Design 1

Easel 5000

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OBJECTIVE

Project Easel 5000 is a cooperative effort between UConn’s Biomedical Engineering Senior design class and the National Science Foundation, or the NSF. The specific project being worked on for the NSF is called “Engineering Projects to Aid Persons with Disabilities.” The objective of project Easel 5000 is to build a new adjustable easel for an artist with cerebral palsy. Previously, an adjustable easel was designed in 2003. However, it did not completely fulfill the needs of the artist. The first design did not have the adjustability needed. It also had a motor that the artist had difficulty using and was a tripping hazard because of the motor’s electric cord at the location where it was used.

The objectives of the project are to build a new adjustable easel that meets the specifications presented by the NSF. These specifications fall into four main categories: environmental, electrical, mechanical, and economical. The environment the easel will be used in will require it to be portable, table top size, and easily used in a busy art room setting. The electrical requirements will include a cordless light source with an easy on/off switch. Mechanically, the easel will need stability, flexible locking joints, and be able to accommodate a 20” x 20” canvas. Economically, the design and construction of the easel must cost less than $750.

The easel design can be broken down into five major components. The components are the light source, the adjustable easel mount, the canvas holder, the easel extension, and the base.
LIGHT SOURCE

The light source has some basic functional requirements. It must be battery operated to reduce any tripping hazard that could result from a power cord. It must be light weight and compact, yet provide sufficient light to illuminate the canvas surface. An easy on/off switch is also desired for ease of use. Also it would be beneficial if the light source was energy efficient and required minimal battery changes.

A light emitting diode, or LED, is the best solution to all of the above requirements. LED’s are low cost, have an extremely long life, are durable, and emit little heat. It was found that an LED lighting system with power supply and various other compact components would not only be time consuming to construct but fairly expensive. After some research it was found that a pre-constructed LED system intended as a head lamp for camping was the best choice. The price was reasonable at $69.95 and it was very compact. Furthermore, it would save time during the construction phase of the project.

Figure 1 includes the Black Diamond space shot head lamp. This product has an integrated xenon LED system that can shine up to 140 meters but can also be adjusted to lower brightness levels. It is light weight, compact and portable. It also has an easy on/off mechanism as well as a rechargeable battery pack that can last for 11 hours. In order to make this product fit the project’s requirements, it will have to be slightly modified. The head mount will be removed and the light portion will be attached to the canvas holder portion of the design via adjustable plastic hinge. This system will be tested simply by mechanical manipulation.
ADJUSTABLE EASEL MOUNT

A steady painting surface is important so that the canvas mounting surface will be held in place securely. Since there will be two supporting “arms” that will hold the easel face, a tilting mechanism similar to that of a mobile chalk board will be used. On each side, a hole will be drilled through the frame of the canvas mount and the supporting beam. A nylon washer will be placed between the edge of the frame and the mounting arm to reduce wear on the surfaces. A threaded bolt will then be fitted through the hole and through the washers. A second washer and a wing nut will then be placed onto the threaded end of the bolt and tightened, acting as a lock so that the easel
mounting surface will not tilt back and forth. A side view is included (See Figure 4). See appendix for mechanical stress analyses.

![Diagram of Adjustable Easel Mount]

**Figure 2: Adjustable Easel Mount**

**CANVAS HOLDER**

The canvas holder will be the portion of the easel that holds the canvas onto the easel. The canvas holder used in this design is very similar to basic easel designs. The easel will hold the canvas and will be the support for the painting. It is to be designed to be capable of holding canvas sizes up to 20”x20”. The canvas holder will be produced out of a 1” x 4” pine wood beams. Pine wood is cost effective as well as lightweight and can still mechanically function as necessary.

The bottom piece of the easel mount will act as the canvas sill to support the bottom of the canvas. Perpendicular to this piece will be another piece of wood to support the back of the canvas. This piece of wood will have a track on the inside made
of aluminum, spanning the entire length. The track is for the canvas clamp. The clamp will be a shorter 1” x 2” pine beam with a thumbscrew through it. When tightened, this screw will make contact with the metal track, tightening on a rectangular nut set in the track. The pressure here will stop the canvas from any movement, thus locking it in place. See appendix for mechanical stress analyses.

**Figure 3: Front View of Canvas Clamp**

**Figure 4: Side View of Canvas Clamp**
EASEL EXTENSION

The easel extension is an important part of the design. This is the part of the design that gives the easel its adjustability. The adjustability will be obtained by an articulating joint system with manual lockable positions. The system will be symmetrical with two arm extensions on either side. The first arm extension comes off of the easel's base, and is 30 inches in length. The second arm extension will be attached with a sliding joint that can lock in several positions. This arm is also 30 inches in length. The arms will be made of 1” x 2” white pine beams. The two arms will be attached to one another by two stabilizing joists. See appendix for mechanical stress analyses.

Figure 5: Side View of Easel Extension
EASEL BASE

The base of the easel needs to support the rest of the easel and attach to a tabletop. The base will attach to the table top via two C clamps. The base will then be attached to the easel extension. The easel extension will attach to the front of the base using a hinged drafting table support (shown left). This hinge is strong enough to support a drafting table and even a bed. When used with a back flap hinge, it lifts to a desired angle, then locks. It operates at a maximum angle of 112 degrees. These drafting table hinges are also inexpensive, costing only $17.95 a pair. In addition to these functions, the base will contain a small drawer for paintbrush storage and a small swing out shelf that will be able to hold a small container for paint brush cleaning. A pivot hinge will be used for the swing-out shelf. The dimensions for the base will be 30 inches wide and 15 inches deep with an estimated weight of 10 pounds. See appendix for mechanical stress analyses.

Figure 6: Top View of Easel Base
Figure 7: Front View of Easel Base

Figure 8: Side View of Easel Base

Figure 9: Easel Base Dimensions
Figure 10: Conceptual Drawing of Easel5000

MATERIALS LIST

White Pine

Canvas Frame
- (2)(1"X2") 23"
- (2)(1"X2") 26"
- (1)(1"X4") 26"

Support beams and extension
- (4)(1"X2") 30"
- (1)(1"X2") 24.5"
- (1)(1"X2") 26"

Base
- (2)(1"X4") 12.5"
- (3)(1"X4") 8"
- (2)(1"X4") 15"
- (2)(30"X.5"X15")
- (1)(7"X7"X.75")

Dimensional Lumber Needed
- (3)(1"X2"X96") ($22.92)
- (2)(1"X4"X96") ($14.70)
- (2)(2"X8"X120") ($45.60)

Hinges
- (1) reversible pivot hinge SKU-219660 ($15.97)
- (2) Hinged drafting table support SKU-286357 ($17.97)
- (2) Back flap hinges SKU-218056 ($5.59)
- (2) Slidding hinges SKU-206248 ($5.38)
C Clamps
(2) Shop Fox H0988 Extra Deep Aluminum C-Clamp ($17.90)

Light
(1) Black Diamond head lamp ($69.95)

Others
Washers
Wing nuts
Nails
Screws
Wood glue

Estimate ($40.00)

Total Cost Estimate
$255.98

MECHANICAL CALCULATIONS

To verify the strength of materials, research was done and the weights of materials to be used were estimated as well as the maximum amount of brush pressure to be applied to the device (See Appendix A-1). By calculating the maximum moment that could be applied to cause the easel to tilt, the appropriate components to support the easel canvas mount could be used. For detailed calculations please see Appendix A-2.

The positioning of the device that would yield the maximum amount of stress on the supporting members was then used to calculate the maximum force and stress that would be placed on the beams. The easel supports are expected to experience the most stress under a bending moment. As such, those calculations were done using a bending cap of 7300 PSI and a factor of safety of 3 giving a potential yield point of 2433.3 PSI. After creating the free body diagrams and proceeding with the calculations, the maximum bending stress that occurred in beam 1 was 191 PSI while the maximum bending stress in beam 2 was 211 PSI. Both were well below the safe yield point of the material. These calculations are show in Appendix A-3.
APPENDICES

Note for Appendix A-1.1 to Appendix A-2.4: These tables are too large to include so they have been provided separately and are attached at the back of the Design 1 packet. This is simply a list of descriptions of each Appendix

Appendix A-1.1: Researched values for wood type strengths, and densities. The items highlighted in gold are used in other tables. Since volumetric calculations are done in in^3, the weight of pine was changed as such.

Appendix A-1.2: Materials dimensions and weight calculations for mechanical analysis, and cost purposes.

Appendix A-2.1: Easel Canvas mounting surface calculations done in Excel involving forces on the joints attaching the easel canvas mounting surface to the extender arms.

\[ \Sigma \text{Moments} = 0 \]
Equations used: \[ M = F \times D \]
\[ \Sigma \text{Forces} = 0 \]

Appendix A-2.2: Easel Canvas mounting surface calculations done in Excel involving stresses on the joints attaching the easel canvas mounting surface to the extender arms.
Equations used: \[ \tau = P / A \]
Appendix A-2.3: Easel extender arm stress calculations. These calculations show that the forces put on the members will not exceed the pressure cap set by the researched bending stress limit.

\[ \sigma = \frac{(M \cdot c)}{I} \]

Equations used:

- \[ I = \frac{1}{12} b \cdot h^3 \]
- \[ M = F \cdot D \]

Where \( \sigma \) is the bending stress, \( I \) is the moment of inertia, \( F \) is force, \( D \) is distance.

Appendix A-2.4: Easel canvas clamp weight and force calculations leading to shearing stress acting on the thumbscrew by canvas clamp.

Appendix B-1.1: Front View of the Easel Canvas Face

Appendix B-1.2: Front view, Free Body Diagram used in Appendix A-2.1 and A-2.2 Calculations.

Appendix B-1.3: Side View of Easel Canvas Face

Appendix B-1.4: Side View Free Body Diagram used in Appendix A-2.1 and A-2.2

Appendix B-2.1: Free Body Diagram used in Appendix A-2.3 Calculations.