Portable Carrier A

Final Report

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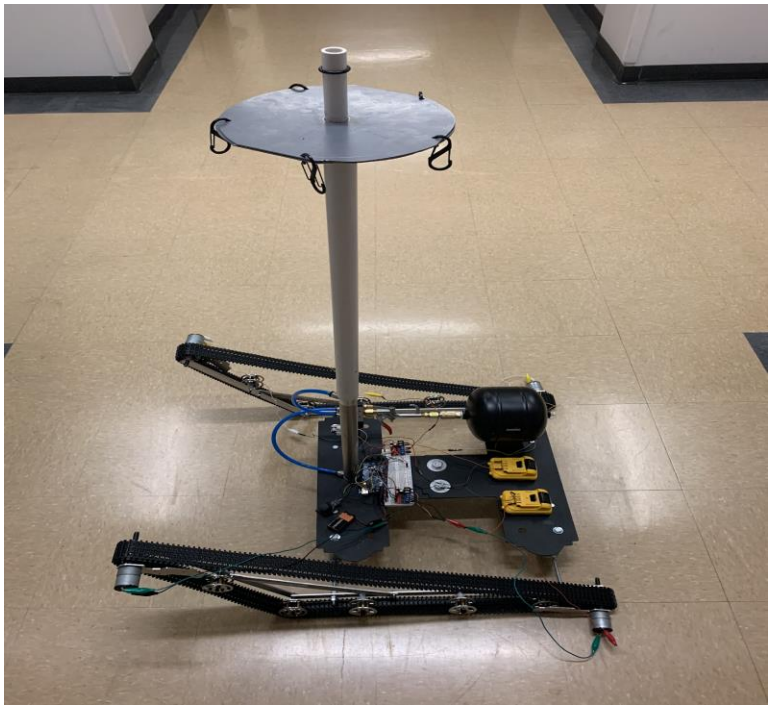

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DISCLAIMER

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EXECUTIVE SUMMARY

This project consists of a portable carrier which has the capability to climb stairs and can carry 50 lbs and 5 bags. The project has started with the description and determine the customer requirements and engineering requirements. Customer requirements have obtained from the client description and engineering requirements have obtained from the customer requirements. After that House of Quality has developed to interlink the engineering requirements with the customer requirements.

Extensive research has done to find different related projects and designs ideas and then few existing designs have found and then developed the black box model to show inputs and outputs and developed the functional model to show the working device. After that subsystem have determined for the project and their existing designs have determined. For each subsystem three different existing designs have determined.

After that 10 new designs ideas have generated on the basis of customer requirements and their pros and cons have mentioned as well. These designs have sketched down by hand and then in the design selection section, final design has selected from the 10 designs.

A Pugh chart has used to narrow down the results form 10 designs to top three designs and then decision matrix has used to find the final design from 3 designs. The final design was design # 10 which was tri-high carrier and this design consist of two tripod tires a straight rod with the straight carrier base touching the ground. It can easily climb the stairs as well.

A CAD model has developed for the final design and different views have presented. Computer Aided Design helps in understanding the design and each dimension describe in the CAD model. After the CAD model, Bill of Material has described to explain the design in details and present the breakdown of project. The project has implemented after developing the prototype, and tested it multiple times. The project has implemented using the telescope developed manually and other products including the chassis has purchased and then assembled the parts. An air cylinder has developed using the solenoid to make the air pressure which will raise the hanger to carry the bags and lift up from the ground. Small design changes have made during the manufacturing as well like telescope has developed personally and hanger shaped has changed as well.

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1. Background

1.1 Introduction

It is a common practice that when people go for grocery shopping in the mall, usually they use the trolley along with them to put all the bags and materials in the trolley because it is difficult to carry bags and grocery items together in hand. Such trolleys were helpful in carrying the bags and make easy to do bundle of shopping together. In the same way when the people reached back to their homes, they need to do multiple trips to shift the grocery items from car trunk to the home. It looks fine for those who have house on ground flow, because they can manage to do some trips for shifting the bags to home. Consider those people who lives in a flat or apartment, on second or third floor or above. When they need to make some trips from ground floor to top floors for shifting the bags, it becomes a nightmare for them. To resolve this issue, a project was developing which was making carrier that will help people in the grocery shopping and help them as well while moving to the stairs, and people will carry all the bags together, so they don't need to do multiple trips and also they don't have to carry all the items in hands. All the items can place into the carrier to shift them from car to the home.

This idea will help people in carrying the items and it will provide the easiness to the people. And this easiness will make this device popular and that's why sponsors have shown interest in this project. As the idea was great and it will help people in carrying the loads and will release their stress. Project will benefit the sponsor because sponsor will get great response from the public for this idea to bring in the market and it will be beneficial for them for their publicity and beneficial for the stakeholders as well, as stakeholders will get this quite useful for selling and buying on commercial scale. When the project will complete stakeholders, clients and sponsors will collect reward from people.

1.2 Project Description

The following was the original project description provided by the sponsor. Team responsibility was to build a "portable carrier" for the people who shop in a grocery store and have at least 5 medium bags. The project should satisfy the customer who lives in the second or third floor to carry his shopping bags from his car to his home or his trash from his home to the disposal with a distance of 100 – 500 feet. The product should help those who were in the range of (7 – 70 years) with no injury. It should be in a convenient size, that can be fit in the trunk and be unfolded easily.

1.3 Original System

> "This project involved the design of a completely new portable carrier system. There was no original system when this project began."

2 Requirements

In this section of report, all the requirements stated by the customer will mention so the reader will understand what was requiring in this project by the client and how the project will develop at the end. Firstly, customer requirements will present and then engineering requirements will present.

2.1 Customer Requirements (CRs)

Customer requirements for the project were listing below and these requirements have obtained from the project description given to the team by the client. As the description was provided in paragraph form so all the main points have obtained from the description and listed below in the form of table and shown in Table 1. As the client want the device to be safe to use and it must carry 5 medium size bag for a total of 50 lbs. It must be light in weight (15-25 lbs) for the whole device because it will carry the load so if it will be heavy then user will have to do more effort to carry the load. The device should also be able to travel 100-500 ft. The size of the device will be half the size of the trunk maximum. The team will also make the device operating in different weather conditions like snow or rain. The device will be required to climb the stairs if the user living on the second or third floor and not having an elevator. All other requirements have taken from the project description.

Table 1: Customer Requirements

Customer Requirements
Safe
Carry 5 bags
Easy to Use
Light Weight
Climb Stairs
Travel distance
Small in size
Different Weather condition operating
Portable and Foldable

2.2 Engineering Requirements (ERs)

Engineering requirements were based on the customer requirements and the design aims to satisfy these requirements. So engineering requirements were the targeting values for the project. As given in the description that the device will have to travel for at least 100 feet so this has put in the engineering requirement, now when the device will develop, it will move for more than 100 feet and if it will not move for 100 feet then will make such changes in the design that it can easily move for 100 feet. It has to carry 5 bags of medium size, so this has put in the engineering requirement and the device will have to carry 5 bags else need to make changes in the design and its weight hasn't defined in the description but as the device must be light weight and light weight comes in the range of 15 – 25 lbs. so limit of 25 lbs. has used for the engineering requirement. Size hasn't defined but it has mentioned that device must be lesser than half of the car trunk and it found that car trunk was around 16 □□^{3} so the ER value has chosen was 8 □□^{3}.

Tire size hasn’t defined but for climbing stairs, we need around 6 in to 8 in radius tire. This requirement will Engineering requirements have shown in Table 2.

Table 2: Engineering Requirements

Engineering Requirements	Target Values
Number of bags to carry	5
Distance travel	100 ft.
Weight	15 lb.
Size	8 □□^{3}.
Tires size	8 in. radius
Weight to carry	50 lb.
Height of carrier	3 ft.

2.3 House of Quality

The House of Quality was used to connection between engineering requirements and customer requirements. It was important to relate engineering requirements with the customer requirements because engineering requirements generates from the customer requirements and it didn’t receive from the client that’s why it’s important to make the relation and determine which engineering requirement was most important and which engineering requirement was least important. House of Quality also determines the technical importance value for each engineering requirement and can give the ranks to the engineering requirements. HoQ has given in the table 3.

Table 3: House of Quality

Engineering Requirements / Customer Requirements	Importance	Number of bags to carry	Distance travel	Weight	Size	Tires Size	Weight to carry	Height of carrier
Safe	9	3	9	1	1	1		
Carry 5 bags	3	1	3			3	1	3
Easy to Use	3	3		3	1		1	3
Light Weight	9		9			3	9	
Climb Stairs	9	1	3	9	9	1	3	9
Travel distance	3	3		3	3	3		1
Small in size	3	1	1		3		1	3
Different weather condition operating	1		9	9		3		1
Portable and Foldable	9	9		1	3		1	1
Technical Importance: Raw Score		141	210	126	138	66	126	121
Technical Importance: Relative Weight		**15.2%**	**22.6%**	**13.6%**	**14.9%**	**7.1%**	**13.6%**	**13.0%**
Techanical Target Value		5	100	15	10	8	50	3
Upper Target Limit								
Lower Target Limit								
Units		-	ft	lb	ft^2	in	lb	ft

Results have shown that most important engineering requirement was distance to travel, second was number of bags to carry, and least important was tires size.

3 Existing Designs

For any project to build from scratch it was important to do some research and find existing designs which will helpful in making the project. According to the chapter any design project need detailed description about its functionality before implementing the designs. Detailed design description can describe in different forms like black box model, hypothesized functional model. Black box model explains the inputs and outputs of a system, what were the inputs to the design project, and what were the outputs of the projects. Hypothesized functional model explain the internal working of a system with all the steps. These information regarding the project can obtain from the existing designs because existing designs explain the working and provide the designs as well. So existing designs were important to find for the design project. In this section few existing designs will present, functional model will present and sub-functional models will present as well.

3.1 Design Research

An extensive research has done regarding the portable carrier and the carrier which can climb on the stairs. This research has done using the Google, by simply typing “Climbing Stair carrier”, “Portable Carrier”, “Small Carrier”, “Grocery carrier” etc. These phrases have used mostly to search similar design ideas, and some articles have found as well regarding the project to understand the design concepts and observed the working of these designs.

Patent Design

A US patent design for the carrier for plastic grocery bags has found. This design has patent by US and the innovator of this design was Wayne. This design gives a remarkable method to convey diverse bags together in the meantime and it lessens the quantity of outings. The design has professed to be fancy design, and it has four snare shape carriers on the gadget [1]. This gadget permits to convey somewhere around 4 to 5 bags at once. What's more, it was light weight gadget also so it doesn't influence the general weight of bags [1].

This was an extraordinary source to utilize on the grounds that it was totally identifying with our task and it has a one of a kind method for portable carrier.

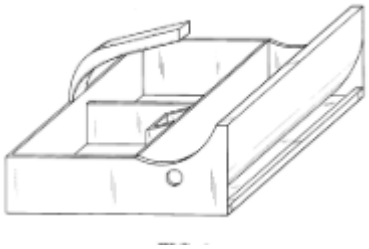

Figure 0: Patent Design

Diary Article

In the article, writers have depicted a design thought to make sack carrier which isn't affecting the earth and give full security to the client too [2]. The design comprises of nylon and it has the capacity to convey part of bags together in the meantime [2].

This article was helpful for our undertaking as far as design since it has given an ecological companion design thought that can use for our task too.

Engineering Report

This report has concentrated on a sack pack carrier which will convey numerous bags in the meantime to spare the excursions. It additionally gives the alternative to convey different bags with it with the assistance of snares [3]. It was minimal in size and convertible also thusly, it can fit into the storage compartment effortlessly and it can convey to anyplace [4].

Course reading book

A course reading has found in which diverse sorts of sack carriers have given. Section 4 of this book was comprise of various designs which identifies with the undertaking [5]. One of a kind method for influencing the bags and the carriers to have exhibited.

The explanation behind choosing this source was that a characteristic fiber material has utilized for pack carrier and we can utilize a similar material in our item to make it light weight and solid too [6].

3.2 System Level

System level means the upper level existing designs, and these designs were the one which have built before. System level design only focus on the complete project and count the complete project as a system therefore in this section all the similar designs which have developed before were presenting.

3.2.1 Existing Design # 1: VEVOR Stair Climbing Cart

This was a design consist of two tripod tires, and a tilted frame at the front to put the bags over the frame and it can easily climb the stairs as well because of its unique tires combination which was tripod tires. This design has presented into the market by VEVOR and it has been using extensively [7]. This design was useful in the regards that it will help us in making a unique design for the project. As the design was portable and climbing stair capability as well therefore we can study this design for our project and develop any similar design like this one and it has shown below in the figure 1.

Figure 1: VEVOR Climbing Stairs Carrier [7]

3.2.2 Existing Design # 2: Powered Tracker Carrier

This design also consists of tripod tires and there was handle under the front side to place the carrier stable and straight as well. This design was also portable and it can easily climb stairs because of tripod tires. It has a small carrier but it can easily carry the bags. This design has presented and made by the LIFTER and readily available in the market as well [8]. his design was also useful for our project in terms that it will be quite easy for use to generate a design similar to this one according to our requirements. This design has shown in figure 2.

Figure 2: Powered Tracker Carrier [8]

3.2.3 Existing Design # 3: Harper Trucks Carrier

This design was simple and it has two tires only with a straight rod shape handle in the upward direction. This design can easily carry the bags but the size of carrier was small and it may not be able to climb the stairs. But the authors claim it can climb the stairs and this design has presented by Harper Truck [9]. It can be seen that this design was useful for the project, to generate some unique idea for our portable carrier and design has shown in figure 3.

Figure 3: Harper Trucks Carrier [9]

3.3 Functional Decomposition

This project was about the portable carrier that can carry the bags of grocery and can climb the stairs and in this section of report, functional decomposition of the project was presenting. Functional decomposition means decomposing the main functions of project and define them separately. As the functions of our project consists of (1) tires, (2) frame, (3) Handles, (4) hydraulic pump, (5) motor. For this purpose, two functional models were presenting in the next section. First was black box model and second was functional model.

3.3.1 Black Box Model

As the name stated black box was a model which shows the inputs and outputs of the system. It has no concern with the working of system. This project has three inputs, Bags, hand as first input, human energy as second input, and third input was either move or stop. In this project, material was handle, bags and human body, energy was human energy and electrical energy and signal was either move or stop. The black box was important for the project because it can help the user to know the inputs like signals or materials and the outputs and outcomes of each. The following was the figure showing black box model.

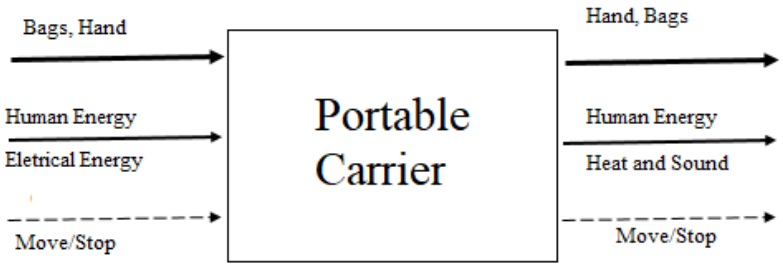

Figure 4: Black Box Model

3.3.2 Functional Model

This was the model which shows all the steps that will perform inside the product to get the output. This model has developed hypothetically after looking at the existing designs and considering the requirements. In the functional model we have sub parts like movement of carrier, loading and unloading of the bags etc. Functional model was important for the project because it explains the complete project process, so when the design ideas will generate, it will focus on the functional model and develop such design which follows the functional model properly that's why it was important and also functional model helps in understanding the project and it's working. Functional model shows all the functions happens inside the system and functional model has presented in figure 5.

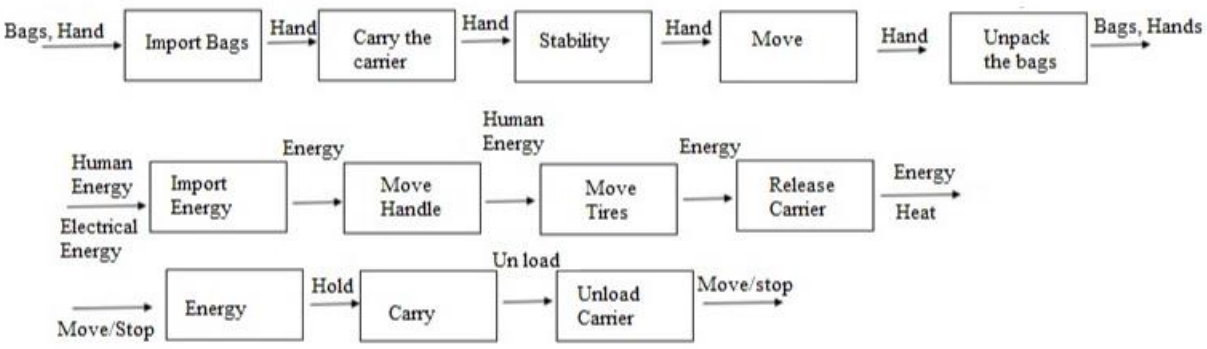

Figure 5: Functional Model

3.4 Subsystem Level

Subsystem levels were the subparts present in the project which were important for the project. In this section existing designs of each subsystem will discuss.

3.4.1 Subsystem # 1: Tires

Tires was the main part of project, as the carrier will move on the ground using the tires and will climb up stairs using the tires as well. There were different types of tires were available in the market.

3.4.1.1 Existing Design # 1: Rubber Tires

Rubber tires were already available in the market and these tires were flexible with the ground and reduce the jerks because of its bumpy nature. These tires can install in the project to make

the carrier comfortable and easy to drive. This material was bumpy in nature which provide smooth driving and that's why this material tire can use in the project. This design can help in selecting the material of tire. An existing design of rubber tire has shown in the figure 6.

Figure 6: Rubber Tire

3.4.1.2 Existing Design # 2: Steel tires

This was another type of existing design for the tire that was steel tires. Steel was strong and hard tire and it can use for the project as well as it will able to move on the stairs there this was also a useful existing design. This material can also use in the project but it was hard and it will push the carrier up and down which will not be safe for the carrier to use but it was strong and it will not break during the load. This existing design can use for the project because we need strong tires and it has shown in figure 7.

Figure 7: Steel Tire

3.4.1.3 Existing Design # 3: Wooden tires

This was another existing design in which a tire was of wood and this tire can also use for the project but it's not that useful and it can break easily. This material was also strong but it will push the carrier that's why this design will may not suitable for the project. Wooden tire has shown in figure 8.

Figure 8: Wood tires

3.4.2 Subsystem # 2: Handle

There was another subsystem of the project and that was handle, as the carrier will move with the help of handle and it will carry by the hands. There were few existing designs available for the handle as well.

3.4.2.1 Existing # 1: Plastic Handle

Plastic handle was the existing design and it was useful in the project as well because plastic handle doesn't hurt the hand and user can easily move the carrier. This material was useful for the project because it will not hurt the user and it will make easy for them to move the carrier and also it was strong that's why this design idea can use for the project. Plastic handle has shown in figure 9.

Figure 9: Plastic Handle

3.4.2.2 Existing # 2: Wooden Handle

Wooden handle was another existing design available for the project and this was useful as well because it was strong and soft for the hand as well so it can use in the project. This material was useful for the project in a way that wooden handles were soft in use and no need to put any cover it so that's why it can use in the project and it has shown in figure 10.

Figure 10: Wooden Handle

3.4.2.3 Existing # 3: Steel Handle

Steel hand was another existing design to use for the project. Steel handle was hard and strong and it can use for the project as well. This material was also safe to use for the carrier because steel was not hard when in rounded shape and this type of handle can put in our project and it has shown in figure 11.

Figure 11: Steel Handle

3.4.3 Subsystem # 3: Carrier Base

The project has a base on which the bags will place so the base of the carrier can be of any type and there were different existing designs available for it.

3.4.3.1 Existing Design # 1: Steel Base

This was the most common base to use, as it was strong and hard. And it can easily carry the bags and carry the load as well. This material was useful because it was strong and light weight and have the capability to bear load and that's why it can use in the project. An existing design has shown in figure 12.

Figure 12: Steel Base

3.4.3.2 Existing Design # 2: Plastic Base

This was another existing design and this design can use for the project as well but it was not as strong to carry lot of load. This material was not as strong as steel was and putting lot of load over it will not suitable but still for a load of 50 lbs. it can use in the project. This existing design has shown in figure 13.

Figure 13: Plastic Base

3.4.3.3 Existing Design # 3: Aluminum Base

Another existing design was aluminum base as the aluminum base was strong and it can use for the project as well. This material was strong and light weight and it can use in the project because it will not bend and it will easily carry the load without any issue and as it was light weight then steel so it can use in the project. It has shown in the figure 14.

Figure 14: Aluminum Base

4 DESIGN CONSIDERED

After the existing design, new design ideas need to generate for the project and these new design ideas will follow the requirements and will also contain the subsystem as well. these design will then pass through Pugh Chart and Decision matrix to select the final design.

4.1 Design # 1: Row side Carrier

This was a design in which two tripod tires have attached with the back corner and front side of base has a stand. It folds from the center, and the rods have placed inside the backside to increase and decrease the height. This design can easily climb the stairs as well and it has shown below in the figure 15.

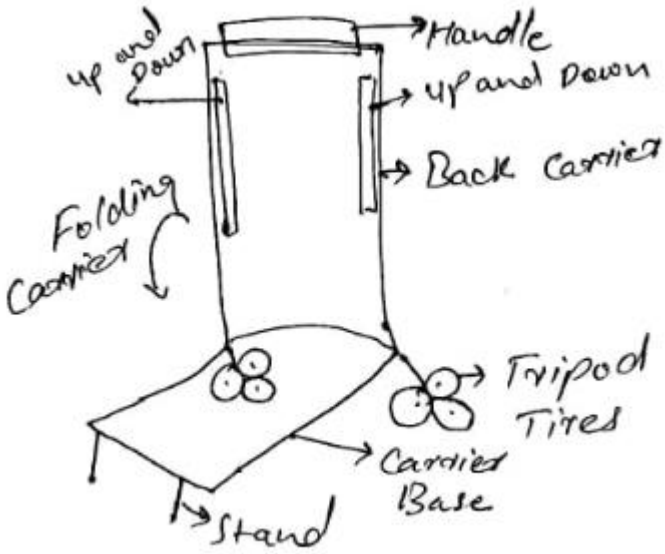

Figure 15: Row side Carrier

Pros:

- Climb stairs
- Easy to use
- Low weight

Cons:

- Costly

4.2 Design # 2: Chair carrier

This design looks like chair at first, and it has two tripod tires at the back corner of base and two simple tires on the front side of base. It was foldable as well, and it can easily climb the stairs. This design has shown in the figure 16.

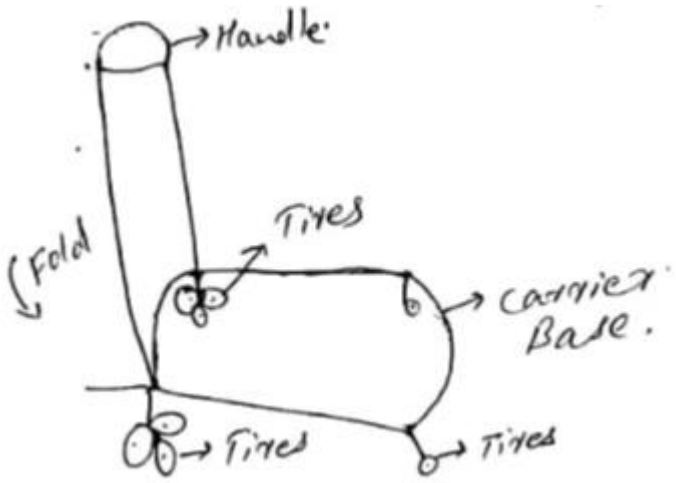

Figure 16: Chari Carrier

Pros:

1. Climb stairs
2. Easy to use
3. Light Weight

Cons:

1. Cause disturbance on stairs because of tires on all sides.

4.3 Design # 3: Tilt carrier

This carrier was already in tilted form with the simple tires and it can easily climb the stairs because of its tilted carrier base and it has shown below in the figure 17.

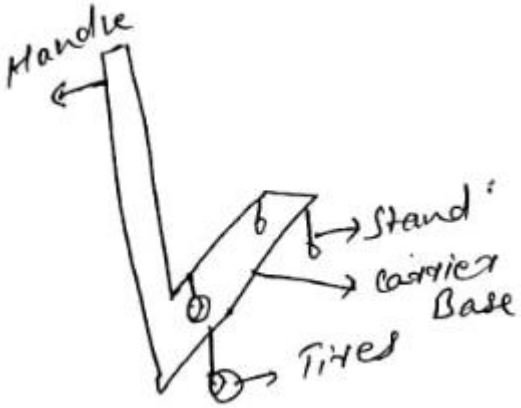

Figure 17: Tilt Carrier

4.4 Design # 4: Simple Carrier

This a most simple form of carrier which can easily climb the stairs and it can also use for shopping. This design has two tires at the back corner of carrier base and the design has shown below in the figure 18.

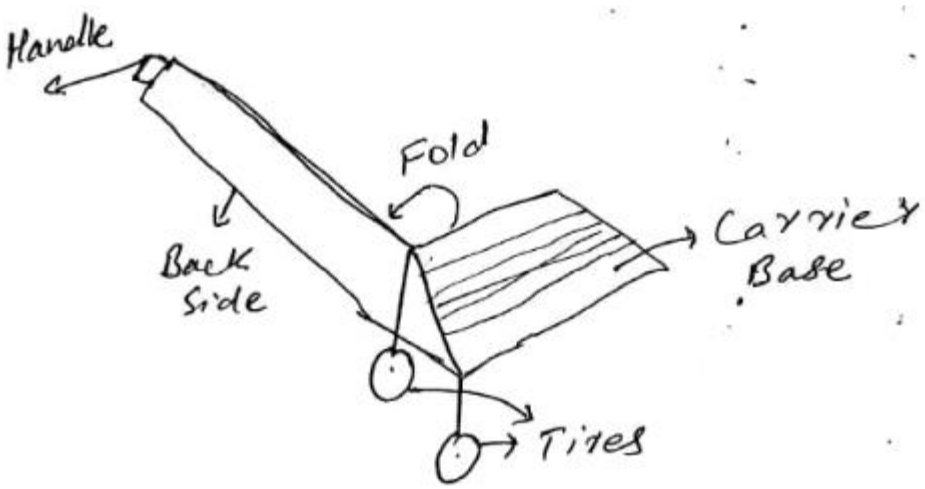

Figure 18: Simple Carrier

Pros:

1. Easy to use
2. Light weight
3. Climb stairs

Cons:

1. Difficult to use on ground

4.5 Design # 5: Straight up Carrier

This design has straight up rod and it has a carrier in front of it. The carrier can easily fold because of its shape as it can be made from any soft material. And it can easily climb over the stairs as well. The design has shown below in the figure 19.

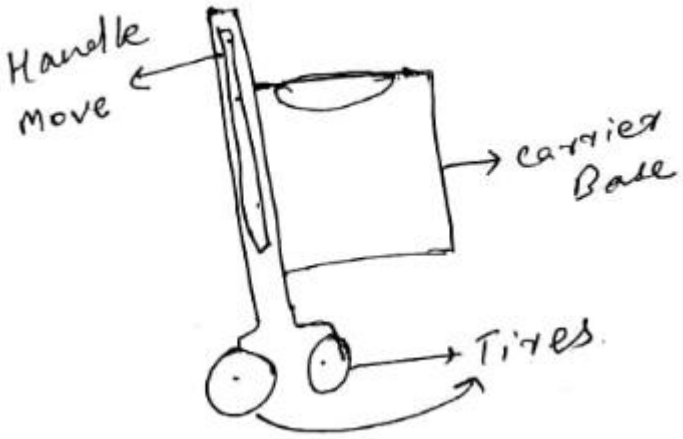

Figure 19: Straight up carrier

Pros:

1. Easy to use
2. Foldable
3. Light weight
4. Climb stairs

Cons:

1. Difficult to move on the ground

4.6 Design # 6: Cross Carrier

This carrier has a shape of cross because its carrier and backside were at some angle to make them easily foldable and it has four tires on all four corner and it can climb the stairs as well. The design has shown below in figure 20.

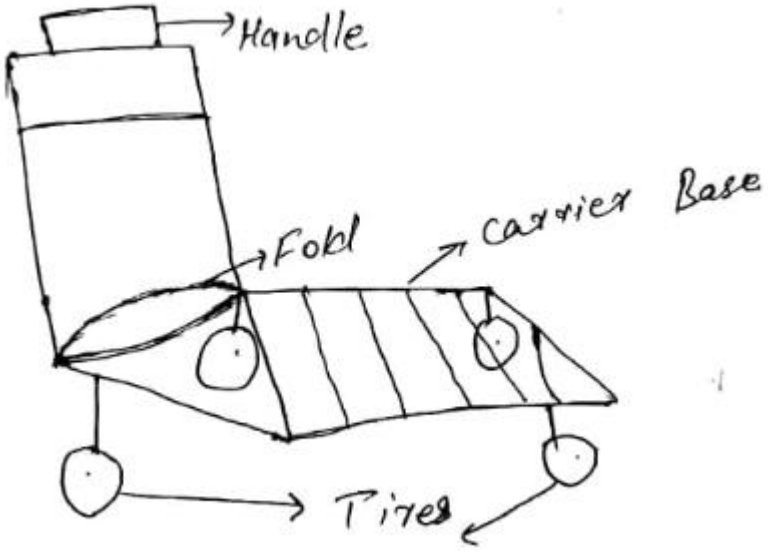

Figure 20: Cross Carrier

4.7 Design # 7: Basket Carrier

This design has a basket for carrier and tripod tires at the back end and single tires at the front end. This was foldable by removing the basket and basket was foldable as well. The design has shown below in figure 21.

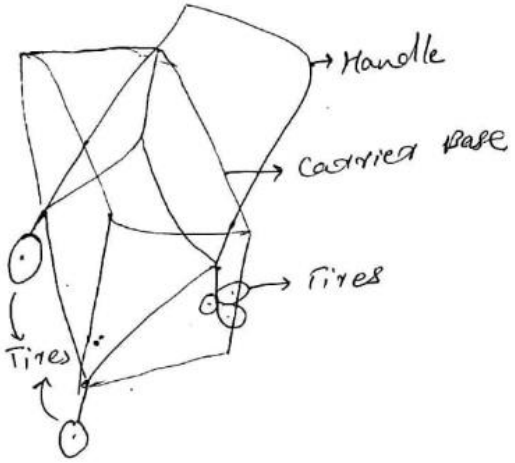

Figure 20: Basket Carrier

Pros:

1. Easy to operate

Cons:

1. Heavy
2. Difficult to fold
3. Difficult to climb on stairs

4.8 Design # 8: Open Carrier

This carrier has tripod tires at the backside and a stand at the front to place it equally on the ground. And it can climb the stairs as well. The design has shown below in figure 22

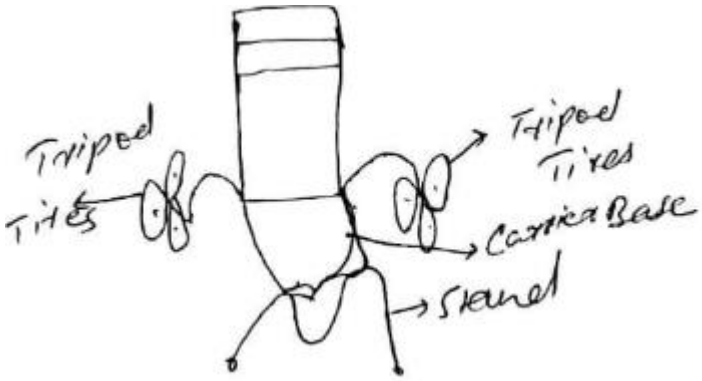

Figure 22: Open Carrier

Pros:

1. Properly place on the ground
2. Climb stairs

Cons:

1. Costly
2. Irregular shape

4.9 Design # 9: Double Carrier

This carrier has two buckets and both were removable from the carrier, and it was foldable and it has tires on both ends to move it properly and the design has shown below in figure 23.

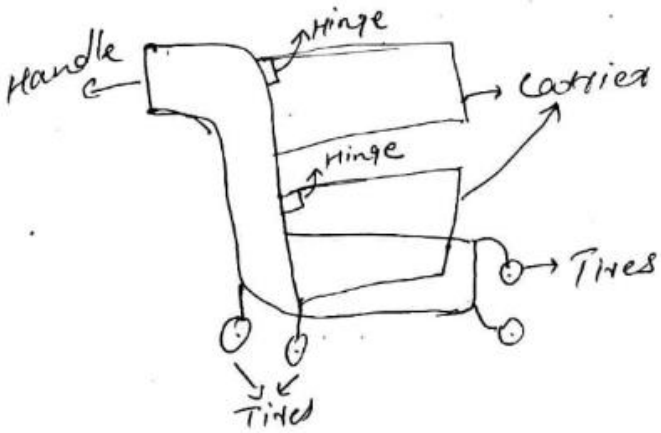

Figure 23: Double Carrier

Pros:

1. Light weight
2. Easy to use
3. Foldable

Cons:

1. Tile the device to move

4.10 Design # 10: Tri-high carrier

This was a carrier which can easily use for the climbing on stairs, as it has tripod tires on the back edge and it need to tilt the carrier to move and climb the stairs as well and it can be seen in the figure 24.

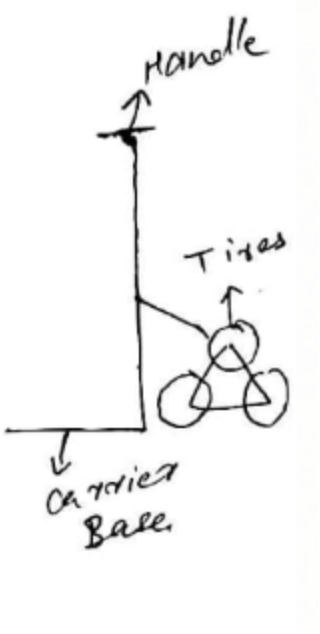

Figure 24: Tri-high carrier

Pros:

4. Light weight
5. Easy to use
6. Foldable

Cons:

1. Tile the device to move

5 DESIGN SELECTED

Chapter 5 talked about the design selection through different methods and it has two stated two main methods to select the design on the basis of criteria and these two designs were Pugh chart method and decision matrix method. These two methods make it easy to select the final design from different generated ideas.

And in this section these two methods will use to select the final design and explain the final design as well.

5.1 Rationale for Design Selection

As 10 different design ideas have generated and from these design ideas, need to select the final design which fulfills all the customer requirements and it can't select directly therefore two methods have used for this purpose. First method was Pugh chart which narrow down the results from 10 to 3 designs and these three design will use for the decision matrix and final design selects from it.

5.1.1 Pugh Chart

Pugh chart was a method which check each customer requirement against each design and then put plus sign if it was present and place negative sign if it was not present in the corresponding box and place 'S' if not depending on that. Then sum up the total plus signs and minus signs and then subtract the number to get the total value of each design. For the design 1 it has checked whether it was safe or not so it was safe because so a positive sign has place in front of design 1 for the safe row. In the same way all designs have evaluated for each requirement. Design 1 can easily carry 5 bags so a positive sign has placed in front of it. Then the top three design count as the selected designs from Pugh chart. Pugh chart has given in the table

Table 4: Pugh Chart

10 Designs	Weight	Design #1	Design #2	Design #3	Design #4	Design #5	Design #6	Design #7	Design #8	Design #9	Design #10
Safe	9	+	+	D	+	-	-	-	+	+	-
Carry 5 bags	8		+		-	+		+	+	+	+
Easy to Use	7	-	+	A	+	+	-		+	-	-
Light Weight	6	+	+		+	+		-	-	-	+
Climb Stairs	5	+	+	T	S	+	+	-	-		+
Travel distance	4	+	+		-	+	-		+	-	+
Small in size	3	-	+	U	+	+	-	-	+		+
Different Weather	2	-	+		-	+	-	-	+	+	+
Portable and Foldable	1	+	+	M	-	+			-		+
Pluses		5	9		4	8	1	2	6	2	7
Minus		3	0		4	1	5	4	3	4	2
Total		2	9		0	7	-4	-2	3	-2	5

Results of Pugh chart has shown that the top three designs were design # 2, design #5 and design # 10 and now move to the decision matrix. The weight next to each requirement shows how important it is to the project, so 9 means highest and most important while 1 is least.The pugh chart shows which design is most important by having pluses and minuses. Then the design with most pluses is going to be the top pick.

5.1.2 Decision Matrix

Decision matrix was a process in which each design checks against each customer requirement then a specific weightage given to it according to its condition regarding the design and then sum up all the values for a design to make total score. For the decision matrix, design 2 has got 6 marks in terms of safety because it was safe to use but it can pull over the person if use in a wrong way and for carrying the bags it has capacity of carrying 5 bags but bas have to be normal in size so it has given 5 marks. In the same way, all designs have evaluated. The highest scored design will be the final design. The table of decision matrix has shown

Table 5: Decision Matrix

Decision Matrix	Safe	Carry 5 bas	Easy to use	Light Weigh	Climb Stairs	Travel Distance	Small in size	Different weather	Portable	Total
Weight	9	8	7	6	5	4	3	2	1	
Design # 2	6x9 = 40	5x8 = 32	2x7 = 14	3x6 = 18	3x5 = 15	7x4 = 28	5x3 = 15	5x2 = 10	1x1 = 1	173
Design # 5	7x9 = 40	7x8 = 56	2x7 = 14	4x6 = 24	4x5 = 20	7x4 = 28	4x3 = 12	4x2 = 8	2x1 = 2	204
Design # 10	8x9 = 72	8x8 = 64	5x8 = 40	6x6 = 36	5x5 = 25	8x4 = 32	5x3 = 15	5x2 = 10	4x1 = 4	298

The results have shown that the top design was design # 10 so this design will use for the CAD model and the detailed breakdown structure for this design will present in the next section.

5.2 Design Description

The design consists of a telescope that is made of two pvc pipes and it has grooving at the top so the double steel plate will be installed on the small pvc pipe. The shopping bags will be placed on the plate by having 5 hiking hooks distributed equally around surface, so the plate wouldn't face any bending or shaking. The telescope will be attached to the pneumatic cylinder from under, so the cylinder would push it up to the person's level. The pneumatic system would be have an air tank to provide the push of it. The pneumatic system would be placed over the body that the team built. The body would have two frames on the sides with 7 wheels on each side and a tank chain attached to it, so it would be operated in different weather conditions and climb the stairs. Each frame would have two motors that will be connected to the arduino and motor

shields. The device would be controlled by joystick and the pneumatic cylinder will be controlled by blower.

Changes in the design:

The design has changed a lot through the semester. The team first changed the frame to a bigger one than expecting due the parts size, the team needed more surface to fit everything. The team changed the first one, as shown in figure 25, that was half the size of the new one, refer to figure 27. The team has also included an air tank rather than using air compressor the whole time because it will waste the battery power. The plate for the telescope was changed to steel rather than plastic, so it can hold up the weight of 50 lbs. The tracks were tilted at the end rather than straight design, so it can help the device to climb stairs.

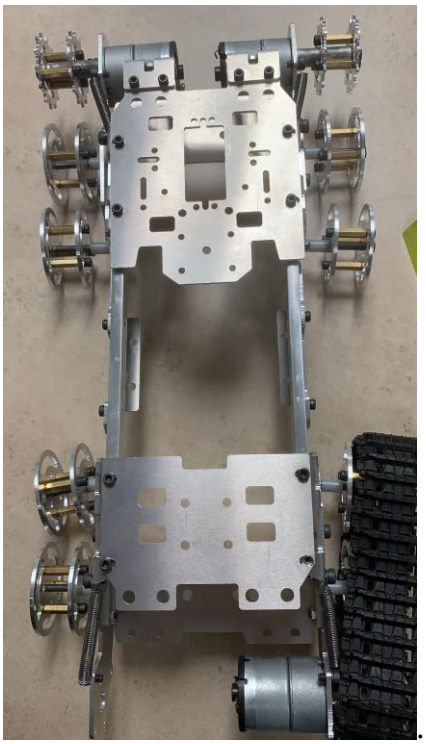 .

Figure 25: First design for body.

CAD Model

For the project complete CAD model has developed and the CAD model has shown below.

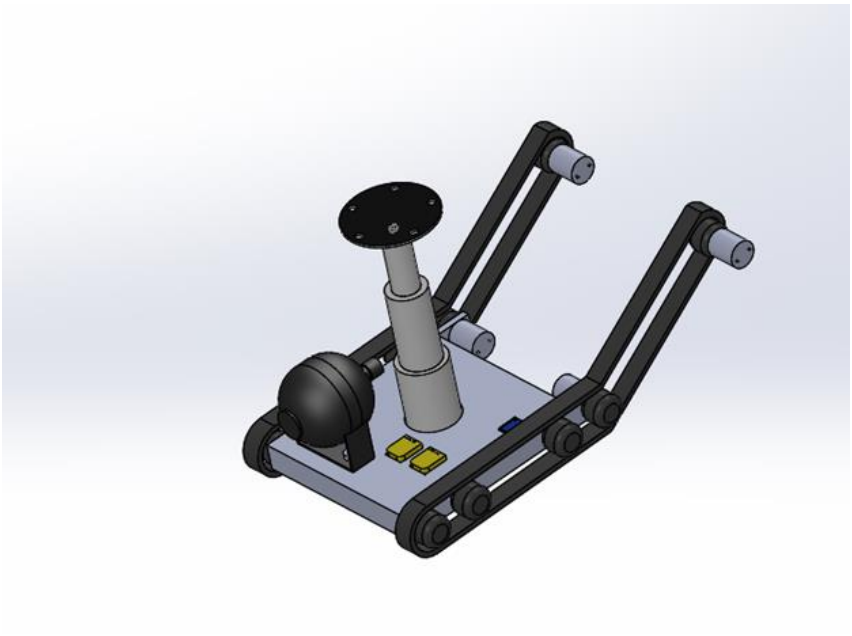

Figure 26: CAD Model

And the description of parts has defined as

Table 6: Parts of Design

Item No.	Part Number	Qty.
1	Wheels	14
2	Frame	2
3	Telescope hanger	1
4	Track	2

Wheels and Tracks:

Wheels, as shown in figure 27, were using in the design to move the carrier on the ground and also on the stairs. As the carrier will have to move and carry the bags so the wheels will play their role and move the carrier. It will be consisted of tank threads and these were chosen specifically to satisfy the requirement of operating in different weather and to climb stairs. Regular tires wouldn't be as useful as the team found similar designs, but those designs wouldn’t actually operate in different weather. The wheels will be controlled by joystick.

Frame:

The body consists of two steel frames that are connected in the middle by two bolts and nuts as shown in figure 27. The base is the heaviest part of the device due to the material chosen because the previous material was plastic and it couldn’t hold the weight. The body was touching the ground when installing the parts over the base. The base would have everything installed over it like hanger, pneumatic system and arduino kit.

Figure 27: Body

Telescope hanger:

The hanger is made of two pvc pipes and it has grooving at the top so the double steel plate will be installed on the small pvc pipe as shown in figure 28. The shopping bags will be placed on the plate by having 5 hiking hooks distributed equally around surface, so the plate wouldn’t face any bending or shaking.

Figure 28: Telescope

Looking at the customer requirement, we can see that all the customer requirements were following by the design.

- This design can easily carry 5 bags and the total weight it can carry was above 50 pounds, so this customer requirement has fulfilled.
- It can travel for 100 feet to 500 feet easily so this customer requirement has fulfilled as well
- It can easily fit into the half of car trunk because its size will be less than 5 square feet.
- It can move in different weather conditions because the material use to build it will be strong.
- It was portable as well and it can carry to any place
- It can climb the stairs as well because of the track available on the tires.

Now move to the implementation details about the proposed design.

6 PROPOSED DESIGN

The design proposed in the previous section was our final design. In this design we have multiple parts and the parts have defined already. Implementation of this project starts by purchasing the parts first. Complete implementation plan can be seen below.

6.1 Implementation Plan

Our product CAD model has been developed and from the CAD model it was clear that the product design can be implemented in real life. As the product needs some cylinder to build. These were the item we purchased to set up the pneumatic cylinder system and the whole system:

1. Cylinder
2. Tubing
3. Tube Connectors
4. Female Shoe
5. Air compressor intake
6. Solenoid
7. Air Compressor
8. Air dispersers
9. Speed Controller
10. Tires
11. Plastic Pipes
12. Arduino Kit
13. 20v Battery
14. DC motor

We bought these item for the main purpose of developing the design and for this purpose we went online and did a search and determined the best option is to buy from online stores as per the low cost of these product, that we found online. After that we have developed the BOM (bill of material) which represent the detail of breakdown parts.

After the bill of materials, we placed the order to buy these products and the items arrived in the past few weeks. We started working on manufacturing the product and assembling the parts. Implementation of the whole design will be done soon in next month or so and all the testing will be done as well on it. The plan is to implement an effective final design without taking too long.

6.2 Bill of Material

Bill of material was presented in Appendix A, and bill of material describe the parts of project and the items that were going to use for implementing the product. Description of the items was also present in the BOM and functionality was present in it as well. Type of material for each item was also presenting in the BOM and dimensions of each item was also mentioning in the BOM. Cost was important as well so it was also presenting in the BOM and link has given as well for the online store. Bill of Material was important for the project because it deliberately provide the complete breakdown structure of the product and make easy for the team to collect the items that need to use for the design product.

6.3 Schedule

For the Schedule of the project, as shown in figure 29 it was important to make a Gantt chart because Gantt charts provide the option to track down the project and determine the status and progress of project. Gantt chart helps in determine if the project was leading or lagging using the bars.

Name	Begin date	End date
Define Project	9/3/18	9/4/18
Project Definition	9/5/18	9/6/18
Meeting Minute 1	9/7/18	9/7/18
Team Charter	9/7/18	9/10/18
Client Meeting	9/10/18	9/11/18
Meeting Minute 1	9/10/18	9/11/18
Staff Meeting	9/12/18	9/13/18
Research for wheels	9/12/18	9/14/18
Research for frames	9/12/18	9/17/18
Research for motors	9/12/18	9/17/18
Research for control ...	9/12/18	9/17/18
Meeting Minute 2	9/12/18	9/12/18
Staff Meeting 2	9/19/18	9/20/18
Customer Requirem...	9/7/18	9/20/18
Engineering Require...	9/7/18	9/20/18
QFD	9/20/18	9/21/18
Client Meeting 2	9/21/18	9/21/18
PowerPoint Presenta...	9/21/18	9/24/18
Concept Generation	9/21/18	10/1/18
Staff Meeting	10/3/18	10/3/18
Discuss Design Ideas...	10/4/18	10/4/18
Client Meeting	10/9/18	10/9/18
Staff Meeting	10/10/18	10/10/18
Revise Design Ideas	10/10/18	10/16/18

Figure 29: Gantt Chart

7 IMPLEMENTATION

7.1 Manufacturing

For manufacturing the device, the team have used every possible resource in order to finish the device. The team have used the machine shop, local home improvement stores and online rearching, so the manufacturing process would be faster and done excellently.

For the body of the device, it consists of two steel surfaces, as shown in figure 30, that are connected to each other through two bolts and nuts.

Figure 30: Body

The base is connected to 4 different screws, which two on each side and on the corners, where the screws are attached to a straight shaped metal as shown in both figures 31 and 32. Those screws are connected to the frames and wheels, where we have drilled 4 holes total into the frames.

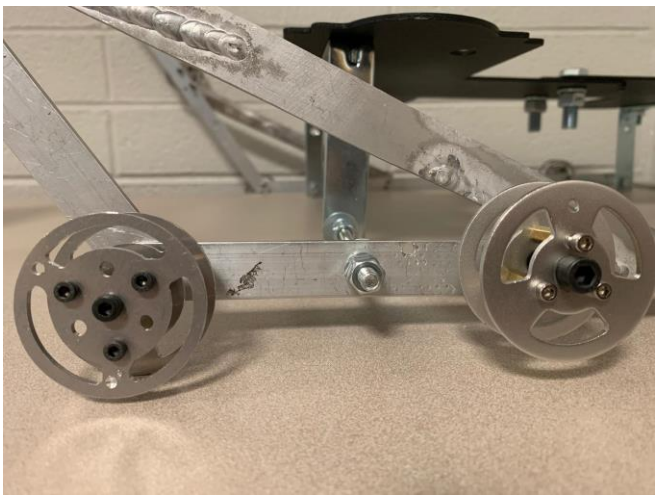

Figure 31: Another side of the body

Figure 32: Another side of the body

The motors will be connected to the frame by drilling holes and attach motors using bolts and nuts as well as shown in figure 33. One at the top corner and other on the bottom part.

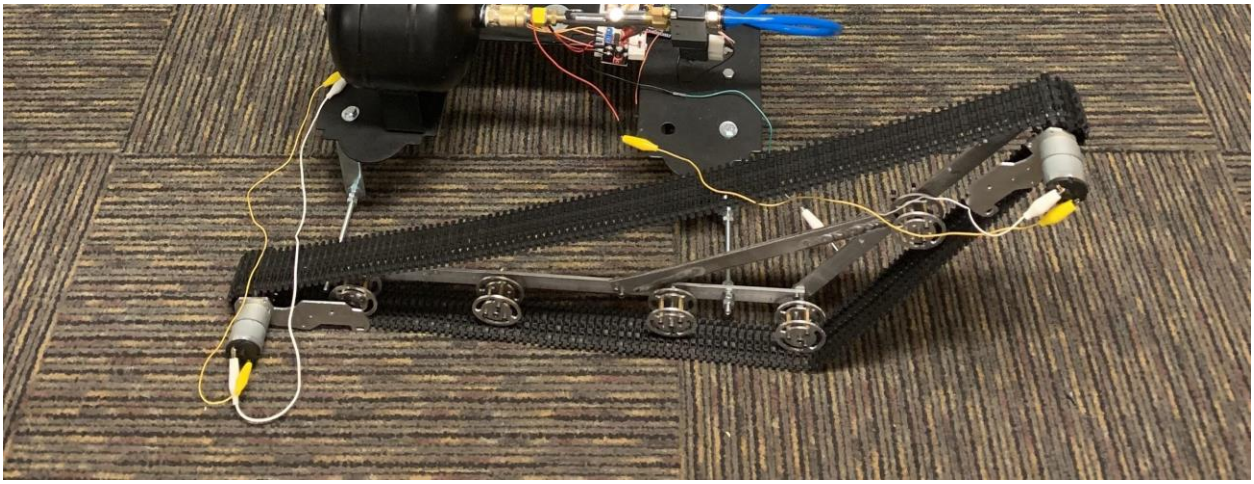

Figure 33: Motors

The telescope hanger is consisted of two pvc pipes. Both pipes have been taking to the machine shop and cut, so we get into the desired level. At the bottom of the larger pipe, two holes have been drilled, so we can fit bolt and nut to make the smaller pipe stay at a certain level as shown in figure 34.

Figure 34: Telescope

The team then bought two steel plates and drilled six total holes, where one large in the middle to fit the smaller pipe and other fives that will be distributed equally around the plate to be attached with the hiking hooks, refer to figure 34.

The smaller pipe would have a grooving job around the top part, so the double steel plate will be stable and not shaking or bending when attaching the bags, as shown in figure 35.

Figure 35: Telescope

Then the bigger pipe has been placed over the pneumatic cylinder as shown in figure 36 below by using washers.

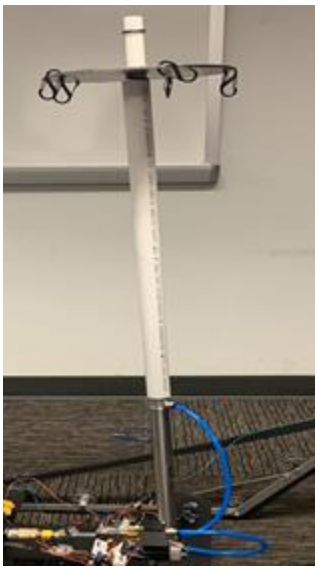

Figure 36: Telescope location.

The manufacturing process in the pneumatic system has not been as much due to have the parts connect without using any tools, but the team struggled in doing the connections. The team had

to first cut the compressor tip and change it ,as shown in figure 37, in order to connect the compressor to the air tank.

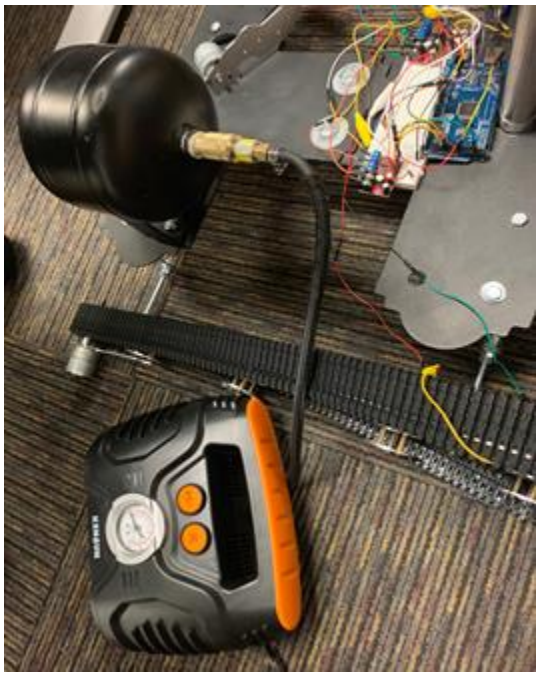

Figure 37: Connection

The team also had to change the fittings of the air tank in order to do this connect since the tank came with different fittings, as shown in figure 38.

Figure 38: Air tank

For the arduino, the team only needed to do the connections between motor, joystick and the board. The team needed to cut wires and complete the circle, so the device can be controlled remotely.

Now move to the implementation details about the proposed design.

Here is the total expenses of the project:

Table 7 : Final Budget

Part	Part Name	Qty	Cost	
1	Cylinder	1	51.08	
2	Tubing	1	15.95	
3	Tube connectors	1	8.99	
4	1/4" female to 1/8" male	1	4.98	
5	Air compressor intake fittings	1	12.87	
6	Solenoid	1	16.75	
7	Air compressor	1	18.99	
8	Air dispursers	1	11.99	
9	speed controller	1	4.8	
10	tires	1	132	
11	plastic pipes	2	7.94	
12	Arduino Kit	1	49.99	
13	20v battery	2	75.2	
14	DC motor	4	23.52	
15	Air tank	1	37.67	
16	teflon	1	1.87	
17	Fittings	6	10	
18	Motor shield	2	100	
19	wheels and bearings	1	19.88	
20	caterpillat chain track	2	21.88	
21	Frame	2	30	
Total Cost Estimate:				656.35

Note: The total budget for the project has not been set by the client nor instructor.

7.2 Design Changes

Before it was decided in the design to make the hanger in a different shape like the hook openly available to hang the bags but latterly during the manufacturing when the nail shaped hangers were not available so we have changed the design and decided to make a round plate. Then put the hangers separately in the hole to make the final design of telescope hanger. The first material that was chosen for the plate was plastic, but it was bending and failed the test. Then the team chose layer of plastic, but also failed the test, so eventually the material chosen was double steel as shown in figure 39:

Figure 39: Double steel plate

Another important change we made to our device is to change our initial idea of the tank treads. The initial idea was to make them straight as seen in the CAD model in Figure 40 below. This creates a problem because it will make climbing stairs impossible. Instead, the tip of the tank tread will be raised and tilted as shown in figure 41 below. The vertical length of the tilt will be a little more than the normal stair unit length. The tilt is better than the straight one because the straight one could never be able to climb up the stairs. So, this change is vital because it allows the design to satisfy one of the most important requirements of the project which is the ability to climb stairs.

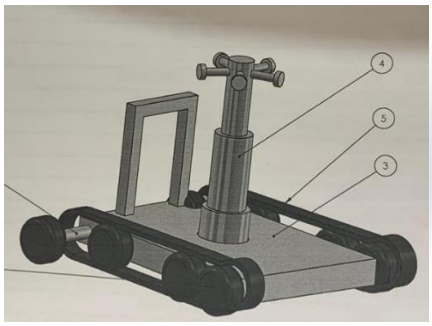

Figure 40: previous CAD

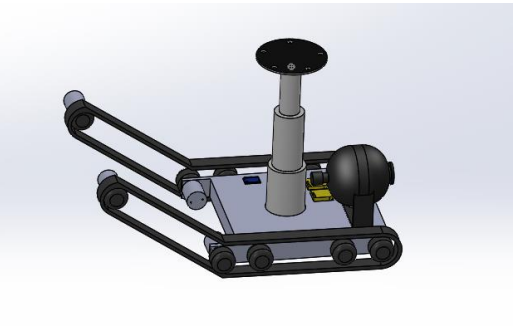

Figure 41: Updated CAD

Changes were also made with another aspect that deals with the movement of the device which is the number of DC motors that is used in the device. Initially, the design was supposed to have only two DC motors however we learned that is it better to use four DC motors as shown in figure 42 below, two on the front and two on the back. This is important because it will allow the user to turn the device freely in any direction, remotely, with the help of the Arduino board and the joystick. The arduino must be coded, to ensure that the device moves in the same direction the user is leading it to with the joystick, and that will be possible by determining which motors moves and which stops in certain setting of the joystick, via the code. This change will ensure user friendly device and make it easy to use.

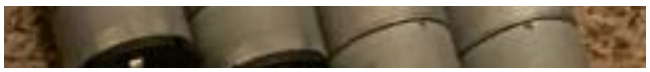

Figure 42: Motors

There was a handle that we were planning to use so the customer who is using the product can lean on it like shopping cart. After starting the manufacturing process, we changed this idea and remove it from the final design because it is adding weight and unnecessary extra part to the product. Since we are shortening in space, we agreed to just take it off the system.

Another suggestion was added our client and that is finding a way to make the product go in and go out of the trunk of the car without carrying it. It is supposed to be automatically done by the customer. As a team, we proposed an idea of having a scissor lift added to the final product that will be controlled by the joystick with one simple button. The team has stopped working on this idea since it was not a requirement and was going to make us struggle in the manufacturing process.

The team had a problem with getting the pneumatic cylinder work without using a portable compressor. After doing some research, the only compressor found was at least 10-30 lbs, which is not acceptable for our requirement of having the whole device weight as 15-25 lbs. Asking some experts into this kind of systems, we found that having an air tank of about 0.5-1 gallon would be actually useful and portable. The weight of this tank is about 4 lbs, refer to figure 38, which can be workable and applied into the system. This air tank might provide around 3-4 lifts before it should be resupplied by the compressor. The number of times can be increased, but it is hard to do that without breaking any of the other requirements especially the weight limit.

We were planning initially of buying a battery of 40 volts to the system, but the weight of it was around 10 lbs, so we figured to do it in a different way. Since our system needed about 24 volts, we found a way of applying that by buying two 20 volts batteries, as shown figure 43, and connect them in series to provide around 40 volts total and this will solve the problem of reaching the weight limit and solve the problem since the two batteries together are 2 lbs.

Figure 43: 2 batteries of 20 volts

The team has changed the body that was chosen since it was smaller and shorter than expected, so it couldn't handle the weight of the parts. The team found online on some existing devices that the length of the body need to be as long as three stairs, as shown in figure 46 below. The team at first bought a design online that came in pieces, as shown in figures 44 and 45 below, with the manual of how to assemble the whole thing, but after assembling, we chose to go with another design. The design we changed into was much bigger in surface and had more wheels and longer treads. The new design has stronger material than the previous one, so when we applied the parts over the surface, it was hundling the weight and there was no bending. The newer design has 7 wheels on each side, refer to figure 33, which can give us enough push and force to climb the stairs and this also made the device longer, which is needed to provide more space.

Figure 44: Previous treads.

Figure 45: Previous body

Figure 46 : New wheels with treads.

Another change in the arduino system, was having two motor shields, so each can control two motors. The two motor shields allows the user to control 4 motors in direction and speed independently. This change has allowed the team to save so much time and effort on doing another wiring for the arduino system.

After testing the device, we faced an issue with power. The motor shield limited us with 12 volts rather than 20 volts, so it made the device not working. To solve this problem, we had to order new batteries of 12 volts and new motor shield to make this device actually functioning. As of now, these are the design changes that the team have changed during the course. After receiving the new order of parts, this section might be updated.

8 Testing

The team has tested the parts individually throughout the semester. Each part has been set to its limit to check whether it can handle the expectations or not.

Starting with the telescope, the team knew that we needed to put 5 shopping bags that each weigh 10 lbs. The hanger must handle this weight without facing any bending or break. The team was skeptical about choosing pvc pipe as our hanger material, but since it was strong and lightweight material, we took our chances and tried it. The team applied 5 shopping bags on the double steel plate, as shown in figure 47 below that were distributed equally. While testing, the hiking hooks that surround the plate were handling the weight as well as the plate. The plate was staple and not bending as our previous design with plastic as the material. Evenmore, the smaller pipe was extending easily since we applied oil around the neck. This part of the design was working properly and it satisfied the carrying 5 bags requirement.

Figure 47 : Testing the telescope

The other testing done was the pneumatic system, The team needed a system to raise the telescope to the person's level with the shopping bags. A team member has done some calculations for density and other properties in order to check whether theoretically the cylinder of 12 in stroke can hold more than 50 lbs since the telescope weight will be added to the weight of shopping bags. The system, as shown in figure 48 below, can only do 3-4 lifts total for one supplied air tank. After that, the user will need to resupply the tank. In testing after connecting the compressor to the solenoid, the cylinder was launching and functioning as needed. Then connecting the air tank to the solenoid, the team faced a problem of

leaking in the system. The tank is losing air, which means the system will not work properly 100% and wouldn't complete the lifts needed. A teflon tape has been applied to the air tank, but didn't solve the problem, so the alternative was using a creamy texture preventer and it solved the problem. This part of the design was working properly and it satisfied the carrying 5 bags requirement as well as the foldable and portable requirement.

Figure 48 : Pneumatic system

The other testing done was the arduino system, the team needed the device to be remotely controlled by the user which will enable it to be easily used by anybody. Having this system can solve this problem since it will be connecting other parts together and make the user controlling everything by having a joystick. A team member has created a circle of the breadboard, motors, batteries and the Arduino board all connected to achieve our goal of controlling the motor with the joystick. This will make the user to safely control the design and move it in any direction. While testing, we were able to control the to motors by the joystick, as we intended. When the joystick is pushed to the front, the two right motors moved, causing the design to turn left. when the joystick is push to the right, the left two motor moved causing the design to turn right. When the joystick was pushed anywhere else, like to the left or backward, all the motor moved which enables the device to move to the front.

The last testing part was the body, as mentioned in design changes, the team found that we needed a three stairs length of wheels. After assembling the new wheels and connecting tank treads, the team tested it by pushing it through stairs. The initial testing was checking whether it is going to be as efficient and as long. The length was as needed. Then after assembling the body, the team tested the wheels and they were moving along with treads.

The team assembled the parts all together to get the device working, as shown in figure 49 below. After attaching the pneumatic cylinder with the telescope and doing the arduino wiring, the team did the first attempt. The attempt concluded with failure even though the motors are working and rotating, but the treads are not. the motors kept rotating until they were detached from the body as it looks like an assembly problem. The pneumatic cylinder on the other hand was launching slowly and not as expected. The telescope that is attached to the pneumatic was also raising, but not as needed. The joystick was giving orders to the motors, but the system as a whole failed.

Figure 49 : Final design

9 Conclusion

9.1 Contribution to the project

There are many factors that contributed to the project's success, throughout the semester. Our purpose was to create a portable carrier design that satisfy the requirement and can be used by disabled and elderly people. We were successful to generate design ideas and solution to solve the challenges and problems given by the project. For us to generate these solution and work in this project, their were ground rules and coping strategies that we stated in the team charter in the beginning of the project. The reason for putting these is to make sure that our team functions properly and that discussion and differences are dealt with in a civilized and fair manners. Many of the ground rules were necessary and contributed positively to our project like everybody should be respectful and professional and everybody should arrive to the meeting on time. The rules were mostly followed by the team members as much and possible. One of the rules, which is whoever does not show up to a meeting or comes late, must carry all of the stuff with him when we leave and bring it with him the next session. This created a consequence for anybody who may want to neglect group meeting and acted as a way of making everybody show up. We also agreed that under any condition, there may not be a use of any inappropriate language to offend each other especially when it comes to personal aspects like; race, religious view, physical appearance, and any sensitive subject. That rule is set because if not followed it could cause conflicts and destroys chemistry between team members. This rule has been followed, because even though we had some conflicts, no inappropriate language has been used. That said, we can confidently state that they ground rules, that we agreed on, definitely worked and caused a more effective team working skills in this capstone project.

There are a lot of aspects that affects the performance and quality of our project. One of our positive aspects is the cost. Even though there wasn't a fixed budget in this project, we were able to do it with a cost under the prediction of our client and instructor. Also the manufacturing of our project is neat and well executed. Another great aspect in our project is that it works remotely. This enhanced the performance of our design because it makes it more convenient and easily used by anyone. This was achieved by using an Arduino board, Pneumatic system, and motors. Using Arduino was a vital part of this project, and is one of the technical things we learned in this project. Arduino is important because when considering anything portable, a carrier in this case, it is important to make sure that the portability is simple and easy and does not require much force, especially when the customer could be of any age (7-70). Using Arduino made that portability possible which we considered a major part of the project and it cannot be successful without it. The pneumatic system is also an important contribution to the success of this project because the pneumatic cylinder raises the hanger so that the user does not have to bend to load and unload the back and it also enables the hanger to get back down again to make sure that the device is foldable and fits into a car trunk. This is an important part in increasing the performance of our device because how could we do a device that could be used by disabled people when we expect them to bend to put and pick up the bags from the device. The aspects stated previously enabled the team to get some success with creating a design that solves the problem at hand, and they had a positive contribution in the functionality of the team.

9.2 Opportunity for Improvement

With all of the hard work that the team have put into this project, they are definitely some shortcomings. There are opportunity of improvements in specific aspects in our project, in both the

design itself and how we functioned the team. We learned that there were more stuff that we had to consider when setting ground rules. One of such example, is that we wished if we had set ground rules and milestones for individual parts of the design. In the beginning period of our project when each person had parts of the design to work on, we got mixed up on what is the expected finishing times set by the other members for us, which created confusion and minor conflicts in the group. For future improvement we would recommend better time management by agreeing on a specific time every week prior to the beginning of the project so that everybody plan and adjust their plan accordingly.

One of the negative aspects of the project's performance is the manufacturing part. Even though eventually we were able to manufacture all the design's part and put them together, we had problems in the beginning. We had to take time to learn many stuff in that part of the project which made us behind other groups, however we were able to learn a lot and we eventually we made our weakness into a strength. Nonetheless, that did exhausted time which delayed and limited our final design, which affects its performance. That also affected us negatively because we had to call to a reassembly and almost a complete change with the manufacturing part of our design, especially the base or body. So, for future improvement, we would recommend to learn more about manufacturing before or during the project, by taking a class or any other way possible.

Another aspect of the project that was negative is time management. Time management became problematic not when we are working on the projects ourselves but when want to work as a team outside of class. In some instances, it was hard to find a time for us all to meet at the same time due to schedule conflicts. So, we had to do two group meeting and two people going to each. Even though we made it work, that did create a negative affect in the group because it created separation between group members and it was hard to make sure that each team member was on the some page.

The team did face some problems in this project. One of the biggest problem is power. This is the problem that made our device fail to climb stairs. We needed around 37 Watts to make our four motors to push our design upstairs, according to our calculations. The motors is capable of doing that but we needed a battery with 37 Volts because each motor had one Amp of current. We used two twenty Volts batteries, but the problem arose when the motor shield burt. The motor shield is important because the Arduino board alone will not be able to generate enough current for the motors so we got a one amp motor shield. It seemed to us that all the numbers matched up but turned up that the motor shield could take a maximum of 15 volts of input voltage which led to it being burned. It was working in the beginning but it unfortunately eventually burned at a testing session on a wednesday, two days before Ugrads. So, for future improvement, I would recommend to make sure that all the numbers match up before ordering and this is one of the most effective lessons that we learned. I would also recommend to consult an expert if you don't know much about that area, for example, the problem we faced was in the electrical engineering field, so if we had consulted an electrical engineer he would easily tell us all of the number that have to match up to prevent burning or failing.

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APPENDIX A

Table 8: Bill of Materials

Team				Portable Carrier A - Team c5				
Part #	Part Name	Qt	Description	Functions	Material	Dimensions	Cost	Link to Cost estimate
1	Cylinder	1	pneumatic cylinder system	uses compressed air	Stainless	1-1/16 inches Bore, 12 inches Stroke, 5/16 inches Rod OD, 1/8" NPT Port	51.08	https://amzn.to/2NG5(
2	Tubing	1	pneumatic cylinder system	Air Tubing Pipe Hose Nylon Air Hose For Air Line Tubing	nylon	8mm Od 5mm Id10 Meters	15.95	https://amzn.to/2NJtIV
3	Tube connectors	1	pneumatic cylinder system	Push In Joint Pneumatic Connector Quick Fittings	Metal, Plas	8mm 1/8	8.99	https://amzn.to/2CfAz
4	1/4" female to 1/8" m	1	pneumatic cylinder system	Adapter for connecting pipes	Brass	1/8" x 1/4"	4.98	https://amzn.to/2yluNz
5	Air compressor intake	1	pneumatic cylinder system	connect system	n/a	1 x 1 x 1 inches	12.87	https://amzn.to/2yluN
6	Solenoid	1	pneumatic cylinder system	switch for routing air to any pneumatic device	Aluminum	4.75" x 2.75" x 1"	16.75	https://amzn.to/2CidK4
7	Air compressor	1	pneumatic cylinder system	compressor	Metal	19 x 19 x 18 inches	89.99	https://amzn.to/2CNW
8	Air dispursers	1	pneumatic cylinder system	diffuse air and muffler noise	Brass	5.5 x 2.2 x 0.5 inches	11.99	https://amzn.to/2J1Md
9	speed controller	1	pneumatic cylinder system	reduce dynamic noise of the pneumatic components	Brass	2 x 1 x 1 inches	4.8	https://amzn.to/2pTAI
10	tires	1	moving subsystem	used to move the whole design	Metal	393mmx206mmx84mm	132	https://ebay.to/2FDNx
11	plastic pipes	3	telescoping	used to lift bags	plastic	1.25" - 1" - 0.5""	7.44	https://thd.co/2yZ98h
12	Arduino Kit	1	kit for programming	programming the device	n/a	n/a	49.99	https://bit.ly/2PYyaqC
13	20v battery	1	power source	provide power	plastic	2.3 x 2.8 x 3.1 inches	33.99	https://amzn.to/2Sh4v
14	DC motor	1	machine	convert current electrical energy to ME energy	metal	4.2 x 2.9 x 0.5 inches	11.4	https://amzn.to/2TPvG
				Total Cost Estimate:			452.22	

APPENDIX B

Table 9: Updated Bill of Materials

Bill of Materials								
	Team			Team C5				
Part	Part Name	Qt	Description	Functions	Material	Dimensions	Cost	Link to Cost estimate
1	Cylinder	1	pneumatic cylinder system	uses compressed air	stainless steel	1-1/16 inches Bore, 12 inches St	51.08	https://amzn.to/2NG5Qna
2	Tubing	1	pneumatic cylinder system	Air Tubing Pipe Hose Nylon Air Hose For Air Line Tubing	nylon	12 x 10 x 1 inches	15.95	https://amzn.to/2NJtIWO
3	Tube connectors	1	pneumatic cylinder system	Push In Joint Pneumatic Connector Quick Fittings	metal,plastic	4mm 1/8"	8.99	https://amzn.to/2CfAz8p
4	1/4" female to 1/8" male	1	pneumatic cylinder system	adaptor for connecting pipes	brass	1/8"x1/4"	4.98	https://amzn.to/2yluNzc
5	Air compressor intake fitting	1	pneumatic cylinder system	connect system	n/a	1x1x1 inches	12.87	https://amzn.to/2yluNzc
6	Solenoid	1	pneumatic cylinder system	switch for routing air to any pneumatic device	aluminum	4.75"x2.75"x1"	16.75	https://amzn.to/2CidK4a
7	Air compressor	1	pneumatic cylinder system	Air compressor	metal	6.00 x 4.70 x 2.30 Inches	18.99	https://bit.ly/2RE8egY
8	Air dispursers	1	pneumatic cylinder system	diffuse air amd muffler noise	brass	5.5x2.2x0.5 inches	11.99	https://amzn.to/2J1MdW1
9	speed controller	1	pneumatic cylinder system	reduce dynamic noise of the pneumatic components	brass	2x1x1inches	4.8	https://amzn.to/2pTAiRl
10	tires	1	moving subsystem	used to move the whole design	metal	393mm x 206mm x 84mm	132	https://ebay.to/2FDNxA6
11	plastic pipes	2	telescoping	use to lift bags	plastic	1.25" - 1" - 0.5" diameter	7.94	https://thd.co/2yZ98hL
12	Arduino Kit	1	kit for programming	programming the device	n/a	n/a	49.99	https://bit.ly/2PYyaqC
13	20v battery	2	power source	provide power	plastic	2.3 x 2.8 x 3.1 inches	75.2	https://amzn.to/2EZIMyv
14	DC motor	4	machine	convert current electrical energy to ME energy	metal	4.2 x 2.9 x 0.5 inches	23.52	https://amzn.to/2TPvGsU
15	Air tank	1	pneumatic cylinder system	used to provide compressed air to the cylinder	n/a	10x10x10 inches	37.67	https://amzn.to/2H7dNmy
16	teflon	1	tape	helps to prevent leak	n/a	n/a	1.87	Homco
17	Fittings	6	pneumatic cylinder system	Connect the system together	metal	n/a	10	Homco
18	Motor shield	2	Aruino system	Drives 2 DC motors	n/a	5 x 3 x 0.5	100	https://amzn.to/2vKN5bL
19	wheels and bearings	1	wheels for tracks and bearings	move device	steel	n/a	19.88	banggood.com
20	caterpillat chain track	2	tank tracks	move device	plastic	2 ft x 3 in	21.88	banggood.com
21	Frame	2	"I" haped frame	The base where parts are going to be installed	steel	n/a	30	Home depot
				Total Cost Estimate:			656.35	