DESIGN 3

By:
Frank Molnar
Adam Ross
Jonathan Sapienza
Jacqueline Tabor

Senior Design TEAM 4

Client Contact: Brook Hallowell, NSF
(740) 593-1356
hallowel@ohio.edu
Introduction

The goal of this project is to design an easel that is adjustable and that is safe and easy to use within a community of cognitively impaired individuals. The easel is required by our sponsor NSF, specifically Brooke Hallowell, to be light-weight and easy to store when not in use, and to be able to move in various directions. Some of the effects of cognitive impairment are that our client, Harry Grim, has limited dexterity and limited arm movement. We have designed an easel according to these specifications and are confident that Harry Grim will be pleased with the outcome of his new easel.

Design

Our easel is electrically controlled by two detachable joysticks which allow the operator to move the easel in multiple different planes. Each joystick moves the easel in various different directions. One of the joysticks will be responsible for the front to back and up and down motions and the other will be responsible for back to front and tilt motions. We decided to use two joysticks instead of one for the movement, because the devices have to be easy for Harry to use with his limited capabilities. If there are too many directions on one joystick it might be difficult for him to reach the desired positioning of the easel. The joysticks are controlled by relays and a design of this setup can be seen later in the report. Once the user makes an input with the joysticks of which way they would like the easel to move, the easel will respond by having the actuators and scissor jack units make the requested movement to the easel. The first action taken to begin a well developed design for our adjustable easel involves a block diagram which states the basics as to what the project must do. This involves an easy set up, elementary styled controls for user input, dynamic movement of the easel, and a basic electrical flow diagram.

Figure 1 - Block Diagram for Easel Operation
The design will essentially be a scissor jack which will be seated on the table. The base unit will have two clamps spanning to each side of the table to keep it sturdy while in use. Adding another clamp to the design of the easel will make our project safer in the environment it will be used in as well as easier to work with and will extend and compress according to the desired movement. The scissor jack will be moved by an actuator attached to the bottom of the unit. The scissor jack will be responsible for balancing most of the weight for the easel and the up and down movement. An actuator will be attached to the back of the canvas that is attached to the unit so that the easel will be able to be tilted towards and away from the user as needed. There will be a non-captive actuator that sits on the scissor jack so that the canvas will be moved from left to right as guided by the joysticks.

There are multiple safety features that our design includes. The easel cannot move at dangerous or uncontrollable speeds so we will use limits to control this motion. We are making sure that all the wires are safely attached and not exposed to anyone who might be tempted to tug or pull them out. We have also included a master on/off switch that lights up that will allow a supervising attendant to decide when the operator is done or use in case of an emergency. This switch will be placed in the back of the easel so that it is not easily accessible to people who aren’t authorized to use it. We have also ensured that the movement of the easel itself is not too fast with the actuators or that it will overextend beyond its maximum range. This is done through the use of adjustable limiting switches which we will preset for the client.

Instead of building a complicated easel frame for which the easel to sit, now a large piece of 1/8” thick sheet aluminum will be included allowing a nice flat surface for the artist to paint on. This 30” by 20” sheet will also be provided with clips and a half inch lip at the bottom for the canvas to sit on. This design will also allow the artist to simply attach the paper of canvas on which they are painting directly to the easel face, removing the need for a required canvas frame.

As stated, vertical positioning for the easel has changed dramatically. Two scissor jacks fabricated with 1”x2” aluminum angle will slide within 2” square tubing, which will shelter moving parts and protect curious fingers from being injured. All the other movements will be controlled similarly to the first design, however the tracking systems and order of operations have changed dramatically. The use of drawer tracks in the first design has been evaluated to be too flimsy and insufficient to stabilize the easel under constant brushing conditions by the painter (i.e. the easel will shake as the artist paints). In order to resolve this problem, the use of rails and heavy duty slides will provide sufficient stability. 1” and 2” casters running through aluminum tubing and channel pieces will allow a steady rail system that can maintain stability under different loading conditions. The scissor jacks and horizontal movements will run through these fabricated rail systems. Four different actuators will be used in this design;
- 9” Linear Actuator for the scissor jacks
- 2” Linear Actuator for the tilting of the easel face
- 12” Linear Actuator for front to back motions
- 9” Non-Captive Actuator for horizontal movement

As stated, this design differs greatly in the approach used to move the easel. After establishing the use of the scissor jack for the backbone of the easel, the process on how to electrically control and move the canvas became a complicated task. The scissor jack will be constructed of the aluminum, and the drawer tracks from the first design will be brought back for left to right motion. Ideally, installing actuators directly into the scissor jack assembly will
safely prevent anyone to tamper with dangerous moving parts. However there will be a variety of calculations to do to configure this arrangement due to the dimensions and sizes of actuators. The base of the easel will be made of sheet aluminum and all electrical circuitry needed for the project will be connected here. There will be a sheet of aluminum covering the top of the scissor jack to maintain the safety of the design. Cubbies and drawers for painting supplies can also be added into the base. The basic front and side views of this design can be seen in figures 1 and 2 respectively.

Figure 1: Front View of Easel
Mechanical Analysis

The mechanical design of this device is greatly different than the first two designs. The clamping mechanism is adjustable to change with the corresponding table to which the easel will be attached. Instead of gripping around the front of the table, however, two arms will expand sideways, clamping to the ends of the table laterally. As seen in Figure 1, the arms will slide within 2” tubing and be adjustable within the base of the easel. The screw clamps are similar to the first design except now the screw clamps will be more accessible and easier to tighten. Adjusting the arm length will also be easier in this design, as the arms will rest nicely on the table making the procedure to fasten the arms less demanding on the artist. However, problems
with this clamping style include circumstances where a table is propped against a wall. Circle or oval shaped tables can also pose a problem to the way this easel can be clamped. The arms will have a total stretching range from 30” to 54”, providing a 24” length range for the tables provided at Passionworks. Figures 3 and 4 show the contracted and expanded versions of the clamps.

**Figure 3: Clamp Arms Retracted**

![Figure 3: Clamp Arms Retracted](image)

**Figure 4: Clamp Arms Expanded**

![Figure 4: Clamp Arms Expanded](image)

Movement of the easel will be provided through four actuators as stated before. Front to back movement will run along two Accuride® Heavy Duty Full-Extension Slides mounted on the 2” tubing base. These slides are much sturdier than the drawer tracks used for design 1 and will provide the sufficient stability for hard brush strokes to the canvas. A 12” actuator will provide this front to back movement. One end of the actuator is situated to the base of the easel while the adjustable end is attached to a lip connected to the scissor jack frame. The 2” x ¾” W slides will mount nicely to the tubing, and have been cycled 10,000 times. The 12” actuator comes equipped with adjustable limit switches and a 14 in/min driving speed. Figures 5 and 6 depict this front to back movement.

**Figure 5: Retracted Slides**

![Figure 5: Retracted Slides](image)
Vertical movement is the most distinguishable difference in this design. The use of a well built scissor jack made from aluminum angle pieces bolted back to back will provide an extremely sturdy and unique way to raise and lower the easel. Two scissor jack assemblies will be constructed on the left and right sides of the easel. Running bars connecting the jacks will provide even and steady movement. A 9” actuator attached at the midpoint of the bars will allow one actuator to control both scissor arms. The angle pieces will be connected by casters to the inside of slotted 2” tubing. The tubing will safely enclose the rail system, safely protecting the artist from any dangerous movable parts. The 9” actuator connected at the base ends of the running bars will allow the 15” long scissor arms to elevate 12” off the table. This produces a much larger vertical range of motion for this easel, allowing the easel to be used on a shorter table. This design can also showcase an artist’s masterpieces better, elevating the artwork high above a table for a more climactic effect. Figures 7 and 8 show the vertical capabilities of this device.
Figure 8: Scissor Arms Stretched

*Note that the actuator would normally be hidden behind the slotted tubing, but for purposes of these diagrams they are drawn slightly above.

Horizontal movement is the next step in the design of the easel. On top of the scissor jacks, two pieces of rectangular tubing will act as rails for horizontal movement, where a 9” Non-captive actuator provides motion in this plane. The function of this movement is somewhat similar to the first design, however now the actuator must provide movement for a larger load (in design 1, the horizontal movement simply moved the light-weight face of the easel).

Finally, tilting functions will work on top of the rectangular rails, allowing the easel face to pitch front to back. The aluminum sheet will be pivoted around a point with a range of 9 degrees back to 30 degrees forward. It has been determined that an artist sitting down needs the forward tilt much more than tilting the easel back, and away from the artist. Having this larger forward tilting range is more ideal as the artist will not need to stretch forward as much. In addition, the position of the actuator attached to the easel face has changed so that a 2” linear actuator can be used instead of a heavier 9” actuator. Figures 9 and 10 show this range of motion.
Electrical System

The electrical system controlling the easel is a vital component in the overall functioning of the system. While it requires little mechanical design, the mechanism controlling current flow throughout the system must be efficient, practical, and reliable as it powers the actuators which are perhaps the most important modules in the design.

The easel itself will be powered by 120 VAC which will be supplied from a standard wall socket. The ground terminal of from the socket will be attached to the aluminum frame of the easel to protect against any electrical shocks in the event of an accident. The 120V line from the socket will feed into a single pole single throw switch which will be mounted to the frame and serve as a master control for the easel. By turning the switch off, all current flow to the easel and its circuit is halted. The output leg of the switch and the neutral line of the socket will then be run into a transformer and the voltage will be stepped from 120VAC to 12VDC. The majority of the electrical system will run on the 12VDC power.

The four different actuators used in the system will run on 12 volts DC and at a full load will draw 3 amps. Because a maximum of two actuators can be run at any time the total current draw for the circuit should not exceed 6 amps. To protect against this, a fuse will be inserted into the +12 VDC leg from the transformer. Any circuit portion drawing more than 6 amps at any given time would indicate a malfunction with the unit. The +12VDC and ground legs from the transformer will then run to a number of locations. Eight relays will be used to control the current to the actuators. These relays will be double pole double throw and rated for 5 amps at
12V. The main terminal of each pole will be connected to +12VDC and ground respectively. The normally closed terminals will be left unwired, and the normally open terminals will be wired to the two legs of the actuator. Two relays are needed for each actuator; one to control extension and a second retraction. This is because the direction of the actuator is controlled by simply reversing the wire connections. Therefore each set of 2 relays will be wired oppositely.

The joysticks used to control the movement of the easel consist of a 4 directional handle and 4 separate momentary micro switches – one switch for each direction. Because these switches are not capable of carrying the high 3amp load of the actuators, each switch will be connected to a 12 VDC supply. The output of each switch will be wired to one end of the coil on one of the relays. The second end of the relay coils will be connected in parallel to ground. As a result, when one of the joysticks is moved in a certain direction, the micro switch will be activated. This will allow the 12VDC to power the coil in a particular relay. The relay mechanism will then engage the contacts on its poles and allow the actuator to be powered.

This design allows for more than one actuator to be active at a time by using the two joysticks. However, because of the mechanics of the joystick, only one direction of any actuator can ever be active at a time. A full circuit diagram can be found in Figure 11.
Figure 11 – Electrical System Wiring Diagram

Joystick 1

Joystick 2

Actuator 1

Actuator 2

Actuator 3

Actuator 4
Budget:
Total = $750.00 allowed

(1) 9" Actuator .......................... $34.95 ea.
(1) 12" Actuator ..........................$34.95 ea
(1) 2" Linear Actuator ......................$59.95
(1) Non-captive actuator .........................$unavailable KGS-1610
(2) Joysticks ...............................$15 ea.
(8) Relays .................................$70  Magnecraft General Purpose
Part # 92S7D22D-12D
(1) Accuride series 9301 Slides 16" length ......$89.99

Miscellaneous ...............................$70

Aluminum  Scissor Jack) ...........................$0 (donation)

$374.84  $ (All parts will require shipping charge as well)

Timeline:
A timeline for the project can be found attached to this report.

Conclusion:
Designing the most efficient adjustable easel is a task that involves intricate evaluation of mechanical, material, and electrical principles of a device. After gathering a variety of information and doing a surplus of research, a well developed plan as to the fabrication and achievement of the easel has been derived. Specified dimensions, movements and safety features have all been incorporated and integrated within this design.

References
Surplus Center Catalog 278. Lincoln, NE. 2005. (402 474-5167)
Accuride Heavy Duty Tracks