

PORTABLE CARRIER

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DISCLAIMER

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EXECUTIVE SUMMARY

This project consists of a portable carrier which has the capability to climb the stairs and can carry lot around 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 been 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 based on 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 is design # 10 which is 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.

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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 lot of bags and grocery items together in hand. Such trolleys are 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 floor, 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 night mare for them. To resolve this issue, a project is developing which is 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 is 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 is the original project description provided by the sponsor. Team responsibility is 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 are 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 is 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 are 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 are the requirements which have technical values and these technical values are the one that will achieve by the project. So engineering requirements are 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 is around 20 ft² so the ER value has chosen is 10 ft². 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 is 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 is most important and which engineering requirement is 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%
Technical 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 is distance to travel, second is number of bags to carry, and least important is tires size.

3 Existing Designs

For any project to build from scratch it is important to do some research and find existing designs which will help in making the project. According to the chapter any design project needs a 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 are the inputs to the design project, and what are the outputs of the projects. Hypothesized functional model explains the internal working of a system with all the steps. This information regarding the project can be obtained from the existing designs because existing designs explain the working and provide the designs as well. So existing designs are important to find for the design project. In this section a few existing designs will be presented, functional model will be presented and sub-functional models will be presented as well.

3.1 Design Research

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

Patent Design

A US patent design for the carrier for plastic grocery bags has been found. This design has a 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 a 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 is a light weight gadget also so it doesn't influence the general weight of bags [1].

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

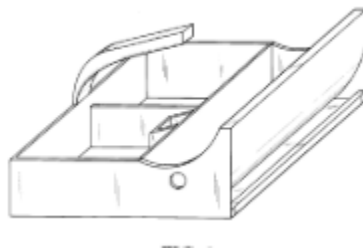


Figure 0: Patent Design

Diary Article

In the article, writers have depicted a design thought to make a 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 is 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 is minimal in size and convertible also thusly, it can fit into the storage compartment effortlessly and it can convey to anyplace [4].

A course reading has found in which diverse sorts of sack carriers have given. Section 4 of this report is comprised 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 is 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 are 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 are presenting.

3.2.1 Existing Design # 1: VEVOR Stair Climbing Cart

This is 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 is tripod tires. This design has presented into the market by VEVOR and it has been using extensively [7]. This design is useful in the regards that it will help us in making a unique design for the project. As the design is 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 is handle under the front side to place the carrier stable and straight as well. This design is 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 is 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 is 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 is 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]. This design is 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 is 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 is 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 are presenting in the next section. First is black box model and second is functional model.

3.3.1 Black Box Model

As the name stated black box is 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 is either move or stop. In this project, material is handle, bags and human body, energy is human energy and electrical energy and signal is either move or stop. The black box is important for the project because it provide the details about the project like what is 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 is the figure showing black box model.

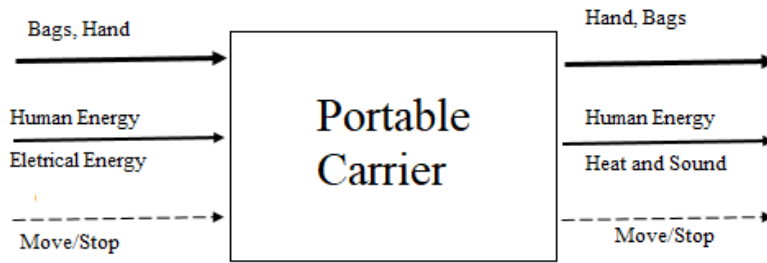


Figure 4: Black Box Model

3.3.2 Functional Model

This is 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 is 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 is 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.

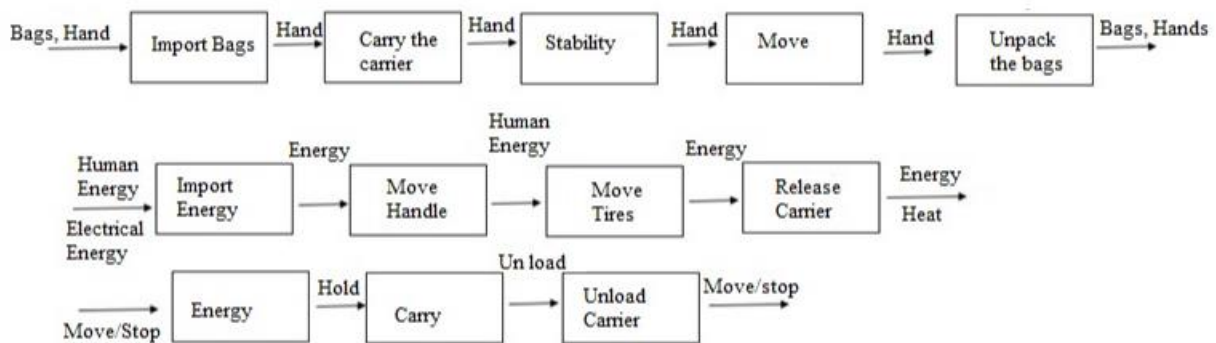


Figure 5: Functional Model

3.4 Subsystem Level

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

3.4.1 Subsystem # 1: Tires

Tires is 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 are different types of tires are available in the market.

3.4.1.1 Existing Design # 1: Rubber Tires

Rubber tires are already available in the market and these tires are 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 is 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 is another type of existing design for the tire that is steel tires. Steel is strong and hard tire and it can use for the project as well as it will able to move on the stairs there this is also a useful existing design. This material can also use in the project but it is hard and it will push the carrier up and down which will not be safe for the carrier to use but it is 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 is another existing design in which a tire is of wood and this tire can also use for the project but it's not that useful and it can break easily. This material is 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 is another subsystem of the project and that is handle, as the carrier will move with the help of handle and it will carry by the hands. There are few existing designs available for the handle as well.

3.4.2.1 Existing # 1: Plastic Handle

Plastic handle is the existing design and it is useful in the project as well because plastic handle doesn't hurt the hand and user can easily move the carrier. This material is 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 is 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 is another existing design available for the project and this is useful as well because it is strong and soft for the hand as well so it can use in the project. This material is useful for the project in a way that wooden handles are 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 is another existing design to use for the project. Steel handle is hard and strong and it can use for the project as well. This material is also safe to use for the carrier because steel is 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 are different existing designs available for it.

3.4.3.1 Existing Design # 1: Steel Base

This is the most common base to use, as it is strong and hard. And it can easily carry the bags and carry the load as well. This material is useful because it is 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 is another existing design and this design can use for the project as well but it is not as strong to carry lot of load. This material is not as strong as steel is 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 is aluminum base as the aluminum base is strong and it can use for the project as well. This material is 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 is 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 be generated for the project and these new design ideas will follow the requirements and will also contain the subsystem as well. these designs will then pass through Pugh Chart and Decision matrix to select the final design. Also note that all designs will have motors (DC or Stepper) and a controller (joystick) on the source of motion (tires, tracks, treadmill, three-tires method) that would be possible using Arduino kits

4.1 Design # 1: Row side Carrier

This is 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.

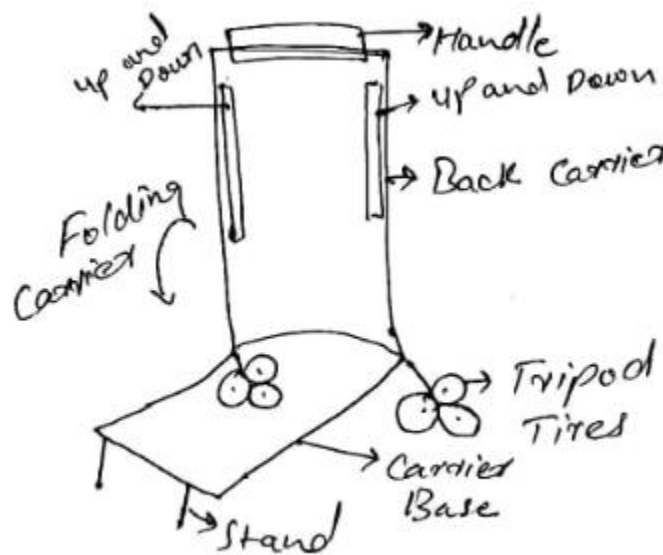


Figure 15: Row side Carrier

Pros:

- Climb stairs
- Easy to use
- Low weight

Cons:

- Costly

4.2 Design # 2: Chair carrier

This design looks like a normal bag at first, it has two tires to walk on straight ground like most carriers. However, the unique thing is that it has tires in the bag's "stomach" to climb the stair. The handle can be tilted so when the user pulls it up the stairs he can be standing instead of leaning down. This design is shown in figure 16.

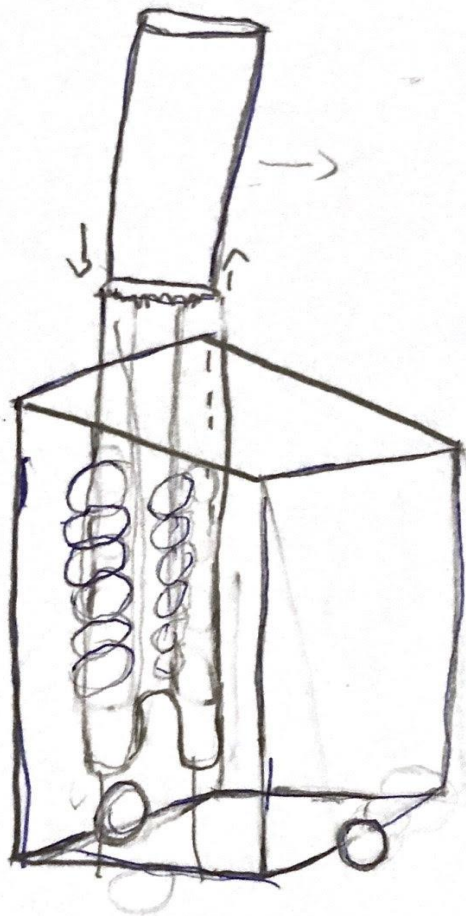


Figure 16: stomach tire

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 is 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.

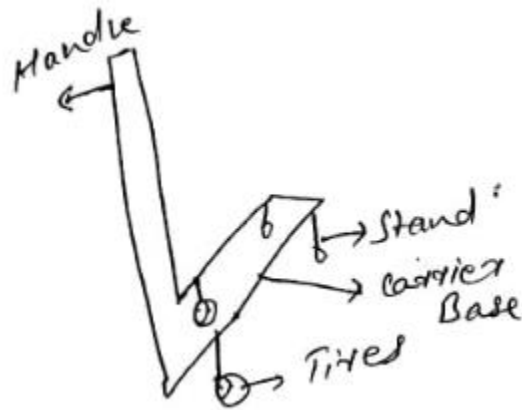


Figure 17: Tilt Carrier

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.

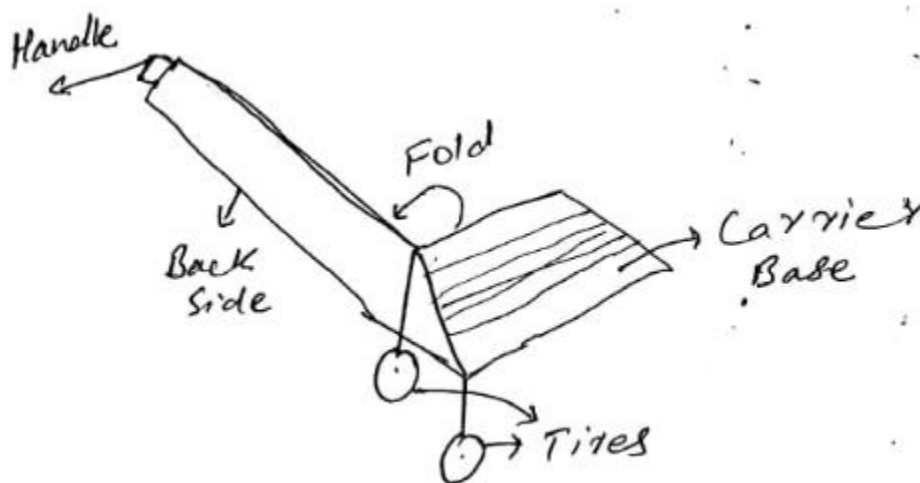


Figure 18: Simple Carrier

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 uses tracks for mobility. The tracks help movement in rough ground. It had a tilt in the front because that will help it when climbing the stairs. Scissor lift is used to make the box on top more stable, so when the device is climbing the stairs, it tilts but the box on top don't. The design is shown below in the figure 19.

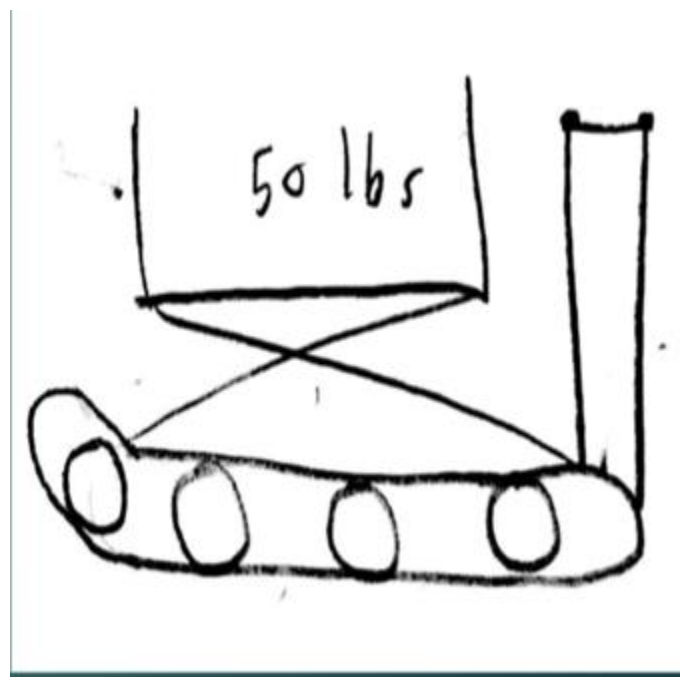


Figure 19: tank carrier

Pros:

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

Cons:

1. Heavy

4.6 Design # 6: Cross Carrier

This carrier has a shape of cross because its carrier and backside are 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.

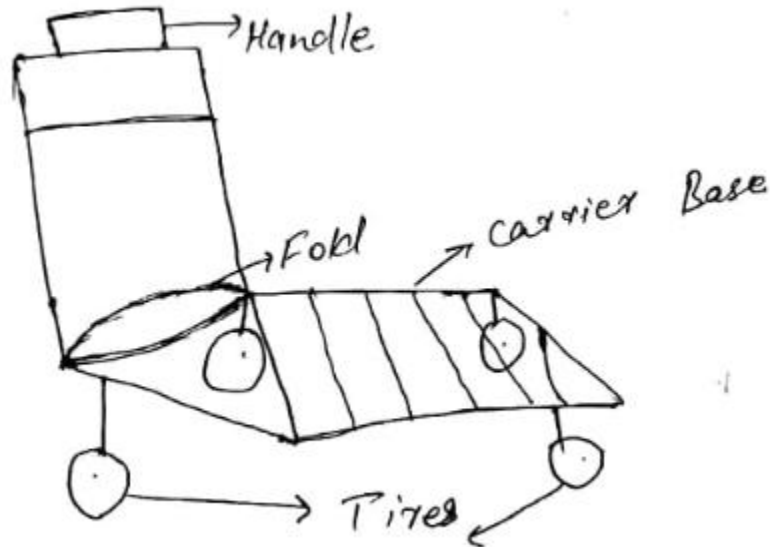


Figure 20: Cross Carrier

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 is foldable by removing the basket and basket is foldable as well. The design has shown below in figure 21.

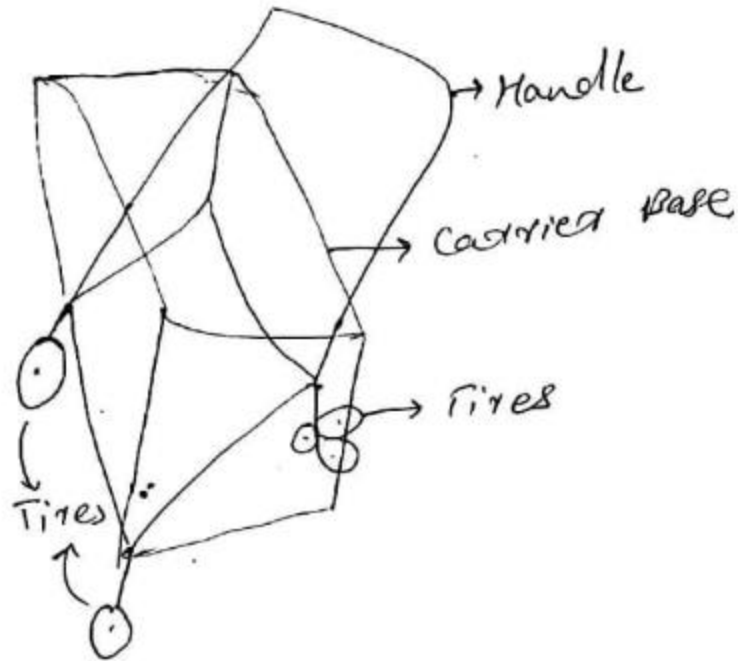


Figure 20: Basket Carrier

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

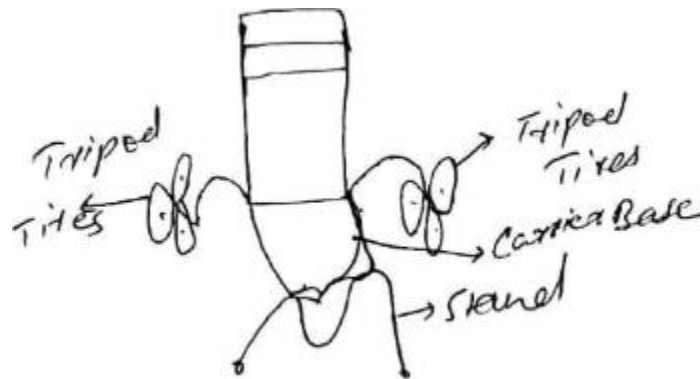


Figure 22: Open Carrier

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 are removable from the carrier, and it is foldable and it has tires on both ends to move it properly and the design has shown below in figure 23.

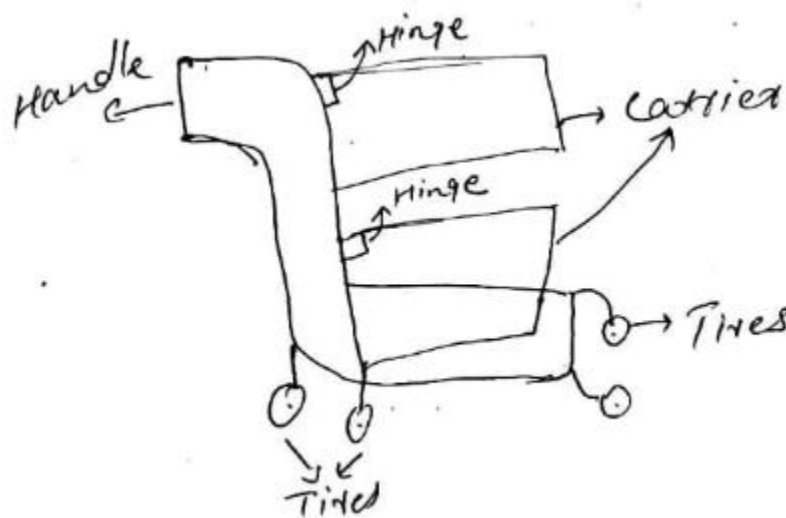


Figure 23: Double Carrier

Pros:

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

Cons:

1. Tilt the device to move

4.10 Design # 10: Tri-high carrier

This is 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.

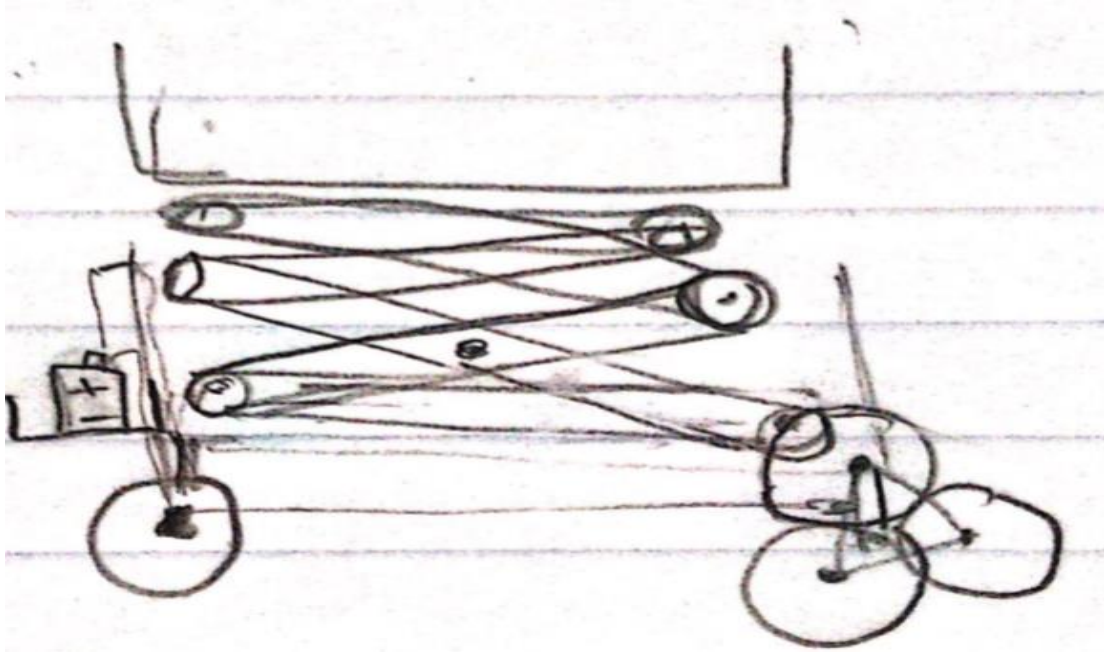


Figure 24: Tri-tire carrier

Pros:

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

Cons:

1. Tire the device to move

5 DESIGN SELECTED

In section 5 we will talk about the design selection through different methods and we have two main methods to select the design on the basis of criteria and these two methods are 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 is Pugh chart which narrow down the results from 10 to 3 designs and these three designs will use for the decision matrix and final design selects from it.

5.1.1 Pugh Chart

Pugh chart is a method which check each customer requirement against each design and then put plus sign if it is better than the chosen datum and place negative sign if it is not better in the corresponding box and place 'S' if it is the same. 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 is safer than the datum or not and it is safer, 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. Then the top three design count as the selected designs from 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 are design # 2, design #5 and design # 10 and now move to the decision matrix.

5.1.2 Decision Matrix

Decision matrix is 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 is safe to use but it can easily fall to the sides because it is a bit tall and stands on only two tires. In the same way, all designs have evaluated. The highest scored design will be the final design. The table of decision matrix has shown

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

6 PROPOSED DESIGN

The results have shown that the top design is design # 10. It is a good solution that satisfies the criteria. It does satisfy the requirement because it is safe and has the capacity to carry five bags, climb stairs and travel at least 100 – 500 feet. It is also portable and work in different weather because it is stable because is has tires in all four ends.

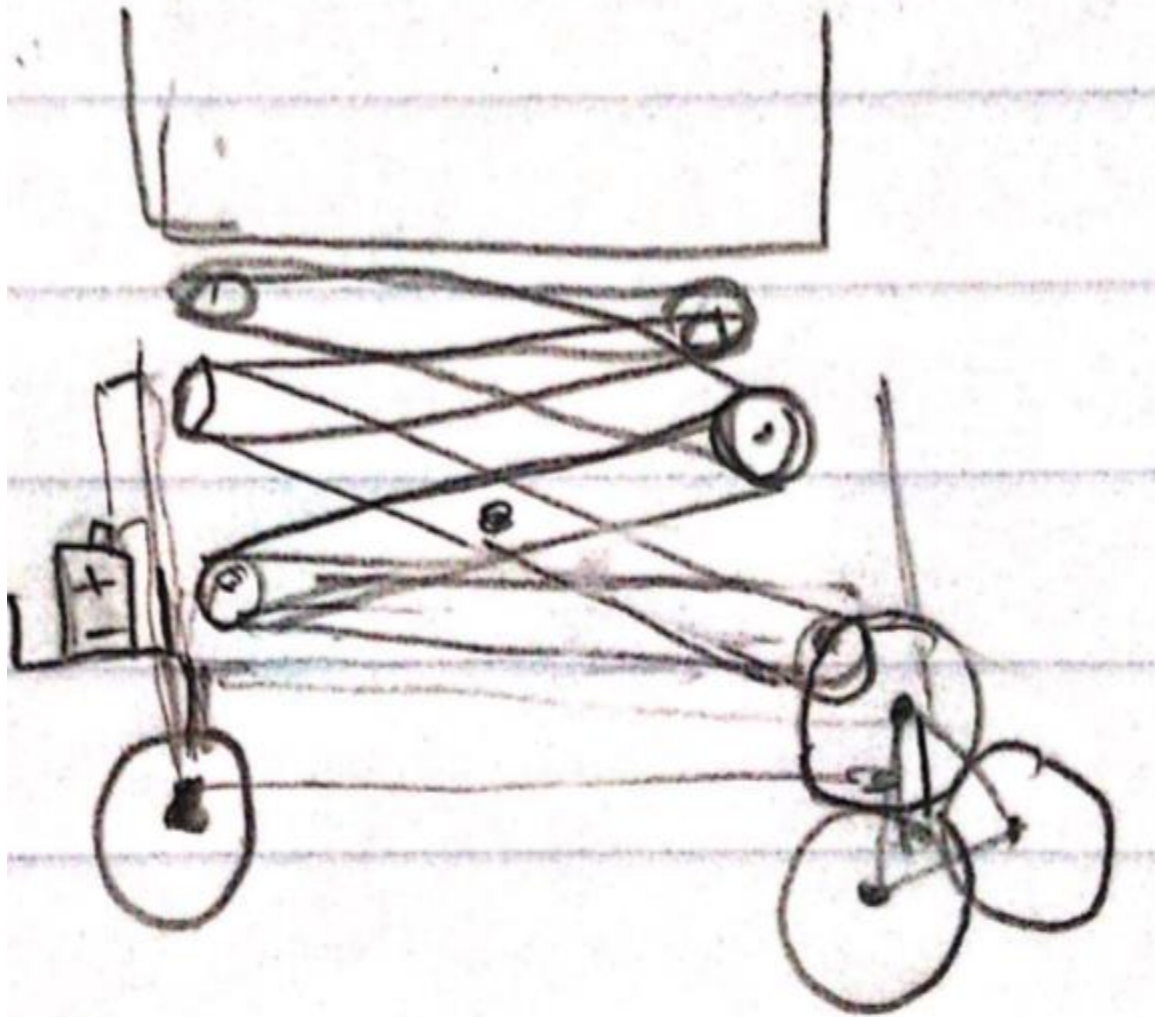


Figure 25: Final design

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