Mobile Computer Cart

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Final Project Proposal

Submitted towards partial fulfillment of the requirements for
Mechanical Engineering Design I – Fall 2014

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Abstract

In today's technology world, mobile work station is needed to perform experiments conducted outdoors. Our client Dr. Kosaraju is currently managing multiple student teams for capstone classes at Northern Arizona University. He is requesting two mobile computer carts capable of outside use to perform experiments. The need for these mobile carts is that the current available mobile computer carts are too expensive and are not designed for outside use.

This report outlines the steps that Team 12 went through to meet all the customers' requirements. Each member of the team researched and analyzed carts that are already on the market today. From this ten different designs were conceptualized and critiqued. Two different concepts out of the ten ideas were chosen perform analysis and initiate the bills of material. The first concept is the two-wheel dolly design, which has adjustable monitor, weather proof, and interior storage space. The two-wheel dolly design will measure 48.07 inches in height when stored and 71.54 inches in length when in use, 24.75 inches deep, and 24.75 inches in width. Also, it will weigh 104.34 lbs. and costs $443.49. The second concept is the four-wheeled design, which has adjustable monitor, weather proof, and interior storage space. The after both preliminary concepts were created the client decided to move forward with creating a prototype of the two wheeled design. Team 12 will start the initial steps of the building process over winter break.

1. Project Summary

A Northern Arizona University Capstone instructor is looking for two mobile computer carts designed and fabricated by students. The team will work directly with the client Dr. Srinivas Kosaraju to verify if the design meets his needs. The primary objective of these carts is to accommodate a data acquisition computer that can be taken easily outside the engineering building for outdoor experiments. Current available market designs are very expensive and are made to be used indoors only. Two computer carts must be fabricated to carry a CPU, data acquisition equipment, two widescreen monitors, attachment to position keyboard and mouse at adjustable height. It must also have some storage space for user to keep additional cables, manuals of equipment. Neither design must exceed the cost of more than $500.00 apiece.

2. The Problem Statement

This section will include all necessary problem formulation information such as needs and goals statements as well as the project's objectives and constraints.

2.1. The Clients Need Statement

Dr. Srinivas Kosaraju's need statement is, "The current available mobile computer carts are too expensive and are not designed for outside use."

2.2. The Problem Definition

2.2.1. Goal Statement

The project goal is to design two mobile computer stations that are less expensive than available marketed products and can be operated in outside conditions.

2.2.2. Design Objectives

Team 12 determined the objectives based off the client's quantifiable expectation on how the computer cart should perform. These objectives will drive the design process and help the team formulate each part of the design in the future. The objective is as follows "Design two inexpensive mobile computer stations that can easily be taken outside to preform experiments, while resisting the outside elements. In addition the cart must hold dual monitors, CPU, testing equipment, reasonably sized, and be adjustable for different users." The following objectives are listed on (Table 1).

Table 1: Objectives

Objectives	Measurement Basis	Criteria	Units
1. Inexpensive	Cost for 2 prototype production	Cost	Dollars
2. Be able to hold CPU, Monitors, and testing equipment	The amount of the storage space	Volume	ft^3
3. Should be adjustable for multiple users	Able to change the height of the station	Height	ft
4. Should be easily maneuverable	Time it takes to transport inside and outside easily	Time	Minutes
5. Weather Resistant	Ability to resist weather conditions	Water accumulation	In
6. Reasonable size	Fit through a door and is light	Volume and Weight	ft^3 and Ibs
7. Remain functional after transported	Material not deformed after rolling outside	Material Strength	Psi

2.2.3. Design Constraints

The design constraints are based off the permissible conditions of design features, the permissible range of the design and performance parameters our client tasked us with. There are multiple constraints our team needs to abide by in order to create two successful mobile computer station prototypes. The constraints are broken into two categories, which include yes-no constraints and one sided inequality constraints.

- Yes-No constraints
    - The mobile cart has to support two screen monitors.
    - The mobile computer cart has to hold a CPU, keyboard, and a mouse.
    - The mobile computer cart has to move through rough terrain.
    - The mobile computer cart must be easily transported with only one individual.
    - The mobile computer cart must be weather resistant.
- One-sided inequality constraints
    - The cost of each mobile computer cart must be less than $500.00.
    - The storage space must accommodate 2 ft^3.
    - The width of the cart must be less than 3 ft.
    - The height of the cart must be less than 7 ft.

3. Testing Environment

When evaluating the objectives it is necessary to have an ambiguous description of the testing environment. The goal of this environment is to test multiple aspects of our design to conclude whether or not we have met all the project's objectives. In terms of the mobile computer station the test will be an outside field test, which is where our product is meant to operate. The following the analyses that will be completed during this test:

1. The client must be able to role the mobile computer cart outside with no assistance required
    a. Fit through door
    b. Weight
    c. Maneuverability
    d. Time it takes to transport
2. The computer station must move over multiple terrains
    a. Rocky, grass, dirt
3. The computer station must role outside and function properly once stationary
4. Testing components must remain undamaged during transportation
5. There must be no water accumulation inside storage compartment
    a. Simulate rain
6. Must be adjustable once in outside environment
    a. Test any adjustable components once at destination

4. Quality Function Development (QFD)

This section contains information describing the Quality Function Deployment (QFD) stage of the team's design process. This section includes engineering and customer requirements, benchmarking research, and the final QFD table that resulted relates everything together. The QFD can be found on (Table 3) below.

Table 2 : QFD

		Engineering Requirements										Bench Marks	
		Yield Strength	Max Deflection	Weight	Time to transport	Force	Material thickness	Cost	Volume	Center of Gravity	Wheel Diameter	Deluxe Diagnostic Fusion Cart	Ergotron WorkFit-C
Customer Requirements	Holds Dual Monitors	X		X					X				O
	Aesthetics						X					O	O
	Inexpensive			X			X	X					
	Adjustable height	X				X		X				O	
	Storage space			X				X	X	X			
	Mouse and keyboard platform							X	X	X		O	O
	Hold CPU							X	X			O	O
	Portable				X	X				X	X	O	O
	Light weight			X			X	X	X	X	X	O	O
	Easy to transport			X	X	X		X			X	O	O
	Weather proof			X			X	X					
	Durable	X	X	X		X	X	X			X		
	Move through rough terrain	X	X				X	X		X	X		
	Units	psi	in	Ibs	min	Ibs	in	$	ft^3	ft	in		
								500 x2					
		Engineering Targets											

4.1 Customer Requirements

This section contains the requirements specified by the client. The client is going to be using this mobile computer cart when preforming engineering tests and the prototype must meet all his requirements. The relationship to engineering requirements can be seen in (Table 3) of the appendix.

1. Holds dual monitors: The mobile computer cart must be able to hold two computer monitors that both operate in parallel.

2. Aesthetics: The mobile computer station must be aesthetical pleasing.
3. Inexpensive: Each station must cost less than $500.00.
4. Adjustable Height: The monitor's height must adjust for multiple users.
5. Storage Space: There must be enough storage space for engineering test equipment.
6. Mouse and Keyboard platform: A platform should be provided for a mouse and keyboard.
7. Hold CPU: There should be a compartment to put a CPU.
8. Portable: The station must be able to move from one location to another.
9. Light Weight: The station must be light enough to be operated by one person.
10. Easy to transport: The station must move in and out of a building with ease.
11. Weather resistant: The weather station should not be affected by rainy weather.
12. Durable: The station must be able to withstand bumps and other outside elements.
13. Move through rough terrain: The station should be able to move through grass, rocks, dirt, and uneven terrain.

4.2 Engineering Requirements

The engineering requirements were created based off taking the customer requirements and finding how they would be analyzed. Each requirement has a mathematical unit associated with it letting us translate the customer requirements in to units of measurement. The engineering requirements will be used later on when the design and testing takes place. The only exact values know for the requirements are in the cost category, which is $500.00 each per cart. The rest will be specified later on in the process. All engineering requirements can be seen on (Table 3).

4.3 Benchmarking

This section contains two different mobile computer carts that are currently out on the market. Both these carts have some design components our client is looking for, but neither fully meets the customer requirements. This is represented in (Table 3).

4.3.1 Deluxe Diagnostic Fusion Cart

The Deluxe Diagnostic Fusion Cart is a mobile computer cart sold by Versa Tables for $459.00. Although this would meet the cost criteria, other aspects would not qualify. The cart only holds one monitor and space for a CPU. There would be no space for testing equipment and other storage room. The wheels would hinder the cart from moving around outside with ease. All the electronics are exposed to the outside elements as well, making it not weather resistant. Although this mobile computer cart has some of the client's requirements, all are not met.

4.3.2 Ergotron WorkFit-C

The Ergotron WorkFit-C is a mobile computer cart sold by CompSource for $854.99. Its features include dual monitor attachments, a CPU holder, a platform for a mouse and keyboard, and a platform to write on. It also includes four small wheels that allow it to move when pushed. Additional features include 25" total height adjustment, a small footprint and advanced cable management. This particular cart also does not meet all the customer requirements specified. The cost is out of budget and it is not weather proof. The smaller wheels would also hinder it from moving through rough terrain.

4.4 QFD Results

After relating all customer and engineering requirements the QFD concluded that the most important area of focus will be on the cost, material thickness, and weight. Based on the QFD these need to be part of the main focus when designing the cart. Research needs to be done to find out the most cost effective way of designing the cart. By doing this the cost will stay below $500.00 per cart. The weight comes in to play when any customer requirement needs to be added to the cart. If material is added it obviously will add some sort of weight. The QFD shows that the existing products will not meet all the clients' expectations and proves the necessity for students to create a new design. Although some areas need more attention than others, every customer requirement needs to be analyzed in order to have a successful product. All results can be seen in (Table 3).

5. State of the Art (SOTA)

When designing a new product it is essential to research existing designs and products that are already developed. By researching different books and journals it allows your product to reach its full potential. Also it cuts down on wasted time trying to re-invent the wheel, when you could of taken already existing product and improving on it. The following section is a summary of relevant State of the Art (SOTA) complied in the efforts of designing components for the mobile computer station.

5.1 Mobile storage and computer cart patent

The mobile storage and computer cart patent has a wheeled base on the bottom. On top of that is a lockable storage area with drawers and then a mounting location for a computer. This design contains many of the desired objectives for the project. It contains a storage area that is completely enclosed and it has mounting for a computer. The design is lacking in some areas, the location where the computer goes is not weatherproof so the computer could be easily damaged by the elements. The wheels on the base do not appear to be large enough to handle outdoor travel and they do not appear to have any locking mechanism to prevent the cart from rolling if left on an incline. This patent can be seen in (Figure 1) of the appendix.

5.2 Engineering Mechanics Statics

The design of the cart is going to need to be able to handle many stresses and strains because of the computer and the monitors and the desire for it to be able to travel through rough terrain. An engineering statics book contains many useful equations and data about designs and how forces from different directions affect them. The information contained in this book will be helpful in calculating the strength of the design and simulating the stresses it will endure.

5.3 Wheel design

The patent illustrates the structure of an axel rod, brackets, and caster wheel that allow the wheels to swivel. The axle rod will be mounted to the base. The Fabricated brackets swivel to adapt to the swivel cavities providing an accurate disposition of the wheels. This patent wheel structure should provide smooth rotating wheels to ease the cart movement.

5.4 Breaking System

The patent illustrates a braking system which can be activated by foot pressure to hold shopping cart from rolling downhill while unloading the cart. The way this braking system work is by an activated wedge pressing on the cart wheels and not released unless the wedge is pulled. This patent could benefit our project to keep the mobile cart from rolling downhill when conducting an experiment. This patent can be seen in (Figure 2) of the appendix.

5.5 Large Monitor computer cart

This patent talks about the design of a mobile flat panel monitor and computer cart. The cart has a wheeled base, a support structure coupled to and extending above the base, a shelf coupled to the support structure above the base for supporting a computer, and a bracket coupled to the support structure above the shelf. This support structure is adapted to have mounted to it a flat-panel monitor. This patent helps us with the structure of our mobile cart where we intend to add a wheeled base and a support structure for the monitors. This patent can be seen in (Figure 3) of the appendix.

5.6 Multiple Wheel bases

This patent talks about a multi-wheeled base for a mobile cart that includes one or more swiveling, optionally locking, caster wheels and one or more non-swiveling traction wheels. This design improves the maneuverability of the cart by making it easier to steer and stop. The traction wheels may be manually engaged, which may be operated by a cam and lever. The traction wheels may be automatically engaged, operated by a motor and a threaded shaft. Or activated by a motion-sensitive sensor and by an on/off electrical switch or button. The traction wheels are preferably in contact with the floor when

the mobile cart is moving, and rise above the surface of the floor when the cart is stationary. This patent helps us with improving the maneuverability of the mobile cart as it describes a working design of the multi-wheeled base and the functions of each of its parts with their benefits to the base structure.

6. Concept Generations

Each member of the mobile computer cart team generated two full cart designs in the efforts of eventually deciding on two final products that will be used. The following section is describing the ten different designs Team 12 created for the project.

6.1. Design #1

Design #1 is designed for optimal desk and storage space. The storage section is split into three sections where you can fit a printer, CPU and material used for data testing. The middle section has shelving that is easily accessible allowing the user to get the material he needs quickly and efficiently. The two sections around it are made out of either glass or plexiglass. The thought behind using the plexiglass is so that the user can easily see what is going on with the CPU or printer while being weatherproof. The storage will be connected to a rectangle frame where it will be bolted and secured. The desk section has a lot of room so you can spread out all the necessary materials that you need without shuffling through items. Depending on the user's height, you have the feature of raising or lowering the desk to make it accessible to everyone. The keyboard is attached to the bottom of the desk where you can slide it in and out for easy access while keeping it protected from the weather. The desk will be mounted to the main vertical pole in the middle of the design, which will make the final product sturdy. The monitor mounts allow you to swivel the monitor to a certain angle of your choice, making it easier to take data without the glare on the screen. Since this design consists of four wheels, there will be a handle on the right side of the cart where you can pull or push it with ease.

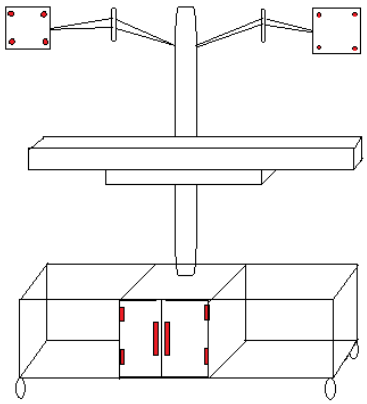


Figure 1: Design #1

6.2. Design #2

Design #2 is designed around the waterproof and maneuverability aspect of our clients need. It will function the same way a stroller works with two large wheels in the rear and one large wheel in the front. Each wheel will have individual axles, helping cut down on the overall weight. The three points of contact will give the cart more stability when traveling to different destinations, while the large wheels help it climb over rough terrain. In addition there will be a handle attached to the back so the cart can be pulled or pushed. The shape is modeled around a cylindrical garbage bin standing roughly 4 feet high and 3 feet in diameter. Two doors will be attached to the front panel, allowing for easy access to the CPU and experimental equipment. The computer monitors and keyboard adjust up and down the center poles. For weather proofing and ease of transportation the monitors and keyboard will move inside the cylinder. Once in the appropriate position the lid can be closed and locked. By doing this the center of gravity is lower making it easier to push the cart. The cart will have a metal interior shell, giving it structural rigidity while transporting. Some sort of thin material will be used for the walls, cutting down on weight. Design #2 can be seen below in figure 2.

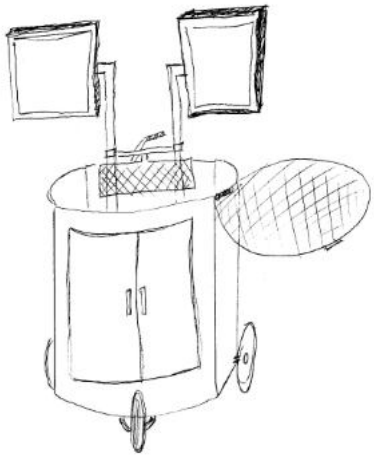


Figure 2 : Design #2

6.3. Design #3

Design #3 is a triangular shaped cart with a canopy for weather protection. The canopy on this cart will provide an umbrella over the whole cart and the person using the computer. It will protect from sun and moisture directly above but will have limited coverage for weather coming from the side. The post holding the canopy is also what the monitors are mounted to. The monitors are adjustable up and down and can spin around to be seen from any angle. The top of the cart allows space for a mouse, keyboard and a limited amount of workspace. The side of the cart is a door that opens to allow access

to the storage inside. The storage includes a specific place for the CPU and cords, as well as general storage space. The design contains three wheels, one at the monitor point and two at the keyboard side. The wheel in the front swivels to allow for easier maneuverability. The two on the rear are connected with an axle and do not pivot. Above them is a handle mounted to the side to allow for easy movement of the cart.

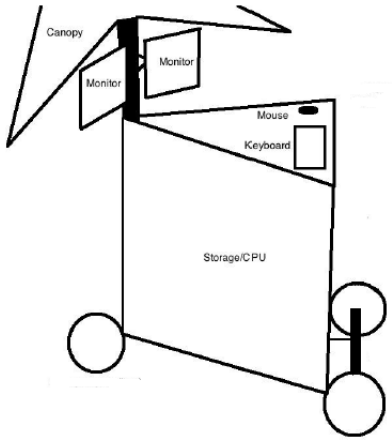


Figure 3 : Design #3

6.4. Design #4

Design #4 will have garden rubber wheels that are used in garden carts with the same pulling mechanism, where a rod is attached to the wheels shaft to direct the wheels and pull the cart. The garden wagon frame could be made or bought. The wheels from a garden wagon will be able to withstand rough terrain. The wheels will be attached to an aluminum cabinet with a garage like door to have the electronics protected when needed and for storage purposes. The garage door can be opened and closed manually. The cabinet will be designed from the inside then welding aluminum plates to the three sides. Inside the cabinet there will be a storage space, a space for the CPU, keyboard, and adjustable monitors. There will be a large storage space and can be shelved and designed to meet the client's needs. The keyboard will be retractable for ease of use. The cart should be easily moved by one person because of the wagon mechanism and should fit through a door easily.

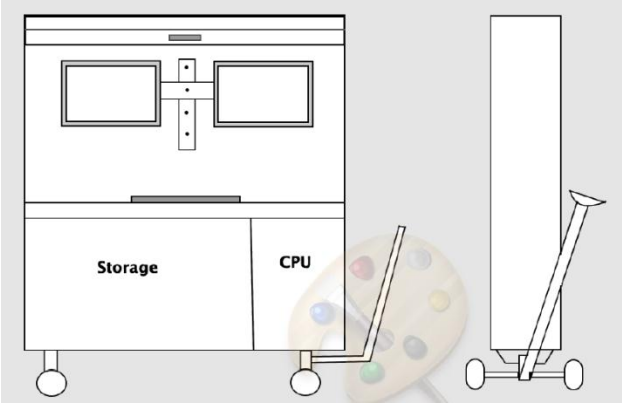


Figure 4 : Design #4

6.5. Design #5

Design #5 will be sectioned into three different parts; the storage, desk and monitor mounts. The storage is circular in shape giving the design a unique attribute. Shelves will be installed in the storage section where you can put a backpack, pencils, etc. The storage unit will be sitting and bolted on a circular frame. Since the storage is split into two sections the right side will consist of just the CPU and the left will be for personal needs and data testing materials. The design will allow the CPU to be protected during harsh and wet weather. The desk section will have the keyboard on it and enough room to take notes on. The desk will be held up by two carefully placed poles, which connect the storage and the desk together. The monitor mounts will allow the user to adjust it to any desired height and angle providing maximum comfort. The mounts will be bolted and secured to the desk keeping the monitors safe during transportation. Since this design consists of only two wheels, there will be a handle at the back of the desk that will allow the user to tip the desk backwards and pull it to the desired location, just like a furniture dolly.

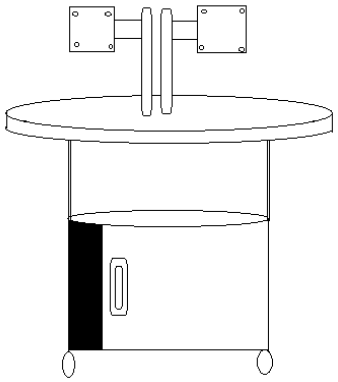


Figure 5 : Design #5

6.6. Design #6

Design #6 will have rubber gate wheels with suspension to ease maneuvering. The suspension could be designed or bought online. The cart will have four wheels. The wheels will be mounted to an aluminum cabinet. The aluminum cabinet will have the storage space and the CPU. The storage space can be modified depending on client needs. Then a bar will be mounted to the top of the aluminum cabinet to hold up the keyboard and the two monitors. The bar will be adjustable to go up and down to adjust the height of both the monitors and the keyboard. If needed the design can be modified to have the keyboard and screen rotate. Furthermore, the box will have hooks to attach a plastic cover to cover the monitors and keyboard when needed. The cover will be transparent to be able to see the monitors while covered. Also, there is a handle on each side to be able to pull the cart easily.

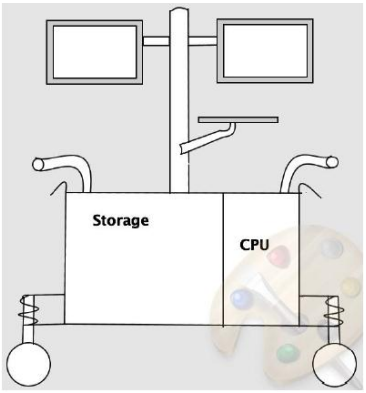


Figure 6 : Design #6

6.7. Design #7

Design #7 is generated around the weight, weather proof, and maneuverability aspects of the client's needs. This design will resemble a dolly that can be moved by one individual. Two large wheels will be attached to the back end, allowing for it to be tilted around the axle and pulled to the desired destination. The long handle on the back allows for two hands to be used, which gives the operator more stability. Once at the destination the cart will be tilted forward and rest on two adjustable legs in the front to keep it level. The cart will consist of a metal frame in the shape of a rectangle. Sheet metal will then be welded on the outside for weather proofing. A single door in the front gives access to the CPU, adjustable shelving, and experimental equipment. The dual monitors and keyboard will adjust up and down the center pole, allowing for multiple users. When the cart needs to be transported the monitors and keyboard slide down into the component and the top lid is slid shut. The same lid can be used as a table that has extending arms for support. A plastic window

will be incorporated on the side wall so the monitors can be seen when the lid is shut. The overall size of the rectangle will be 4 feet tall by 2.5 feet wide. Design #7 can be seen in figure 7 below.

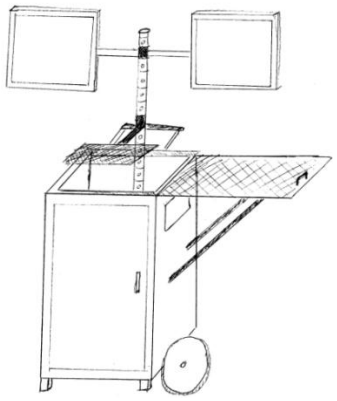


Figure 7 : Design #7

6.8. Design #8

In this concept design, there is a column on both sides of the cart. Both columns are on top of a bar connecting two tires on each side of the cart. Each one of the two monitors will be attached to one column with a few inches in between the two monitors when placed in the vertical position. Both the CPU and the storage space will be placed between the second and the third horizontal bars in the middle between the three columns. A horizontal bar will be placed between the two columns to hold the keyboard stand and any other equipment needed by the client. This horizontal bar will be held by the third column that rises from the middle of the lower horizontal bar between the CPU and the storage space. The third and middle column can also rise higher to hold a circular umbrella cover to provide extra protection to the monitors and top parts of the cart. For easier moving of the cart, there will be a handle attached to each of the two sides of the cart. The cart moves using four medium sized wheels that are placed on each corner to allow for maximum stability.

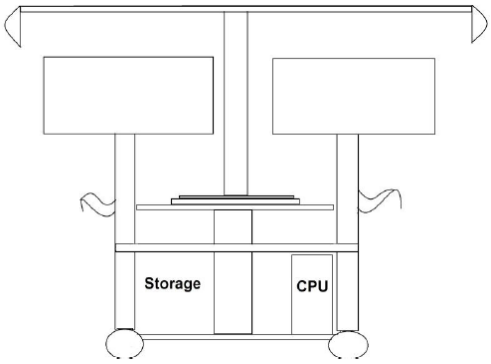


Figure 8 : Design #8

6.9. Design #9

Design #9 is a completely enclosed, completely waterproof cabinet on wheels. The outer shell will be sealed so that no water can get inside. The top portion of the front is a door that will swing up and be held up by hydraulic arms. This will give shade and weather protection while working on the computer. The inside of the top portion will have a large platform to hold the mouse, keyboard, and give ample space to work on. Two monitors will mount side by side at the back and will have height adjustable stands. The bottom portion of the cart will have doors that open and will be split into two sections. One section will be designed specifically to hold a CPU. The other side will be a storage area that will have the option of adjustable shelving. The design will have four wheels mounted to the bottom of the cart. Two of the wheels will have swiveling capabilities to aid in maneuvering the cart. The other two will be fixed to add stability. The wheels will have a braking system that can be activated when the cart is not in motion to prevent it from rolling away.

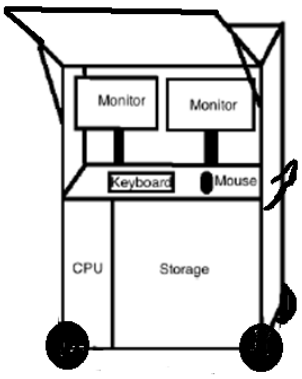


Figure 9 : Design #9

6.10. Design #10

In this concept design, there are two sidebars connecting the tires on each side. A horizontal base will be placed on top of two sidebars that will be the base for the cart. The CPU will be held on top of this horizontal base. A second horizontal shelf will be placed between two sides of the cart on top of the CPU space. This will allow for a large storage space above this second horizontal shelf that will be able to hold multiple medium sized pieces of equipment as needed by the client. Between the two sides and on the top, there will be a horizontal base holding the keyboard and serving as the working table for the client. From this base, a middle column rises holding the attachment of the two screen monitors. Both screen monitors can be adjusted up or down to allow for better positioning for the client. This cart has four medium sized wheels attached to the four corners of the cart to allow for a good stability when rolling indoors or outdoors.

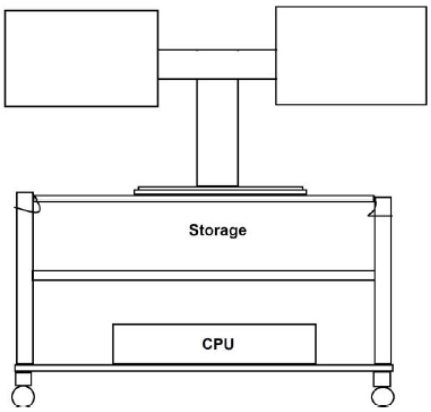


Figure 10 : Design #10

7. Concept Selection

After the ten design ideas were created and shared, they were then evaluated using the decision matrices shown in Table 1 and Table 2. The matrices dove in to the constraints and objectives of the project to score each of the designs and help determine which ones would be the best solution to the problem. Decision Matrix 1 evaluated the cost, ease of manufacturing, and the aesthetics of each design. Decision Matrix 2 evaluated how weather proof the design was as well as the durability, adjustability, maneuverability, storage space, weight and size. Once the designs were evaluated, the scores were added and the top two designs are being taken to the next step in the design process.

Table 3 : Decision Matrix 1

Decision Matrix # 1				
Concepts	**Criteria**			**Score**
	Cost	Ease to manufacture	Aesthetics	
Design #1	6.8	7.4	7.4	21.6
Design #2	4.8	6.8	6.6	18.2
Design #3	6	5.8	6.2	18
Design #4	4.8	6.6	7	18.4
Design #5	6	6	7.4	19.4
Design #6	5.8	6.4	6.2	18.4
Design #7	6.4	5.4	8.2	20
Design #8	7.4	7	6.2	20.6
Design #9	6.6	5	7.6	19.2
Design #10	8.2	8.4	6	22.6
			10 = High , 1 = Low	

- **Cost**: The project was given a cost limit of $500. All of the concepts are expected to be at or below this amount but the designs were graded on how much they were going to cost to build.
- **Ease to manufacture**: With limited funds and limited manufacturing capabilities, it is important to have a design that can be built within reasonable means. This criterion grades how easy it will be to actually build the design.
- **Aesthetics**: In order for a product to be marketable, it needs to be something that the customer wants to look at and is not an eye sore. The designs were graded based on how pleasing to the eye that each of the designs will be.

Table 4 : Decision Matrix 2

Decision Matrix # 2									
Concepts	**Criteria**							**Score**	**Total**: Matrix 1 and 2
	Weather Proof	Durability	Overall Adjustability	Storage Space	Maneuverability Inside / Outside	Weight	Overall Size		
Design #1	1	5.4	9	8.4	5.6	6.8	6.4	42.6	64.2
Design #2	9.4	8.8	4	7.8	6.6	4.8	5.8	47.2	65.4
Design #3	5.4	6	5	5	7.2	7.2	6.8	42.6	60.6
Design #4	9	8	5.2	9	6	4.2	5.4	46.8	65.2
Design #5	1	5.6	7	6.8	5.6	6.6	6.6	39.2	58.6
Design #6	2.2	6.2	7.4	7.6	6.6	6.2	6.6	42.8	61.2
Design #7	7.6	7.6	9.2	6.6	9	7.8	8.8	56.6	**76.6**
Design #8	4.8	5.6	4.8	5.8	5.4	7	5.8	39.2	59.8
Design #9	7.6	7.2	8.8	6.4	8.4	7.2	7.4	53	**72.2**
Design #10	0.8	5.4	4	6.6	5.4	7.6	6.8	36.6	59.2
							10 = High , 1 = Low		

- **Weather proof**: One of the design requirements is that the cart needs to be able to go outside and withstand some weather when experiments are being performed outside. The cart needs to be able to withstand a reasonable amount of weather so that it can still be used even if the weather is not perfect.
- **Durability**: The cart needs to be able to be used outside in areas where the terrain is not smooth and flat. The design needs to be able to withstand a reasonable amount of rough terrain travel and still perform as desired.
- **Overall Adjustability**: More than one person will be using the cart and therefore the cart needs to have a certain level of adjustability to accommodate multiple users. The designs were graded on the overall adjustability including the monitors, the keyboard/mouse, and the work platform.
- **Storage Space**: One design requirement was that the cart needed to have at least 2 ft^3 of storage space. All of the designs are expected to contain at least the minimum amount of storage. This criterion grades the designs on how much storage they offer.
- **Maneuverability inside/outside**: The cart needs to be able to be transported by one person with a limited amount of effort. The carts were graded on how easily they could be transported inside and outside by a single person.
- **Weight**: A lighter cart will generally be easier to transport and easier to maneuver. The carts were graded on how much they would weigh in comparison to the other carts assuming the carts were all made of the same material.
- **Overall size**: The size of the cart is also related to ease of transport and maneuverability. A design requirement was that the cart had to be able to fit through an average sized door so that it could be transported outside and easily through a building. The carts were graded on their overall size.
- **Score**: The score shows the sum of the criteria for each decision matrix.
- **Total**: The total is the sum of the scores from matrix 1 and matrix 2. The top two designs from each member's matrices are highlighted to display what designs scored highest.

8. Final Design Selection

Based on our client's needs, two different mobile computer carts will be designed and fabricated. The two final design choices were based off the final averaged scores of Decision Matrix 1 and 2. The following is the top two designs selected from the decision matrices.

8.1. Design #7: Two Wheel Dolly

The design with the highest score in the decision matrix was design #7. Based on the two wheeled feature and compact look it will be called the two wheel dolly style cart. One of the main deciding factors in this design was its high score in overall size, maneuverability, adjustability, and weather

proofing ability. The overall size will stand about 4 feet tall when the cart is in transport mode, meaning everything is inside the compartment. It also allows for the cart to be stored inside and fit through doors with ease. The maneuverability came into play with the large wheels seen in figure 14 and handle on the back seen in figure 11. The two large wheels will allow for one person to transport it without assistance. The handle will provide a steady support to rest your hands while transporting as well. Another big factor in the decision is the unique adjustability for the monitors, keyboard, and lid. The monitors and keyboard move up and down the center pole, which will make the cart suitable for multiple users. Each monitor will be attached to the pole by the rotating arm seen in figure 12. The lid will retract outwards giving the operator a table to perform various tasks on. Furthermore this design will be protected from the outside elements because it's unique ability to store everything inside the compartment. Once he lid is closed all six sides are protected by sheet metal. Lastly the cart will have a stable metal frame as seen in figure 13, which everything will be built around.

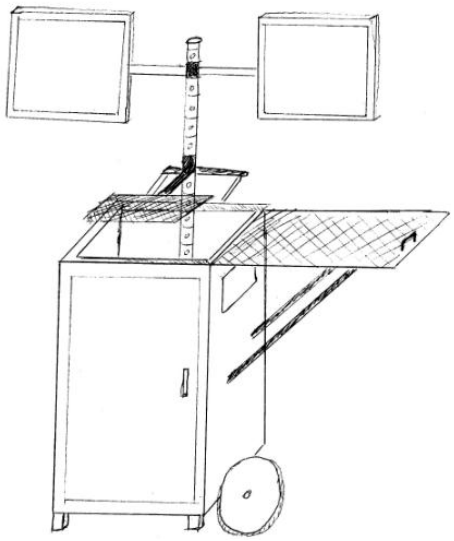


Figure 11 : Final Design 1

Figure 12 : Monitor Mounting System

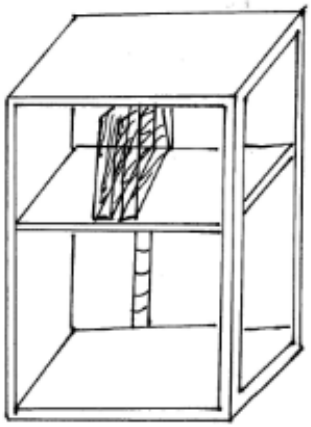


Figure 13 : Final Design 1 Frame

Figure 14 : Wheels for Final Design 1

8.2. Design #9: Four Wheel Cart

The runner up design in the decision matrix was design #9. It has four wheels and a basic rectangular cart shell and is referred to as the Four Wheel Cart. The high scores for this design were its aesthetics, its weather proof design, its adjustability, and overall maneuverability. The approximate dimensions for this design will be 6 feet tall, 4 feet wide and 2 feet deep. The cart will be split into two main sections. The top section will contain two monitors, the keyboard, mouse and a platform to provide a work space. The bottom section will be split into smaller sections with one specifically for the CPU and the others for miscellaneous storage. The wheels will be a large diameter caster with two that swivel and two that are stationary (Figure 15). The swivel wheels will increase maneuverability while the fixed wheels will add stability. The door for the top section will swing upwards and be held open by 2 hydraulic arms (Figure 16). This will keep it out of the way when in use, and provide shade and protection from weather for the monitors and the user. The front of the door will contain a plexiglass window to allow for the monitors to be seen if the door is closed. The complete enclosure allows for an aesthetically pleasing look with no exposed cords and the shell can be painted to increase the overall

look. The monitors will be adjustable within the enclosure to provide better viewing options for different users.

Figure 15 : Caster Wheel

Figure 16 : Hydraulic Arms

9. Concept Generations

9.1 Two Wheeled Dolly Style

The two wheeled dolly style cart is designed to be completely portable and weather proof. It incorporates telescoping tubing which will allow the dual monitors to extrude out of the cart when the operator wants to preform experiments. The design consists of a inter frame created from steel square tubing, while sheet metal lines the exterior. All the experimental components, monitors, keyboard and CPU can be stored inside. The walls will consist of two Plexiglas windows to allow for the operator to watch the monitors when the cart sits in a closed position. Further description of the design and analysis is presented below.

9.1.1 CAD / Drawings

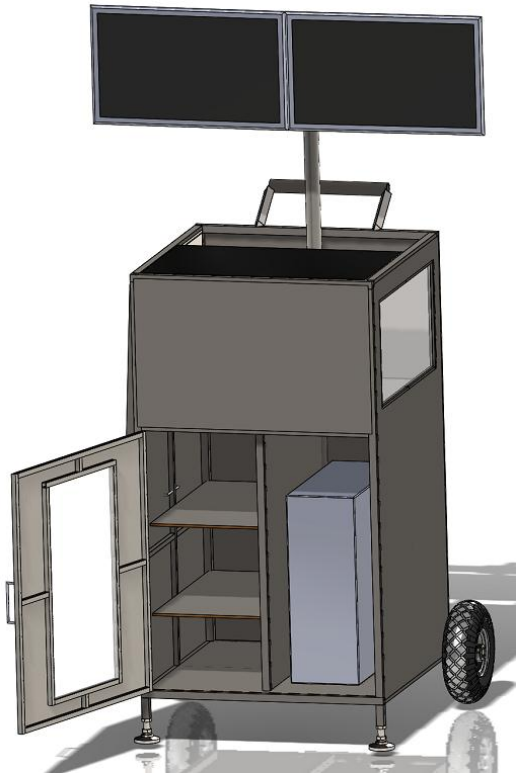


Figure 17 : Cart Design 1

The CAD drawings below are an accurate representation of the design for the two wheeled model. The inner framing of the cart consists of 0.75'' x 0.065'' A513 hot rolled steel square tubing. This frame will give the cart its main structure and stay together during transportation. To prevent the outside elements from damaging any of the interior components .03'' thick steel sheet metal will be welded to the frame. The monitor mounts will be mounted to telescoping tubing with holes drilled at every inch. A pin can be inserted into these holes to position the monitors at the preferred height. There will be two 10'' wheels that will allow for the cart to be leaned back and pushed around. The cart will be 24'' x 24'' x 48'', which will allow for plenty of storage space. The 48'' height is a comfortable position to place your hands and maneuver the cart around. The three Plexiglas windows are made from UV resistant and scratch resistant polycarbonate. This will allow for the operator to look inside when the unit is closed.

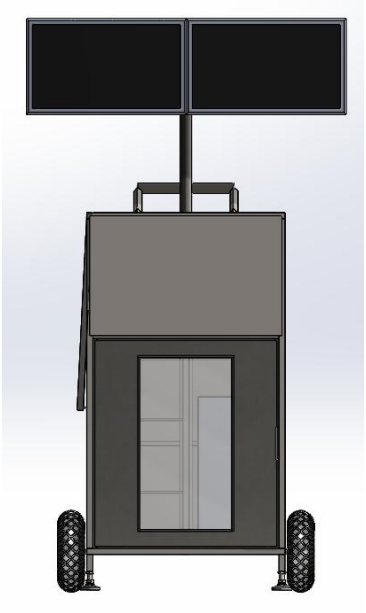


Figure 18 : Cart Design (Front)

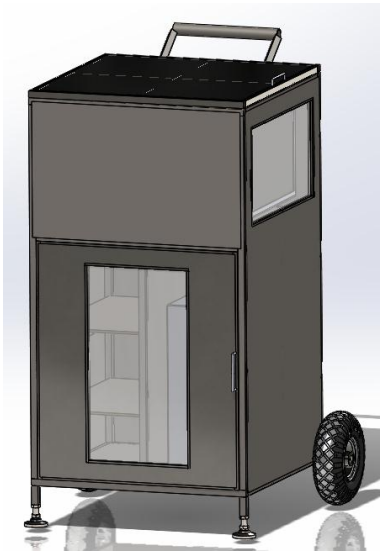


Figure 19 : Cart Design 1 (Closed View)

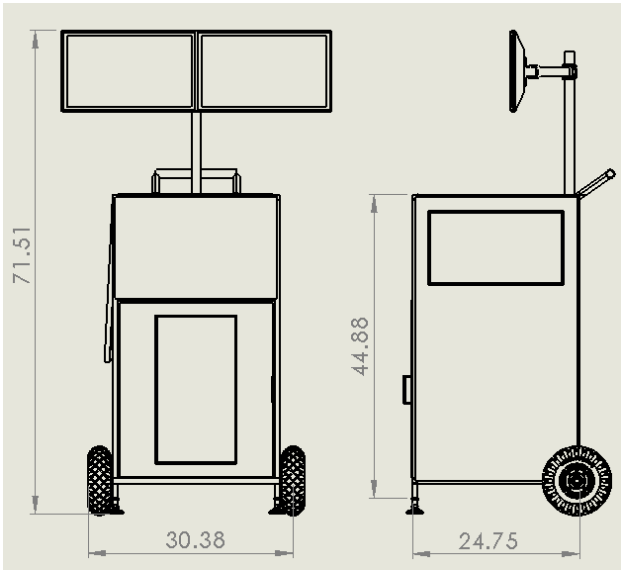


Figure 20 : Design 1 Dimensions 1

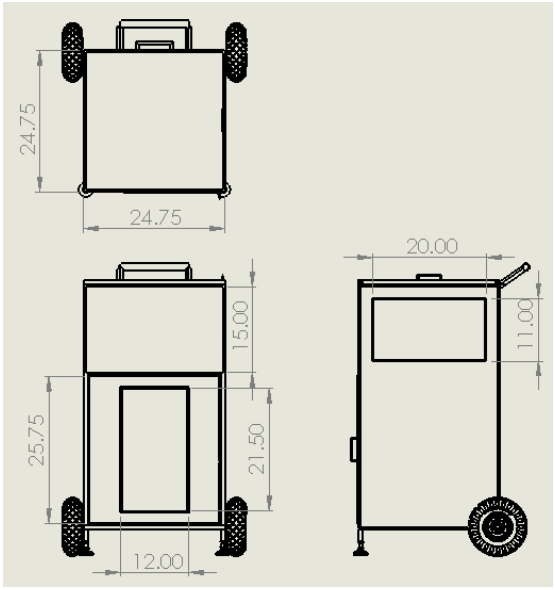


Figure 21 : Design 1 Dimensions 2

9.1.2 Bill of Materials

One of the client's constraints consisted of keeping the carts under a $500.00 budget. To accommodate this request multiple companies were investigated to find the most amount of material we could purchase for the less amount of money; these companies included Online Metals, Mc Master Carr, Amazon, and Home Depot. A bill of materials can be seen below in figure 4. The total calculated cost for the cart was estimated to be $443.49.

Table 5 : Bill of Materials Cart 1

Bill of Materials					
No.	Parts	QTY.	Vendor	Description	Cost
1	8ft Frame Tubing 1	7	Online Metals	0.75" x 0.75" x 0.065" square tubing A513 HOT ROLLED MILD STEEL	$78.68
2	8ft Frame Tubing 2	7	Online Metals	0.5" x 0.5" x 0.065" square tubing A513 HOT ROLLED MILD STEEL	$49.49
3	Sheet Metal	6	Mc Master Carr	24" x 48" x 0.03" steel	$108.80
4	Plexiglass 1	1	Mc Master Carr	12" x 24" x .025" Tinted Polycarbonate	$16.66
5	Plexiglass 2	1	Mc Master Carr	24" x 24" x 1/8" UV Resistant Polycarbonate	$21.53
6	Air Tires	2	Amazon	Double bearing , Dia 10" x Width 3"	$23.38
7	Telescope Tubing	1	Mc Master Carr	2" x 2" x 4ft Telescoping tubing	$50.00
8	Pins	1	Mc Master Carr	5/16" Locking pins	$2.16
9	Hinges 1	1	Mc Master Carr	12" long x 1 1/16 wide x .05" thich piano hinge	$1.93
10	Hinges 2	1	Mc Master Carr	12" long x 1 1/16 wide x .05" thich piano hinge	$2.48
11	Hinges 3	2	Mc Master Carr	270 Degree Hinge	$6.60
12	Monitor Mount	1	Amazon	Tyke Supply Dual LCD Monitor Stand	$43.99
13	Leveling Mounts	2	Mc Master Carr	1/4 - 20 Swivel Leveling Mounts	$3.62
14	Weather Stripping	2	Homedepot	3/8 " x 5/16 " x 10" High-Density Rubber Foam Weatherstrip Tape	$5.14
15	Wood	1	Homedepot	11/32 " x 4 " x 8 " Yellow Pine Plywood Sheathing	$17.43
16	Latches	2	Mc Master Carr	Draw latches	$9.00
17	Door latch	2	Mc Master Carr	Magnet latches	$2.60
				Total:	$443.49

9.2 Four Wheeled Computer Cart

The four-wheeled cart is a versatile, completely enclosed cart with large storage space and a work area. The cart being completely enclosed allows it to be waterproof for use outdoors; in rain or snow. The large front door contains a plexiglass window so that the monitor can be viewed while the door is closed. The sides also contain plexiglass windows to allow visibility through the cart during transportation. The cart will be built by constructing a frame and wrapping it in sheet metal. The bottom of the cart will be split in half. One half will have a large open storage space including the CPU. The other half will be split into two smaller shelves for small item storage.

9.2.1 CAD / Drawings

We wanted the second cart to be completely different than the first cart to give the client different options for different situations. The CAD drawing below is a representation of the second design that will be constructed. This cart is completely enclosed with a large storage space and work area. The designs width, height and depth are four feet by 6 feet by two feet. This makes the cart bigger than the first design.

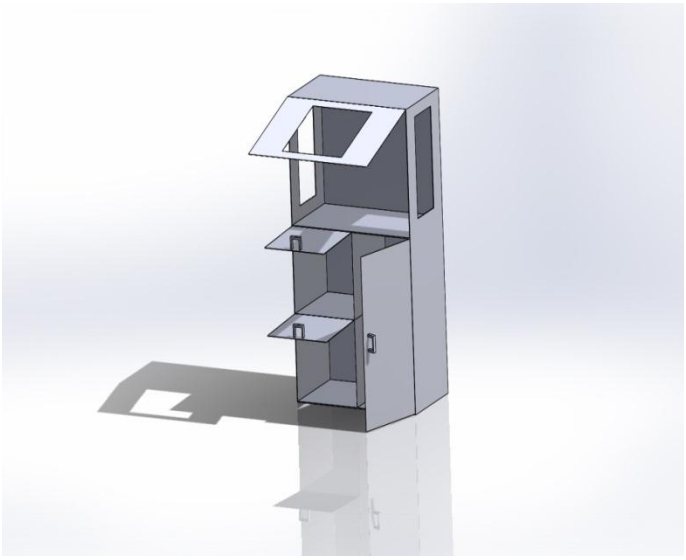


Figure 22 : Four-Wheeled Computer Cart

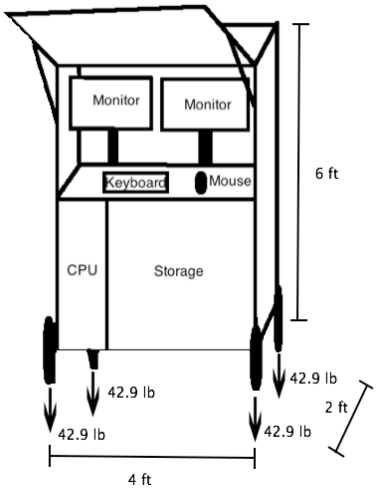


Figure 23 : Force Analysis of the Four-Wheeled Computer Cart

9.2.2 Bill of Materials

A lot of time was put into finding the cheapest but good quality parts for the carts. We found four vendors; Online metals, McMaster Carr, Northern tool and Amazon that will help the group with the parts when time for purchasing come. With the bill of materials, we calculated cost for the cart was it was estimated to be $448.45.

Table 6 : Bill of Materials Cart 2

Bill of Materials					
No.	Parts	QTY.	Vendor	Description	Cost
1	8ft Frame Tubing	11	OnlineMetals	0.065" T 0.75" H A513 Hot Rolled Mild Steel Square Tubing	$121.53
2	Sheet Metal	11	OnlineMetals	0.03" T 24" W 48" L Cold Roll Mild Steel Sheet Metal A366/1008	$163.83
3	Plexiglass	3	McMaster-Carr	Clear 3/32" T Cast Acrylic (Plexiglas)	$38
4	Polyolefin wheels	4	Northerntool	Swivel Caster wheels with brakes	$43.96
5	Hinges 1	1	McMaster-Carr	Steel Piano Hinge with Holes, Unfinished, .025" T, 3/4" W	$7.08
6	Hinges 2	1	McMaster-Carr	Unfinished Steel Piano Hinge without Holes, .025" Thick, 3/4" Width	$1.39
7	Hinges 3	2	McMaster-Carr	Unfinished Steel Piano Hinge without Holes, .025" Thick, 3/4" Width	$2.16
8	Door Latches	3	McMaster-Carr	Magnet Latches	$3.90
9	Open-Up Lid Supports	1	McMaster-Carr	Soft Close, for Side Lid, Right Side Mounting	$17.62
10	Monitor Mount	2	Amazon	Wall Mount Bracket for Monitor TV, up to 37" screen size	$48.98
Total					$448.45

9.2.3 Purchased Components

The enclosed design of the four-wheeled cart required using a big amount of both square frame tubing and steel sheet metal. This increased the total cost of the cart and led the team to consider using more cost-effective internal parts and reducing the cost of the cart to coincide with the required budget of the client. For the frame, we will use A513 Hot Rolled Mild Steel Square Tubing with dimensions 0.065" T 0.75" H. This material fits our cart design and was primarily chosen because of its weight and cost.

Covering the cart, we will use Cold Roll Mild Steel Sheet Metal A366/1008 with dimensions 0.03" T 24” W 48” L. This thickness will help keep the cart at an optimal weight that is not too heavy to maneuver.

Figure 24 : Hot Rolled Mild Steel Square Tube A513

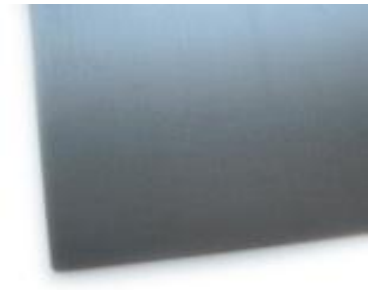


Figure 25 : Cold Roll Mild Steel Sheet A366/1008

In order to allow the use of the cart outdoors even when it is closed, we will use three Plexiglas windows, one on the front and two on the sides. We will use Clear 3/32" T Cast Acrylic Plexiglas. This will allow the client to view the screen monitors inside the cart during experiments even when the cart is enclosed.

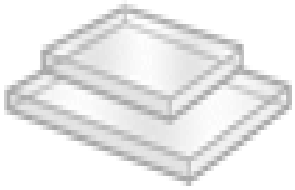


Figure 26 : Clear 3/32" T Cast Acrylic Plexiglass

We will also use four Polyolefin wheels to move the cart. We chose Swivel Caster wheels with brakes due to their ability to support high loads up to 400 lbs each. The brakes will be helpful in maneuvering the cart on outdoor terrain.

Figure 27 : Swivel Caster Wheels with Brakes

Holding the three doors in the front of the cart, we will use three piano hinges. For the two small doors, we will use Steel Piano Hinge with Holes, Unfinished, .025" T, 3/4" W and Unfinished Steel Piano Hinge without Holes, .025" T, 3/4" W. For the big door, we will use two Unfinished Steel Piano Hinges without Holes, .025" T, 3/4" W. The cost of the piano hinges aligns with our budget for the cart.

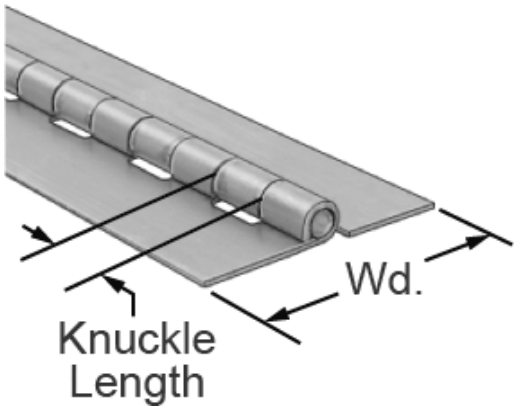


Figure 28 : Thick Leaf Steel Piano Hinges without Holes

We will also use three magnet door latches for those three doors. To open and close the window in the front of the cart, we will use an open-up lid support. We chose Soft Close for Side Lid Mounting due to its ability to hold the Plexiglas and its cost-effective price.

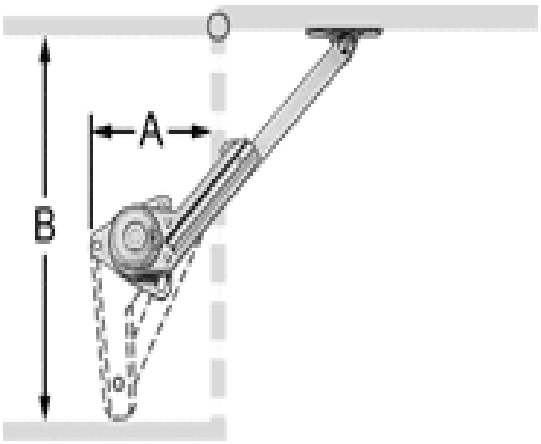


Figure 29 : Soft Close for Side Lid Mounting

We will also use two wall mount brackets to support the two 24” screen monitors. They can support up to 66 lbs each. They can also tilt 20 degrees up and down, and swivel 180 degrees left and right 180 degrees.

Figure 30 : Wall Mount Bracket

Most of the cart parts were found on the websites of McMaster-Carr and OnlineMetals with some parts from Northerntool and Amazon. The total cost of the cart parts is $448.45 which is less than our budget of $500.

10. Analysis

10.1 Concept 1

To make the first design maneuverable the weigh needed to be kept to a minimal, while still having the strength to support all the equipment. To do this the frame will be constructed out of A513 steel square tubing 0.75'' x 0.065'' thick. The doors and lid will be made out of smaller tubing specified to 0.5'' x 0.065'' thick, which will not only save on cost but on weight too. After analysis how much material the frame will be made out of the total weight came to 104.34 lbs. This can be seen in the table below.

Table 7 : Concept 1 Analysis

Frame weight					
Material	Description	QTY.	Length (ft)	Weight/ft (lbs)	Weight (lbs)
0.75" x 0.065" thick	A513 steel Square tubing	7	8	0.6054	33.90
0.5" x 0.065" thick	A513 steel Square tubing	7	8	0.3845	21.53
24" x 48" x .03" thick	Steel sheet metal	5	n/a	9.7804	48.90
				Total	104.34

A static analysis was conducted on three different components that we felt were necessary. The frame, pin, and telescoping tubing were analyzed using static force to verify the material will be suitable for the design. Both the frame and telescope tubing underwent compressive stresses to see if the weight applied will affect the material. For the frame the overall weight was applied to one member to verify it does not exceed the yield strength. The same analysis was completed on the telescoping, but with two 16 lb. monitors as the weight. The final calculation preformed was a shear stress on the pin that will be used. The pin will be inserted though the telescoping holes and a double shear could occur. A 5/16'' diameter pin was assumed and the results verify only one pin is necessary. The following calculations can be seen below.

Table 8 : Concept 1 Material Specifications

Material Specifications			
Parts	Material	Cross-section (in^2)	Yield Strenght (Psi)
Pins	A513 Hot rolled steel	0.0767	72,000
Telescoping Fixture	A513 Hot rolled steel	0.1656	72,000
Frame Tubing	A513 Hot rolled steel	0.3869	72,000

- Compressive Stress : $\sigma = f/a$
- Shear stress : $T = f/a$
    - Where : f = force (lbs.)

      a = area (in^2)

- Frame tubing compressive stress
    - $\sigma = f/a = (105 \text{ lbs.})/(0.1656 \text{ in}^2)$

  $= 634.06 \text{ psi} < 72{,}000 \text{ psi}$

- Telescoping tube compressive stress
    - $\sigma = f/a = (16 \text{ lbs. })(2)/(0.3869 \text{ in}^2)$

  $= 82.708 \text{ psi} < 72{,}000 \text{ psi}$

- Shear stress of pin
    - $T = f/a = (16 \text{ lbs./monitor})(2 \text{ monitors})/(2)(0.0767 \text{ in}^2)$

  $= 208.604 \text{ psi} < 72{,}000 \text{ psi}$ (only 1 pin needed)

10.2 Concept 2

The design of the four-wheeled cart allows a storage space of at least 10 ft^3. The two wall mount brackets can support up to 66 lbs. each. This is sufficient to support the weight of the two screen monitors at 9 lbs each. There was no stress analyses needed for the four-wheeled cart due to its stability. The four 5" D wheels we will use can support up to 400 lbs. each which is significantly more than the weight of the cart including the inside components. Most of the frame weight of 171.727 lbs. comes from the steel sheet metal. The inside parts of the cart are estimated not to exceed 70 lbs. Because of that, the total weight of the cart frame with the inside components should not exceed 242 lbs.

Table 9 : Cart 2 Material Specification

Material Specification				
Material Description	Amount	Price	Total Price ($)	Weight (lbs)
0.065" T 0.75" H A513 Hot Rolled Mild Steel Square Tubing	86.5 ft	1.405 $/ft	121.53	48.523
0.03" T 24" W 48" L Cold Roll Mild Steel Sheet Metal A366/1008	86 ft^2	1.905$/$ft^2$	163.83	107.580
Clear 3/32" T Cast Acrylic (Plexiglas)	10 ft^2	3.80 $/$ft^2$	38	15.624
Total			**323.36**	**171.727**

11. Initial Steps

After discussing with our client we are going to move forward with the two wheeled design for prototyping. The next steps will be to order the different materials need from the bill of materials. The goal is to have the monitor mount, square tubing, and sheet metal delivered to Northern Arizona University by winter break. This will allow for us to begin the manufacturing process inside the NAU machine shop. First the square tubing will be cut to length using the specified lengths from the cut list on solid works. Next the frame will be MIG welded and constructed using the two different square tubing. After the frame is structurally sound the sheet metal will be welded to the exterior to enclose the structure. By doing this it will give us a head start on the next semester. The following process can be seen in the figure below.

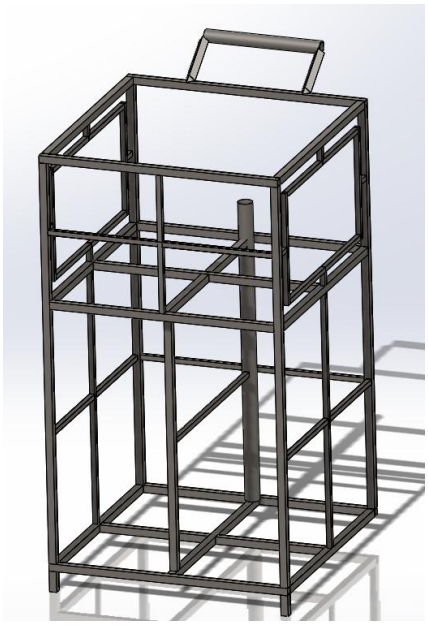


Figure 31 : Design 1 Frame

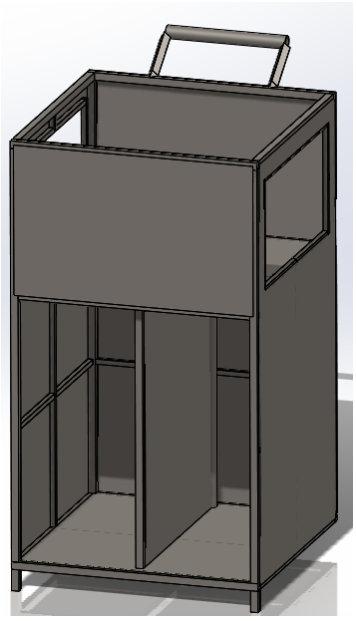
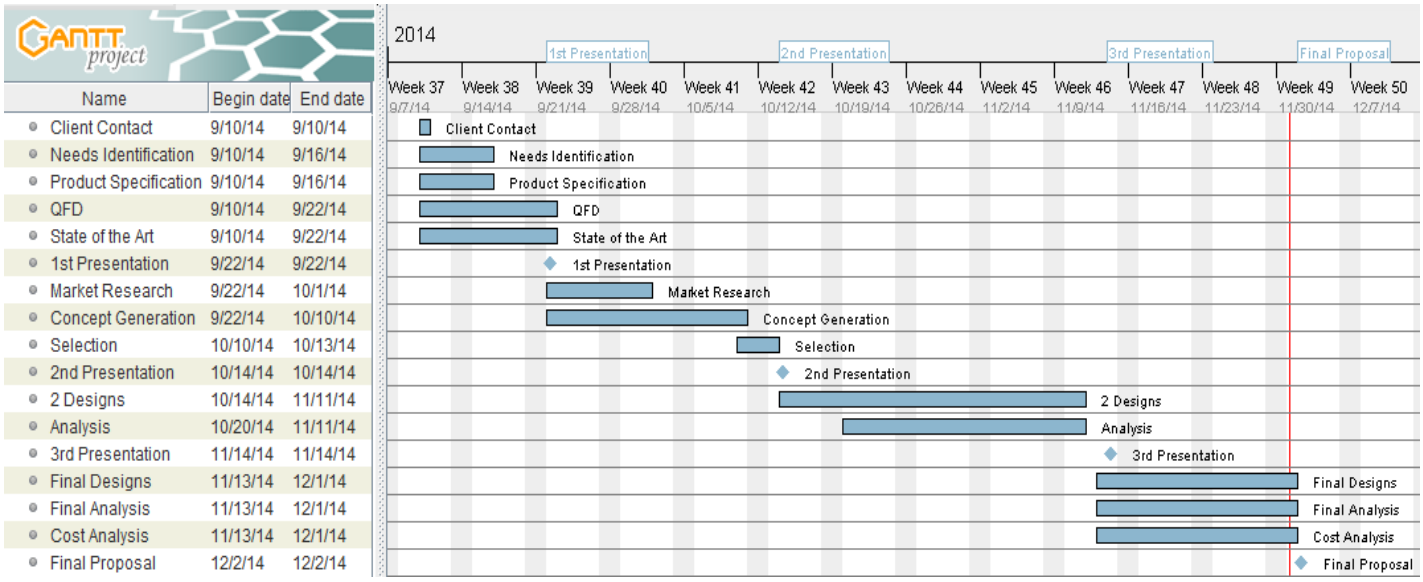


Figure 32 : Design 1 Frame / Sheet metal

12. Project Progression

A Gantt chart is used to give our team a rough estimate of the progression of the project, deliverables and designs goals. It serves as an outline of the milestones that we will encounter during the preparation and analysis phase of our project. Our team has completed all the deliverables for this phase of the project. The team started this phase by contacting the client to collect the client's initial needs and requests. The team then proceeded with searching the current designs in the market and suggesting different design concepts to our client. After narrowing down the design concepts to two final designs, the team then did the engineering analysis along with the cost and material estimates. Our team then concluded this phase of the project by delivering our final proposal to the client.

The team will now transition into the building phase of our project. The team has already ordered some of the needed material for our first final design. The team will then start building the first design to finish it by the early spring semester. The team will then finalize the second design and start building it so that both final designs are delivered to our client by the end of the spring semester.



13. Conclusion

Dr. Kosaraju requested our team to design two mobile computer carts capable of outdoor use to perform experiments since the current available mobile computer carts are too expensive and are not designed for outside use. The team members researched and analyzed carts that are already on the market then generated ten concepts that fit the client needs. Out of the ten concepts, the two wheeled dolly cart and the four wheeled computer cart were chosen using a team averaged decision matrix. Furthermore, the team determined that steel tubing and steel sheet metal is appropriate built material based on the force

analysis and client needs. Moreover, both carts will be designed to have adjustable monitor, weather proof, interior storage space, and cost less than $500. The team succeeded to meet the milestones by the due dates on the Gantt chart initiated at the beginning of the project. In conclusion, the team will start the initial steps of building the two wheeled cart design over winter break.

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Appendix

1. Abdulrahman Alhamdi: Decision Matrix 1 and 2

Decision Matrix # 1				
Concepts	**Criteria**			**Score**
	Cost	Ease to manufacture	Aesthetics	
Design #1	8	7	8	23
Design #2	5	7	4	16
Design #3	7	5	6	18
Design #4	7	7	5	19
Design #5	5	5	6	16
Design #6	7	6	6	19
Design #7	8	5	7	20
Design #8	8	7	6	21
Design #9	8	7	8	23
Design #10	8	9	6	23
			10 = High , 1 = Low	

Decision Matrix # 2									
Concepts	**Criteria**							**Score**	**Total**: Matrix 1 and 2
	Weather Proof	Durability	Overall Adjustability	Storage Space	Maneuverability Inside / Outside	Weight	Overall Size		
Design #1	2	5	8	7	6	7	7	42	65
Design #2	9	8	3	7	6	4	5	42	58
Design #3	7	6	5	4	8	7	7	44	62
Design #4	9	7	4	8	4	3	3	38	57
Design #5	2	7	7	5	7	7	6	41	57
Design #6	3	6	6	7	8	6	7	43	62
Design #7	8	8	8	7	7	8	8	54	74
Design #8	6	6	4	7	6	8	6	43	64
Design #9	8	8	8	8	9	9	9	59	82
Design #10	2	7	3	7	6	8	7	40	63
							10 = High , 1 = Low		

2. Mohammed Aldosari: Decision Matrix 1 and 2

Decision Matrix # 1				
Concepts	**Criteria**			**Score**
	Cost	Ease to manufacture	Aesthetics	
Design #1	9	8	7	24
Design #2	5	6	8	19
Design #3	7	5	4	16
Design #4	4	7	8	19
Design #5	8	8	8	24
Design #6	5	5	7	17
Design #7	5	5	9	19
Design #8	7	8	6	21
Design #9	7	5	9	21
Design #10	9	9	6	24
			10 = High , 1 = Low	

Decision Matrix # 2									
Concepts	**Criteria**							**Score**	**Total**: Matrix 1 and 2
	Weather Proof	Durability	Overall Adjustability	Storage Space	Maneuverability Inside / Outside	Weight	Overall Size		
Design #1	1	6	10	8	6	9	9	49	72
Design #2	10	9	7	8	8	6	7	55	74
Design #3	6	6	6	4	7	8	7	44	60
Design #4	10	9	7	9	9	5	6	55	74
Design #5	1	6	8	6	6	8	8	43	66
Design #6	5	6	8	7	9	8	8	51	68
Design #7	10	9	10	4	9	9	10	61	80
Design #8	6	7	7	6	6	8	6	46	67
Design #9	10	9	8	3	6	8	8	52	73
Design #10	1	8	7	8	6	9	9	48	71
							10 = High , 1 = Low		

3. Joel Asirsan: Decision Matrix 1 and 2

Decision Matrix # 1				
Concepts	**Criteria**			**Score**
	Cost	Ease to manufacture	Aesthetics	
Design #1	6	8	7	21
Design #2	6	7	6	19
Design #3	5	6	8	19
Design #4	5	5	7	17
Design #5	4	8	8	20
Design #6	6	7	6	19
Design #7	6	8	10	24
Design #8	6	7	7	20
Design #9	6	6	8	20
Design #10	6	8	6	20
			10 = High , 1 = Low	

Decision Matrix # 2									
Concepts	**Criteria**							**Score**	**Total**: Martix 1 and 2
	Weather Proof	Durability	Overall Adjustability	Storage Space	Maneuverability Inside / Outside	Weight	Overall Size		
Design #1	1	6	9	10	4	5	3	38	59
Design #2	10	10	0	5	6	5	4	40	59
Design #3	2	3	4	5	5	7	6	32	51
Design #4	8	7	5	9	5	3	4	41	58
Design #5	1	6	5	10	5	4	5	36	56
Design #6	1	5	5	8	2	4	4	28	47
Design #7	10	7	10	10	10	7	8	62	86
Design #8	4	6	3	5	3	4	4	29	49
Design #9	10	7	10	10	10	6	7	60	80
Design #10	1	5	0	6	4	5	4	25	45
							10 = High , 1 = Low		

4. Samuel Martin: Decision Matrix 1 and 2

Decision Matrix # 1				
Concepts	**Criteria**			**Score**
	Cost	Ease to manufacture	Aesthetics	
Design #1	6	7	8	21
Design #2	3	8	8	19
Design #3	4	6	8	18
Design #4	3	7	8	18
Design #5	6	5	9	20
Design #6	5	7	5	17
Design #7	6	4	8	18
Design #8	9	6	6	21
Design #9	6	4	7	17
Design #10	10	9	5	24
			10 = High , 1 = Low	

Decision Matrix # 2									
Concepts	**Criteria**							**Score**	**Total**: Matrix 1 and 2
	Weather Proof	Durability	Overall Adjustability	Storage Space	Maneuverability Inside / Outside	Weight	Overall Size		
Design #1	2	5	10	8	8	8	9	50	71
Design #2	10	10	5	10	6	5	7	53	72
Design #3	7	8	5	6	9	7	8	50	68
Design #4	10	10	5	10	7	5	7	54	72
Design #5	2	4	10	7	6	8	7	44	64
Design #6	2	6	10	8	7	8	8	49	66
Design #7	2	6	10	6	9	7	8	48	66
Design #8	5	4	5	5	7	9	7	42	63
Design #9	2	5	10	6	9	7	7	46	63
Design #10	1	2	5	5	7	10	8	38	62
							10 = High , 1 = Low		

5. Trevor Scott: Decision Matrix 1 and 2

Decision Matrix # 1				
Concepts	**Criteria**			**Score**
	Cost	Ease to manufacture	Aesthetics	
Design #1	5	5	7	17
Design #2	5	6	7	18
Design #3	7	7	5	19
Design #4	5	7	7	19
Design #5	7	4	6	17
Design #6	6	7	7	20
Design #7	7	5	7	19
Design #8	7	7	6	20
Design #9	6	3	6	15
Design #10	8	7	7	22
			10 = High , 1 = Low	

Decision Matrix # 2									
Concepts	**Criteria**							**Score**	**Total**: Matrix 1 and 2
	Weather Proof	Durability	Overall Adjustability	Storage Space	Maneuverability Inside / Outside	Weight	Overall Size		
Design #1	1	5	8	9	4	5	4	36	53
Design #2	8	7	5	9	7	4	6	46	64
Design #3	5	7	5	6	7	7	6	43	62
Design #4	8	7	5	9	5	5	4	43	62
Design #5	1	5	5	6	4	6	7	34	51
Design #6	1	8	8	8	7	5	6	43	63
Design #7	8	8	8	6	10	8	10	58	77
Design #8	3	5	5	6	5	6	6	36	56
Design #9	8	7	8	5	8	6	6	48	63
Design #10	1	5	5	7	4	6	6	34	56
							10 = High , 1 = Low		