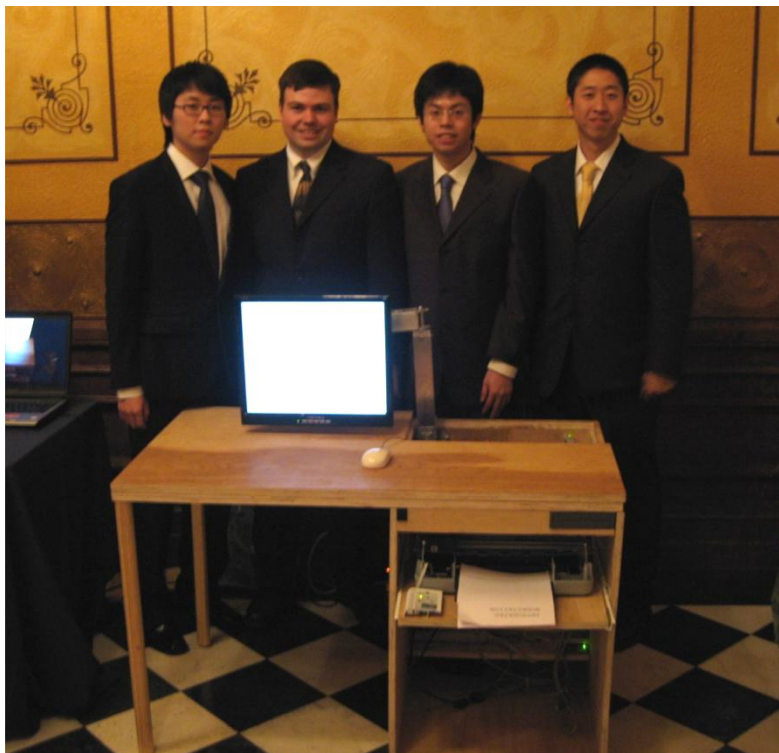


ME450: Design and Manufacturing III

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Design and Prototype of Next Generation Integrated Workstation

Sponsored by Mr. Senthil Arul



Section Instructor: Professor Kazuhiro Saitou

Dec.13.2007

Wei-Han Chen

Kyoung-Yoon Kim

Joe Knakal

Woo-Young Yang

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1. ABSTRACT

The next generation workstation will appear as a desk when it is not in use, but with a simple manipulation, the hidden components of the computer will appear. This project is to integrate multiple components of a computer into a single workstation so that the workstation will function as a desk when the computer is not in use. The computer will not be the only system installed in the desk but the monitor and printer will also be integrated into the desk. The goal of this project is to create a stylish workstation that is easy to set-up, use, and reduces amount of space needed.

2. INTRODUCTION

Senthil Arul is our sponsor for the next generation integrated workstation. As an individual, he was initially inspired by Apple's success in integrating multiple systems into an innovative single device such as the iPhone and the iPod. Therefore, he believed that there are significant opportunities and needs in the markets for integrating multiple systems into a single unit. The range of integrated devices is not solely limited to PC, MP3 players, phones and Laptops, but further extended into the integration of laboratory and medical instruments.

The target consumer for our project is the high-end, office, and home office users. With these consumers in mind, we anticipated that high-end users will be more interested in the appearance and style of the workstation, while office and home office users will be more concerned with the functionality of the desks. Understanding that a lot of high-end users do not repair their own computers and companies are usually focused on business rather than establishing an IT department solely for the maintenance and upgrading of their computers, we can provide a monthly service to our customers with a yearly upgrade.

With his vision, we decided to design and prototype a workstation that fully integrates a PC with its multiple components into a workstation. The idea is that the workstation will function as a desk with the computer and its components completely hidden when they are not needed. The computer and its components will not be the only system integrated into the desk, but also the printer and other external devices. Drawers will also be included, which function as storage room just like an ordinary desk. The system is expected to make the set-up and the use of the workstation easier while minimizing the amount of space needed. The main goal is to maximize integrated workstation's functionality while minimizing the cost and complexity of the set-up.

3. INFORMATION SEARCH

The idea of an integrated workstation has been prevalent for a while though it had not been publicized successfully until the Apple Inc. became popular. Through the years Apple has developed the integrated computer and monitor, Apple emphasized simplicity and compactness

in designs of their computer products. Other integrated furniture companies' have been also successful in many designated areas.

The current market for an integrated workstation is very small and only limited to a customer who can afford the high price of them. The reason is that most of the innovative workstation manufacturers are not implementing mass production and the cost of product is exceptionally high.

In this project, we benchmarked designs and ideas from the Apple product, iMac. Also, we referred to the past design of an integrated workstation, i-Con desk from Arco, a contemporary furniture company in Netherlands, as an optimal design. The difference between i-Con desk and our prototype is that our prototype will have embedded the monitor and printer.

When we looked at the iMac we used it as a benchmark for how we should have our wiring. When you compare the wiring on the iMac to the wiring on a Dell's PC, you see that there are only a few wires on the iMac compared to many wires from the Dell's PC. One of our goals is to minimize the number of visible wires on our workstation by having them hidden in the workstation. This will improve the overall appearance of the workstation. Using a wireless keyboard and mouse would help solve the wiring problem too.

i-Con desk from the work of designer Michiel van der Kley demonstrates how well PC components can integrate into a desk. PC components are installed into the drawer spot and CD-ROM and auxiliary ports are easily accessible from the front panel of the desk. Even though the designer excluded monitor from their design consideration, they still maintained simplicity of design and provided enough working space on the table. Detailed information on benchmarks is supplied in APPENDIX A.

While searching through the United States Patent and Trademark Office website, we found a patent on an integrated workstation, which was registered in 1986. Even though the patent includes a detailed design plan of the workstation, the design is very far from our idea of an integrated workstation. The major difference of the two is embedment of the computer devices into the desk. While the patent suggests an idea of having computer and other office devices stored in the drawers of the desk, our workstation will have embedded computer devices within different locations of the desk surfaces.

'Freemote' from Powerdesk also introduced a product that provides all PC controls in front surface of the desk. The initiation of their product came from current appearance of the computer. However, this product is just providing an extra device that extends from the standard PC and is hard to integrate into the desk. Detailed pictures of the 'Freemote' are available in Appendix A.

We have information gaps currently. During the moment of further search and manufacturing process, we will be challenged by the lack of information on laminated tooling. Since we have planned to embed the devices, the greatest difficulty we might find would come from the wiring technique and this will be done easily if we understand the manufacturing technique about laminating table.

4. CUSTOMER REQUIREMENTS AND ENGINEERING SPECIFICATIONS

We generated a Quality Function Deployment (QFD) (Figure 1) in order to identify the design goals and learn how to approach them. We determined the customer requirements and produced engineering specifications that can be quantified and control the customer requirements.

Furthermore, we chose three products that are available in the market to benchmark those products with our customer requirements. Three products that we chose to benchmark were iMac of Apple, i-Con of Arco design, and Cyril desk of IKEA. Among these products, i-Con desk best satisfied our customer requirements with the iMac being the worst.

4.1 Customer Requirements

In order to fulfill the requirements of our target customers, we initially considered customer requirements for both computer and desk users. From them, we ranked the stylish and aesthetic side of the product the highest since our target consumer group is high-end and non-computer savvy clients. Ease of operation, stability of desk, quietness, and serviceability were also considered as important issues. The integrated workstation should also provide an ergonomic design, easy accessibility, and easy setup.

4.2 Engineering Specifications

We generated engineering specifications (Table 1) that consist of quantifiable parameters in order to determine the correlation between customer requirements and further to set the engineering targets. After working on the correlation between customer requirements and engineering specifications, we found that number of parts was the most important engineering consideration and time to power/setup and steps to setup were the next most important things. This implies that minimizing the number of components of the computer and desk while maintaining its design and simplicity of setup is going to be our main objective.

Engineering Specifications	Unit of Measurement
Fits through standard door	cm
Weight of desk	kg
Color availability	#
Steps to power	#
Steps to setup	#
Number of parts	#
Manufacturing steps	#
Volume of drawers	cm ³
Time to power/setup	sec.

Table 1. Engineering Specifications

(+) => more is better
 (-) => less is better

Relationships

++ Strong Positive
 + Medium Positive
 - Medium Negative
 -- Strong Negative

Engineering Specifications / Customer Requirements	Weight*	Relationships										Benchmarks		
		Fits through standard door (+)	Weight of desk (-)	Color availability (+)	Steps to power (-)	Steps to setup (-)	Number of Parts (-)	Manufacturing steps (-)	Volume of drawers (+)	Time to power/setup (-)	iMac	ARCO design	CYRIL (IKEA)	
Look nice / Attractive / Stylish	10	3		9		7		5			5	5	3	
Ease of operation (automation)	9				9	7			9		3	2	2	
Stability of desk	8	1	3				1				2	1		
Quietness	8					1					4	3	3	
Serviceability	8				5	9					3	2	3	
Easy to setup & adjust	7		1	5	9	5			9		4	3	3	
Comfortable / Ergonomic	7	5						5	5		3	4	1	
Maintainability / Accessibility	7				3	7					1	1	3	
Enough size of space for work	6	9										4	1	
Enough storage space	6	5				5		9				3	2	
Hardness of desk surface	6		7									4	3	
Cost of product shouldn't be high	5	3	3	5	5	5	9	9	5	7	3	1	2	
Easy to clean desk	4											4	3	
No reflective desk surface	4			3								3	4	
Safety	3										4	4	1	
Lightweight	3	5	9			3		3			3	4	4	
Variety of colors	3			9							1	1	1	
Waterproof	2					1					1	2	3	
Measurement Unit		cm	kg	#	#	#	#	#	cm ³	sec.				
Target Value														
Importance Rating		4	8	6	7	3	1	9	5	2				
Total		187	115	154	141	212	320	53	173	214	0			
Normalized		0.12	0.07	0.10	0.09	0.14	0.20	0.03	0.11	0.14	0.00			

Key:

9 => Strong Relationship
 7 => Moderate Relationship
 5 => Medium Relationship
 3 => Weak Relationship
 1 => Very small Relationship
 (blank) => Not Related

*Weights are figured on a scale of 1 to 10
 (ten being most important)

Figure 1. Quality Function Development of Integrated Workstation

5. CONCEPT GENERATION

5.1 FAST Diagram

In order to produce ideas with concept drawings, we made use of function analysis system technique, the FAST diagram, to generate the functions of our workstation for assessing our design specifications and concept generation. We started the FAST diagram by defining the task function, which is to ‘do work’, this is a function of a workstation to do either computer or paper based work. After figuring out the task function, we identified and classified the primary basic and primary supporting functions. The primary basic functions are to contain storage, to maximize workspace, and to enable computer work, which are the functions essential to the performance of the task function, ‘do work’. These primary basic functions are selected because one cannot do work without a place to store their documents, without maximizing workspace and without computers to do computer work. We then identified primary supporting functions, which are to assure convenience, to assure dependability, to please senses, and to maintain stability. These primary supporting functions are not essential to the performance of the task function. After we formulated the primary basic and supporting functions, we expanded each of the primary basic and supporting function into the secondary functions which linked them to the primary functions directly by a “how” relationship. Therefore, we will be able to create space, contain storage, and maximize workspace by hiding computer components and simplifying the wiring. Other secondary functions can be observed in the FAST diagram (Figure 2). Finally, we stopped expanding the functions when the function is fulfilled by the mere existence of an object without an action. Considering the importance of each function, we chose 5 functions from FAST diagram to concentrate on 5 functions that we can do practical modifications.

Therefore, we concluded that our integrated workstation needs to create space by containing storage, and to hide the computer equipment, such as printer, monitor, keyboard, mouse, and PC, to maximize workspace. We then generated our design concept drawings based on the FAST diagram.

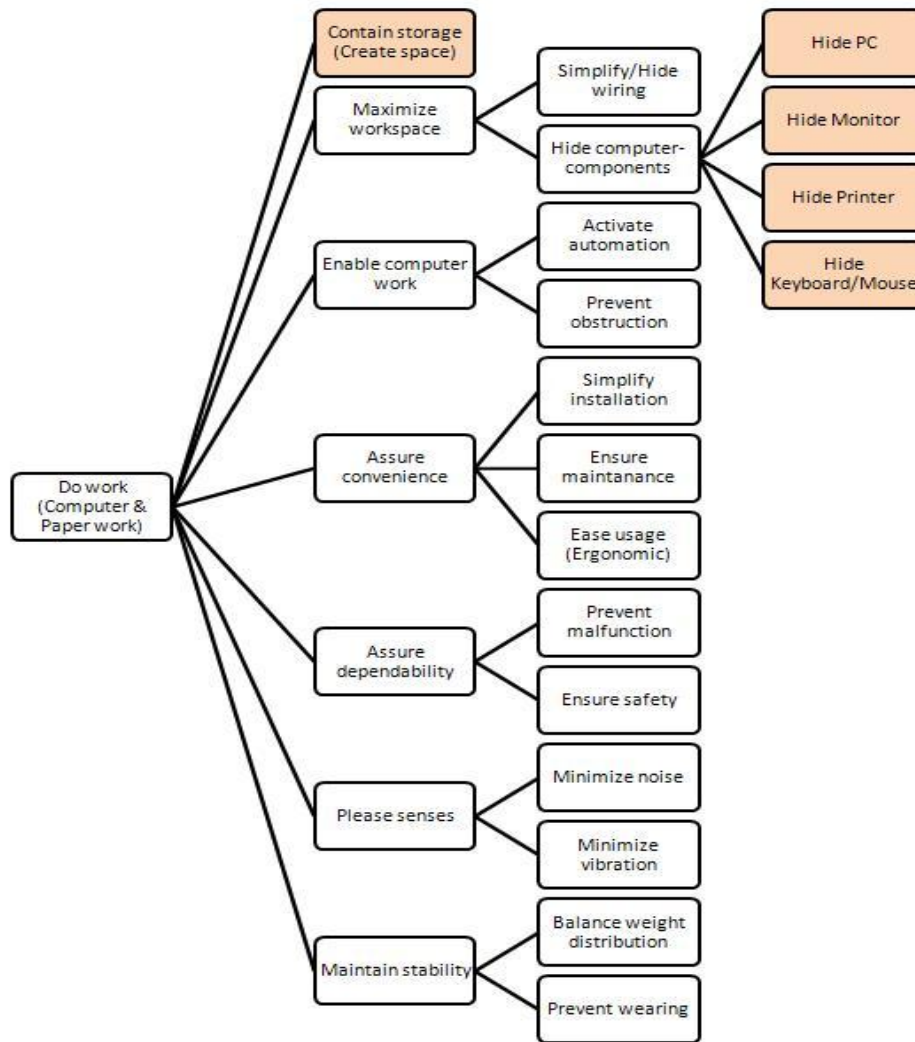


Figure 2. FAST Diagram of Integrated Workstation

5.2 Morphological Method

Based on the FAST diagram, we determined 5 main functions: Hide PC, hide monitor, hide keyboard/mouse, hide printer, and create space. Hiding computer components (PC, monitor, keyboard/mouse, and printer) is to maximize the working space when computer is not in use. Creating space is to provide storage space in terms of drawers, shelves, and etc. We then generated a morphological chart (Figure 3) of design concepts for each function.

5.2.1 Function 1: Hide PC

Hiding and integrating the PC into the workstation will ensure maximizing the workspace. The PC components can be attached or inserted as a combined unit in the back of the workstation; however, several parts on PC component should be easily accessible by the user. Those parts include the optical drives (CD/DVD Drive), USB ports, and auxiliary ports. The main PC components should be also easy to maintain and receive service without difficulty. The wires from the PC, such as power supply cord and wire that connects to the monitor should be hidden inside the workstation.

5.2.2 Function 2: Hide monitor

The main function is achieved when the entire monitor is embedded into the workstation when the computer is not needed. However, when the computer is required, the monitor should be fully loaded onto the table top within a short operation time. Not like other PC components, the monitor requires motion from inside the workstation to the table top; it should also guarantee safety during the operation. Moreover, any motion mechanism should be controllable within a range of different monitor sizes.

5.2.3 Function 3: Hide keyboard/mouse

The main function is to hide keyboard/mouse into the workstation without hampering the storage space. Since the keyboard and mouse are compact and the current technology using Bluetooth will ensure no wires need to be connected to any PC components. For the mouse, the surface of the desk should be suitable so that an optical mouse can be operated.

5.2.4 Function 4: Hide printer

By hiding the printer, eventually the users will just need to feed paper into the paper tray or slots on the workstation in order to obtain printed papers. Similar to PC components, printer should be easily accessible for maintenance and service.

5.2.5 Function 5: Create space

The workstation should provide storage space where the user can store objects and access easily when needed. The important issue is to have a maximum storage space without harming the user's comfort within the limited size of the workstation.

Functions	Concept 1	Concept 2	Concept 3	Concept 4	Concept 5	Concept 6	Concept 7
Hide PC							
Hide Monitor							
Hide Keyboard / Mouse							
Hide Printer							
Create Space (Drawers)							

Figure 3. Morphological Chart of Design Concepts for Five Functions

6. CONCEPT EVALUATION AND SELECTION

From the morphological chart, we established 5 different themes of combined concepts. Each concept from each function was chosen to have a combined set of concepts. Those 5 themes are ‘High-tech’, ‘Economic’, ‘Flip Flip’, ‘Modest’, and ‘Simplicity’. Then, the combined concepts for each theme are evaluated using a Pugh chart (Table 2). Each combined concept was weighted by customer requirements according to the QFD (Figure 1) introduced earlier. When there is an advantage or disadvantage on the concept, we rated ‘+’ and ‘-’, respectively.

6.1 Concept Evaluation

Each combined concept was determined through different themes. 5 different concepts have their own merits and limitations, which were evaluated from the customer requirements.

6.1.1 ‘High-tech’

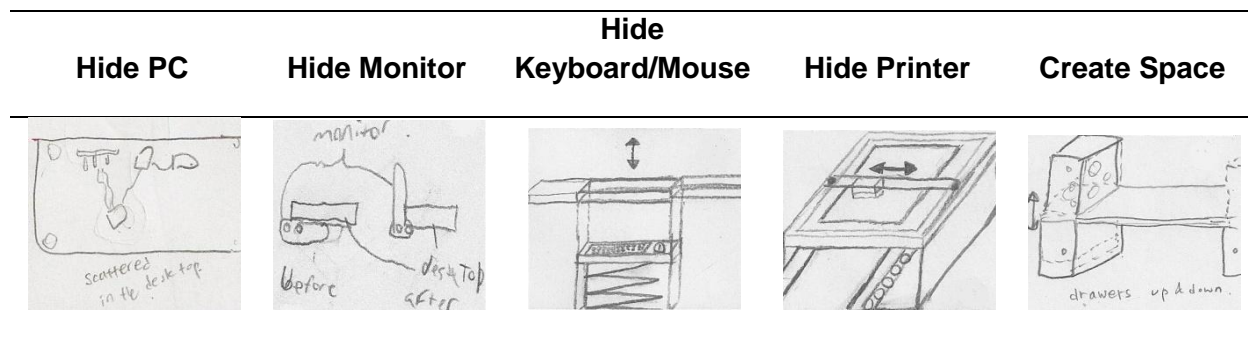


Figure 4. Individual Functions of ‘High-tech’ Concept

Functions of the ‘High-tech’ concept were selected from considering the maximum degree of automation and user comfort. Hiding the PC is achieved with scattered computer parts embedded on the desk surface. Monitor has a vertical movement from moving rotational axis along the side of the rear edge of the desk and keyboard and mouse are elevated from the inside of desk surface. A printer without the casing is completely embedded inside the desk and the printouts will come out from the surface of the desk which will force us to create a cavity on the desk surface. There is a moving shelf on the side of desk so that when the users don’t need them, they can lift up the storage space and bring it down when needed.

6.1.2 'Economic'

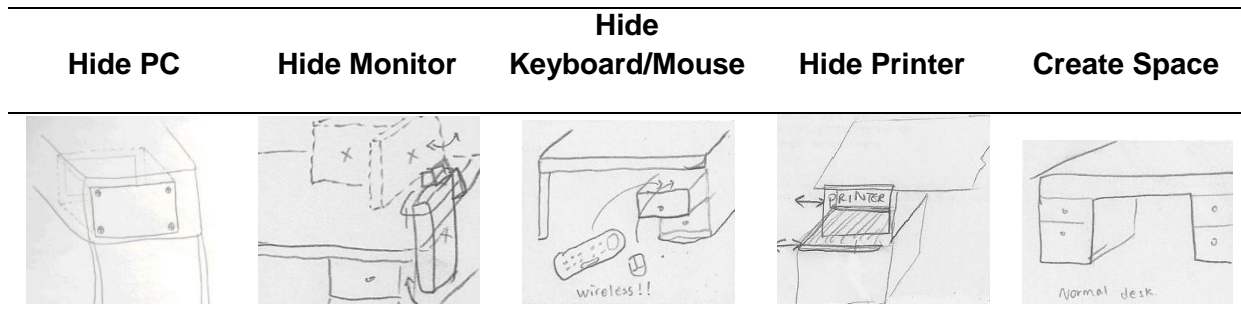


Figure 5. Individual Functions of 'Economic' Concept

Concepts of "Economic" were selected from consideration of the lowest cost of components and manufacturing. The PC is embedded in the casing that is built behind the drawer space and monitor is manually brought up from the cavity on the side of the desk. Keyboard and mouse are just placed inside the top drawer when they are not in use. User can access printer from the side of the desk by sliding the plate that supports printer. Two equal sized drawers are on both sides of the desk.

6.1.3 'Flip Flip'

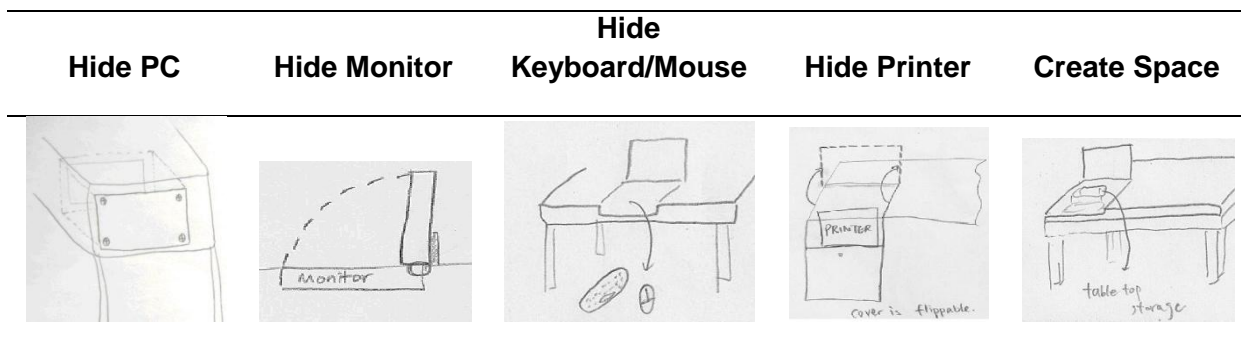


Figure 6. Individual Functions of 'Flip Flip' Concept

'Flip Flip' combined all concepts that require a simple flip motion in order to access monitor, keyboard/mouse, printer, and drawer space. User can access the storage space by flipping up the cover on the table top. The PC is embedded in the casing that is located behind the drawer space.

6.1.4 'Modest'

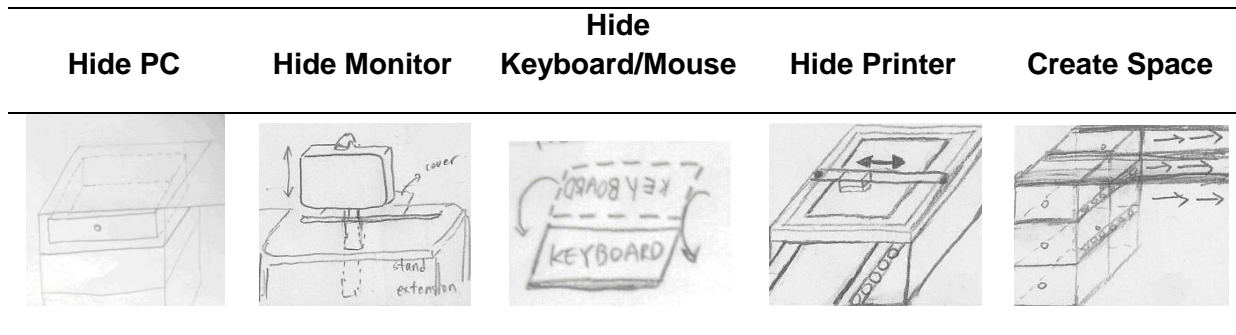


Figure 7. Individual Functions of 'Modest' Concept

Considering more comfortable access to the workstation than 'Economic' model, concepts of 'Modest' were determined. The PC is embedded behind the back of the desk and easily accessible by using a drawer rail for plate that supports the PC. Monitor provides a vertical and horizontal movement along the desk surface. In order to provide horizontal motion on the desk we created a guide slot so that the monitor stand can move without tilting along the surface. The Keyboard is under the desk surface when it is not needed, however, the user can click on the surface to flip out the keyboard from the inside of the desk surface. The drawer can move along the bottom of table top, so that the user can locate the drawer in their favorable position.

6.1.5 'Simplicity'

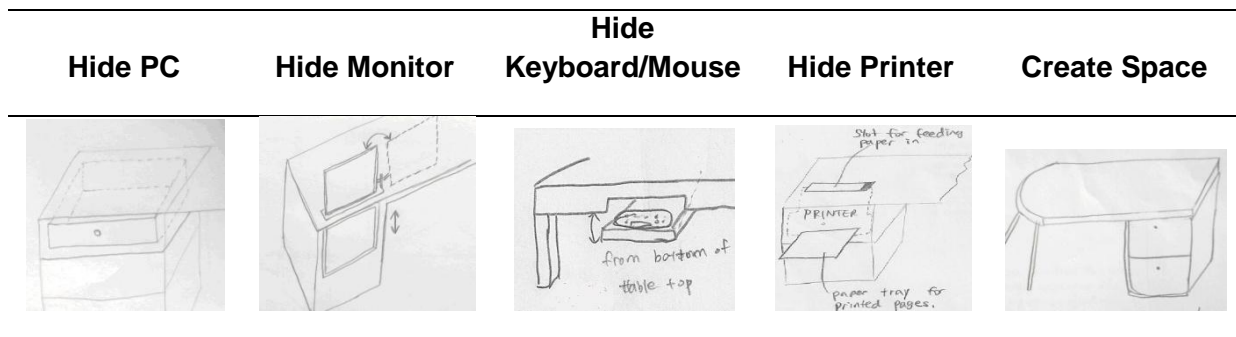


Figure 8. Individual Functions of 'Simplicity' Concept

The monitor is brought up vertically from the back of drawer space and the user can rotate it 180 degrees to locate it at preferable position. Keyboard and mouse are stored in casing under the desk surface. The Embedded printer has paper filling from the front of the desk while the printouts come out on the desk surface. The drawer is only on one side of the desk while the other side is supported by 2 table legs.

6.2 Concept Selection

Evaluation of concepts from weighted customer requirements was conducted to find the most suitable concept for concept selection. Detailed Pugh chart (Table 2) is listed below.

Customer Requirements	Weight	High-tech	Economic	FlipFlip	Modest	Simplicity
Look nice / attractive / stylish	10	+	-	-	0	+
Ease of operation (automation)	9	+	-	0	0	0
Stability of desk	8	0	0	0	0	0
Quietness	8	0	0	0	0	0
Serviceability	8	0	+	+	+	+
Easy to setup & adjust	7	0	-	-	0	0
Comfortable / Ergonomic	7	0	0	0	0	0
Enough size of space for work	6	0	0	0	0	0
Enough storage space	6	0	-	-	0	0
Hardness of desk surface	6	0	0	0	0	0
Cost of product shouldn't be high	5	-	+	0	-	0
Easy to clean desk	4	0	0	0	0	0
No reflective desk surface	4	0	0	0	0	0
Safety	3	-	-	0	0	+
Lightweight	3	-	0	0	0	0
Variety of colors	3	0	0	0	0	0
Waterproof	2	-	0	-	-	-
Total +		19	13	8	8	21
Total -		13	35	25	7	2
Total		6	-22	-17	1	19

Table 2. Pugh Chart for Five Combined Concepts

Merits and limitations of each concept were evaluated through the Pugh chart. The ‘High-tech’ design was intended to give more comfort to users; however, there were some disadvantages of its design. The scattered PC on the desk surface and printer would have a lack of serviceability and difficulties in mass production. The moving drawer will allow more availability of space; however, the automation will produce noise and also cost more than other concepts. Moreover, we cannot ensure safety while the shelf is moving.

‘Economic’ has an advantage in the cost of components and parts, while it requires manual action from the users to load up the monitor. Considering compact size of the desk, having drawers on one side will provide more space for lower part of body than having drawers on both sides.

‘Flip Flip’ design has a disadvantage in drawers, which reduces the workspace size when the user flips up to access the storage. Moreover, there are some unnecessary flips required to access the components.

‘Modest’ would give more flexibility to users for using the monitor and the drawers. Users can locate the monitor anywhere along the desk surface because the monitor has a horizontal movement from one end of desk to the other side. However, the guide slot that supports horizontal movement is visible even the monitor is not in use. Moreover, users can locate the drawer in their preferable position anytime they want. On the other hand, the rail under the table will cost more and since the users would move it just once after they purchase it, it won’t have a big advantage.

‘Simplicity’ allows access to PC easily by using a drawer rail for plate that supports PC. The monitor cavity on the desk surface is small compare to other design concepts. The design has advantage of having monitor load up to the desk surface automatically, however, the user still have to manually rotate in order to have a correct setting.

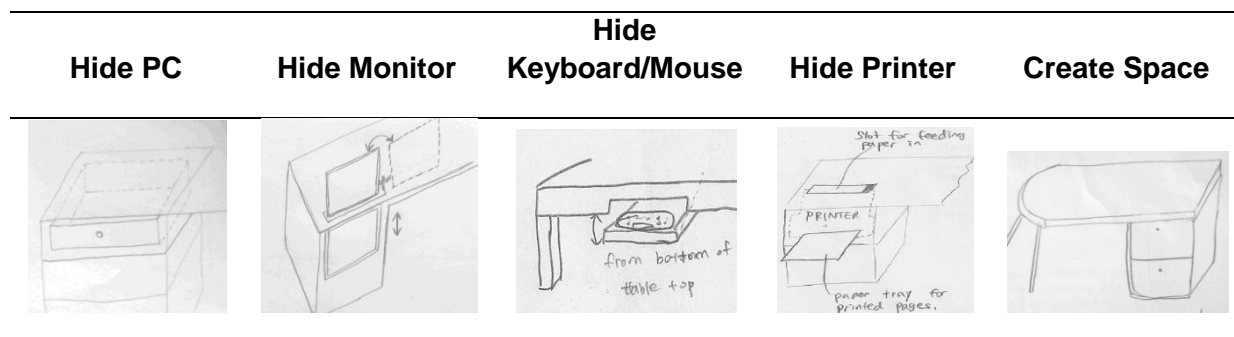


Figure 9. ‘Simplicity’: Selected Individual Concepts for Integrated Workstation

Based on the result of Pugh chart, ‘Simplicity’ met the customer requirements the best. (Figure 9) Each concept has merits and limitations and the description of functions are explained below.

- Hide PC: PC will be hidden inside of the drawer space. It will be stored into the back of the drawer space and disassembled components of the PC part will be embedded onto the board, which is detachable. This allows more accessibility and serviceability for the user. The concept has limitation since the casing of PC part reduces the storage space. The PC mount board will be installed vertically on the back of the drawer space. It will be minimized by installing vertically on the back of the drawer space. Hiding PC behind the drawer can obstruct the movement of hiding monitor but this has settled by limiting the movement of monitor as small as possible.
- Hide monitor: Monitor will automatically perform the vertical motion from inside of the drawer space. The goal for hiding monitor is to give user freedom to load up monitor and locate it in a preferable position. The user can tilt and rotate the monitor from the fixed position. As explained in the above paragraph, the vertical movement of the monitor will be limited to ensure the space for PC. The detailed concept selection on horizontal guide will be selected in this week.
- Hide keyboard/mouse: Using space under the tabletop as storage for keyboard and mouse is selected. Since we aim for simplicity and neatness of the outlook of the desk, the concept is selected because it does not produce any lines on the desk surface. The placement of the storage space for keyboard and mouse can be selected anywhere unless the design does not interrupt the wiring from optical drives to PC.
- Hide printer: According to customer requirement, which emphasizes on style and comfort, the concept is selected. The paper being fed through the surface of the desk, the printer will print out along the guide provided on the drawer. Feeding paper on the surface of the desk has limitations because it might take away from the appearance of the desk.
- Create space: To create storage and work space, we selected having drawers on just one side. While having drawers on each side can provide more space for storage, it limits the work space under the desk so that it reduces the movement of the user in a chair or it increases the overall size of the desk.

7. SELECTED CONCEPTS

Our selected design will hide both the motherboard and the monitor behind the drawers with the monitor right next to the motherboard. The keyboard and mouse will be wireless and hidden under the desk surface in the middle of the desk, length wise. Once you turn on the computer the monitor will rise up and the rotate 180 degrees so that it is positioned in the center of the desk, length wise. The keyboard and mouse will have to be brought out manually and set on the desk. This is all shown in Figure 10. To create this the desk will be made out of wood, with the loading system for the monitor made from aluminum. In order to provide loading of the monitor from the

bottom of drawer space, a motor will be ordered. Linkage arms that provide rotation of monitor will be made from aluminum square tube. The power for the motor will be a 24 Volt power supply which is what is specified by the manufacturer as the suggested power. The computer will use a standard computer power supply which will be plugged into a surge protector that will be mounted in the bottom of the desk. Detailed drawings of all parts can be seen in Appendix D.

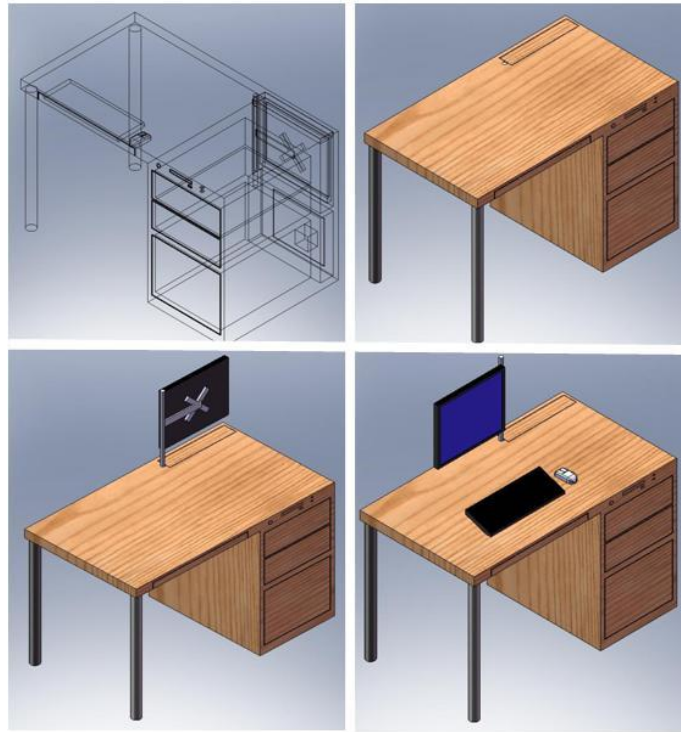


Figure 10. CAD Drawings of Selected Design Concepts

8. ENGINEERING ANALYSIS

Based on the selected concept, we have conducted quantitative and qualitative engineering analysis on each functional concept to decide on material choices, dimensions, tolerances, specifications of off-the-shelf components, and choice of suppliers. In following sections, we have analyzed design variables to determine values. First, we performed monitor mount analysis to find the minimum diameter of the supporting rod. Second, minimum torque required to operate the loading system was determined. Then, the material for the rotational axle and the minimum power need for the circuit were determined.

8.1 Quantitative Analysis

8.1.1 Monitor Mount

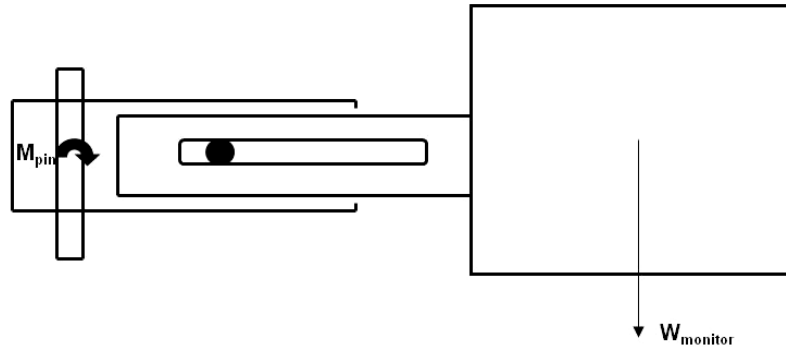


Figure 11. Monitor Mount Free Body Diagram

$$M_{\text{monitor}} = 11 \text{ lbs}$$

$$\text{Minimum extension of linkage bar} = (8.5 + 0.5) / 12 = 0.75 \text{ ft}$$

$$\text{Maximum extension of linkage bar} = (8.5 + 8.5 - 1 - 0.5) / 12 = 1.29 \text{ ft}$$

$$M_{\text{pin}} = 11 \text{ lbs} \times 1.29 \text{ ft} = 14.2 \text{ lb}\cdot\text{ft}$$

Stress on upper part of pivot bracket of the linkage bar

$$\text{Thickness of upper part of pivot bracket, } t = (1/8)'' = 0.0104 \text{ ft}$$

Radius of the hole for pin, r

$$\text{Area experiencing stress} = [(2 \times \pi \times r) / 2] \times t = 0.125 \times r \text{ in}^2$$

$$\text{Force acting on the area, } F = M_{\text{pin}} / [2 \times (1/12)] = 85.20 \text{ lbf}$$

$$\text{Stress, } \sigma = F / A = 682 \times r \text{ psi}$$

$$\text{Yield strength of Aluminum (Alloy 2014-T6)} = 400 \text{ MPa} = 5.8 \times 10^4 \text{ psi}$$

$$\sigma < \text{Yield strength of Aluminum when } r < 86 \text{ in.}$$

The stress analysis on monitor mount pin allows us to determine the material and dimension of the pin. Considering maximum extension of the linkage bar, at the point where the maximum moment is created, the moment of pin is found to be 14.2 lb·ft. Maximum and minimum extension of monitor arm were constrained due to the limited cavity for monitor under the desk surface. Assuming the upper part of pivot bracket of the linkage bar will experience the greatest stress, we found that the maximum stress that the pin will experience to be $(682 \times r)$ psi. Unless the radius of hole is smaller than 86 in., the stress value is way lower than the yield strength of Aluminum, 5.8×10^4 psi.

8.1.2 Loading system analysis

Analyzing and selecting parts for loading system was done in three parts. The first section shows the selection and analysis on motor. The second is selection of drive system, which is calculated based on the performance of the motor. The third section consists of calculated analysis on the loading guide.

8.1.2.1 Motor analysis

To find a motor, we need to make sure RPM and torque. Because we planned to control the coiling speed mechanically, we had to choose a motor that is slow and also provide sufficient torque. Since there were so many factors that can affect the speed and torque, we had to determine some factors before we go on analysis. We first determined the loading time to be around 10 seconds and length of the wire that is coiled for loading to be 36 inches since the monitor was loading approximately 18 inches up. Also another factor was pre-determined by the team.

$$10\text{sec} \times \frac{X\text{revolution}}{1\text{min}} \times \frac{1\text{min}}{60\text{sec}} \times \frac{2\pi \cdot \text{radius}}{1\text{revolution}} = 36\text{inches} \quad \text{Equation 1}$$

According to the equation above, there are two factors that determine the loading time and the length of the wire, RPM and radius of the reel. The radius of the reel also determines the torque needed. The equation above showed us that if we decide to go with smaller revolution, the radius has to be bigger and torque required will increase. On the other hand, if we go with bigger revolution, the radius can be smaller and the torque required will decrease. Due to these relationships, we had to determine one more factor and we decided to make the radius of the reel 0.2 inches.

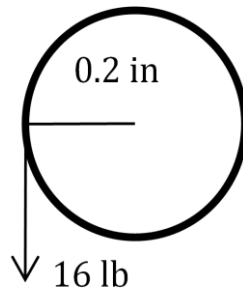


Figure 12. Torque Analysis

From given number of factors, we found the RPM of the motor to be around 170. Also based on the equation below, we found the torque needed was 3.2lb-in, 51.2oz-in. With the information found, we chose a motor.

A standard part number of the motor is 415A159-3 from Globe Motors. It can create continuous torque of 96 oz. in. The sintered gearing motor provides approximately 168 RPM. Detailed specification of the motor is listed in the table below.

Part Number	Voltage (VDC)	RPM	Current No load (max amps)	Continuous Torque (oz. in.)	Current at Rated Torque (max amps)	Resistance (ohms)
415A159-3	24	168	0.140	96	0.40	30.0

Table 3. Motor specification

8.1.2.2 Rotation analysis

With given radius of the reel and RPM, we performed rotation and axle analysis. The radius of the reel was chosen to 0.2 inches. Given 36 inches of wire to be coiled, the reel makes 28.6 revolutions in 10.2 seconds.

The selection of the material for driving axle was done based on maximum stress on the rod and the diameter of the rod. First, we had to make sure the diameter of the rod was smaller than the reel, so we chose a standard sized rod with a diameter $3/16$ in = 0.1875 inches.

The moment acting on the rod was calculated by equations below where $R = 3/32$ inches.

$$\sigma = \frac{M \cdot y}{I} \quad \text{Equation 2}$$

$$\sigma = \frac{\frac{8}{2} \frac{\text{lb} \cdot \text{in} \cdot \frac{3}{32} \text{in}}{\pi \cdot R^4}}{4} \quad \text{Equation 3}$$

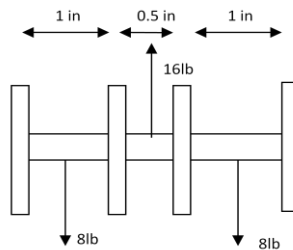


Figure 13. Reel Free Body Diagram

Since we found the minimum stress on the rod to be 6181psi, both aluminum 6061 with yield strength 40,000 psi and stainless steel with yield strength 159,800psi would work for our design. We have decided to use stainless steel (17-4 PH) which has yield strength of 159,800 psi. The size of the pulley was selected through website McMaster.com. Two small mounted 2 ½” pulleys, fabricated out of galvanized steel, that are available on the website were chosen.

Pre-determined constraints		Determined variables through analysis	
Radius of reel	0.2 inches	RPM of motor	168 RPM
Approx. loading time	10 sec	Minimum torque	51.2 oz-in
Length of wire coiled	36 inches	Minimum stress on rod	6181 psi

Table 4. Pre-determined vs. Determined Variables

8.1.2.3 Circuit Analysis

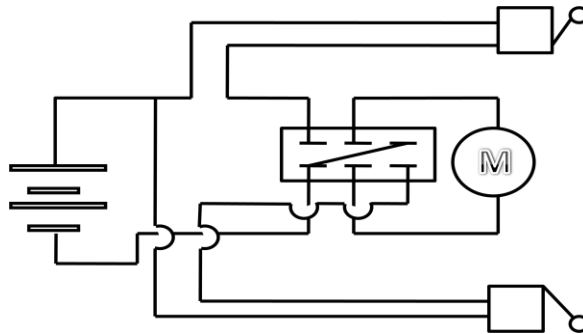


Figure 14. Circuit Diagram

Since the motor we have runs at 24V DC, we will need AC adapter that connects to the normal outlet. In that way, AC voltage will be converted to the DC voltage and supply the power needed to the motor. The minimum power needed for the motor is $24V \times 0.4A = 9.6$ watts and small amount of power needed for the switches can be neglected. Two micro-switches that will limit the horizontal movement will connect and disconnect the current when triggered. The purchased power supply provides 60 watts and 2.5A.

8.1.3 Printer

We will use a wood plate with 18”L × 14”W × 1”H as the dimension and a tolerance of ± 0.5 inches. Wood was chosen to be the material because it is environmentally friendly, relatively lighter than metal, easier to manufacture and served our purpose of mounting the printer on top of it. For the sliding mechanism of the wood plate, we will be using a standardized 16 inch drawer slide which can hold up to a weight of 75 lb (34 kg) and has an extension capability of 3/4 its total length. Since the weight of the printer and the wood plate together add up to approximately 11 lb, our drawer slide is sufficient to withstand the weight with a safety factor of

approximately 7. The drawer slide will not merely allow the sliding but also has a build in mechanism which is a limit that prevents the user from overdraw. The fake drawer wood board will be hinged from inside and will have a dimension of (19”L × 0.5”W × 7”H) which will be large enough to disguise the cavity for the printer.

8.2 Qualitative Analysis

Qualitative analysis on each function was done in three ways, design for manufacturability and assembly, design for the environment, and failure mode and effect analysis.

8.2.1 Design for manufacturability and assembly

Five guidelines were applied in order to make sure that the parts are easy to manufacture and assemble. The five guidelines are consists of simplifying the design and reducing the number of parts, standardizing and using common parts and materials, designing for ease of fabrication, designing for parts orientation and handling, and designing for ease of assembly.

By simplifying the design and reducing the number of parts, the probability of having errors and defective parts decreases. Since the number of parts and total cost of fabrication are co-related, reducing the number of parts is essential. Standardizing and using common parts and materials minimizes the amount of inventory in the system. Common parts will cause reduced total costs and higher quality. Designing for ease of fabrication and assembly will lower the manufacturing time. The reduced manufacturing time will allow the total costs drop. A detailed DFMA is attached in Table 5.

	Simplify the design and reduce the number of parts	Standardize and use common parts and materials	Design for ease of fabrication	Design for parts orientation and handling	Design for ease of assembly
Table	Apply same design for front table leg and back leg to reduce the number of parts and interchangeable use of part.		The threaded holes on the table surface are designed so that common machining tool can easily achieve machining.	Avoid sharp corners on the table surface.	When assembling table surface and the table legs, make threads on legs and the table surface so that assembling legs to the table is easy.
Monitor Mount		Use common parts for pivot brackets and linkage mechanism. Such parts can be same size of head cap screws, washers, pins, and bearings.		Smooth edges for each sub components of the linkage bars.	
Monitor Loading System	Simplify reel by making smaller two reels One reel fixed to the other surface	To hold the reel to the bar itself, use set screws Common sized bearings and stiff rod	Avoid unique design Hollow bar with two openings for pulley, then a rod going through Use pre-fabricated part	Symmetry along rod Having fixed position of handling No sharp edges	Two axis assembly (along & perpendicular to rod) Separated big components, only connected by wire
Printer	Use pin bracket to press fit instead of screws if possible Use premade drawer slide to eliminate complexity of making it Use existing printer to eliminate complexity of making it	Desk should be made of the same material: wood, plastic, metal Buy standardized printer and drawer slide to eliminate complexity Automation of the product-line should be engineered	Use standardized dimensions for parts Design uniform cross section for parts if possible Fixed size of brackets Simple parts, but still meet engineering specifications	Maintain symmetry Light weight parts Maintain flat and smooth surfaces Avoid sharp edges, Add lubrication if needed Avoid small sized screws and bracket	Minimize the amount of screws and bracket used Minimize the number of assembly axis Start assembly with larger part

Table 5. Design for Manufacturability and Assembly

8.2.2 Design for environment

Five guidelines of design for environment of National Research Council of Canada were applied to our final design. The five guidelines are consists of physical optimization, optimizing material use, production techniques, distribution, and End-of-Life systems.

Environmental impact was important to the design of our prototype because a large amount of wood was used to build the desk. Detailed DFE analysis is attached in Table 6.

Physical optimization	Optimize material use	Optimize production technique	Optimize distribution	Optimize End-of-Life system
Integrated workstation – computer, printer, desk, drawer in one	Use wood- environmentally friendly	Use press fit pins, fit with a hole drilled	Use cardboards if necessary, or transport without packaging	Reusable parts: printer, monitor, keyboard, mouse and desk
Maintain compatibility for monitor and printer	Minimize material waste and maximize material usage	Use corner bracket for joint of wood	Avoid using Styrofoam, chemically toxic material	Assembly using screws, bracket for ease of assembly and disassembly
Provide reliability and durability through monthly services	Parts should be able to have replacement easily with renewable material	Use energy from ordinary power plants that goes to home	Ground shipping	Make use of press fit to eliminate the use of screws and bracket
Easy to repair PC & Printer & monitor	Use easily recyclable material: wood, aluminum	Use hollow metal parts for linkage instead of solid bar		Use aluminum, steel, wood that can be easily recycle
Additional functions: Print, document storage, calendar, clock	Use reusable components and parts: printer, monitor, screws, bracket	Pre-made casing decrease steps to assembly		Safely and easy remove parts that are desired to be reused
Modular printer cavity allows universal fit for any printer model	Parts for table surface, legs, and drawer can be decomposed and use again			The drawer can be separated and reused as a single drawer unit
Multi-tasking: Allowing both computer work and paper work at the same time.	Aluminum cylinder bar and all linkage bars are made of hollow tube or rectangular tube			Screw from outside so that it is easy to dissemble

Table 6. Design for Environment

8.2.3 Failure mode and effect analysis

In order to help us determine the potential failures of our design, we completed a failure mode and effect analysis. Five major components, table, monitor mount, loading system, storage space and printer and their sub-parts were analyzed. The degree of severity on the most of potential effects of failure was very high but these risks were likely to occur rarely and very easy to detect. Most of the risks could be reduced by carefully analyzing the parts before selecting the material.

The failure mode effective analysis for the printer consists of three major parts. The first part is the mounting plate which supports the weight and holds the printer in place. The second part is the printing component which outputs the paper and a power supply that transfers the power up to the printer. The third part is the paper tray and output tray which hold papers and guide the printouts.

The failure of the mounting plate is the most severe scenario and the occurrence is quite frequent if there is excessive load acting on the plate. If the mounting plate failed to support the weight or the drawer slide which attached to the mounting plate has a low tolerance on the weight, the system will yield, deflect and finally collapse causing damage to the printer mechanism. Therefore we wanted to design the tolerance weight for the mounting plate and drawer slide, in addition, laboratory test should also be conducted, such as stress distribution test, to verify the validity of our design and with proper material choice and dimensioning so that safety is achieved and the printer will not be damaged.

Although the failure of the printing component is mid level, but the occurrence is relatively low, and it will depend on the printer brand that we desired to integrated into our workstation, therefore less attention will be geared toward this second part. Finally, the failure of the tray has little effect to the overall performance of the printer system, and with careful design and proper material selection, we can be able to minimize the possibility of tray failure.

The detailed FMEA diagrams are attached in APPENDIX C.

The table can be divided into two parts with functions; the table top, which provides proper working space and the table legs, which support the table. Possible potential failure modes of the table can be scratching, unstable, and loose fittings. Failure of table legs can be critical to the function of the workstation, however, the occurrence rating is low and it is easy to detect by compression test.

Parts that come into the consideration for monitor mount is the aluminum cylinder tube and monitor arm linkage. Aluminum cylinder tube, which has functions of lifting up the monitor and supporting the load from monitor and arm linkage has potential failure mode of deflection, misalignment, and unstable. This failure can lead to malfunction of hiding monitor; however, proper material choice and stress distribution test can help detecting the potential causes of

failure. Excessive loading can lead to failure of monitor extension mechanism, however, similarly, proper material and stress testing can reduce its occurrence and detection rating.

9. Final Design

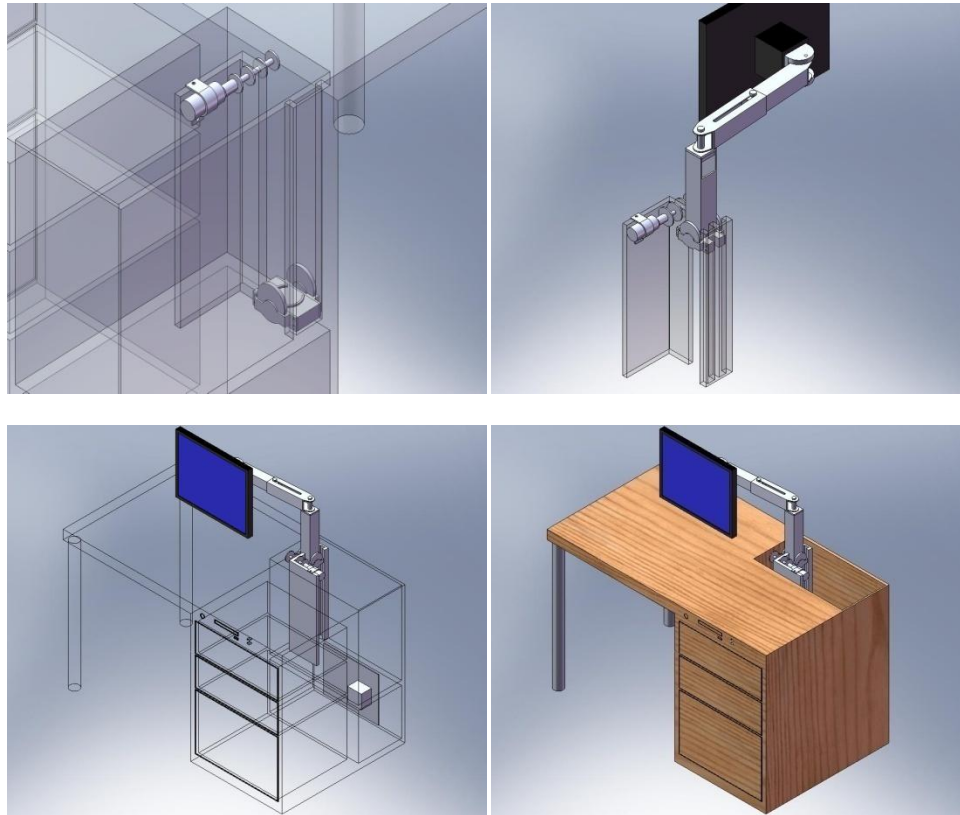


Figure 15. CAD Drawings of Final Design

9.1 Monitor

From the space behind the drawer, the monitor is vertically loaded up using the switch, and once the loading system reaches its maximum height by hitting the top limit switch the monitor will need to be rotated at the pivot point to adjust to the desired location. After it is vertically loaded up and location adjusted, the monitor can be stretched to the front or to the side of the desk depending on the user preference. In addition, the monitor mount purchased has tilting and rotating capability for the user to easily adjust the angle for the monitor. This design allows user to use and hide the monitor with one click and some monitor adjustments. Moreover, the user can adjust the monitor depending on their visibility.

9.2 Loading System

The vertical loading is done with reels and pulleys. The reels and pulleys are linked with stainless steel wires while the two reels are connected to the 3/16” steel rod with set screws. The motor and steel rod will be connected through a coupling, and the pulley mount-attached square tube with linkage system connected is expected to be lifted up to the surface by the winding of the wire onto the reels. A detailed description of the system is shown in APPENDIX D. Before manufacturing the prototype, we took the selection of the wire into consideration. Since the loading system requires the wire to be pulled under tension, and the strength of the cable is strongly thickness dependent, therefore a 1/16” diameter stainless steel wire rope was selected which has a breaking strength of 500 lb which is sufficient to lift the load of 16lb of our system.

In order to lock the wire ropes to the reels and w-shaped guide, we are going to use ferrules, which is a device that acts as a stopper from tiny holes drilled with the wire rope tip through and be swaged with the device. This device is expected to withstand a load of 90 lb which is sufficient to hold the loading system.

The W-shaped loading guide is screwed on the back of the desk and the L-shaped guide is made out of two separate pieces and attached together with corner brackets and screws. After the L-shaped guide is build, it is mounted on an inserted surface in the desk by using corner brackets and screws.

9.3 Printer

Since hiding the printer is one of our primary tasks in designing this integrated workstation, therefore, after some careful considerations of our preliminary designs we came to a combined finalized design. This finalized design is meant to hide the printer in between the desk surface and the drawer space while maintaining the printer to be easily accessible and serviceable. This means that the user can easily reload the paper tray, retrieve the printouts and at the same time be able to change the cartridge without any difficulties. The printer should act as a module that can be installed into the designed printer cavity (18”L × 14”W × 6”H) of the workstation so that the extra materials of the printer can be removed and thus minimizing the amount of space required for the printer. Ideally our designed printer cavity is expected to work for any printers, but for the prototype purpose, we decided to use a HP DeskJet-F300-series printer which feeds in paper from the paper tray below the output tray and print out to the output tray.

Since the printer will act as a module, we decided that it will be inserted as a module drawer into the desk through the use of drawer slide. The idea was to fix the printer onto a piece of wood plate (18”L × 14”W × 1”H) so that the drawer slide can be mounted onto the wood plate. The other half of the drawer slide can be installed onto the two side surfaces of the storage space in

order for the printer to be easily inserted into the workstation and so that the cartridge can be changed without difficulties. In order to retrieve the paper from the printer, there will be an opening in the front surface of the desk so that the user can easily load paper into the paper tray and to retrieve printouts from the output tray, which as mention before, is right on top of the paper tray. The cavity will also include a board with hinge mechanism so that the user can close the cavity to maintain exterior appearance of the desk when not using the printer. Finally if the user decided that the printer is not needed, the cavity can also serve as a drawer slot by simply replacing the wood plate with a real drawer. This concluded the mechanism of the designed concept of hiding the printer.

9.4 Storage Space

The storage space was designed as the space not occupied by the concept of hiding the printer. There will be two ordinary drawers right underneath the cavity for the printer that will serve as storage space. Both drawers will be moving into and out of the workstation using drawer slide as expected since they are simply ordinary drawers. As mentioned, the printer cavity can also serve as a storage space if printer is not needed so that there will be a maximum of three drawers for this integrated workstation.

10. Manufacturing and testing plan

The prototype manufactured includes five major parts, monitor mount, loading system, circuit system, desk, and printer system. Since our prototype is physical, there are parts that were manufactured and purchased. The monitor mount and loading system parts were mostly manufactured in the machine shop out of aluminum alloys. While the desk with printer system and circuit system was built outside of the machine shop in the lab work-area. For reference, Engineering drawings and prototype manufacturing plans are supplied in APPENDIX D and list of purchased items are summarized in the Bill of Materials in APPENDIX E.

Since the design of the workstation is aimed toward hi-end customers, we did not intend for mass production. However the existing manufacturing process with future improvements needs to be modified to satisfy engineering, cost and environmental requirements. As we can see, the existing manufacturing process consist of several parts and is time consuming with human labor, and the loading system was hindered by tilting. Therefore a new design was proposed to compensate engineering inadequate. The new design consists of a simpler loading system. This new design will be more stable and consist of fewer parts which reduce labor cost as amount of manufacturing time decreases. However, the new design consists of an internal threading which is harder to manufacture and thus increases manufacturing cost. For the side of the environmental requirement, since the workstation was made out of wood, which is environmentally friendly material, therefore the workstation itself doesn't really create a potential threat to the environment. The existing loading system is made out of aluminum and

steel which are neither toxic nor harmful, careful manipulation and material reduction with new design will satisfy the environmental requirements.

10.1 Monitor mount

While the mass production design allows the monitor to be loaded up vertically and rotated along the table to be positioned in the center, in the prototype, only the vertical loading is automated. The user has to rotate along its arm linkage from the far end of the table to the center.

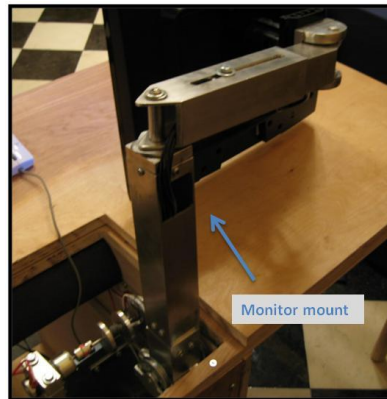


Figure 16. Monitor Mount

10.2 Loading system

The loading system requires three separate components, top rotating axle, bottom connecting pulley, and loading guide.

10.2.1 Rotating axle

The rotating axle consists of two reels, two bearings, a rod, a coupling, motor, and motor mount. One bearing is mounted on the front L-shaped guide and the other is mounted on the wood board on the left. The rod then goes through the holes connecting two reels on each side fixed by set screws. Then the rod is connected to the coupling with the motor shaft. The reels are the only parts that are manufactured.

10.2.2 Bottom pulley mount

Bottom pulley and pulley mount that connects the vertical rectangular tube are the main parts for the bottom components. Mounted pulleys are purchased and the pulley mount is fabricated out of aluminum block. Before operating, we need to make sure to apply lubricants on the surfaces of both guide and the pulley mount so that it reduces friction caused between the pieces.

10.2.3 Loading guide

The guides that aid straight vertical movement are manufactured. The W-shaped guide on the back is attached to the wall of the desk with screws and the front guide is mounted by brackets on the bottom. Both pieces will be fabricated out of aluminum alloy and some nylon coating or lubricants are applied to make sure the undisturbed vertical movement of the loading system.

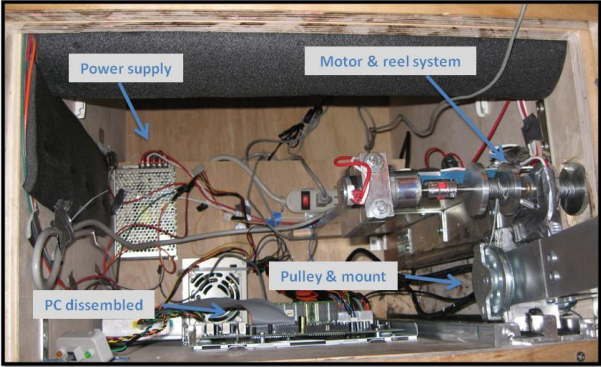


Figure 17. Monitor Loading Mechanism

10.3 Desk

In order to manufacture the integrated workstation, there are three major categories to consider. First of all, we need to build the desk with two legs supporting on the left side of the desk surface and a storage area that support the right side of the surface. The surface of the desk is going made out of wood and should contain all necessary holes, cavities and grooves that are manufactured using drills, mills and saws. As for the storage area, there will be 4 plates of wood along with the top surface which needs to be joined together to create a cavity with the desk front being opened for drawer and printer installation.



Figure 18. Desk

The four plates of wood will be cut to desire dimension using a saw and will be joined together using a combination of screws and corner bracket which will be purchased. The legs for the table will also be purchase as off-shelf stock and will be install to the desk surface along with the storage area to complete the manufacturing of the desk.

10.4 Printer

In order to install the printer into the workstation, we made use of standard 16” drawer slide which will be screwed on to the two side surfaces of the storage area. Since the exact dimension on holes for screw is difficult to simply design it, therefore we decided that it will be better to simply drill through the holes from the drawer slide that will create a hole on the side surface which is concentric with the holes from the drawer slide. By doing this, we have a better control of the exact location, and the holes will be aligned. After mounting the drawer slide onto the side surfaces, we cut the wood with saw to our desired dimension for the wood plate, and the other half of the drawer slide will be mounted on to the side of the mount plate using the same method as before. We then can mount our printer onto the mount plate with screws and insert the plate into the workstation using drawer slide. Another wood plate will be cut to right dimension and with hinges on it, and it will serve to disguise the printer cavity.



Figure 19. Printer

10.5 Circuit

A simple circuit design is produced and electrical wire, two micro-switches, a rocker switch, AC-DC converting power supply are purchased. To connect wire to the devices, wire connectors are used. Power cable is used to provide AC voltage to power supply. The rocker on/off/on switch is placed on the front desk surface. The upper limit switch is placed in which the bottom pulley mount reaches the upper limit and the bottom limit switch is placed in which monitor hits the allowed bottom limit.

11. TESTING

To satisfy the engineering specifications, we considered carefully from manufacturing. Because the prototype didn't require to go through complicated test procedure but to ensure the size, weight, and number of steps to assembly and manufacture, we had to make sure that we have the components done with some considerations.

We built the length, depth, and height of the desk similar to standard desk size to make sure the access through standard-sized door. The number of parts is greater than we had planned before while we went on assembly. And because of the greater number of parts, it took longer than we thought to assemble. We set the weight of the desk to be heavy enough for two adults to carry. It was heavier but still manageable for two adults to carry. The heavier weight was expected due to the increased number of parts.

The most important engineering specification was steps to setup or time that takes to setup. We originally planned 10 seconds to be ideal time for setting up and designed other parts. However, due to the friction and tilted vertical movement of the monitor, it increased. Without friction, it took about 11 to seconds to bring up 18 inches. With friction and monitor in place, it took about 25 seconds for loading with human support. Because the friction on every side that was touching the monitor also was produced, the time for setting up took longer.

12. FUTURE IMPROVEMENTS

One of the biggest problems that we encounter in testing and validating our prototype are with the tilting of our existing monitor- loading system. The tilting of the system generated huge amount of friction both in loading up and loading down of the monitor. This increase in friction creates torque that is too great for the motor; therefore suggested improvements are needed to reduce the torque well below the threshold of the motor. In order to reduce the friction, first of all, we suggested reducing the tolerance to have the pulley mount and motion guide fit tightly and also to increase the length of the pulley mount to its maximized contact area with the motion guide. These two suggestions were listed to limit the spaces that are potential factors to tilting; however they will increase friction even to a higher level. Therefore we also suggested attaching bearings onto the pulley mount to minimize the friction that will otherwise be generated between the contact areas of the pulley mount and motion guide if without bearings. With these suggestions, the tilting problem alone with friction should be minimized.

Since safety issues was another key factors of our workstation that was not addressed in detail for either our design or prototype other than no sharp edges. Therefore we also suggested for the future improvements to install detecting sensors to avoid obstruction. With this detecting sensor, the monitor is less likely to be damaged due to incorrect manipulation of the loading system. This sensor should also detect any obstruction such as hands that are misplaced at the opening

which might result in finger jamming. This suggestion is meant to increase the safety use of the workstation.

One improvement that can be made is to change the loading system completely. For the new loading system you could make it so that it is two parts an outside part which would be a round tube and threaded on the inside of the tube and the second piece would be a hollow rod that is threaded on the outside. The way this system would work is that you would have a motor attached to the bottom of the rod that is threaded on the outside so that when the motor is on the inside rod would spin causing the outside tube to move up along the threads. You could also make this so that once it reached the desired height it would also rotate by having the motor turn another 180 degrees after it reaches the end of the threads, See figure 20 for a sketch of this system.

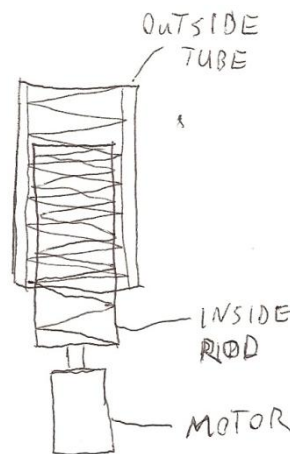


Figure 20. Concept for New Loading System

With the Current design of the printer system in our integrated workstation, the user is required to open up the disguised drawer cover in order to retrieve the print outs. However it may introduce inconvenience to the user since there will always be an extra step as oppose to simply retrieve the paper when the printer is on the desk. Therefore, in order to eliminate this inconvenience, future improvement will need to have the printer as close as possible to the desk surface, so that a small slot on desk surface with slanted guide will allow the paper to print out on the desk surface. This also means that more study of the printer will be required in order to achieve this improvement. Since we also need to make sure it is easy to load paper as well as changing the cartridge.

13. CONCLUSIONS

The objective of this project is to design and prototype the next generation integrated workstation. This idea came from the success of Apple in integrating multiple systems into an

innovative single workstation and with the increasing number of integrated furniture flooding into current market. In order to accomplish this, we decided to integrate an entire PC with the monitor and printer into an ordinary desk. With the preliminary designs, we desired to make the workstation easier to setup, easier to use, and reduce the amount of space needed. The target market will be the high-ins and office uses. To accomplish this we have come up with a final design that automates the motion of the monitor-loading system and minimized the step to power to one step.

Our design of the workstation is no larger than a standard desk. The prototyped workstation satisfied our first design goal, which is easier to setup. The workstation came with PC, monitor and printer build into it and by connecting the power cord to a wall power input, the user can be able to turn on the PC as well as loading up the monitor with the switches. The third design goal, to reduce the amount of space needed, is achieved, since our workstation is no larger than standardize desk and with computer components hidden inside the desk, we were able to create more working space for the user when the use of computer is not needed. Finally, for our second design goal, the quality of the prototype is not as good as we expected. From the final design, we expected the monitor to be lifted up 18 inches with a loading time of 10 seconds. However, our tested loading system took 20 seconds to reach the desired height due to the tilting that occurred which generated higher friction than was initially expected.

14. ACKNOWLEDGMENT

We wish to thank our sponsor Senthil Arul and professor Kazuhiro Saitou for their supervision and guidance throughout the project. We also want to thank Professor Rodemer Michael from the art school for his knowledge in design of desk with wood and Professor Thomas J Armstrong for his expertise in the field of ergonomics. Finally we would like to thank Bob Coury, Marvin R Cressey and Steve Emanuel for their help and advice in the manufacturing process.

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16. BIOS

Wei Han Chen



My name is Jeff Chen, Wei-Han. Jeff is just my made-up English name as a lot of Asians do. I was born in Taiwan, and spent 12 years there before I moved to China and started my journey in learning English and later on study in US. The main reason I studied mechanical engineering is because I wanted to help my father with his family business, which is closely related to mechanical and electrical engineering with the emphasis on the mechanical discipline. I believe that in order to become a better businessman in mechanical and electrical field,

I need to acquire some of the basic knowledge about engineering. With what I learned in school, here at Michigan, I believe that in the future, I will be a great help to my father's family business. As I have mentioned, my future plan will be returning to Taiwan after I graduated, and start to help with the family business and hopefully with two years of working experience, I will be able to realize what I am lacking in business, and return to school for degree in MBA.

In the past two years, I have been an intern at TSM, a company back in Taiwan, during summer vacation. It was a great experience, since I get to manipulate some of the manufacturing tools and machines such as mill, lathe and grinder. I also learned Auto-CAD which is a drawing application that is widely used in Taiwan. These are great opportunities for me to see some of the real world manufacturing processes and these experiences are definitely valuable for my future careers. I hope to gain more knowledge through this ME450 project and to be able to apply what I have learned in the past three years of education.



Joe Knakal

My name is Joe Knakal. I am from Clarkston, MI. I have lived in Clarkston for 21 years. I am currently staying with my sister in Milford, MI and commuting to school every day. I am interested in mechanical engineering because I have grown up around cars and I like to build things and take things apart to see how they work. Specifically I am

interested in the design side of mechanical engineering. I am graduating in December and then plan to find a job and join the workforce, with the possibility of getting a masters sometime down the road. I am getting married in March to a girl I met in high school. She is going to Rochester College in Rochester, MI studying to be a math teacher.

Kyoung-Yoon Kim

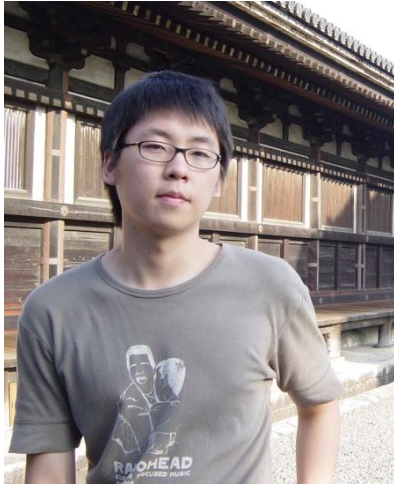


My name is Kyoung-Yoon Kim. I'm from Korea and just turned to twenty two yesterday (Sep. 26th). The first part of my name, 'Kyoung' means to respect the others and 'Yoon' means to shine. I've been living in the United States for six years. When I first came to the United States, I was with my family. After the high school graduation, they went back to Korea. First three years of my US life, I went to a high school, close to Pasadena, California. Then, entering to the U of M here has broadened my view about America. In fact, as I visit every new place, I am used to be astonished.

About the reason I'm interested in mechanical engineering, I don't know really. I liked car when I was young, and I liked airplane when I grew up older. Also, music was part of my life. It doesn't mean that I'm good at it but I just enjoyed it and wanted know how those worked. I guess that's the reason that I'm interested in mechanical engineering, the most basic but fundamental study of all mechanisms.

Now, I'm planning to go graduate school and looking for research position that I'm interested in. I just took GRE about a week ago and I am planning to take it one more time because even though it might be enough to get an admission, I am not satisfied. Since every Korean man has to serve army, I have to pick a right time to fulfill the call of duty for two years and I cannot postpone this for too long.

Woo Young Yang



I was born in South Korea and raised there until 7 years old. Before entering the elementary school, I was moved to Indonesia, a country that I've never heard of before. I attended Korean International School in Jakarta, Indonesia and transferred to American International School for my high school. First reason that I chose Mechanical Engineering for my major was because I was always interested in automotive engineering and industry. Along the study of Mechanical Engineering at U of M, I became more interested in designing and manufacturing, system and controls. Currently, I am planning to go to graduate school studying Industrial Operation Engineering. However, since I am Korean, I have to fulfill the military service for 2 years. Therefore, I might go to graduate school after I finish my military obligation.

APPENDIX A: BENCHMARKS



Figure A1: iMac vs. Dell Wiring

U.S. Patent Dec. 10, 1985 Sheet 1 of 3 **Des. 281,686**

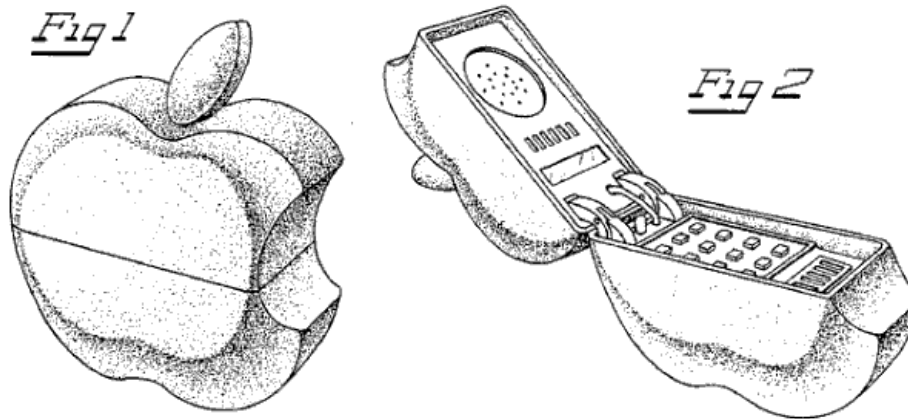


Figure A2: iPhone patent design



Figure A3: i-Con desk



Figure A4: i-Con Desk's Sub-Fuctions



Figure A5. Freemote System

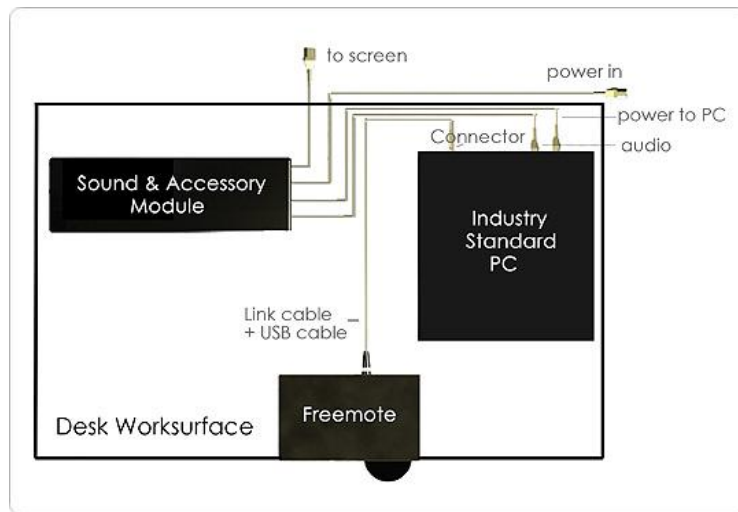


Figure A6. Freemote Function Diagram



Figure A7. Freemote Concept

APPENDIX B: GANTT CHART

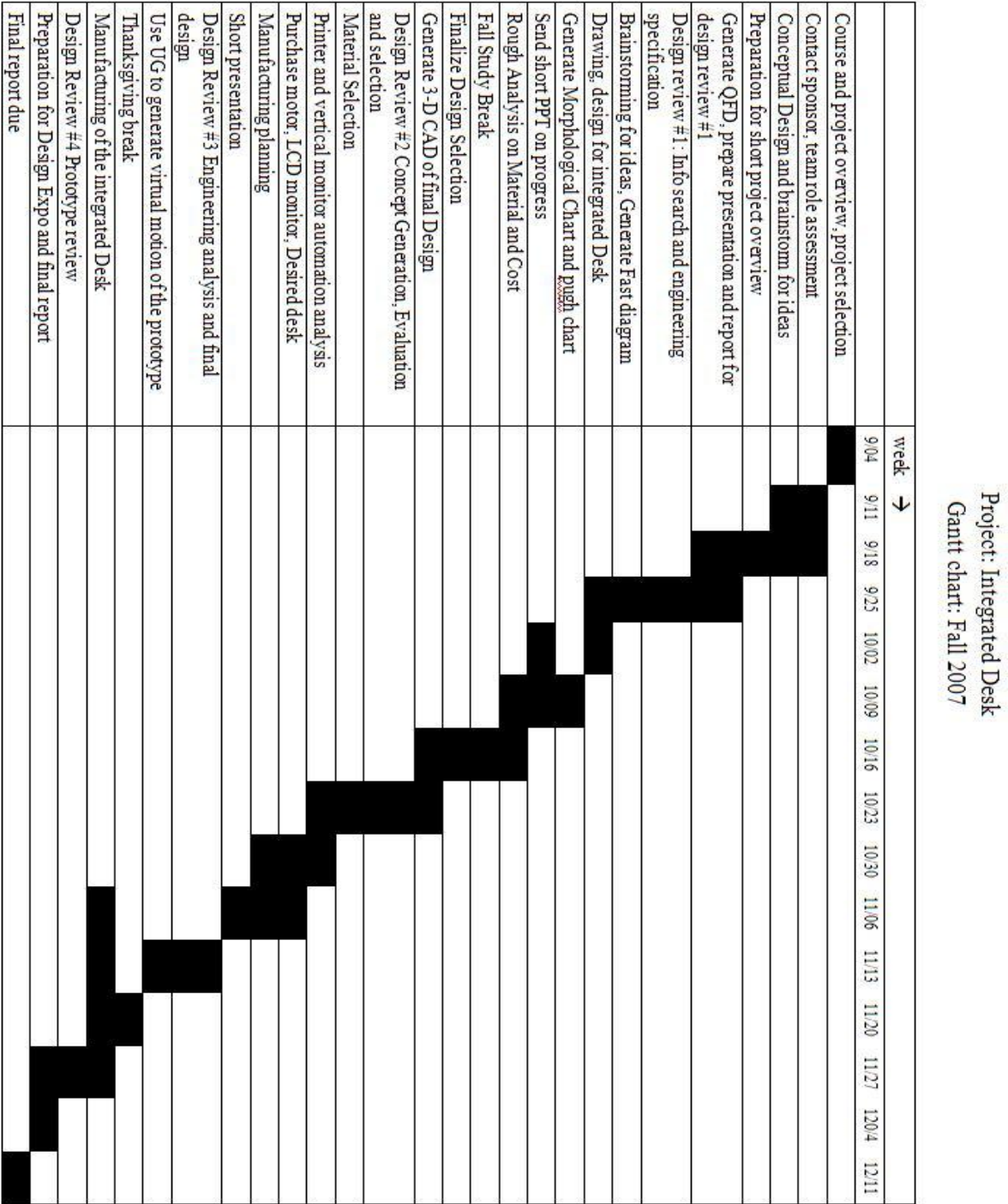


Figure B1. Gantt Chart

APPENDIX C: FAILURE MODES AND EFFECT ANALYSIS

Part # & Functions	Potential Failure Mode	Potential Effects of Failure	Severity (S)	Potential Causes, Mechanisms of Failure	Occurrence (O)	Current Design Controls/ Tests	Detection (D)	Recommended Actions	RPN	NEWS	NEWO	NEWD	NEW RPN
Tabletop –provide working space	Scratching, deflection	Deteriorated life of table	4	Improper usage	4	Laboratory test: hardness test	3	Sufficient wax coverage 48	48	4	2	3	24
Table legs - support table	Unstable, loose fitting	Hazards to users, Fail to function	9	Excessive loading	2	Laboratory test: axial loading test	2	Proper material selection and dimensioning 36	36	6	2	2	24

Table C1. Table FMEA

Part # & Functions	Potential failure mode	Potential effects of failure	S	Potential causes, Mechanisms of failure	O	Current design controls/ Tests	D	Recommended actions	RPN	NEWS	NEWO	NEWD	NEW RPN
Horizontal bar – lift monitor up - support monitor and linkage	Deflection, misalignment, instability	Failure of loading mechanism	9	Improper alignment, excessive loading	2	Laboratory test: stress distribution on the bar	3	Proper material selection and dimensioning, sufficient lubricant	54	6	2	3	36
Arm – support monitor	Deflection, loose fitting, noise	Failure of monitor extension	7	Excessive loading, insufficient lubricant	4	Laboratory test: stress distribution along linkage	2	Proper material selection and dimensioning	56	4	2	2	16

Table C2. Monitor Mount FMEA

Part # & Functions	Potential failure mode	Potential effects of failure	S	Potential causes, Mechanisms of failure	O	Current design controls/ Tests	D	Recommended actions	RPN	NES	NWO	NED	NEWPN
Drawer slide - easy access	Loosening, fail to slide	Unable to access	6	Heavy load, wrong material, loose screws	4	Retighten screw	2	Tighten each screw, lubrication	48	5	3	2	30
Drawer - store	Material yield, deflection, deformation	Collaps e	5	Heavy load, wrong material	4	Perform a stress analysis	2	Proper material dimensioning and selection	40	4	3	2	24

Table C3. Storage Space FMEA

Part # & Functions	Potential failure mode	Potential effects of failure	S	Potential causes, Mechanisms of failure	O	Current design controls/ Tests	D	Recommended actions	RPN	NES	NWO	NED	NEWPN
Upper Axle - Coil wire	Deflection, loose fittings, noise	Fail to function, damage monitor and PC	9	Excessive loading, insufficient lubricant, poor fastening	3	Laboratory test: stress distribution along rotating rod	1	Separate loading and PC compartments	27	5	3	1	15
Lower pulley - make easy to pull	Wearing, loosening	Fail to function, damage monitor and PC	9	Excessive loading	1	Laboratory test: stress distribution along pulley mount	1	Separate loading and PC compartments	9	4	1	1	4
Wire - pull	Vibration, misalignment, loosening	Fail to function, damage monitor and PC	9	Hanging over long period, rapid coiling	3	Tensile test of wire, motor test	1	Fix firmly, use a lock to support the hanging load	27	4	3	1	12

Table C4. Loading System FMEA

Part # & Functions	Potential failure mode	Potential effects of failure	S	Potential causes, Mechanisms of failure	O	Current design controls/ Tests	D	Recommended actions	RP N	NE W S	NE W O	NE W D	NE W RP N
Mounting plate - support weight - hold printer	Yield, buckling, deflection	Damage printer	9	Excessive loading	5	Laboratory test: stress distribution test	1	Proper material dimensioning	45	8	4	1	32
Printing component - printout - supply power	Leaking, loosening, thermal fatigue	Damage printer, poor quality-printouts, toxic gas generation	5	Poor fastening, bad allocation	1	Repetitive operation test, thermal generation analysis	5	Integrate certified printer	25	4	1	4	16
Tray - hold paper - guide printouts	Failure to feed and receive	Paper jam	2	Overloaded printouts, excessive usage	3	Laboratory test: stress distribution test	2	Proper selection of material 12	12	2	1	2	4

Table C5. Printer FMEA

APPENDIX D: PROTOTYPE MANUFACTURING PLAN

All Dimensions in inches.

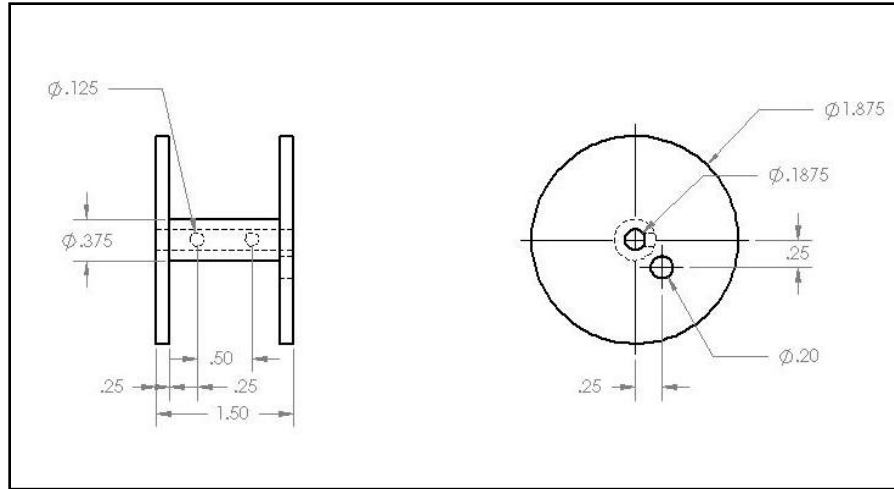


Figure D1. Dimensioned Drawing of Reel

Part Name: Reel x 2

Raw Material: 2" Diameter Aluminum Rod x 2

Op.#	Operation	Machine Tool	Speed	Fixture	Time (hr)
1	cut to 6" length	Chop Saw	300 FPM	Vise	1/12
2	Face one end	Lathe	750 RPM	3 Jaw Chuck	2/12
3	Reduce diameter to 1.875" for 1.5" length	Lathe/Facing	750 RPM	3 Jaw Chuck	4/12
4	Part 1" length of 0.375" diameter	Lathe/Parting	250 RPM	3 Jaw Chuck	24/12
5	Center drill	Lathe	750 RPM	3 Jaw Chuck	1/12
6	Drill 3/16" diameter hole 2" deep	Lathe/Drilling	750 RPM	3 Jaw Chuck	6/12
7	Cut the extra length	Band Saw	300 FPM	Vise	1/12
8	Face the cut End	Lathe/Facing	750 RPM	4 Jaw chuck	4/12
9	Drill two Set screw holes	Drill Press	1150 RPM	Vise	2/12
10	Drill 0.2" diameter for cable stopper	Drill Press	1150 RPM	Vise	2/12
11	Repeat the process for 2 nd reel				47/12
				Total	94/12

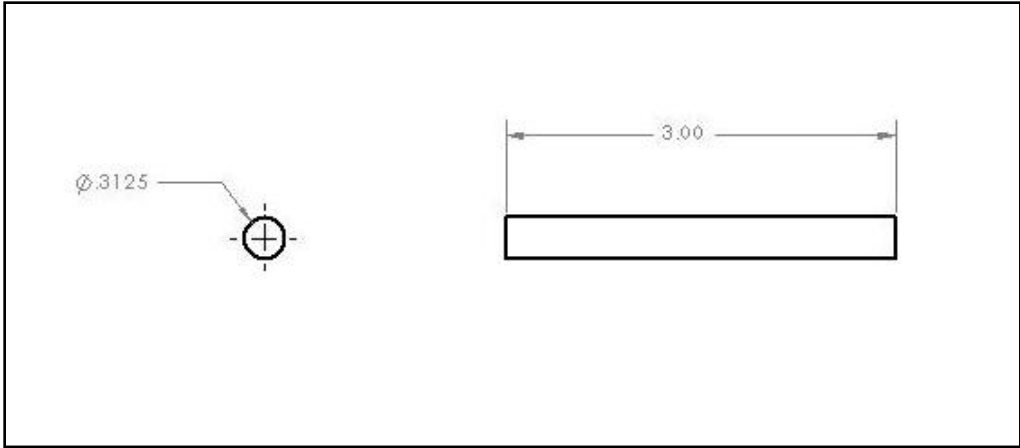


Figure D2. Dimensioned Drawing of Monitor Mount Supporting Rod

Part Name: Monitor Mount Supporting Rod

Raw Material: 0.5” Diameter Aluminum Rod

Op.#	Operation	Machine Tool	Speed	Fixture	Time (hr)
1	Cut to 6” length	Chop Saw	300 FPM	Vise	1/12
2	Face one end	Lathe	750 RPM	3 Jaw Chuck	2/12
3	Reduce diameter to 0.3125” on 3” length	Lathe/Facing	750 RPM	3 Jaw Chuck	12/12
4	Cut the extra length	Band Saw	300 FPM	Vise	1/12
5	Face the other End	Lathe/Facing	750 RPM	Collar	3/12
6	Put exterior Thread	Lathe	Hand Spinning	Collar	3/12
				Total	22/12

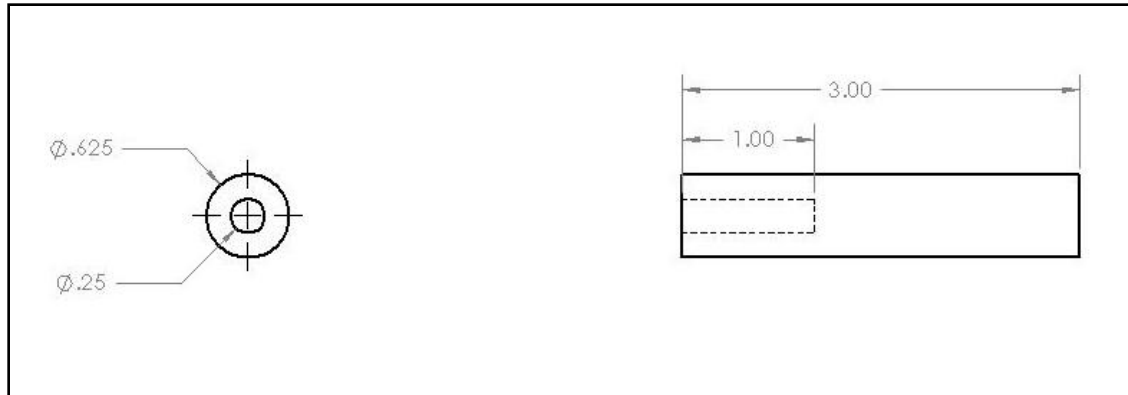


Figure D3. Dimensioned Drawing of Linkage Supporting Rod

Part Name: Linkage Supporting Rod

Raw Material: 1" Diameter Aluminum Rod

Op.#	Operation	Machine Tool	Speed	Fixture	Time (hr)
1	Cut to 6" length	Chop Saw	300 FPM	Vise	1/12
2	Face one end	Lathe	750 RPM	3 Jaw Chuck	2/12
3	Reduce diameter to 0.625" on 3" length	Lathe/Facing	750 RPM	3 Jaw Chuck	12/12
4	Center drill	Lathe	750 RPM	3 Jaw Chuck	1/12
5	Drill 0.25" diameter hole 1" deep	Lathe/Drilling	750 RPM	3 Jaw Chuck	4/12
6	Tap the hole	Tap		Vise/Hand	2/12
7	Cut the extra length	Band Saw	300 FPM	Vise	1/12
8	Face the other End	Lathe/Facing	750 RPM	Collar	3/12
9	Put exterior Thread	Lathe	Hand Spinning	collar	3/12
				Total	29/12

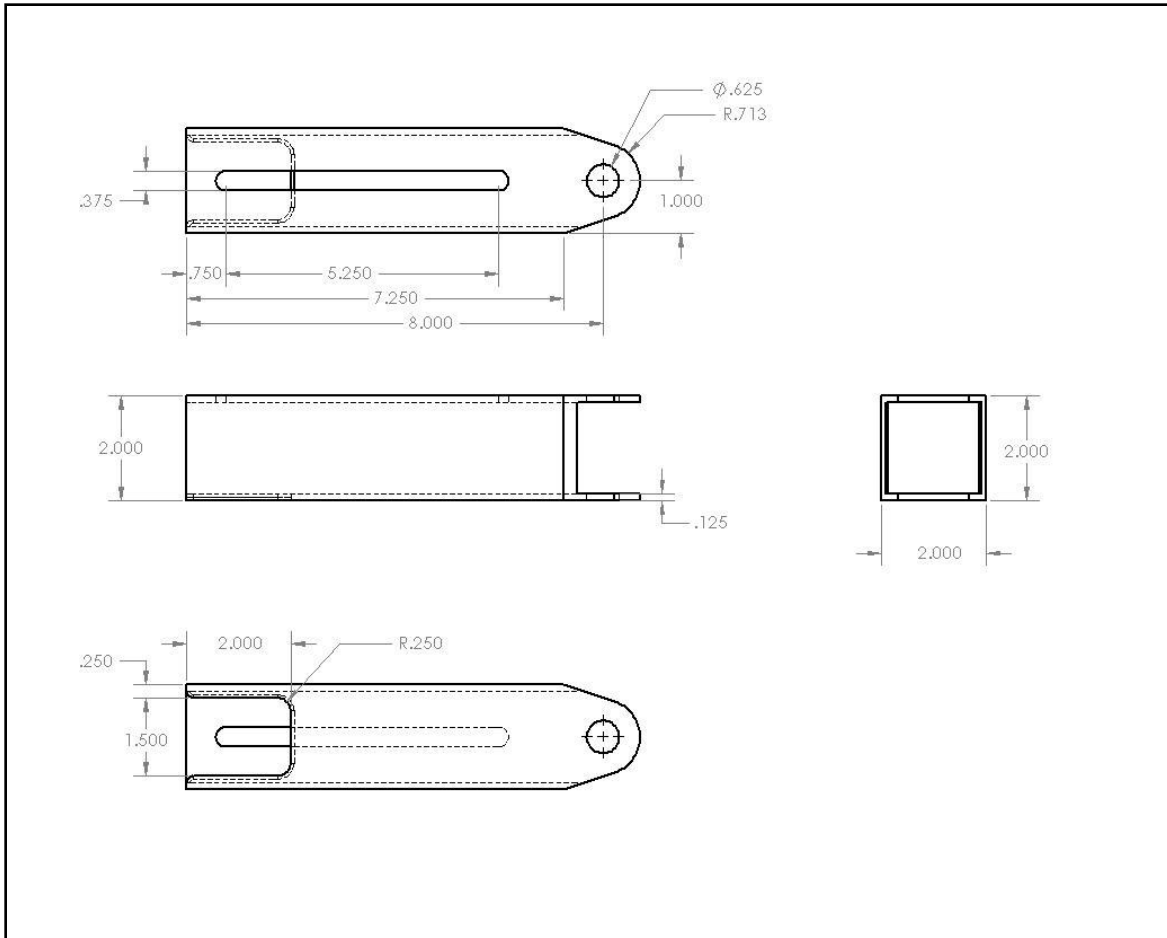


Figure D4. Dimensioned Drawing of Linkage Bar 1

Part Name: Linkage Bar 1

Raw Material: 2" by 2", 0.125" Wall Aluminum Square Tube

Op.#	Operation	Machine Tool	Speed	Fixture	Time (hr)
1	Cut to 8.75" length	Band Saw	300 FPM	Vise	2/12
2	Mill the slot of 5.250" long 0.375" wide	Mill	1500 RPM	Vise	6/12
3	Drill 0.625" diameter hole	Mill	1500 RPM	Vise	3/12
4	Cut out a space of 1.5" by 2"	Mill	1500 RPM	Vise	4/12
5	Create circular shape on the hole side	Band Saw	300 FPM	Vise	4/12
				Total	19/12

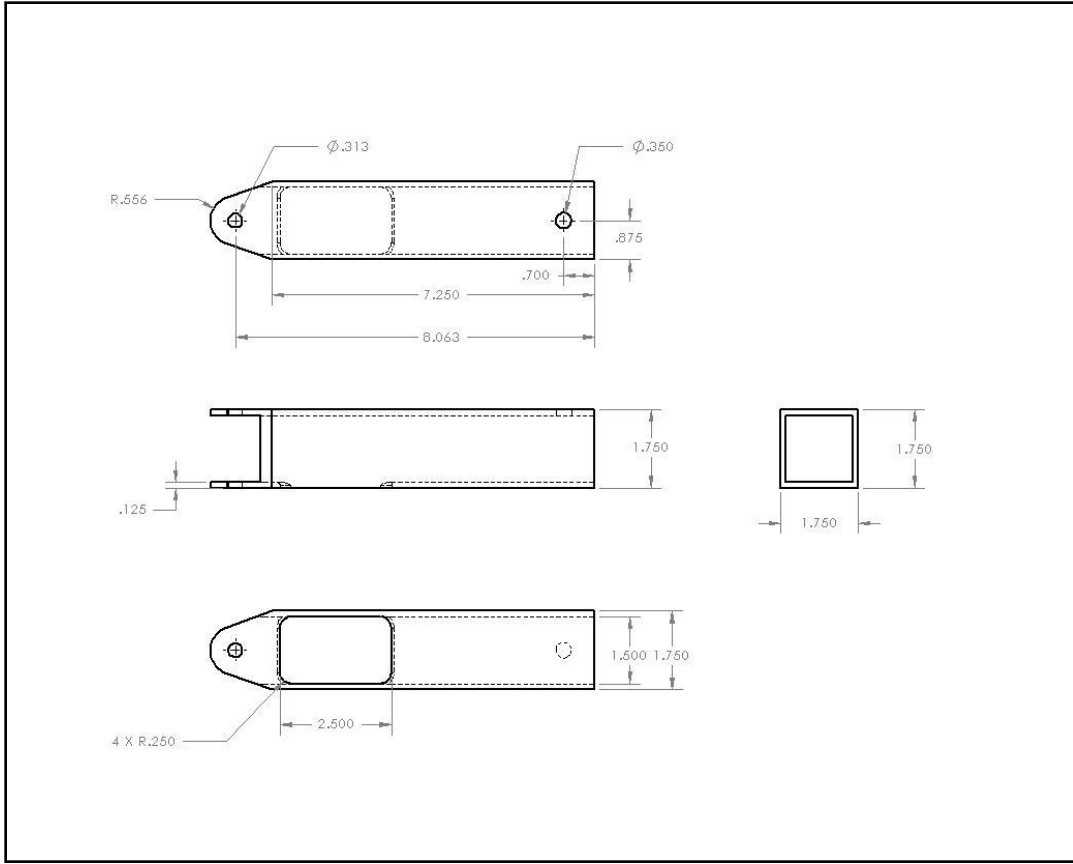


Figure D5. Dimensioned Drawing of Linkage Bar 2

Part Name: Linkage Bar 2

Raw Material: 1.75" by 1.75" by 1' length 0.125" Wall Aluminum Square Tube

Op.#	Operation	Machine Tool	Speed	Fixture	Time (hr)
1	Cut to 8.876" length	Band Saw	300 FPM	Vise	2/12
2	Drill 0.313"(5/16") diameter hole	Mill	1500 RPM	Vise	3/12
3	Drill 0.350" diameter hole	Mill	1500 RPM	Vise	3/12
4	Create a cavity of 2.5"x1.5" for wires	Mill	1500 RPM	Vise	4/12
5	Create circular shape	Band Saw	300 FPM	Vise	4/12
Total					16/12

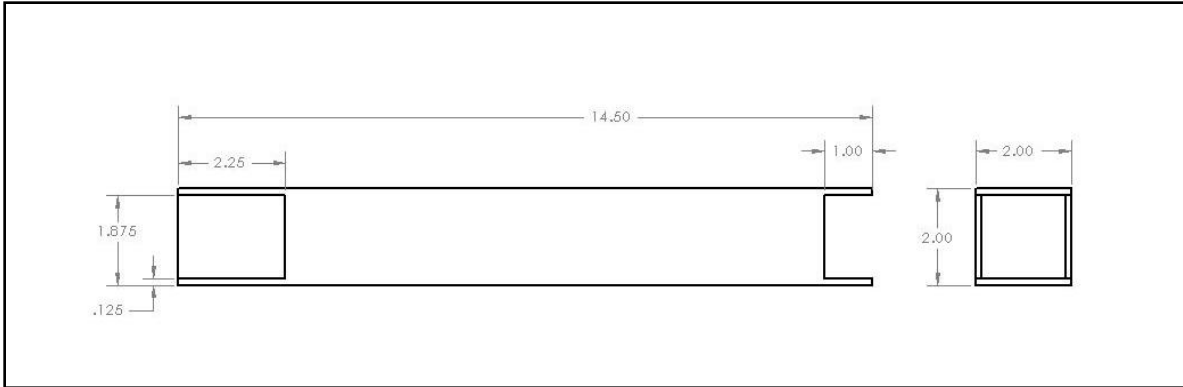


Figure D6. Dimensioned Drawing of Main Support Bar

Part Name: Main Support Bar

Raw Material: 2" by 2", 0.125" Wall, Aluminum Square Tube

Op.#	Operation	Machine Tool	Speed	Fixture	Time (hr)
1	Cut to 14" length	Band Saw	300 FPM	Vise	2/12
2	Create cutout section 1" deep for welding of the bar to pulley mount	Mill	1500 RPM	Vise	6/12
3	Create cutout section of 2.25"x1.75" for wire	Mill	1500 RPM	Vise	6/12
				Total	14/12

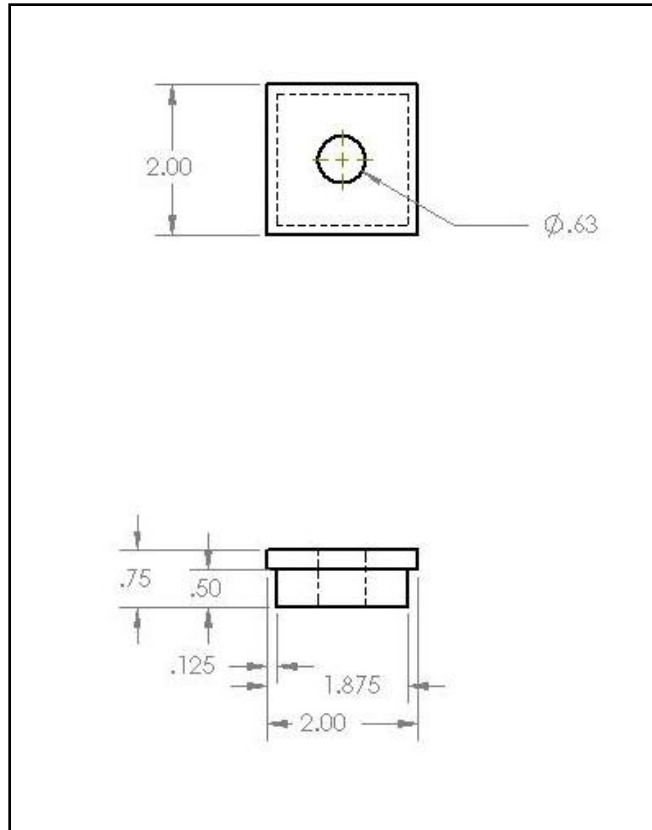


Figure D7. Dimensioned Drawing of Square Support Block

Part Name: Square Support Block

Raw Material: 0.75" Thick Aluminum Plate

Op.#	Operation	Machine Tool	Speed	Fixture	Time (hr)
1	Cut to 2" x 2" square block	Band Saw	300 FPM	Vise	3/12
2	Face Mill the cut side	Mill	1500 RPM	Vise	6/12
3	Make 0.5" depth into 1.75" by 1.75"	Mill	1500RPM	Vise	8/12
4	Drill 0.625" Diameter hole in the center	Mill	1500 RPM	Vise	4/12
5	Put thread the hole	Tap		Vise	3/12
6	Drill 3 holes when attached to the main support Bar	Drill Press	1150 RPM	Vise	6/12
7	Thread the 3 holes	Tap		Vise	6/12
Total					36/12

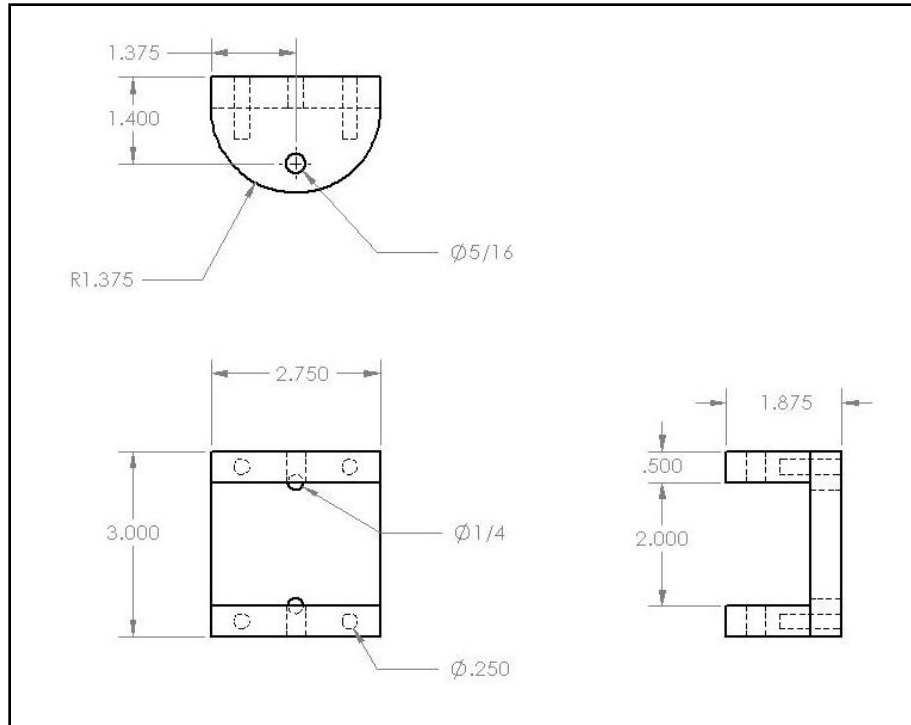


Figure D8. Dimensioned Drawing of Pivot Bracket

Part Name: Pivot Bracket

Raw Material: 0.5" Thick Aluminum Plate (2.750" x 1.375" block x 2, and 3" x 2.75" block)

Op.#	Operation	Machine Tool	Speed	Fixture	Time (hr)
1	Generate 3 aluminum block with given dimension	Band Saw	300 FPM	Vise	8/12
2	Face Mill the cut side	Mill	1500 RPM	Vise	8/12
3	Drill 4 holes of diameter 0.25" on 3" x 2.75" block	Mill	1500 RPM	Vise	8/12
4	Counter sink the 4 holes	Mill	1500 RPM	Vise	5/12
5	Drill diameter 0.25" holes x 2 on 2.750" x 1.375" block	Mill	1500 RPM	Vise	4/12
6	Drill 2 holes of diameter 0.25" on each of the 2.750" x 1.375" block	Mill	1500 RPM	Vise	4/12
7	Thread the 4 holes	Tap		vise	6/12
8	Create the circular Arc on on each of the 2.750" x 1.375" block	Band Saw	300 FPM	Vise	8/12
9	Assemble the pieces with screws	Screw driver		Hand	3/12
10	Drill 5/16" diameter hole through both 2.750" x 1.375" block	Drill Press	1150RPM	Vise	4/12
11	Put thread in the lower block	tap		vise	2/12
				Total	60/12

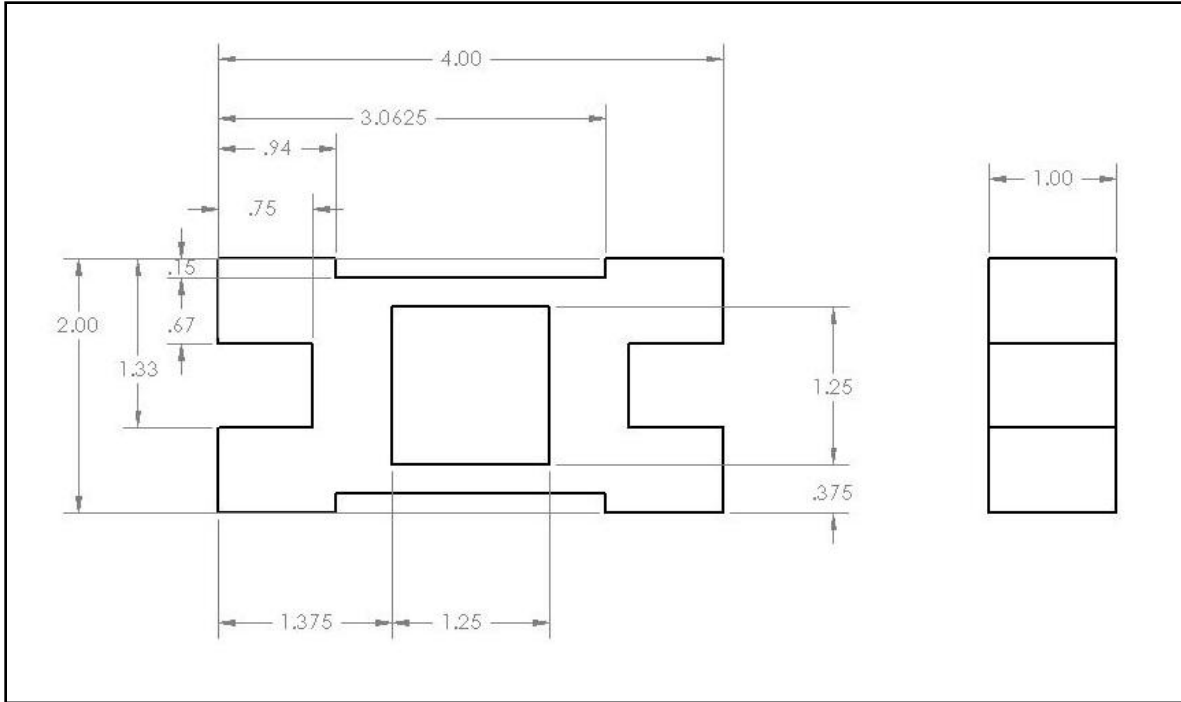


Figure D9. Dimensioned Drawing of Pulley Mount

Part Name: Pulley Mount x 2

Raw Material: 1" Thick Aluminum Plate

Op.#	Operation	Machine Tool	Speed	Fixture	Time (hr)
1	Cut to 4" x 2" block	Band Saw	300 FPM	Vise	5/12
2	Face Mill the cut side	Mill	1500 RPM	Vise	6/12
3	Generate two opening 0.75" x 0.51" on two ends	Mill	1500 RPM	Vise	10/12
4	Generate 2 grooves 0.15" x 2.1225"	Mill	1500 RPM	Vise	5/12
5	Generate a cavity 1.25" x 1.25"	Mill	1500 RPM	Vise	6/12
6	Repeat the operations for the 2 nd pulley Block				32/12
				Total	64/12

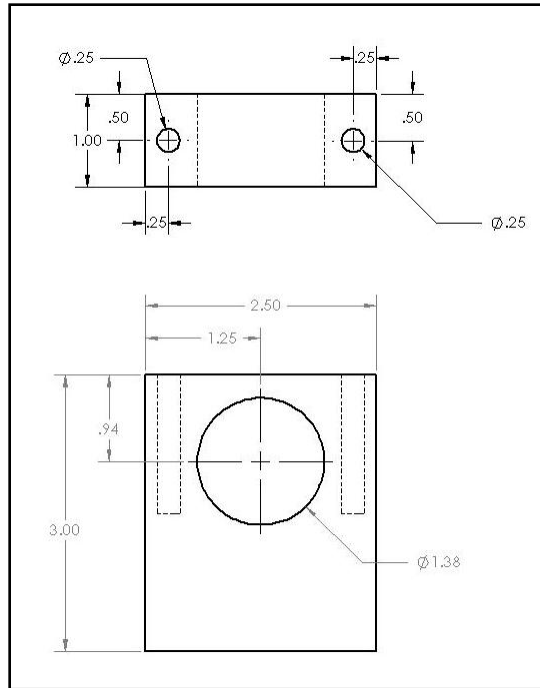


Figure D10. Dimensioned Drawing of Motor Mount

Part Name: Motor Mount

Raw Material: 1" Thick Aluminum Plate

Op.#	Operation	Machine Tool	Speed	Fixture	Time (hr)
1	Generate a block 3" x 2.5"	Band Saw	300 FPM	Vise	5/12
2	Face Mill the cut side to create flat surfaces	Mill	1500 RPM	Vise	6/12
3	Drill a 1" diameter Hole	Mill/Drilling	1500 RPM	Vise	4/12
4	Make the hole to 1.38" diameter	Mill/Boring	150 RPM	Vise	8/12
5	Drill 2 - 0.25" diameter hole for screws	Mill/Drilling	1500 RPM	Vise	6/12
6	Cut the aluminum block in the center of the hole on 4" length side	Band Saw	300FPM	Vise	3/12
7	Put threads in the lower half of the block	Tap		Vise	4/12
Total					36/12

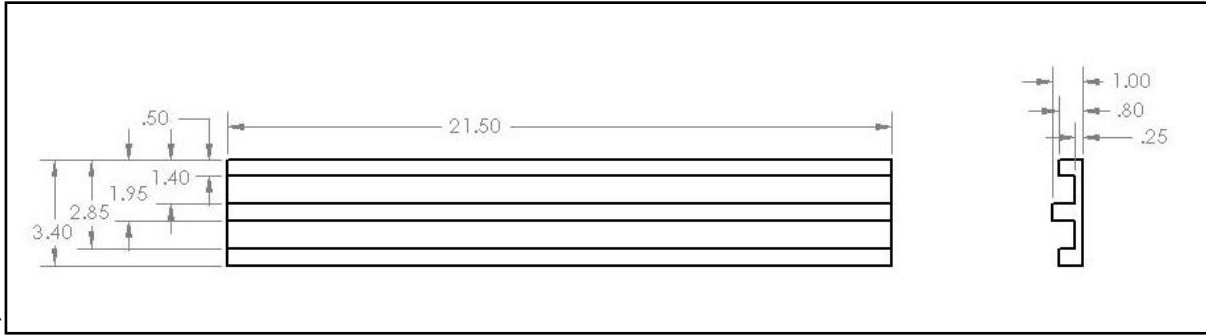


Figure D11. Dimensioned Drawing of W-shaped Motion Guide

Part Name: W-Shaped Motion Guide

Raw Material: 1" Thick Aluminum Plate

Op.#	Operation	Machine Tool	Speed	Fixture	Time (hr)
1	Generate a plate of 21.5" x 3.4"	Chop Saw & Band Saw	300 FPM	Vise	6/12
2	Face Mill the cut side to create flat surfaces	Mill	1500 RPM	Vise	6/12
3	Generate the long slot cavity	Mill	1500 RPM	Vise	16/12
4	Reduce the thickness of two sides from 1" to 0.8"	Mill	1500RPM	Vise	6/12
				Total	34/12



Figure D12. Dimensioned Drawing of L-shaped Motion Guide

Part Name: L-Shaped Motion Guide

Raw Material: 0.5" Thick Aluminum Plate (21.5" x 3" & 20" x 5.5")

Op.#	Operation	Machine Tool	Speed	Fixture	Time (hr)
1	Generate two plate of given dimension	Band Saw/Chop Saw	300 FPM	Vise	8/12
2	Face mill the cut side to create necessary flat surfaces	Mill	1500 RPM	Vise	5/12
3	Drill a 5/8" diameter hole on 21.5" x 3" plate	Mill/Drilling	1500 RPM	Vise	3/12
4	Assemble two plates into L-Shape with corner bracket	Drill Press/Tap	1150 RPM	Vise	8/12
				Total	24/12

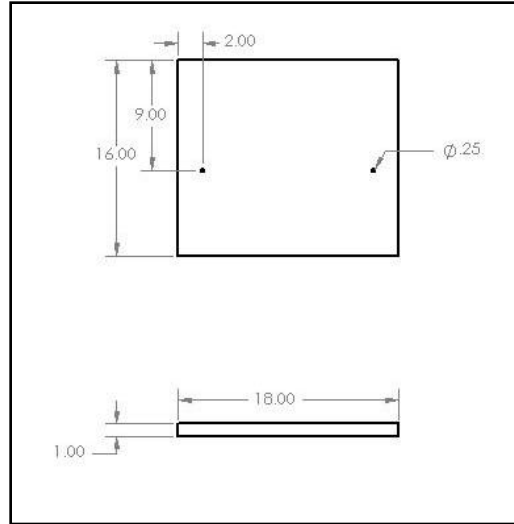


Figure D13. Dimensioned Drawing of Printer Plate

Part Name: Printer Mechanism

Raw Material: 1" Thick Birchwood

Op.#	Operation	Machine Tool	Fixture	Parameter	Time (hr)
1	Generate Mounting Plate	Saw	Hand held	18"x14"x1"	6/12
2	Mount drawer slide	Hand drill	Hand held	With screws	8/12
3	Mount printer and control panel on the plate	Hand drill/screw driver	Hand Held	With screws	4/12
				Total	18/12

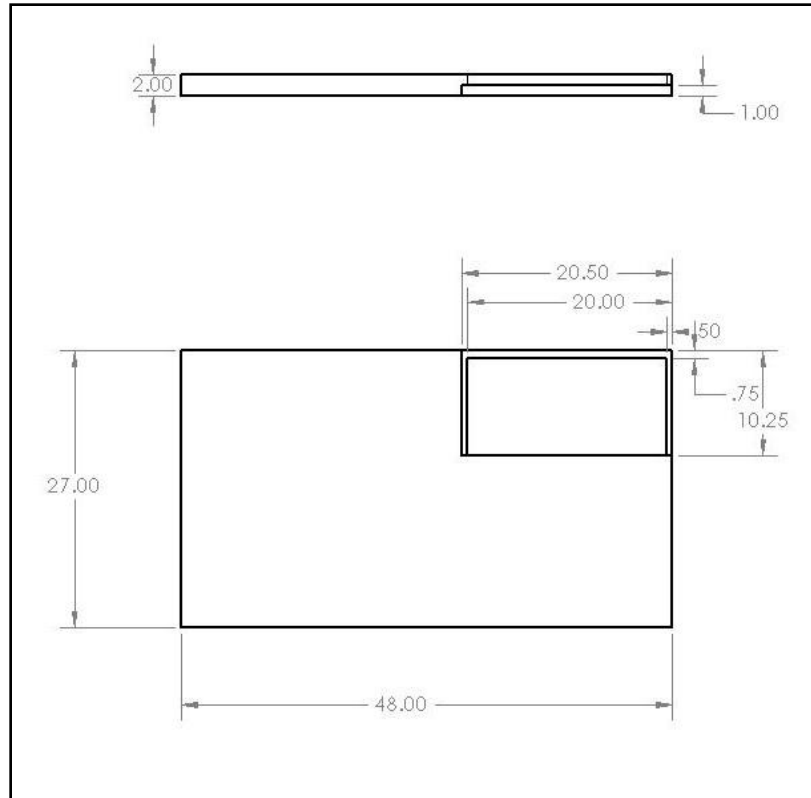


Figure D14. Dimensioned Drawing of Workstation

Part Name: Workstation

Raw Material: Birchwood

Op.#	Operation	Machine Tool	Fixture	Time (hr)
1	Generate upper surface with 20.5" x 10.25" cutout	Circular saw	Hand held	3/12
2	19.5" x 9.5" cavity for lower surface	Circular Saw	Hand Held	2/12
3	Generate 4 surfaces of two 28" x 28" side surfaces, 20"X26" bottom surface and 20"X28" back surface	Saw	Hand held	12/12
4	Holes for screws	Drill	Hand Held	6/12
5	Construct storage space	Drill/Hand	Hand Held	8/12
6	Install PC system	Drill/Hand	Hand Held	18/12
7	Install loading system	Drill/Hand	Hand Held	48/12
8	Install printer system	Drill/Hand	Hand Held	2/12

9	Install CD-ROM and switch system	Drill/Hand	Hand Held	12/12
10	Attach Legs (28" long hand rail) to Lower Surface	Drill/Hand	Hand Held	3/12
11	Attach lower surface to storage space	Drill/Hand	Hand Held	4/12
12	Paint coated the upper surface			4/12
13	Attach the upper surface to lower surface	Drill/Hand	Hand Held	4/12
			Total	126/12

APPENDIX E: BILL OF MATERIAL

Quantity	Part Description	Purchased From	Part Number	Price (each)
1	Drawer Slide 16"	Home Depot.	022788795794	\$ 5.78
5.08ft	Hand Rail for Wood Legs	Home Depot	049437901146	\$ 2.39/ft
2	1" 4'x8' Birch hardwood	Home Depot	596019 D21	\$ 63.89
1	Outlet Power Strip	Carpenter Bros. Hardware	544086	\$ 8.99
1	SWITCH ROCKER DPDT SLD LUB BLACK 4A/125VAC	Digikey.com	CKC2041-ND	\$ 11.27
2	SWITCH SIM ROLL SPDT .1A .110QC	Digikey.com	SW805-ND	\$ 3.70
2	SAE 841 Bronze Flanged- Sleeve Bearing for 3/16" Shaft Diameter, 5/16" OD, 1/2" Length	McMaster-Carr	6338K311	\$ 0.59
1	17-4 Ph Stainless Steel Precision Ground Rod 3/16" Diameter, 1' Length	McMaster-Carr	9095K331	\$9.80
2	Aluminum HI-Misalignment Spider Coupling Hub 3/16" Bore, 3/4" Outside Diameter	McMaster-Carr	9845T101	\$10.74
1	Red Shore 98A Spider for 3/4" OD Aluminum HI- Misalignment Spider Coupling Hub	McMaster-Carr	9845T11	\$4.98
8Ft.	Type 302 Stainless Steel Wire Rope 1X19 Strand Core, 1/16" Dia, 500# Break Strength	McMaster-Carr	3458T28	\$0.34
2	Mounted Pulley for Wire Rope W/Single Galv Iron Pulley, for 3/16" Rope Dia, 2.5" OD	McMaster-Carr	3074T31	\$17.26
1	Motor	Motor Allied Electronics	415A159	\$ 61.35
1	Mean Well USA Enclosed P 60W 24V 2.5A	Mouser Electronics	709-S60-24	\$ 39.24
1	Alloy 6063 Aluminum square Tube 2"X2", 0.125"wall 3' length	McMaster-Carr	88875K673	\$ 21.35
1	ALLOY 6063 ALUMINUM SQUARE TUBE, 1-3/4" X 1-3/4", .125" WALL, 1' LENGTH	McMaster-Carr	88875K641	\$ 8.14
1	Hanns.G HX192DPB/19"/2ms/700:1	Tigerdirect.com	H94-1918	\$ 169.99

	SXGA 1280 x 1024/DVI/Black/LCD Monitor with Speakers			
1	Moview MVWMTS LCD Wall Mount with Tilt and Swivel	Tigerdirect.com	S755-1012	\$ 44.99
1	HP Printer	Joe	F300 Series	\$ 0.00
2	2" Aluminum Rod, 5" length	University of Michigan		\$ 0.00
1	1" Aluminum Rod, 5" length	University of Michigan		\$ 0.00
1	0.5" Aluminum Rod, 5" length	University of Michigan		\$ 0.00
6	Aluminum Block/plate	University of Michigan		\$ 0.00
#	Screws	University of Michigan		\$ 0.00
#	Corner Bracket	University of Michigan		\$ 0.00
	Miscellaneous			\$ 32.85
	Shipping Cost			\$ 66.43
			Total	694.68

Miscellaneous

MOLDG Mill (wood sand block):\$3.97

Bit, Zip1/8: \$10.38

Tape: \$ 0.99

In Ferrules \$ 1.19

Grease, Mul –PR 11b: \$ 3.79

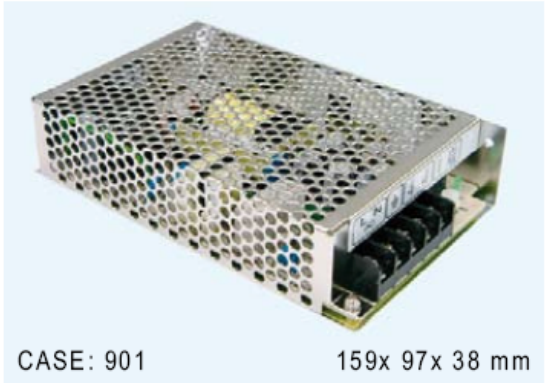
Nuts, Bolts, Nails, screws: \$ 6.19+tax \$ 1.48 = \$ 7.67

Level Torpedo 9": \$ 3.49

Wood Saw

APPENDIX F: PRODUCT SPECIFICATIONS

60W Single Output Switching Power Supply



- Universal AC input / Full range
- Protections: Short circuit / Overload / Over voltage
- Fixed switching frequency at 50KHz
- Approvals: UL / CUL / TUV / CB / CE
- Cooling by free air convection
- 100% full load burn-in test
- 2 years warranty

AC input voltage range	85~264VAC; 120~370VDC
AC inrush current	Cold start, 20A at 115VAC, 40A at 230VAC
DC adjustment range	±10% rated output voltage
Overload protection	105%~150% hiccup mode, auto-recovery
Over voltage protection	115%~135% rated output voltage
Setup, rise, hold up time ..	300ms, 50ms, 90ms at full load and 230VAC
Withstand voltage	I/P-O/P:3.0KVAC, I/P-FG:1.5KVAC, 1minute
Working temperature	0~45°C@100%, -10°C@80%, 60°C@60% load
Safety standards	UL1012, UL60950-1, TUV EN60950-1 approved
EMC standards	EN55022 class B, EN61000-3-2,3 EN61000-4-2,3,4,5,6,8,11, ENV50204
Connection	5P/ 9.5mm pitch terminal block
Packing	0.51kg ; 24pcs / 13.1kg / 0.70CUFT

Stock No.	Model No.	Output	Tol.	R&N	Effi.
10051	S-60-5	5V, 0~12A	±2%	120mV	73%
10052	S-60-12	12V, 0~5.0A	±1%	120mV	76%
10053	S-60-15	15V, 0~4.0A	±1%	150mV	77%
10054	S-60-24	24V, 0~2.5A	±1%	150mV	79%

IM-13 GEARMOTORS

DC Permanent Magnet Spur Gearmotors

E-2135



torque rating: Standard sintered gear strength to 100 oz. in. Wide-face sintered gear strength to 180 oz. in.

weight: 8 to 11 ounces

gears: Precision high density sintered steel

shaft: Precision-ground; through hardened AISI 1137-1141 steel. Options: length, flats, pinions, gears. Shaft material may change depending upon options selected

bearings: Motor and gearbox bearings are life-lubricated sleeve bearings. Ball bearing option available

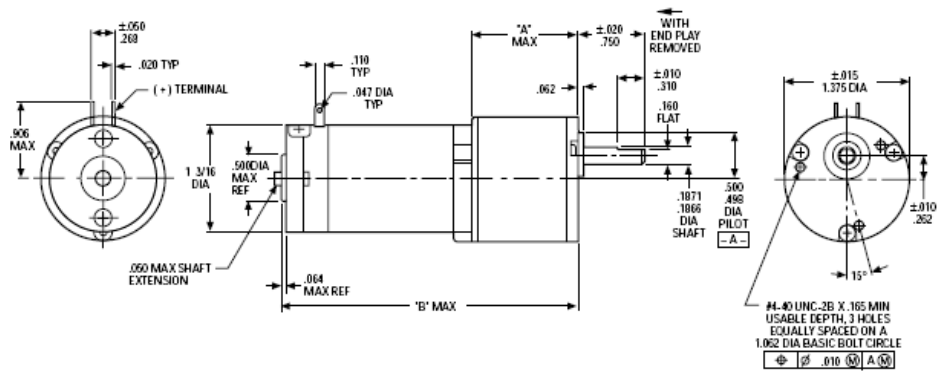
gearbox cover: Corrosion-resistant aluminum housing

mounting flange: Die-cast zinc, coated to prevent oxidation

options available:

- Ball bearings
- Leads
- EMI suppression

Dimensions



ROTATION (SEE CHART, OPPOSITE PAGE) VIEWED FROM SHAFT END WITH POSITIVE VOLTAGE ON (+) TERMINAL. REVERSE POLARITY FOR OPPOSITE ROTATION

NOTE: Consult factory prior to preparing spec control prints. Dimensions are for reference only

E-2135



Standard Part Numbers and Data Standard Sintered Gearing

STANDARD PART NUMBER PREFIX*	DIMENSION "A" MAX (in.)	DIMENSION "B" MAX (in.)	REDUCTION RATIO	TORQUE MULTIPLIER	CONTINUOUS TORQUE		DIRECTION OF ROTATION
					-2* (oz. in.)	-3* (oz. in.)	
415A154	.960	2.794	6.30	5.35	8	8	CW
415A155	.960	2.794	9.99	7.85	12	12	CCW
415A156	.960	2.794	19.53	15.35	23	23	CCW
415A157	.960	2.794	30.96	22.35	34	34	CW
415A158	.960	2.794	60.54	43.71	66	66	CW
415A159	.960	2.794	95.97	64.11	96	96	CCW
415A160	.960	2.794	187.68	125.36	100	100**	CCW
415A161	1.186	3.020	297.52	182.67	100	100**	CW
415A162	1.186	3.020	581.82	357.22	100	100**	CW
415A163	1.186	3.020	922.31	522.93	100	100**	CCW
415A164	1.186	3.020	1,803.64	1,022.61	100	100**	CCW

Wide-face Sintered Gearing

STANDARD PART NUMBER PREFIX*	DIMENSION "A" MAX (in.)	DIMENSION "B" MAX (in.)	REDUCTION RATIO	TORQUE MULTIPLIER	CONTINUOUS TORQUE		DIRECTION OF ROTATION
					-2* (oz. in.)	-3* (oz. in.)	
415A176	1.186	3.020	19.53	15.35	23	23	CCW
415A177	1.186	3.020	30.52	22.35	34	34	CW
415A178	1.186	3.020	60.54	43.71	66	66	CW
415A179	1.186	3.020	94.60	64.11	96	96	CCW
415A180	1.186	3.020	187.68	125.36	160	160**	CCW
415A181	1.398	3.232	293.26	182.67	160	160**	CW
415A182	1.398	3.232	581.82	357.22	160	160**	CW
415A183	1.398	3.232	909.09	522.93	160	160**	CCW
415A184	1.398	3.232	1,803.64	1,022.61	160	160**	CCW

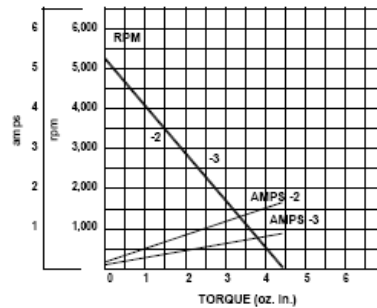
*When You Order

Each of the basic motor armature windings (bottom chart) can be used with any of the gear ratios listed above. To order, state the gear train standard part number prefix, plus a motor armature winding dash number. EXAMPLE: 415A154-2 is a 6.30:1 IM-13 gear train with a "-2" armature winding, 12 volts, 5,200 rpm, 1.50 oz. in. torque, etc.

** NOTE: 100 oz. in. is the maximum strength of this gearmotor series using standard sintered steel gears; 160 oz. in. is the maximum strength of this gearmotor series using wide-faced sintered gears. Damage may result if this torque is exceeded.

Typical Motor Performance

Dash 2 and 3 armature windings



Basic Motor Data

ARMATURE WINDING DASH NO.*	VOLTAGE (VDC)	SPEED ±10% NO LOAD (rpm)	CURRENT NO LOAD (max amps)	RATED TORQUE (oz. in.)	CURRENT AT RATED TORQUE (max amps)	TORQUE CONSTANT (oz. in./amps)	RESISTANCE (ohms)
-2	12	5,200	.230	1.50	.80	2.9	7.3
-3	24	5,200	.140	1.50	.40	5.6	30.0



moview®

tvmount

Product Number MVWMTS

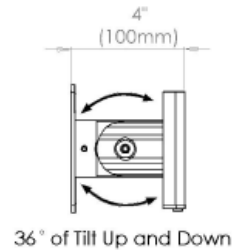
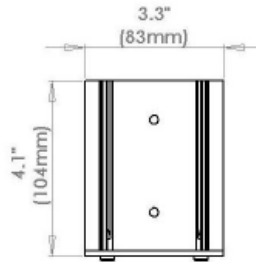
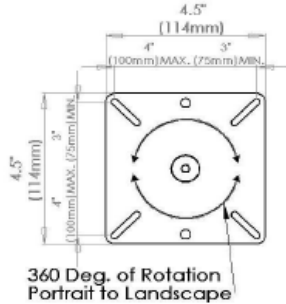
smalltilt

Supports TV screens up to 26" or 30 lbs.



Product features:

- 180° rotation portrait to landscape-allows for easy leveling.
- VESA compliant hole pattern.
- Includes anti-theft fasteners for added security.
- Allows for quick and easy removal of flat panel from wall.
- Up to 36° tilt range allows for easy viewing accomodation.



Product specifications:

Model #:	MVWMTS
Screen size:	10"-26" (25.4cm-58.4cm)
Max Load:	30 lbs. (13.6 kg)
Hole pattern range:	75, 100 mm
Dimensions:	4"x3.25"x1.875" (10x8x10 cm)
Shipping weight:	1.75 lbs (.80 kg)

10 year warranty!

**No buttons or knobs to adjust!
Fully assembled!**

Easy 3-step installation:

1. Attach wall track to wall.
2. Attach flat panel to wall mount.
3. Attach wall mount to wall track.

MOVview, Inc. 11116 Fitzgerald, Suite B, Nunica, MI 49448, Phone: 616.837.0246, Web: moview.com



HX-192RPB 19" Active Matrix TFT Display



DISPLAY

Size: 19" Active Matrix TFT Display
Resolution: 1280 x 1024 SXGA Resolution
Color: 16.2M (8-Bit)
Pixel Pitch: 0.294mm x 0.294mm
Brightness: 300 cd/m2
Contrast: 700:1
Response Time: 2ms with X-Celerate™ Technology
Viewing Angle (H/V): 150°/135°
Panel Treatment: Anti-glare Hardcoating
MTBF: 50,000 Hours MTBF

INTERFACE

Analog Input: (1) D-Sub 15 Pin
Digital Input: (1) DVI-D
Audio Input: (1) 3.5mm Stereo

CONVENIENCE

Color: Black
Audio: 1W x 2 Channel Built-In Stereo Speakers
Video: User Selectable Color Temperature Settings, 9300K, 6500K, User
Tilt: 0° - 20° Vertical Adjusting Stand
Mounting: VESA Standard Mounting Points

CERTIFICATIONS

Safety: UL, C-UL, TUV, CB, BSMI, FCC, CE, NOM
Power Savings: EPA Energy Star

POWER

Input Voltage: 100VAC - 240VAC, 50/60HZ Autodetect
Power Consumption: 42W Maximum

WEIGHTS & DIMENSIONS

Net Dimensions: 16.4"W x 8.0"D x 16.3"H
Net Weight: 12.6 lbs.
Shipping Dimensions: 19.0"W x 5.5"D x 18.0"H
Shipping Weight: 15.9 lbs.
EAN Code: 4710859553416
UPC Code: 842651000318

WARRANTY

3 Year Limited Warranty

INCLUDED ACCESSORIES

- (1) User Manual CD-ROM
- (1) DVI Cable
- (1) D-Sub 15 Cable
- (1) Power Cable
- (1) Warranty Card



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See our entire product line up at
www.hannsg.com/us
or email us at sales@hannsg-usa.com for more information.

Always the best, always innovative and
always going beyond – that is **HANNS-G**

Ref: HM9060801-09E