Mobile Computer Cart

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Engineering Analysis

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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. The carts must be weather proof, adjustable, and cost $500 each. The team chose two different concepts out of the ten ideas to 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 Four-wheel design will measure 6 ft. in height, 4 ft. in width, and 2 ft. deep. The Four-wheel design will weigh 171.73 lbs and cost $448.45. The two design concepts meet Dr. Kosaraju requirements.

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, etc. Neither design must exceed the cost of more than $500.00 apiece.

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

Team 12 is assigned to build two mobile carts sponsored by Dr. Kosaraju. He needs two carts that are weather proof, adjustable, and cost $500 each. The carts are needed to be easily maneuverable and support computer use during outdoor experiments especially in Flagstaff weather. The team come up with ten concepts to expand the client's choices. Then two designs were narrowed down using decision matrix. In this report, the two concepts will have force analysis performed and bill of material initiated with full CAD drawings.

3. Concept Generations

3.1 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.

3.1.1 CAD / Drawings

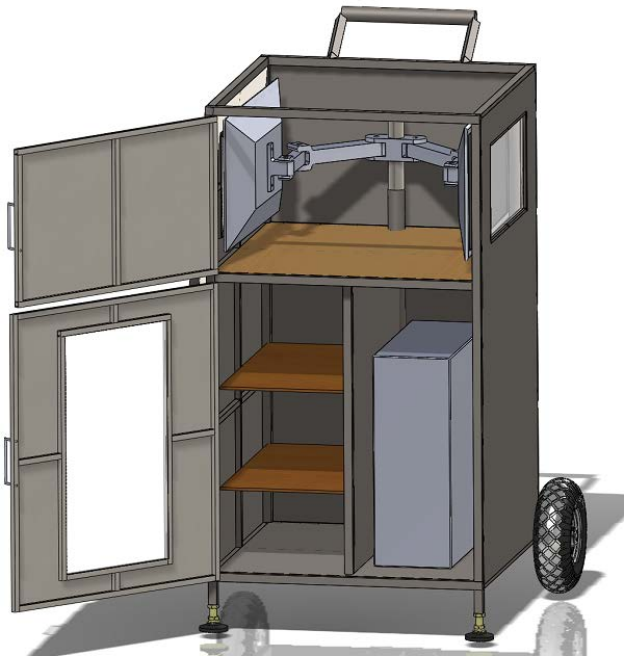

Figure 1: Cart Design 1

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.

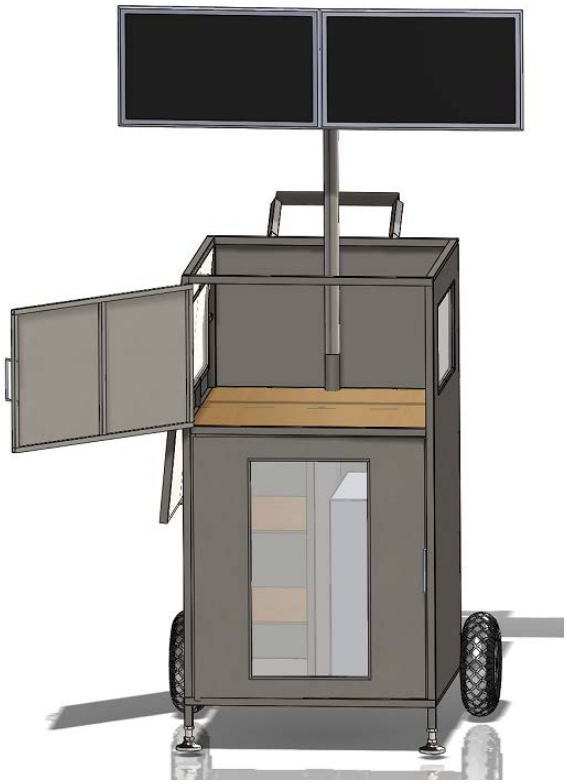

Figure 2: Cart Design (Front)

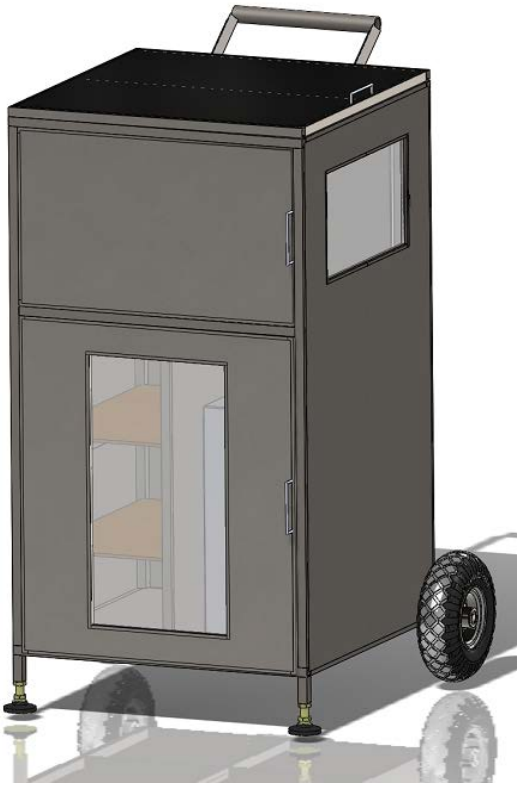

Figure 3: Cart Design 1 (Closed View)

3.1.2 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 Homedepot. A bill of materials can be seen below in figure 4. The total calculated cost for the cart was estimated to be $443.49.

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

Table 1: Bill of Materials

3.2 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.

3.2.1 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.

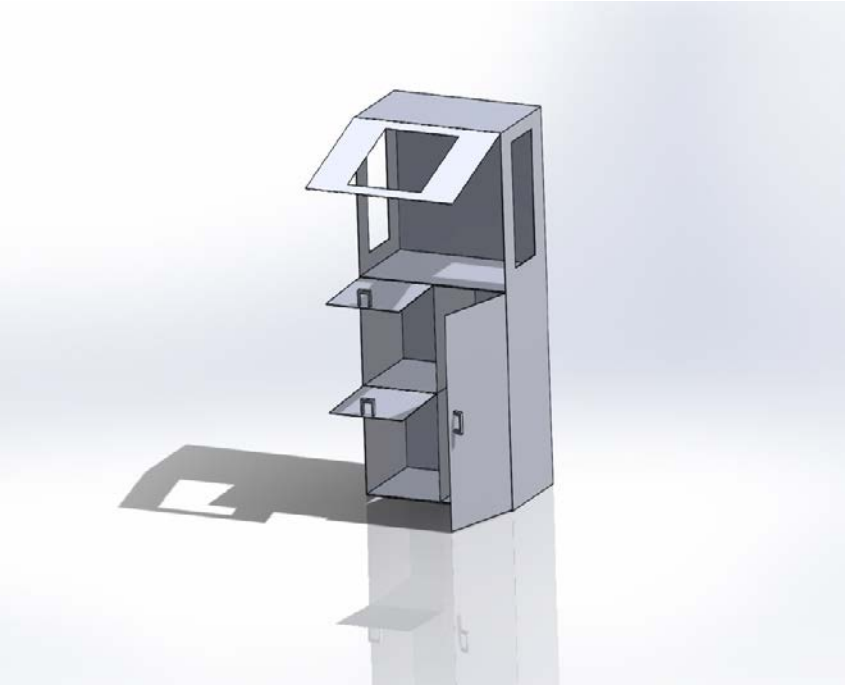

Figure 4: Four-Wheeled Computer Cart

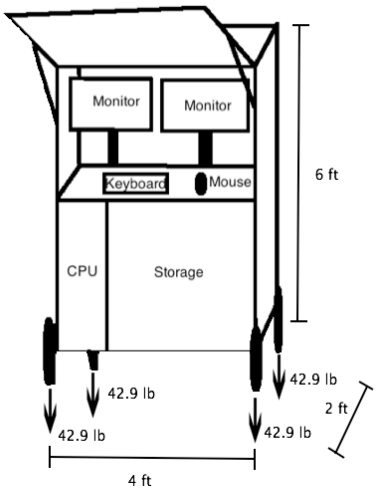

Figure 5: Force Analysis of the Four-Wheeled Computer Cart

3.2.2 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.

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

Table 2: Bill of Materials Cart 2

3.2.3 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 6: Hot Rolled Mild Steel Square Tube A513

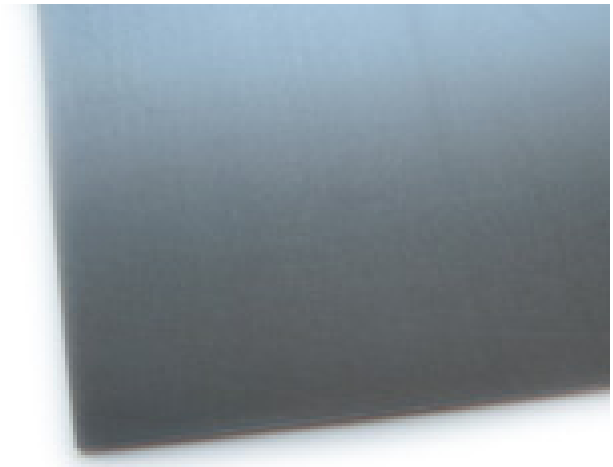

Figure 7: Cold Roll Mild Steel Sheet A366/1008

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.

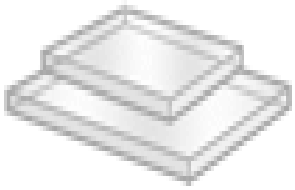

Figure 8: Clear 3/32" T Cast Acrylic Plexiglass

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 9: 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.

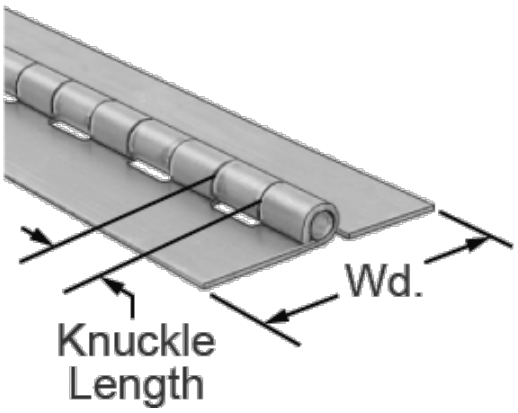

Figure 10: Thick Leaf Steel Piano Hinges without Holes

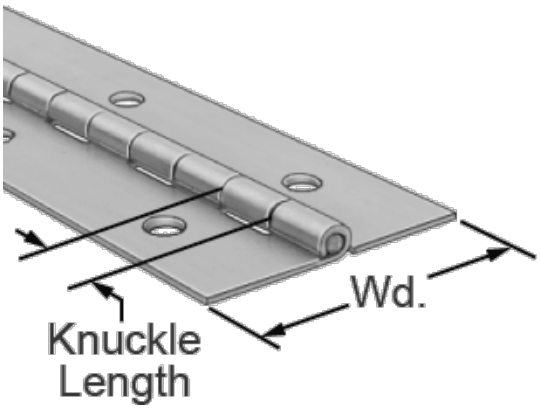

Figure 11: Thick Leaf Piano Hinges with Holes

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.

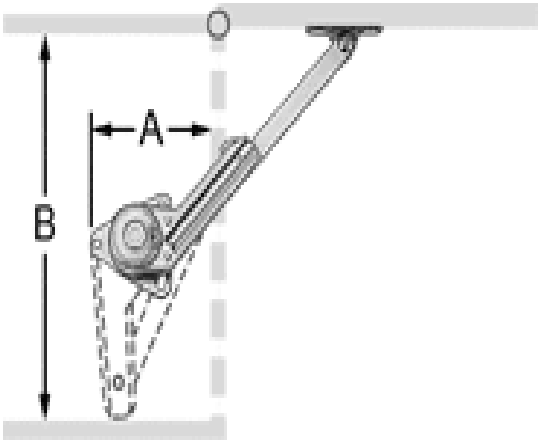

Figure 12: Soft Close for Side Lid Mounting

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 13: 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.

4. Analysis

4.1 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.

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

Table 3: Concept 1 Analysis

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.

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

Table 44: Concept 1 Material Specifications

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

    a = area (in^2)

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

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

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

= 82.708 psi < 72,000 psi

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

= 208.604 psi < 72,000 psi (only 1 pin needed)

4.2 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.

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**

Table 5: Concept 2 Material Specification

5. Project Progression

A Gantt chart is used to give our team a rough estimate of the progression of the project, deliverables and designs goals. The group has already made the final designs of the two chosen concepts. In-depth analysis has been done on the carts to ensure their stability and ease of use. The frame parts and interior components have been chosen for both carts within the assigned budget. The group is now transitioning into the fourth phase to make the final proposal with the final designs, cost, and analysis calculations. Our team will continue to make use of the project plan in order to guarantee that appropriate progress is fulfilled with this project.

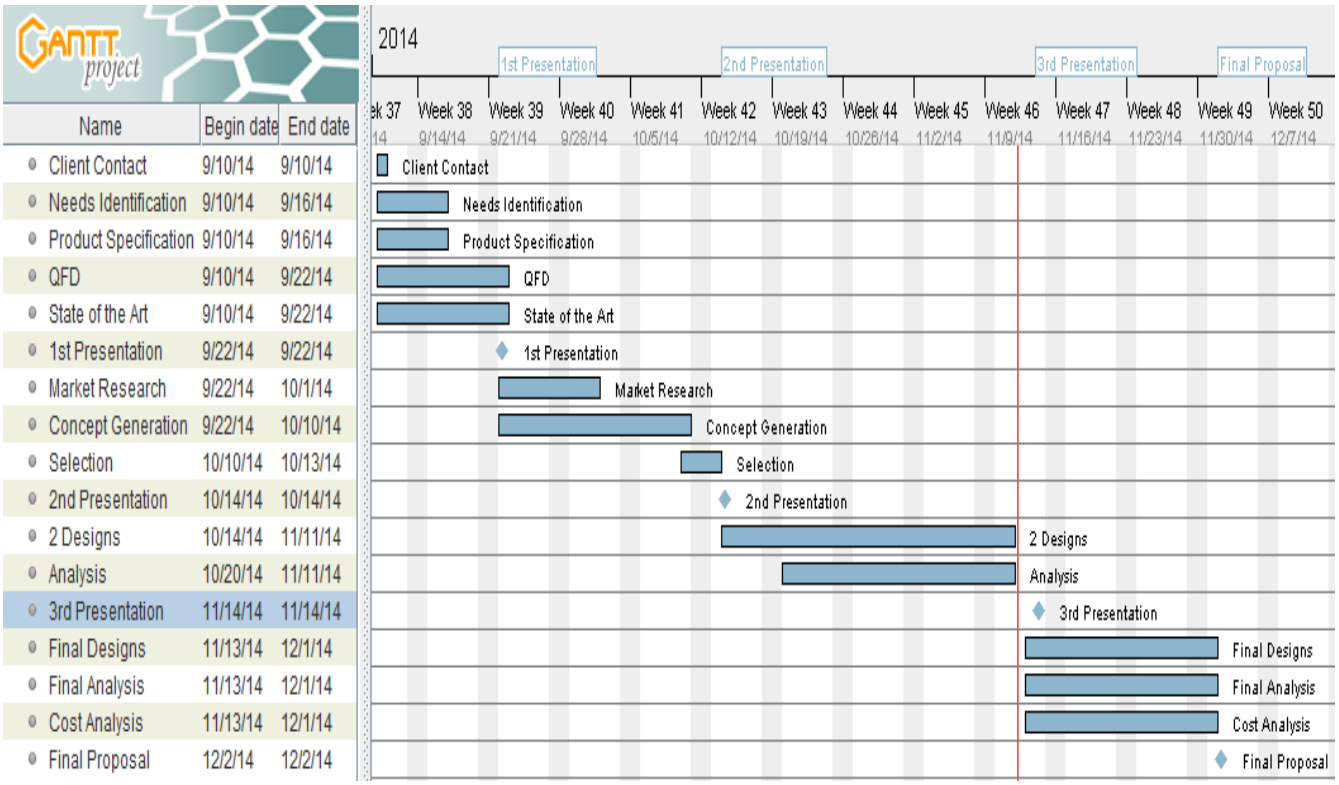

Figure 14: Gantt Chart

6. Conclusion

The team did both force analysis and bills of materials on the final two design concepts. The two designs will be built using square tubing as a skeleton frame using 0.75x0.065 thick A513 steel square tubing. Then the frame will be covered with 24”x48”x0.03” steel sheet metal. Also, both designs will have Plexiglas that is strong to withstand the tough weather in order to make it easy to see the data while the cart is enclosed. Moreover, both designs will be adjustable, weather proof, and cost less than $500 each. The two-wheeled dolly design has a smaller frame than the second when stored or while in use, which make it weigh 104.34 lbs and cost $443.49. The second design, the four-wheeled design, has the larger frame weighing 171.73 lbs and costing $448.45. In conclusion, both designs will be less than $500, easy to maneuver, weatherproof, have enough storage space, and adjustable.

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