Final Report

Motor Assisted Shopping Cart

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Easy Cart

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Table of Contents

Abstract Summary

There is a need for a shopping cart that can assist the user moving larger amounts of supplies with less effort. A cart that can help those with disabilities or those that can walk but do not have the leg strength to push a cart full of items to the register and to their cars. There are few products similar to this idea, self-propelled dollies or pallet jacks, products made more for the industrial use. This idea brings the idea of easier movement of bulk items to a consumer aspect. The idea of a self-propelled cart stems from that there is limited room in the buggies most shopping centers provide and some people may not feel comfortable using them. The Easy Cart is designed to be a low cost retro fit option for standard carts and an alternative to the electric buggy.

Designing and engineering the Easy Cart taped into knowledge and skills acquired in various courses taken by the Easy Cart team at Indiana University Purdue University Fort Wayne. Classes like Technical Graphics Communication gave this team the skills to start with a working drawing of an idea which then was transferred to a CAD model. Designing this cad model took knowledge acquired from Computer Aided Modeling & Design which was further reinforced by CAD Tool and Fixture Design. With the model now designed the prototype could be assembled using skills acquired in the Basic Machining class. The knowledge and various skills learned through these courses helped to push this project from an idea to a designed piece of equipment to a working prototype.

The Easy Cart team was thrust into a real world application of our skills and given the option of get organized and work together or fail. This team was required to demonstrate the practice of identifying a problem, coming up with a solution to that problem, then taking that solution and putting it into a real world application to solve that problem in a timely manner are skills that are invaluable to any engineer. This experience gained through this project is essential to prepare the team for any work in the engineering field.

Miscommunications, downed email accounts, delayed shipping, and unforeseen design complications all contributed to setbacks faced by the Easy Cart team but this team was able to push through these setbacks to reach the end goal on time. The strategy of device and conquer vastly contributed to this allowing each member their space but maintain knowledge of the rest of the groups progress. Even with the setbacks the team was pleased with the end result of this project and has hopes for the future potential of this project.

Introduction

There is a need for a shopping cart that can assist the user moving larger amounts of supplies with less effort. A cart that can help those with disabilities or those that can walk but do not have the leg strength to push a cart full of items to the register and to their cars. To complete this task, the cart would have to be retrofitted with motors to drive the wheels, a power source to get the motors running, and a way for the user to control the speed of the motors. The purpose of this modification to a shopping cart would be to solve the issue of moving a heavy cart full of items and it will give the feeble the ability to move more bulk with less effort. There are few products similar to this idea, self-propelled dollies or pallet jacks, products made more for the industrial use. This idea brings the idea of easier movement of bulk items to a consumer aspect. The idea of a self-propelled cart stems from that there is limited room in the buggies most shopping centers provide and some people may not feel comfortable using them.

Background

Shopping mart owners and shoppers have been innovating on ways to get more groceries home. It started around 1915 with the paper bag to help customers get more than an armful of items home. From there stores began getting larger and customers began having to collect their own items, this proved problematic for customers so they were supplied with wire baskets. This allowed customers to carry more but the customers still couldn't carry much due to the weight of the basket. The solution to this problem was an early design for the shopping cart as we know it which consisted of two wire baskets suspended over each other on a push cart. The main issue with this design was storing them, the baskets had to be taken out and stacked, then the dolly folded up and put away. The storage problem was fixed with nesting carts which consisted of fixed baskets that were hinged at the back so the carts could simply be pushed together to be stored; employees could easily handle 12 of these carts at a time when stacked and shoppers could quickly grab a cart from the line by pulling back on the cart. From here we arrive at the modern single basket shopping cart that has nesting capabilities; there are a few variations of this cart such as carts that have child carriers or carts that have larger baskets for whole sale stores, another iteration of the modern shopping cart is a combination of a cart and a mobility scooter which allows disabled customers to still get their needed items.

Objective

Then end goal of this project is to remove that inconvenience for more feeble people and allow shoppers to move more groceries.

- Allow carts to be user friendly.
- Move upwards of 200 lbs. with minimal effort.
- Safe for personal use and use around other people.
- Low price range.
- Allow carts equipped with this device to be stacked like normal carts.
- Make an alternative to the electric buggy for under $500

Problem Statement

The problem of having too much to carry and not enough space or having enough space but a cart that's too heavy to move, that is the problem that the Easy Cart team is setting out to solve. In a most stores now you have three options for collecting and carrying your groceries: a basket, a cart, or an electric buggy. Two of those three options don't hold too much and while the cart can hold the most it gets quite heavy. People who are feebler may not be able to push a large cart full of groceries so these people opt to use the buggy but need more items. There are people that are still able to walk but lack the strength necessary to move a cart full of items and they may need more than the electric buggy's basket will hold or they may feel like they are giving up some of their independence by having to ride around on said buggy. So to avoid the buggy they use a cart and only get part of what they need or they opt for the buggy and still have to make multiple trips causing shopping to become highly inconvenient.

Solution

The easy cart was designed to be a quick retro fit of a standard cart with three main components: the wheel-motor assembly, a battery, and a Hall Effect sensor. The following is an in-depth explanation of the calculations, design, and fabrication of each component.

Wheel-motor Assembly

Figure 1: Wheel Assembly

The drive system for the Easy cart is two chain driven wheels powered by two 24V motors. From the ground up the system sets on an 8 in caster wheel with a 55 tooth sprocket designed for a #25 chain which links to the motor which has a 9 tooth sprocket attached to the drive shaft giving it a gear ratio of 6.11. The motor mount is a piece of recycled steel that is mounted to the carts rear wheel bracket via two 5/16th inch holes drilled below the main axel hole of the wheel mount, once the wheel and the motor are attached to the plate with a spring tensioner to hold the chain taunt the whole assembly is easily attached to the cart. The motors chosen for the drive system for the cart were picked due to price, availability, and power. The motors needed to have a higher torque to provide enough force to overcome the static friction of a fully loaded cart (200 lbs.) The equation used to find this torque was F*r = T. With this information the proper motors could be selected and used with the standard scooter sprocket.

Battery and Hall Effect Sensor

Figure 2: Throttle Assembly

The initial choice for the Easy Cart was a 12 V car battery but the decision was made to switch 2 scooter batteries for their smaller size and shorter charging time. The Easy Cart runs on two 12 V batteries that give the user an hour and 45 minutes of run time and have a 4 hour charge time using a 120 V wall socket. The batteries weigh 6.72 lbs. together which is a 57% reduction in weight from the car battery and is also roughly half the price of a car battery at only $47 for the two of them. These batteries were connected to a Hall Effect sensor to control the speed of the motors. A Hall Effect sensor alters the voltage in an electric circuit in response to a change in the magnetic field, in this specific application the sensor is used as a position sensor in the Easy Cart. The position of the magnet in the outside of the throttle is picked up by the sensor which then alters the voltage supplied by the batter to the motor to adjust the speed. Pictured in figure 2 is the throttle used in the Easy Cart.

Testing and Results

A series of tests were run in order to test the capabilities of the Easy Cart. These tests consisted of a top speed test, a stopping distance test, and the carts ability to turn; all tests were performed three times while the cart was under a full load (200 Lbs.), half load (100 lbs.), and no load. The test for the turning abilities of the cart was based on how the cart reacted when only one motor is activated. The results of this test show that while the motors assist with moving the load in a straight line, their ability to assist with turning decreases as the

load increases and there is no major difference in this performance indoors or outdoors. The figure below shows the testing results of the top speed test and the stopping test. These results show that indoors versus outdoors, the cart's speed is similar. The reason for the minor variation in speed is the natural variation of the testing grounds such as: wind, un-level ground, cracks, and debris. The stopping distance varies majorly between the inside and the outside; this is due to the texture of the ground and levelness of the ground. The asphalt surface outside was more uneven and this contributed to a stopping distance reduction of up to 75%.

Outside Full Load	Trial 1	Trial 2	Trial 3	Average
Top Speed (mph)	1.84	2.20	2.01	2.02
Stopping Distance (ft)	3.5	1.58	3.17	2.75
Outside Half Load				
Top Speed (mph)	2.52	2.53	2.67	2.57
Stopping Distance (ft)	6	5.33	6.5	5.94
Outside No Load				
Top Speed (mph)	3.20	3.86	3.71	3.59
Stopping Distance (ft)	4.38	7.21	7.75	6.44

Inside Full Load	Trial 1	Trial 2	Trial 3	Average
Top Speed (mph)	1.82	1.84	1.89	1.85
Stopping Distance (ft)	12	9.5	7.5	9.67
Inside Half Load				
Top Speed (mph)	2.54	2.67	2.76	2.66
Stopping Distance (ft)	13.58	167	16	15.53
Inside No Load				
Top Speed (mph)	3.24	3.96	4.14	3.78
Stopping Distance (ft)	23	27	26	25.33

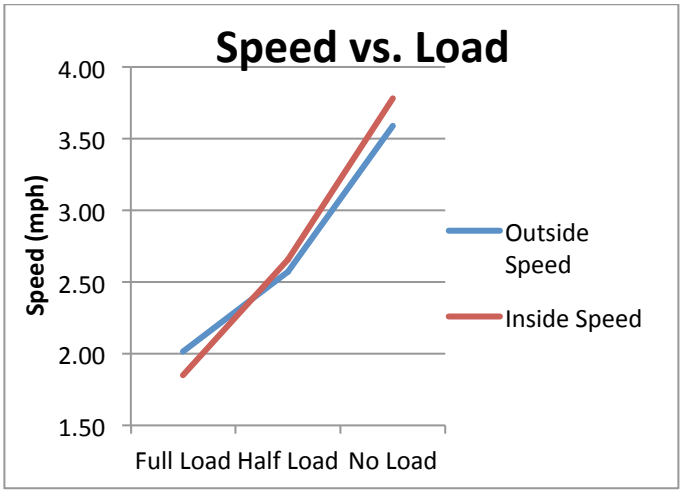


Figure 5

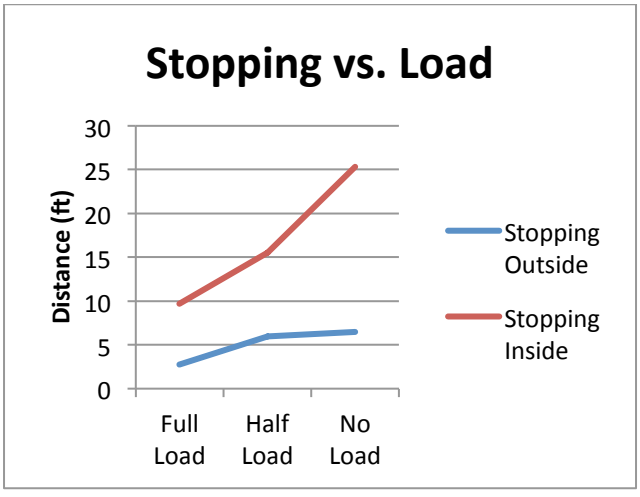


Figure 6

Cost Analysis

The following is the cost breakdown of the Easy Cart.

Easy Cart Components				
Components	Qty.	Price	Total	Description
Wheels	2	$29.99	$59.98	8IN Caster Wheels (Polyurethane)
Mounting Plate	2	$0.00	$0.00	1/4in Thick Steel (Recycled)
Axil	2	$5.48	$10.96	1/2IN Hex cap Screw x 6IN Long
Spacing Washers	80	$0.06	$4.80	1/4IN Flat Washer
Sprocket Bolts	8	$0.43	$3.44	1/4IN Hex Cap Screw x 1.5IN Long
Mounting Bolts	8	$1.12	$8.96	5/15IN Hex Cap Screw x 3IN Long
Motors	2	$23.50	$47.00	Razor E100 Motors
Sprocket	2	$10.99	$21.98	55 Tooth #25 Sprocket
Twist Accelerators	2	$15.99	$31.98	Variable Speed Throttle
Batteries	2	$23.64	$47.28	12 volts Scooter batteries
Motor Mount	2	$0.00	$0.00	(Recycled Scrap Metal)
Shopping Cart	1	$0.00	$0.00	Kroger Shopping Cart (Donation)
Axil Nut	2	$0.64	$1.28	½ IN Nylock Hex Nut
Sprocket Nuts	8	$0.10	$0.80	¼ IN Nylock Hex Nut
Mounting Nuts	8	$0.16	$1.28	5/16 IN Nylock Hex Nut
Axil Washers	2	$0.24	$0.48	1/2 Flat Washer
Motor Bolts	6	$0.36	$2.16	M5 x 5mm long
Chain	2	$16.99	$33.98	#25 86 Link Chain
Motor Controller	2	$29.99	$59.98	Control Module
Chain Tensioners	2	$10.31	$20.62	Spring Loaded Tensioner
Total Spent			$356.96	
After Tax			$381.95	

The cost analysis shows the team's ability to meet the initial costing objective of $500 per cart. The costing does not include the cost for the cart used; it was donated by a local Scotts. This product is designed to be a retrofit option for any cart so it can be used with minor alterations to the cart itself, making it a cheap alternative to the electric buggy which sells for around $1000 a piece.

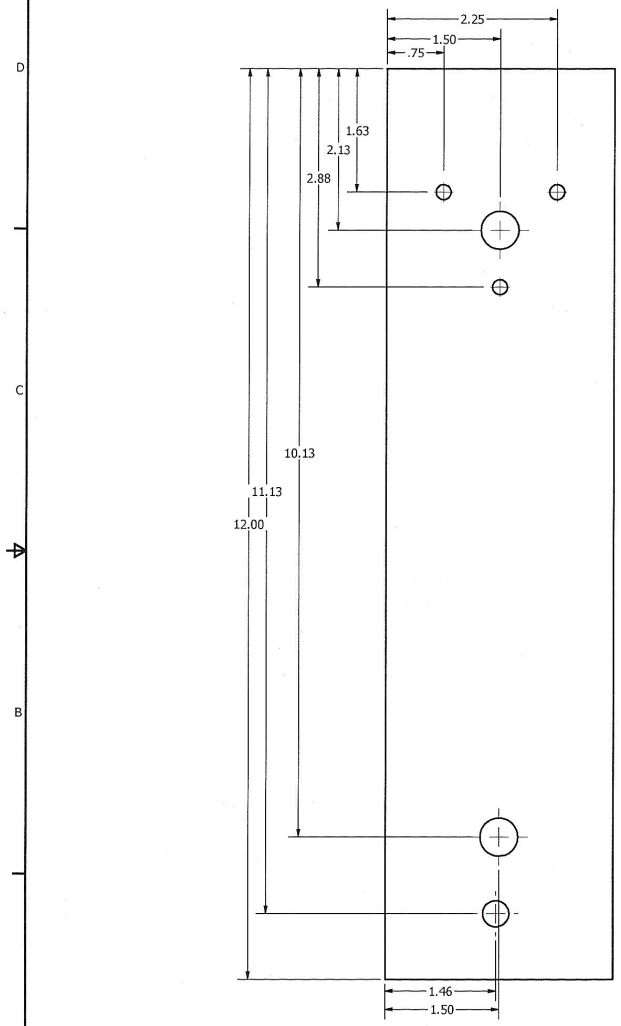
Observations

The difficulty of turning decreased as the cart's load decreased with the location, parking lot and indoors, having little impact on these results. The prototype was not as high of quality as a final product and as a result there were several sources of error, primarily, the chain for the motor assembly fell off several times, however, we are certain we minimized these sources of error.

Conclusion

The Easy Cart provides a solution to heavy carts as well as a cost effective alternative to the electric buggies. It offers an easy bolt on design that allows store owners an alternative to the buggies that is still stackable for storage. The variable speed controller allows the user to set their own pace and still give them the ability to push heavier loads. It meets the goals initially set for this project but still has room for improvement which may come in the form of additional sensors to limit speed based on total load, bettor motor mounts to eliminate the need for a tensioner, and quicker recharging batteries. With these improvements to this design the Easy Cart could become a much more viable option for stores as an alternative to a traditional cart, buggy, or basket.

CAD Models



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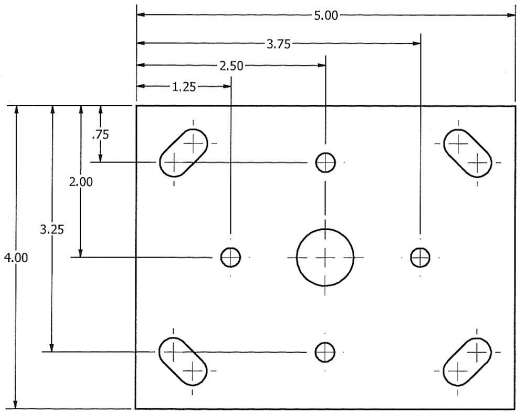

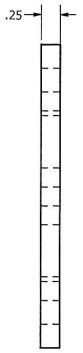

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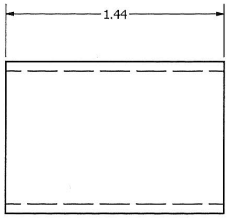

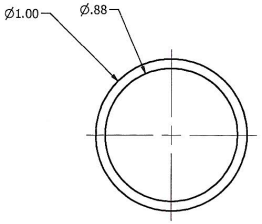

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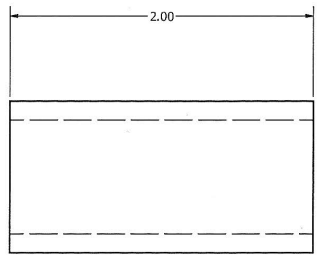

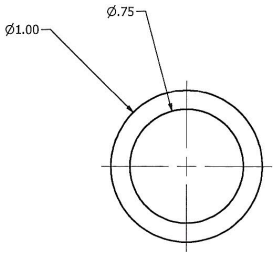

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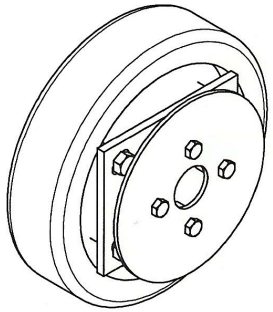

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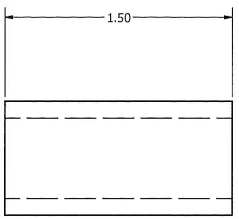

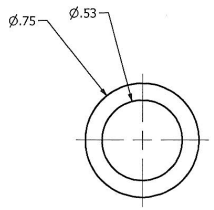

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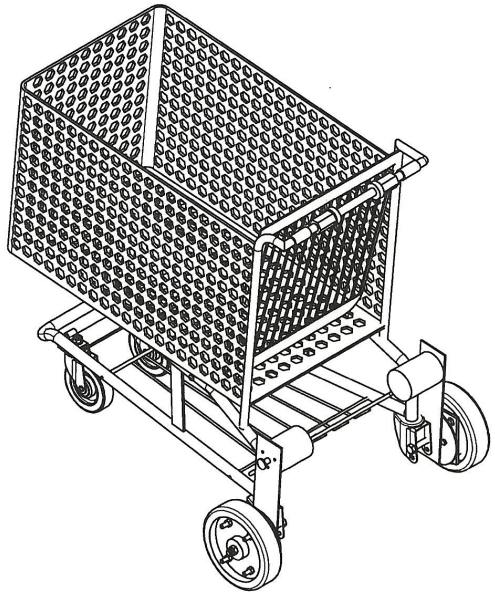

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Assembly Instructions

Step 1

First you must assemble the 8 inch wheel assembly. This is done with the following parts, 8in caster wheel (fig. 1), mounting plate (fig. 2), sprocket (fig. 3), spacing washers (fig. 4), plate mounting bolts (fig. 5), and sprocket mounting bolts (fig. 6). Using a drill to create the through holes in the wheel that fit the bolt pattern of the mounting plate. Then holes are drilled in the mounting plate by using the sprocket as a pattern to match the holes of the sprocket. Once the holes are drilled in the mounting plate a hole is then drilled in the center of the mounting plate for the axil to go through. Once that is done the sprocket was then mounted using the sprocket bolts, hex nuts, and 10 spacing washers. Once that is assembled the assembly is bolted to the wheel tightening the bolts so that the mounting plate is parallel with the wheel as shown in figure7.

Figure 1

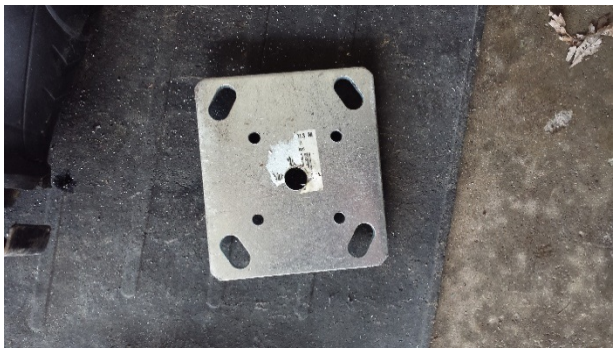


Figure 2

Figure 3

Figure 4

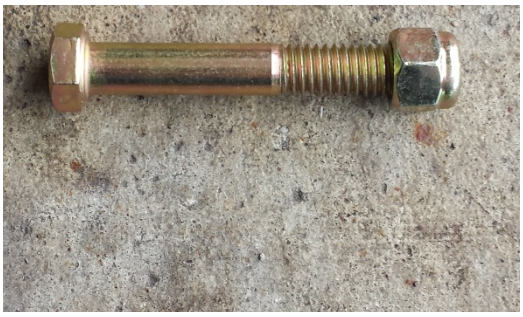


Figure 5

Figure 6

Figure 7

Step 2

This is where the axil spacer and wheel spacers are cut to length. The axil spacer shown in figure 8 is cut to 1.5 inches. The wheel spacer shown in figure 9 is cut to 1. 4375 to allow the wheel to spin freely when the axil is tightened.

Figure 8

Figure 9

Step 3

At this step the holes where the axil will mount on the cart are drilled so that the new wheels will be mounted at a height in which they keep the original height the cart sits. This is done by using a tape measure setting the end on the ground and placing a mark with a marker at 4 inches above the ground because the wheel in 8 inches in diameter, then once marked, the holes are hand drilled.

Step 4

At this step the motor mounting bracket is made. It is made out of 1/8 inch thick steel sheet pieces that were scrap pieces of metal to save cost. The bolt pattern of transferred to the steel by making a pattern on a piece of paper from the motor and transferred to the metal so the bolt pattern and drive shaft location would be correct. After the holes were drilled the motor was mounted then the chain put on both the drive shaft and the sprocket mounted to the wheel so that the distance between the center points could be measured. Once measured the hole where the axil goes through the motor mount plate was dilled. Then to prevent the motor plate from moving the original holes where the carts original wheels mounted was used to put a hole in the mounting plate. Once bolts were put there the mounting plate was unable to rotate about the axil. Once assembled it was realized that the center point to center point distance was not exactly were it needed to be due to the fact the holes were not professionally made so chain tensioners were added to maintain chain tension. Figure 10 shows the completed motor mounting bracket mounted to the cart.

Figure 10

Step 5

The wheels were placed on the axil with the spacers and tightened down. Figures 11 and 12 show the completed wheel assembly mounted on the cart.

Figure 11

Figure 12

Step 6

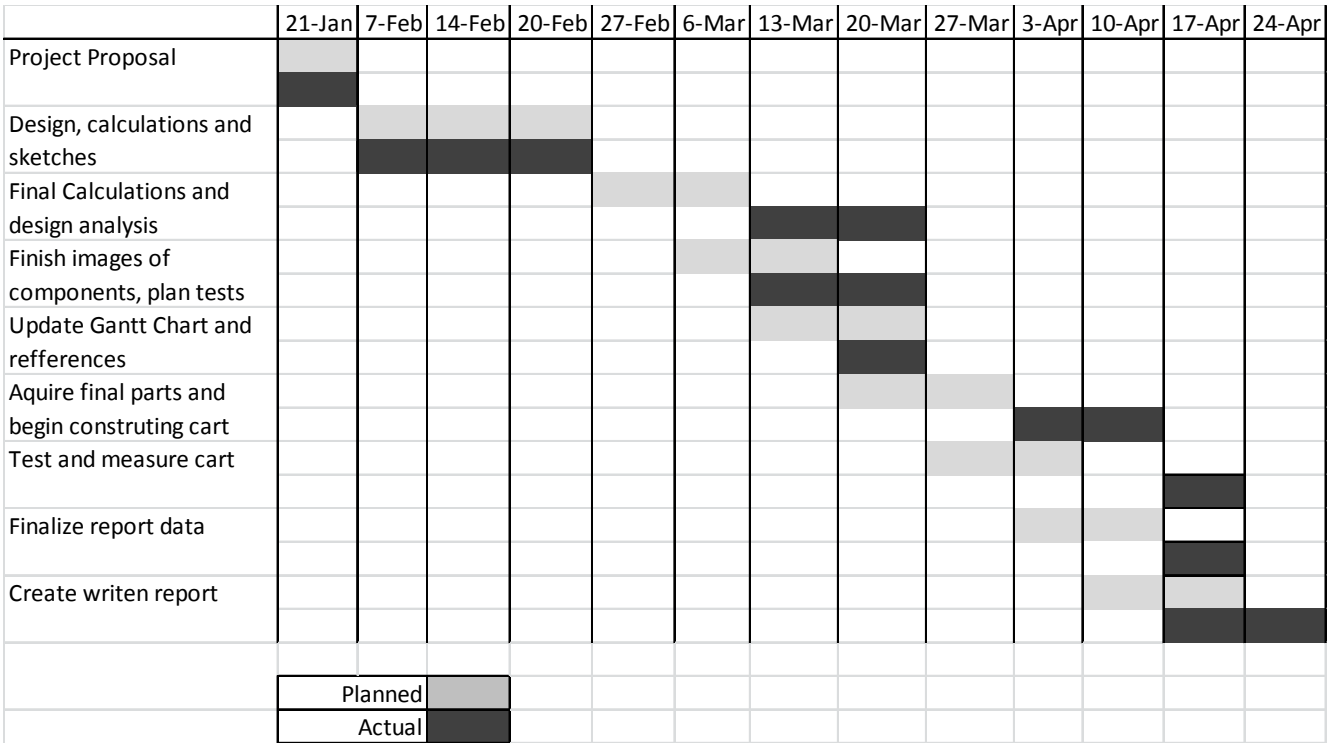
The next step was to use a hack saw to cut off the handle of the shopping cart. Once off a buffing wheel was used to remove the paint so that the twist accelerators could be slid on and tightened in place. Tthen tubing was cut to 2 inch long pieces and slide over the portions of cut off Handle bar and slid of the outside of the handle bar still connected to the cart. Then using self-drilling screws the tubes were mounted holding the cut off handle back to the cart. Figure 13 shows the final stage of the handle mounting tubes.

Figure 13

Step 7

This is the step where the batteries were wired to the controller box and the motor to the controller box.

Gantt Chart



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