drawing board is in the utmost vertical position. In this design, the utmost vertical point on the drawing board is 45” above the bottom. To ensure proper design specifications, a vertical point of 50.5’ above the vertical access is chosen. Drawing doesn’t impose large forces, however; testing the easel using large forces is essential to ensure safety. A force of 50 pounds is used when testing the easel to adequately cover a wide variety of drawing forces. When the 50 pound force is applied vertically to the easel at a height of 50.5” a moment by that force, about the opposite lower corner of the easel. This maximum moment based upon these data values is 2525 inch-pounds. The centroid (or center of gravity) of the easel was calculated around 19.2” in the horizontal direction and 15.5” in the vertical direction. Using this point as the application for the majority of the weight of the easel, the easel would need to weight in at around 132 pounds to overcome to moment created by the 50 pound force. The assembled easel will weight well over this weight, considering it is made from steel and contains four large linear actuators.

Figure 3.1: General side view with adjustable easel at utmost vertical position
Figure 3.2: General back view of adjustable easel

Figure 3.3: Side view of adjustable easel with drawing board tilted forward
Figure 3.4: General 3D drawing of adjustable easel
Block Diagram 3.1: General block diagram demonstrating the adjustable easel mechanism
## Budget

### Tabletop Adjustable Easel
1. (10)- General purpose 1008/1015 low carbon steel (6’ sections) - $12.00
2. (1)- DC Linear Actuator- (24” stroke) - $79.00
3. (3)- DC Linear Actuators- (18” stroke) - $79.00
4. (1)- Power supply (AC/DC conversion) - $40.00
5. (4)- 3-way switches (extend-off-retract) - $6.00
6. (3)- Guide rails - $98.00

### Patient Support System
1. Webbing - $10
2. Single Lock Double Bar Buckles - $5
3. Lateral Supports and Cushioning - $40

### Paint Dispensing Brush
1. Linear actuator (Size 11: 28 mm Captive) - $121.20
2. Large Pressure Variable Switch (Diameter: 5’’) - $40.00
3. Velcro and Heavy Duty Fabric - $15.00
4. Syringe (Needle-less) - $3.00
5. Brush Nylon/Polyester Filaments - $5.00
6. Battery (9 V) - $7.00
7. 3-way toggle switch - $5.00

Total - ($1045.20)
Conclusion:

The combination of the shoulder support system, the adjustable easel, and the paint dispensing brush, will help to enhance the painting experience of our client and other users with cerebral palsy. The products are designed specifically for users with mobility limitations. Although there are current market products addressing these issues, they do not meet the needs of our specific client. The following designs accomplish all specifications needed for ease of use.