# PORTABLE CARRIER A

# Mid Point Report

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# EXECUTIVE SUMMARY

This project consists of a portable carrier which has the capability to climb the 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.

# Table of Contents

# 1. Background

## 1.1 Introduction

It was 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 was difficult to carry lot of 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

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 bags as written in the description. It must be light in weight because it will carry the load so if it will be heavy then user will have to do more effort to carry the load. 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 have extracted from the customer requirements and these were the requirements which have technical values and these technical values were the one that will achieve by the project. 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 10 – 20 lbs. so limit of 15 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 20 ft^2 so the ER value has chosen was 10 ft^2. 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** | 10 ft^2. |
| **Tires size** | 8 in. radius |
| **Weight to carry** | 50 lb. |
| **Height of carrier** | 3 ft. |

## 2.3 House of Quality

House of Quality make 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.

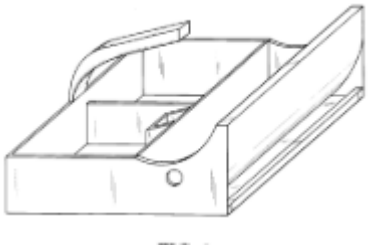


Figure 0: Patent Design

#### 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 provide the details about the project like what was needed at the inputs and what will be the outputs and from this black box model we can develop the design which takes the same inputs and provide same outputs. Following was the figure showing black box model.

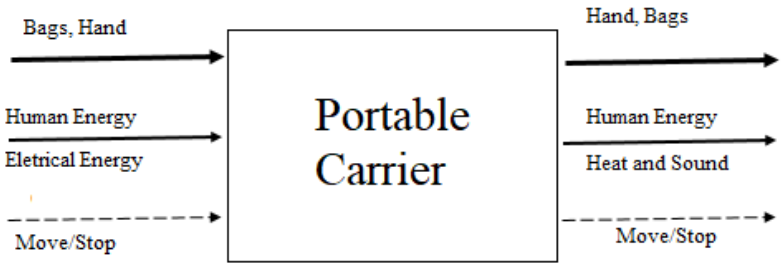



Figure 4: Black Box Model

### 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.

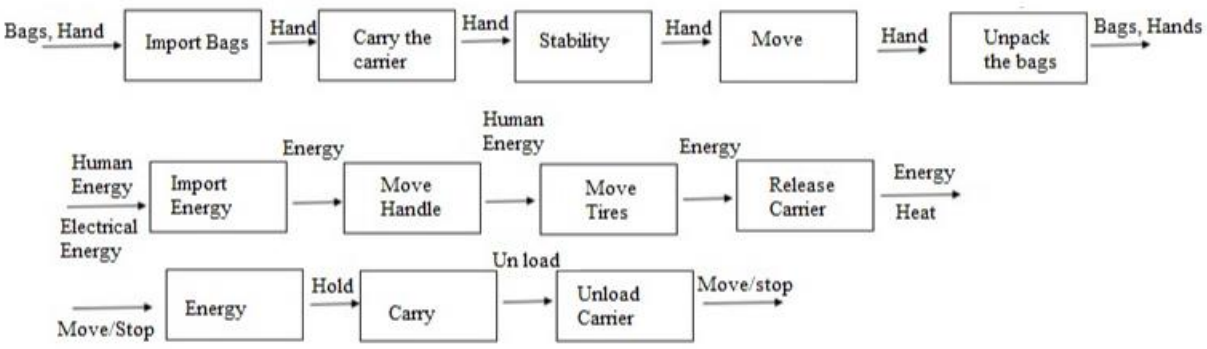



Figure 5: Functional Model

## 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 upstairs 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.

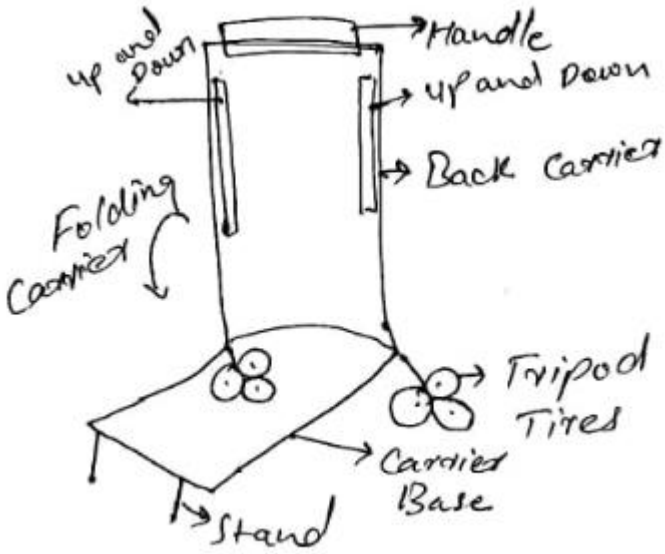



Figure 15: Row side Carrier

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.

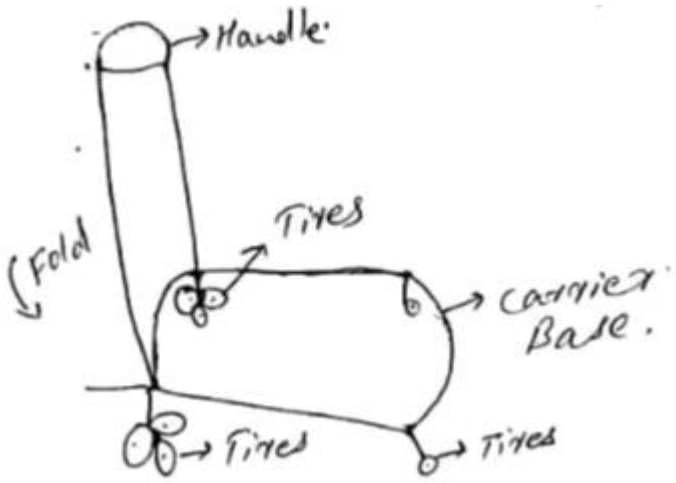



Figure 16: Chari Carrier

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.

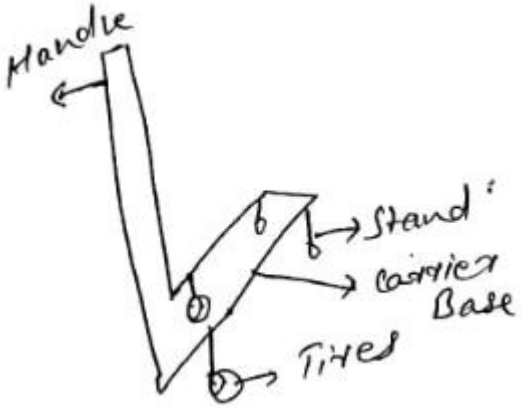



Figure 17: Tilt Carrier

### 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.

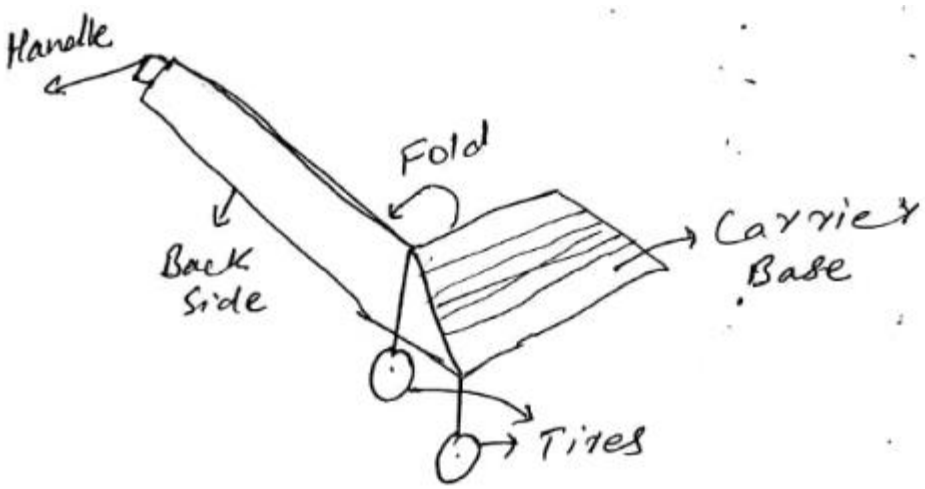



Figure 18: Simple Carrier

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.

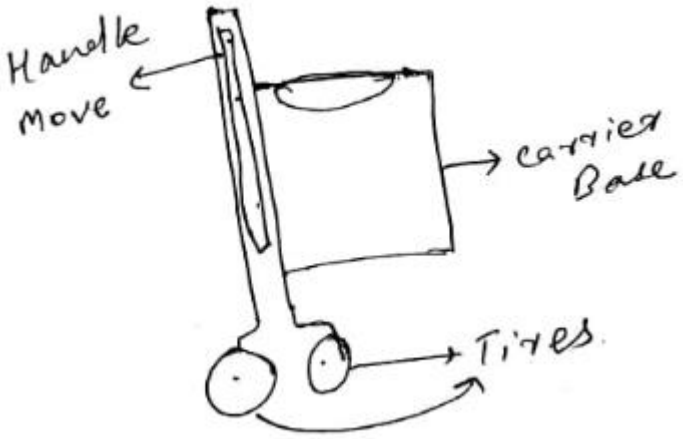



Figure 19: Straight up carrier

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.

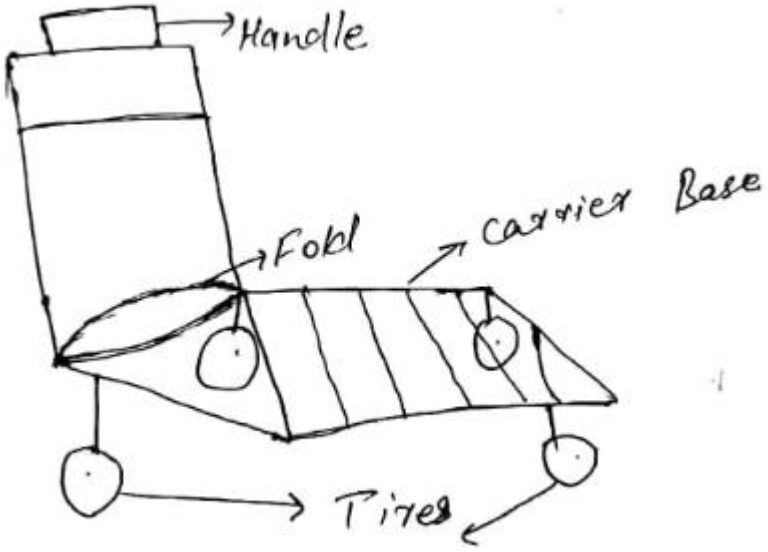



Figure 20: Cross Carrier

### 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 n figure 21.

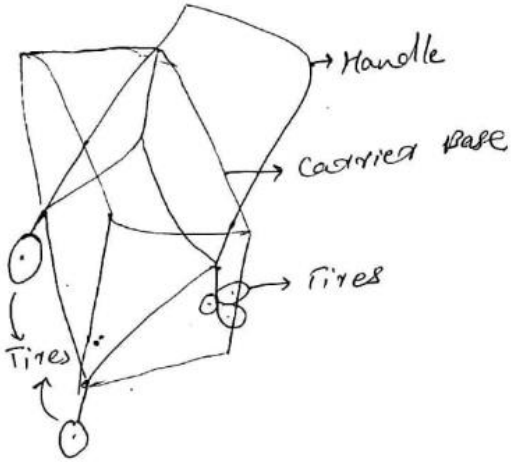



Figure 20: Basket Carrier

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

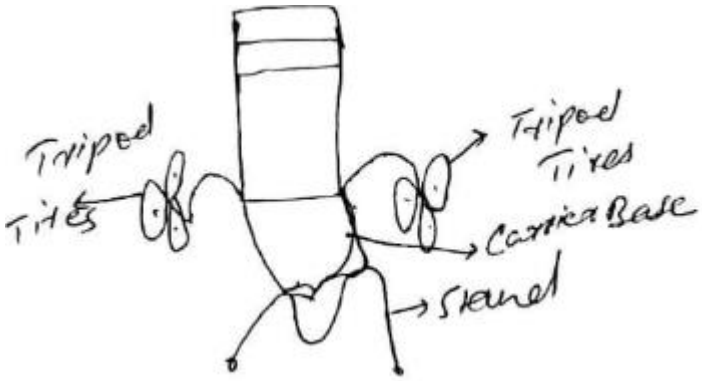



Figure 22: Open Carrier

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.

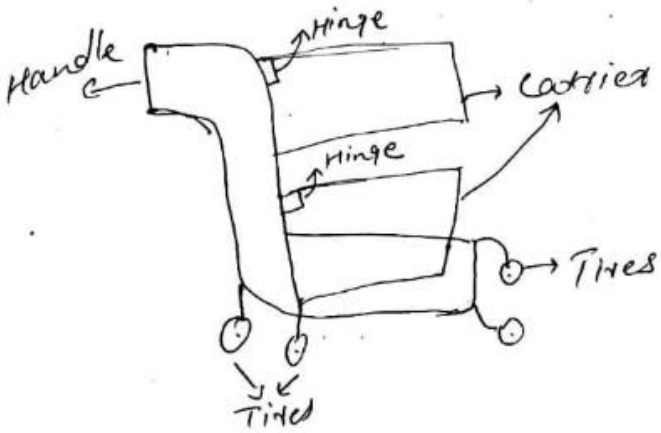



Figure 23: Double Carrier

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.

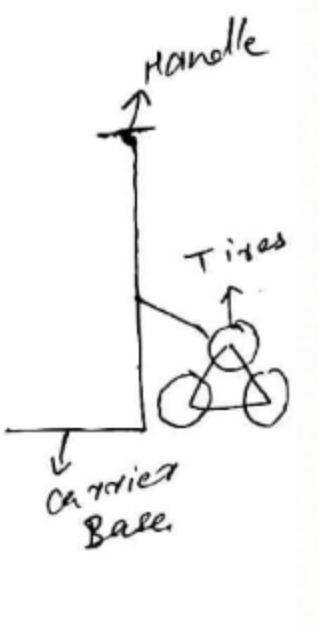



Figure 24: Tri-high carrier

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.

### 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 straight rod with the tripod tires at the back side and it has a carrier base in straight direction which can easily move after tilting the device. But there were some amendments in the design made as well.

Changes in the design:

Tires have changed to different style, now it has four tires on each side and conveyer belt rotating all the tires together. There was a wheel axel along with the wheels which rotate and move the wheels. A base has used on which telescope hanger has placed along with the hangers, on which bags will hang. This telescope hanger height can increase or decrease as well.

CAD Model

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

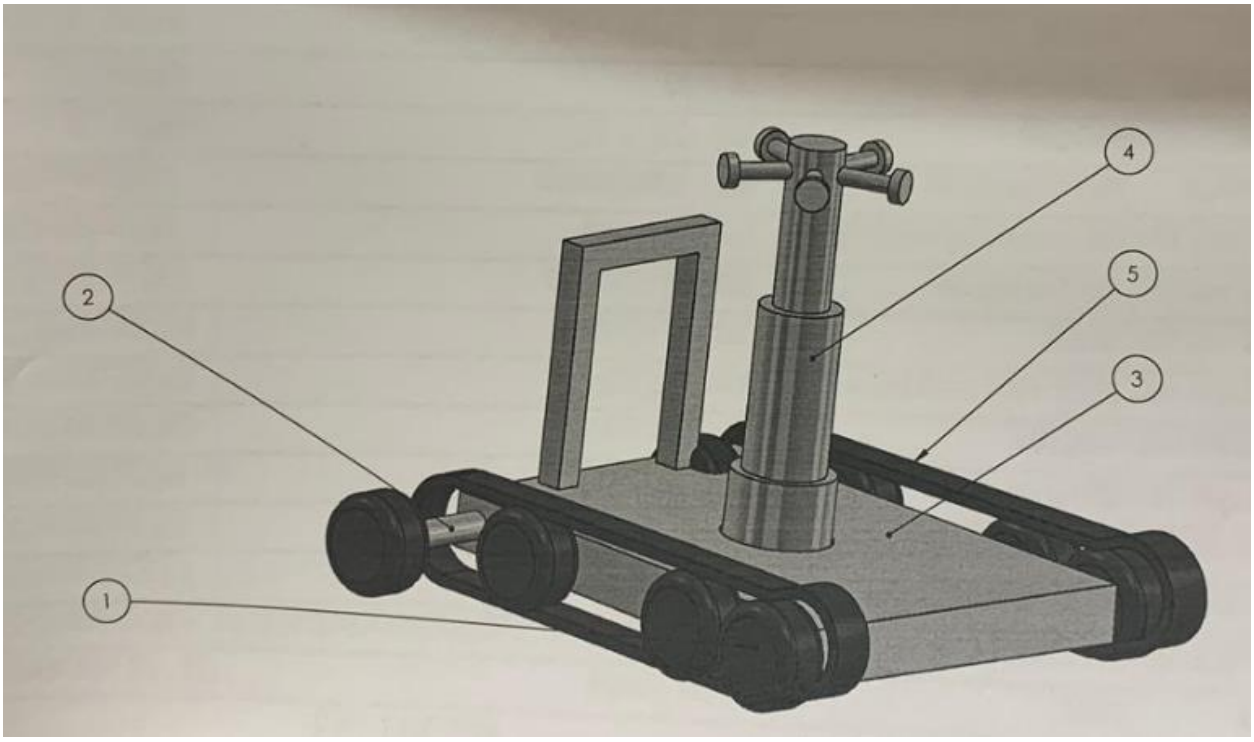



Figure 25: CAD Model

And the description of parts has defined as

Table 6: Parts of Design

| Item No. | Part Number | Qty. |
|---|---|---|
| 1 | Wheels | 8 |
| 2 | Wheel's Axial | 4 |
| 3 | Frame | 1 |
| 4 | Telescope hanger | 1 |
| 5 | Track | 2 |

Wheels

Wheels 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.

Wheel's Axial

Axial was a thing which create a link between the source and deliverer. This design has wheels so the axel connects with the wheels to move the wheels together.

Frame

Frame was the base, and all the wheels, hangers and everything connects with this frame. This frame was in square form like a straight ground.

Telescope hanger

This was a hanger on which the bags will hang, and the height of this hanger can easily move up or move down.

Track

Track was the conveyer belt form which provide the support in rotating the wheels and make a complete path for the wheels to move.

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.

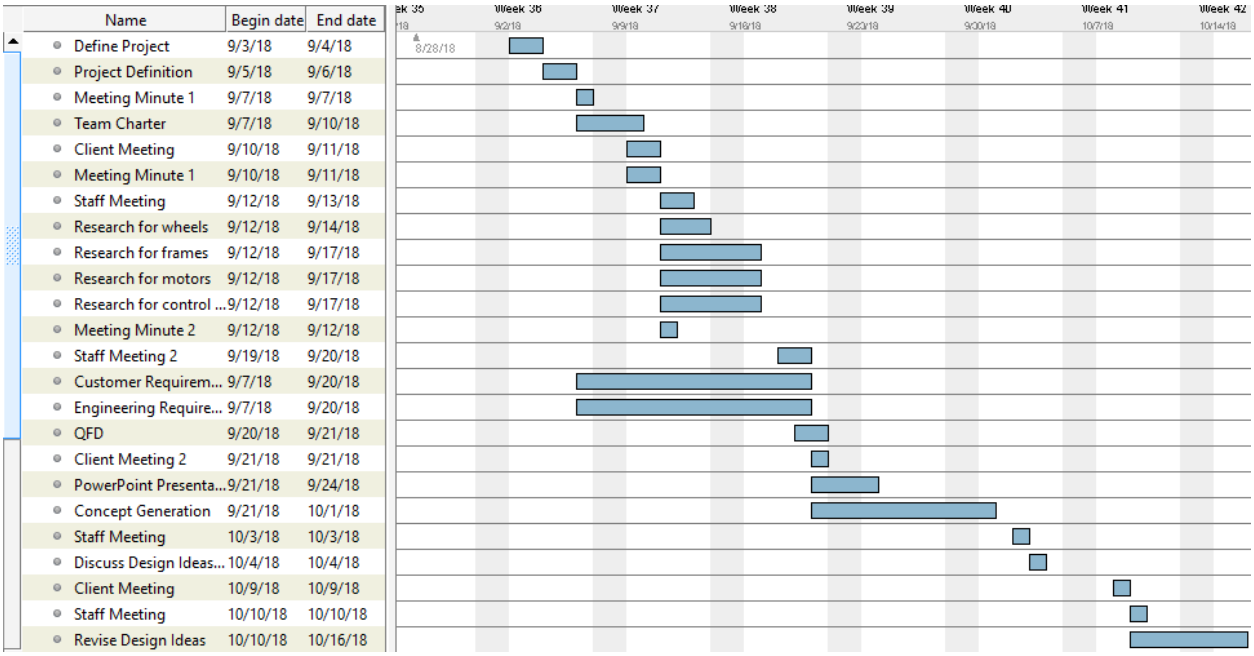
After the bill of materials, we placed the order to buy these products and the items arrived in the past few weeks. We started working on manufacturing the product and assembling the parts. Implementation of the whole design will be done soon in next month or so and all the testing will be done as well 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 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 26: Gantt Chart

# 7 IMPLEMENTATION

## 7.1 Manufacturing

For manufacturing the device, we have developed a prototype first using the pneumatic cylinder, and for making the hanger to carry the bags we have used the rounding plate with the hangers attached to it and then use the cylinder to lift up the loads and see the design is working.

For manufacturing the device, an aluminum structure has developed first. In the aluminum structure. This structure has available at first which has shown in the figure

Figure 27: Aluminum Base structure

After that the conveyor belts have ordered as we have four edges so four conveyor belts have ordered.

Figure 28: Conveyer belts

These conveyor belts have used with the wheels, a pair of three wheels for each and each pair of wheel connects through the motor.

Figure 29: Motors

After that we wanted to buy the telescoping system however, it wasn't available with the requirement to fit in our product. The team decided to design our own telescope by buying the parts and combining them. The parts were bought from 'Home Depot'. 'Two pipes' with different diameters were bought with 'rubber o ring' to connect the pipes. Five hiking hanging kits were also in the purchase for carrying one (10lbs) bag each. The team went to the workshop at NAU next to the police station. A team member has an experience at manufacturing so he led the process. The smaller diameter pipe was grooved three times in different spots, so the rubber or rings will not be moving while sliding it into the bigger pipe. A lubricated oil was put also on the smaller pipe, so it would be smoother on the movement and sliding. The bigger pipe was drilled at nearly the bottom with a 5 mm hole on both sides and then use a screw with that size to fit into the two holes. In that way, the smaller pipe wouldn't go under the bigger one. The team noticed that the process has to be smoother and that why the lubricating oil was used. A moving box was also used in this subsystem and it was cut into a circle and five holes on it, so the hanging kit would stick. This subsystem was primarily for being as an elevator for the bags and lift them up to the kitchen's table level. It would be the telescoping part on the middle of the base in the system.

Figure 30: telescopic system with hanger

We have ordered the pneumatic pipe of 8mm which is Tubing pipe with nylon hose. This tube has outer diameter of 8mm and inner diameter of 5mm and the length of the tube is 10 meter.

Figure 31: Tube Pipe [12]

In order to make the pneumatic properly working, pneumatic connector have used which can easily fit the tube of 8mm.

Figure 32: Pneumatic connector [13]

For fit the pneumatic cylinder fitting pipe made up of brass has used with the male pipe of 1/8'' and female pipe of ¼''.

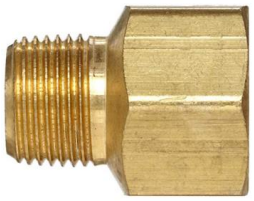


Figure 33: Brass Pipe Fitting [14]

Coupler plug kit has used for coupling with the pneumatic cylinder for creating the pressure properly and the male and female plug has used.


Figure 34: Coupler plug kit [15]

Electronic solenoid has used to create the pressure to fil in the cylinder and for this purpose, we have used 5 ways, 2 position pneumatic electric solenoid valve which operate with 12 V DC.


Figure 35: Electric solenoid [16]

And to supply the power to the solenoid, a power supply has adjusted with it. which is portable air compressor pump with analog display to 120 PSI for home (110V) and car (12V).


Figure 36: Power Supply [17]

And the exhaust muffler has used to provide the exhaust and the size of 1/8'' NPT it is brass body.

Figure 37: exhaust muffler [18]

Pneumatic speed control silencer has attached with the solenoid.

Figure 38: Speed Control Silencer [19]

And the battery used to provide the power supply to all the parts has connected to it after that. It has the capacity of 12V and 20Ah to provide long backup for supply.


Figure 39: Battery [20]

And the cylinder used to connect through the solenoid using the tube is 12 inches with the 1/16 inches of bore.


Figure 40: Air Cylinder [21]

So after setting up all the parts, solenoid with the coupler kit and tube has shown below


Figure 41: Solenoid with other parts

And the tube connected with the cylinder has shown below

Figure 42: Cylinder

And the complete setup of cylinder with the solenoid and power supply with the air compressor has shown below

Figure 43: Cylinder setup

An arduino mega board will be used to control two main systems, the motor and the pneumatic cylinder. An arduino board will enable the user to control the device remotely which makes it more convenient especially with old customer or people with back problems. To achieve that is one of the projects requirement which makes the arduino important. The team have began setting up the arduino with the codes, wires, and a recliner to achieve the ultimate goal of higher result with minimum work by user.

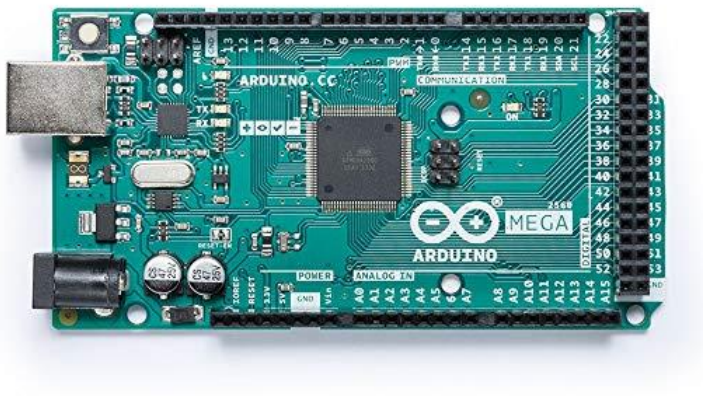



Figure 44: Arduino Mega

In this way complete setup has processed, and cylinder has developed. This has attached with the telescopic system developed manually and then fitted with the tank to move and rias up and down.

An updated bill of material is presented in Appendix B. It describes the parts of project that are being used for implementation. Description of the items as well as functionality are provided. Type of material, dimensions and Cost for each part is provided in the BOM. The links for the parts have been written and provided as well. The BOM is a breakdown structure of the product that will make our implementation process easier.

A complete table of the budget is shown below with a total cost estimate of $455.08 and the total budget for this project has not been provided by either the client or the professor.

| 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 | 1 | 5.88 |
| 15 | Air tank | 1 | 37.67 |

Figure 45:Total Cost Estimate

## 7.2 Design Changes

Before it has decided in the design to make the hanger in different shape like the nails 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 and hold in it. Then put the hangers separately in the hole to make the final design of telescope hanger.

Another change in the design has made in the telescope as the telescope required for our product was not available so we have decided to make our telescope. We have used two pipes with different diameters, then put the smaller diameter pipe into the bigger diameter pipe and make a hole in the round plate which fitted around the pipe. After that used the cylinder to raise the height of telescope in order to lift the bags. So the complete pneumatic cylinder has developed for making the cylinder. Also the the chassis that we bought and assembled was a design change as our initial idea was to build our own base with wood and tires.

Another important change we made to our device is to change our initial idea of the tank threads. The initial idea was to make them straight as seen in the CAD model. This creates a problem because it will make climbing stairs impossible. Instead, the tip of the tank thread will be raised and tilted. 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.

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, by doing further analysis, we learned that is it better to use four DC motors, 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. Ofcourse, 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 the user friendly of our device and makes it easy to use.

By looking at our CAD model, there is a handle that we were planning to use so the customer who is using the product can lean on it. 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 requirement was added to our list of requirement by our client and that is finding a way to make the product goes into the trunk of the car and out without actually 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 is still working on this idea of how to build one or where to actually apply it into the system.

The team had a problem with getting the pneumatic cylinder work without using a portable compressor. After doing some researches, 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 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 3-5 lbs, which can be workable and implied into the system. This air tank might provide around 3-4 lifts before it should be refuel by the compressor. The number of times can be increased, but it is hard to do that without breaking any of 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 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.

These are the design changes we implemented as of now. We expect that there might be more aspects that might need changing or improving in the future. We would not hesitate to change something to make sure that our device works and is as best as possible.

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# APPENDIX A

Table 7: 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/2CfAa |
| 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/2yluNa |
| 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/2vZ98h |
| 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 8: Updated Bill of Materials

| Bill of Materials | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| Team | | | | Team C5 | | | | |
| Part | Part Name | Qty | 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 Stroke, 5/16 inches Rod OD, 1/8" NPT Port | 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 fittings | 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 | 1 | machine | convert current electrical energy to ME energy | metal | 4.2 x 2.9 x 0.5 inches | 5.88 | 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 |
| Total Cost Estimate: | | | | | | | 455.1 | |