EASELECTRIC

Team 4

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Easelectric
The project under consideration is to design an electronically adjustable easel for an individual with special disabilities. Using different mechanical, electrical, and material principles of engineering, a well developed and cost efficient project can be produced. The general requirements of the project are to design a device that can safely and easily be controlled by adults with moderate cognitive impairments. Our proposal includes some basic design options, including different material, mechanical, and electrical systems. The basic limiting issue of our project is our budget of $750. More on the cost of certain items including actuators, joysticks, and other material costs will be discussed in the budget proposal. Other goals of the project include efficiency of the device, a lightweight yet durable design, with safety being the number one concern.

Passion Works® is a community program that assists adults with cognitive and physical impairment with artistic activities to better enhance their quality and experience of life. Their operation, located on the outskirts of Ohio University, is nationally acclaimed for their produced artwork. One specific member of their community is becoming a well-known artist, painting high priced works of art. Harry Grim is a 44 year old man who experiences symptoms associated with cerebral palsy, limited dexterity, visual acuity trouble and moderate cognitive impairment. Harry has trouble painting on occasion, due to limited arm movement. He desires an electronically adjustable easel to reduce physical strain when reaching areas of the canvas less accessible from his wheelchair. Recently Harry’s art has been selling for high prices, emphasizing the need for a helpful artistic aid. Some of his fantastic artwork can be seen below.

![David Barbra’s Family](image1.jpg)  ![School Bus](image2.jpg)

Previously, Harry received a movable easel developed by former UConn students in 2002. This device was not adequately suited for him, however. Problems with the design included complicated control mechanisms, dangerously exposed wires and circuitry, and in general, built too heavy and bulky to store in the facilities at the Passion Works studio. The design did not leave much room for Harry’s feet and wheelchair, which became another inconvenience as certain mobile functions of the easel were limited.

General Requirements
Our design must fit the needs and requests of Harry precisely. Every fabricated part, every movable piece, every trivial bolt and nut must be carefully evaluated to their safety and efficiency in the community. Our client contact, Brooke Hallowell, is our
primary communicator through the specified dimensions and criteria of the project. As she put it, some members of the Passion Works community tend to be a bit “grabby”. If someone sees an exposed wire, an electronic button, or shiny metal part, they may have a tendency to touch and grab certain exposed parts of the device. It is necessary to make sure a master switch to turn the device on and off is accessible to the supervisors at Passion Works. The concealing of wires and dulling of sharp edges is critical to the safety aspects of the easel.

The physical aspects of our project will accurately fit Harry’s specific needs. Brook Hallowell has included dimensions of his different canvas sizes and wheelchair dimensions. These size restrictions require the device to allow 27” for his wheelchair to fit under. After careful planning, we have decided to design the easel to clamp securely to a table or desk already available. More information regarding the mechanical properties, including an adjustable clamp to fit different sized tables will be discussed later in the proposal. The construction of the easel’s face, where the canvas will sit, needs to adjust to the different canvas sizes Harry uses. These dimensions include a minimum 8” by 8” square canvas to a maximum 30” high by 38” wide.

Along with these parameters, the design must be lightweight and able to store away easily. Another important feature the project must include is an easy setup for the supervisors. Setting up the easel should be a quick and simple task that doesn’t involve a long confusing process. Too many detachable pieces can result in lost parts and ultimately an unusable device. Small screws and pins that can be swallowed are also a safety concern that would greatly jeopardize our primary goal.

A procedure for turning on the easel should be quick and simple as well. A master switch is desired by the supervisors to prevent community members from accessing the easel unmonitored. Along with this desired function, the controls specified by Harry to move the device include the use of joysticks. The circuitry features for the controls and actuators will be discussed later in the circuit design portion of the proposal.

**Extra Features**

One of the strongest aspects of our design will include the extra features that can be added to the project without exceeding the budget. Creativity and engineering imagination will play a vital role in the successful planning and overall functionality of the device. Cubbies for storing paints, paint brushes, cups, etc. can be incorporated into the project. Such a design would call for a securely fashioned holder that will not spill or expel its contents.

Another convenient idea is to attach some sort of light source to the easel. This feature would be ideal especially for a room with poor lighting or for an artist with poor eyesight. The light should be mounted on some sort of adjustable arm that is either physically moved by the artist or programmed to move electronically as well. The power can be supplied by the same source as the actuators via a wall outlet, or perhaps independently powered by batteries.

Cup holders or trays for easy access to paint, watercolors, etc. are other possible devices that can be attached to the easel. Extending arms can hold these items right in front of Harry, which in turn can prevent spilling or an inability to reach certain colors. How and where these attachments will be included in the easel’s final design are still being considered.
Materials of the Design

When creating a project there are many things to consider as far as design, actual workings, practicality, and the presentation of the product. Picking an appropriate material to work with during the construction is a big part of the design process. When considering the easel that our group plans to construct there are many choices that come to mind referencing the materials to build the easel with. There are a ton of choices that we could pick to make our easel from and this is a breakdown of our thought process.

There are a few parts to the easel that we will be constructing. It is necessary to examine each of them separately and make sure that we have picked a material that will have the easel as a whole move correctly and be aesthetically appealing as well. We surveyed a variety of people to get their opinions, but the final decision was up to us. After looking at a variety of web sites as well as mechanical books we narrowed it down to few choices to pick from. All of the materials that we on our list have their pros and cons it is just a matter of which is the best for our project as a whole. The first that we looked at for the construction of our project was wood. When asking the advice of my materials teacher wood was also the first response that came to his mind. Wood is a very common material to be used in projects such like our easel and generally an all around material. However, after thinking about it, our group decided that wood really wouldn’t be the best choice for our project. There are certain specifications that the easel has to accomplish. A main concern of our project from both our group and our sponsor is that the easel wouldn’t be sturdy enough. The client is cognitively impaired and this easel must be build keeping that in mind. It is a necessity that the easel be sturdy so that Harry can paint his pictures on it without having to worry about it tipping over or creating other hassle; that wouldn’t be ideal for situation. We need to pick a material that will withstand any sort of unusual motion and that can accommodate our client. Wood has the potential to have weakness and instability and therefore wouldn’t be a good choice for Harry’s easel. With all the motion that we have going on mechanically with the easel it is unlikely that the wood would be able to accommodate it. Wood is not the most ideal material to use considering that we will be having a lot of electrical movement. The surface of the wood will not withstand a great deal of sliding that the easel will make when changing positions. Wood will not help us fulfill all of our client’s needs with this project and so we can rule this out as a possible material to use.

Another idea was to use PVC piping. This was used in a previous design of an easel that was given to Harry and proved that it was unacceptable. The PVC pipe was reported to us as being too flimsy. Although this was specified by the sponsor as something that shouldn’t be used it had to be taken into consideration so that our group doesn’t overlook anything important in the design process. Our brainstorming led us to the same conclusion that the sponsors found out after using the previous easel. We decided that the easel would be too flimsy again and wouldn’t support the electrical motion and variety of movement that would be occurring on the easel. PVC has a few more downfalls as well that helped us rule it out. As far as looks go on our design PVC
wouldn’t be such a good pick. The piping itself looks cheap and won’t look professional on our project. We want our design to look like it came from an already established company and be professional.

The third idea that we had was to use stainless steel. This is a big jump from our other idea of PVC pipe. After looking in the mechanical books provided in the design lab we realized that the stainless steel would be too heavy for our project. The easel has to be moveable by the nurses in the Passion Works® organization so that they can set Harry up to do his painting. If they are unable to move the design then it has potential to be in the way and a bother to have around. We want our project to be a pleasure to work with both for the nurses and the client. Along with this it is important to keep in mind that we do have a budget when designing this project. With a constraint of $750 it is impossible to be able to use steel in our project and still be able to have money left over to buy the necessary components for the mechanical design. We need to keep in mind that there isn’t an extreme amount of money available to create this design. It is an important feature to have because in industry it is just the same way. We want too keep our product competitive with the products that are already on the market. It is impossible to use stainless steel and expect that the price of our design will be similar to that of a project already being manufactured.

That brings us to our final pick and potentially the one that we will be using to create our project. There are many advantages to aluminum that the other picks don’t have. Aluminum is lightweight and therefore if we use it for the project like we intend to, then it will be easy to move for the nurses and able to be stored. Also, unlike stainless steel it is cheap. We will be able to buy a large amount of aluminum for our project and still have money left over to spend on other items needed for the project. When thinking about the mechanical part of the easel, aluminum has an ideal surface for the electrical and motor motion to ride on. There are a variety of ways that the aluminum is available and that we can choose from. There are alloys from 1000 to 7000 that we can choose from. We have yet to pick the most ideal one for our project. Aluminum also comes out of the manufacturer with a variety of different finishes. This will be important to consider when thinking of how we want our easel to look in the aesthetic component. Aluminum is bendable and able to be shaped without being too rigid. All these options allow us to have a wide range of options once we chose aluminum. We have to carefully consider which will be the best for our design. Below are a few examples of our decisions. It is mechanically more ideal that we use the square tubing found in figure 2.2, however we found it to be too expensive which leads us to using the channel tubing in figure 2.1. There are many more little design choices that we need to make but as far as the material is concerned for the majority of the project, aluminum is our best bet.
Mechanics of the Design

The design for the device must be mechanically sound, stable, safe and reliable, but must also be remarkably lightweight and easy to store. To do this requires using light-weight materials such as aluminum for a majority of the design, however where the forces and moments on the design will be the greatest and weight is not a particular issue, square steel tubing will be used not only for strength, but also because it is significantly cheaper than aluminum.

The main design of the easel will consist of three distinct parts; the base, the carriage, and the drawing surface. All three of these parts are designed to be able to be disconnected from each other and possess the ability to fold flat and store easily. All three modules of the easel are responsible for different aspects of motion at a speed that will be determined by the amount of voltage being applied to the connected actuator or motor. Each module serves a specific purpose and each pose unique challenges.

The base is the framework for the stability of the entire device. To attain maximum stability, a rectangular base measuring approximately 30 inches wide by 24 inches deep constructed of 2-inch square tubing will be laid on the table (Figure 3.1). To attach the base to the table, two specially fabricated clamps (Figure 3.2) resembling c-clamps will connect to the base via a pin and extend under the table approximately 12 inches. The clamp can be adjusted up and down through a range of 5 inches and the threaded rod that will do the clamping to the table will have a range of movement of approximately 2.5 inches to accommodate any sort of lip that the table may have. The base also contains either two heavy duty sliding drawer tracks or two grooved channels to facilitate movement front and back in the Y direction, depending on the most efficient design. In the case of the heavy duty drawer track, the carriage will be attached to the
track by means of removable bolts. The drawer tracks have the capacity to hold 150 pounds, which exceeds the predicted 40 pound weight of the device and yields an expected factor of safety of around 3.75, which is more than sufficient. In the case of the channel tracking, the carriage will ride on urethane casters in the slot which too are able to hold much more than the weight of the device.

The carriage is the most complex part of the device and controls all motion but forward and backward. This component has four actuators, one for tilting the drawing surface, one for moving the drawing surface up, another for moving the drawing side to side, and one that connects back to the base and allows for the base to control its position depth wise. The carriage will be constructed out of 1 inch square or round aluminum tubing so that it is lightweight but sturdy. If actuators are unavailable due to their high cost, a system resembling a rack and pinion has been designed that will move the required parts in their respective directions. However, since there are inherent safety concerns with moving parts such as shafts, it is unlikely that this design will be used. Instead, cheaper shafts with shorter throws could be used and will implement a cam system (Figure 3.3) that can amplify the shorter movement of the actuators to a length that is better suited for the easel. The carriage will also feature a jig which will allow for the attachment of several different drawing surfaces which can be swapped out at will by the client.

The last main component of the device is the drawing surface. While this component does not perform any complex movements, to the artist it is the most important piece of the whole device. The drawing surface that will come with the easel will be made out of flat stock aluminum for strength and light weight. It will also be attached to the carriage by means of a sturdy 4-bolt jig (Figure 3.4) and will feature a light that connects to the power supply, since lighting is one of the most important features for an artist.

Figure 3.1 Base Unit
Figure 3.2 Clamp Without Threaded Rod

Figure 3.3 Sample Design of Cam
Electrical System

The electrical system for the easel is an important aspect of the project and is one of the unique features that are specially designed to meet the specific needs of our client. Because the easel has been designed to move in four distinct ways, the need for four separate actuators, each individually controlled, demands a solid system for controlling them and preventing any undesired movement. The current design calls for 4 four linear actuators which will provide all necessary movement of the easel. The actuators will run on either 12 or 24 volts depending on the type chosen. Typically, the voltage can be varied between 12 and 24 volts to adjust the speed of the actuator. The exact specifications vary greatly between different manufacturers, however those proposed for use in the easel will each draw around 8-10 amperes of current. Because of the methods of controlling the actuators, no more than two can ever be in operation simultaneously. Therefore, there should not be much need for overload protection.

The client requested the use of some sort of joystick to control the easel which, in this case, needs only to be a simple four-position switch. An example of one proposed joystick can be seen in Figure 4.1. The speed of the easel will not be controlled by the degree of movement of the joystick and therefore no analog control is necessary. The joysticks which will be used are simply comprised of four individual switches which are activated depending on the position of the handle. However, the switches are designed to carry low voltages and small amounts of current. As a result it is necessary to have some sort of system of accepting inputs from the joystick and relaying those to the heavier duty actuators. There are a few methods which will be considered for this project.

The first method is through the use of a small digital controller which can accept up to 8 inputs (four from each joystick) and then activate the actuators. The joystick
portion of the circuit would be based on a standard digital control voltage of +5 volts with minimal current. A zero voltage to the controller would indicate “off” and a positive 5 volts would indicate “on.” Each position would have a separate input to the controller. The controller, after receiving a signal from the joystick would then engage a larger switch more capable of handling the 12-24 volts and higher current of the actuators.

The second proposed method of controlling the easel movements would be through the use of relays (Figure 4.2). This device in composed of a small coil which, when powered, activates a switch capable of handling large loads. The benefit of the relays is that only a small voltage with minimal current is required to power the coils. A combination of 8 relays, which would each be activated by a joystick position, could easily turn power on and off to individual actuators.

It may also become necessary that both options are employed. If the joystick cannot handle the current needed to activate a relay, it may be necessary to design a circuit which could interface with the joystick as well as drive the relays. Final designs for this aspect of the electrical system are still being considered and until the exact specifications of the actuators are known, the control system cannot be fully completed.

Another important part of the design is to incorporate a limit switch into the actuators. This switch will prevent the actuators from extending beyond a certain degree. This is extremely important to ensure that the easel does not move beyond any distances for which it was designed. Some actuators have these switches built in. It may, however, be necessary to actually place switches on the easel which would be activated after the travel distance exceeded a certain limit. This would most likely require the use of a small circuit to interface with the actuator control as well as joystick control.

One of the design specifications requested the incorporation of a master on/off switch for the easel. This will be easily implemented and placed at the main power source of the easel, in this case where the wall outlet power is received. This will ensure that when the easel is turned off there is no chance of any current flow and the device cannot be operated without supervision.

As far as power to the easel, it will run off the output of a standard wall socket, 120 volts AC. This voltage will be converted to 12-24 volts DC through the use of a transformer, and then stepped down again to 5 volts if necessary to power a circuit. The easel will have a standard 120 volt AC male receptacle into which an extension cord of any length may be used to provide power. This prevents the need for cord storage on the easel and also provides flexibility in cord length. Either a fuse or circuit breaker will be implemented to protect against any sort of electrical malfunction that may occur. Should any shorts develop this breaker will engage before any damage can be done to the easel or any danger presented to the user.

Lastly, the design is planned to also implement a 120 volt AC female receptacle into the easel. This receptacle can be used to power any additional attachments to the easel such as a canvas light. This plug will eliminate the need for an additional cord and will allow the lamp to be powered from the same supply feeding the easel.
Figure 4.1  
Linear Actuators

Figure 4.2  
Joystick Controller For Easel

Figure 4.3  
Standard Duty 24V DC Relay

Figure 4.4  
Master Switch Variety
References
Pictures of Harry’s Art provided by www.passionworks.org

More information on the project can be found online at:

http://www.bme.uconn.edu/bme/sendes/Spring06/Team4/index.htm

http://www.argylein.com/cgi-bin/search_dies.pl?words=EQUALANGLE

Mouser Electronics Catalog 2005.