PUT WHEELS ON ANYTHING

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Team 5

Abstract
The objective of this project was to create a product that would allow us to put "wheels on anything." This product would allow the user to move any large objects easily by being able to put the object on our product and wheel it to its desired location. We began with creating a survey that would allow us to figure out what the customer wants in this type of product. While waiting for the results from the survey we sent out, we began researching other products that were similar to what we wanted to create. We mostly looked at push dollies that were similar to the ideas we had formed. Our results from the survey and PCC charts allowed us to focus on the ease of use, the size, the strength, the safety and the price of the product. These are the aspects of our product design we mainly focused on. Through external research and benchmarking we were able to create our own design concepts. The Pugh Charts helped us to figure out what designs were most important for our final design. We were then able to create our prototype and test the product to make sure it fit our standards.

1.0 Introduction

The project that we chose to do is from the Design for Emerging Markets (DEM) options. The option we chose to pursue was the "Put Wheels on Anything" project. For this project we need to design, create and test a product that allows us to "put wheels on anything" to be able to move larger items quickly and easily. We decided that our target consumers are the working class adults. In order to find out what our customers would want in a product like this, we created a Google document survey and had our parents send this out to their fellow co-workers. After receiving the results, we then started creating some general concepts. Using these concepts we created the AHP and PCC charts. By using these charts we were able to figure out what aspects and features of our product are most important to the consumer. These aspects included the ease of use, the size, the strength, the safety and the price of the product. Now knowing what the consumers want in this product, we began generating designs for the platform/ramp, handle, and wheels of this product. When creating different designs for each concept, we used the information collected from our benchmarking and external research. We then created the morphological charts and Pugh charts. The Pugh charts allowed us to narrow down the best design for each concept and to create our final design. Once our final design was decided upon, we began working on our prototype. In the following sections you will see our results for the AHP charts, PCC charts, Pugh charts, TRIZ charts, and all other research that was done for this project. In each section there are charts, tables, and pictures to furthermore explain the process of this project.

1.1 Initial Problem Statement

The purpose of our project is to design a product that will allow the consumer to put wheels on any large object that needs to be moved. The initial problems that we face are what materials to make this out of, what is going to be moved with this product, and keeping the price affordable.

2.0 Customer Needs Assessment

First, we created a survey through Google documents consisting of ten questions. After creating the survey we sent the link to our parents, so they could take the survey and send it to their co-workers. We then could get feedback from the adult work force. Through this process we received thirteen responses.

2.1 Weighting of Customer Needs

Table 1. Initial Customer Needs List Obtained from Team Focus Group and Individual Interviews/Surveys

To create a weighted list of customer needs we wrote down ideas that we could use for designing and creating a dolly to put wheels on anything. After some time we came up with a list of the most important ideas that we could incorporate into our design of a dolly to put wheels on anything.

User Friendly
Easy to load and unload
Easy to operate
Safe
Portability
Light-weight
Collapsible
Able to fit through standard doors
Durability
Strong
Easy maintenance
Carry heavy loads
Price
Cheap
$40-50

Table 2. Hierarchal Customer Needs List Obtained from Survey

We split our initial customer needs list into four main categories, User friendliness, portability, durability, and price. Our constraints are having the wheels on everything product able to carry heavy loads and for it to be cheap. These are constraints because it will be difficult to make our product very strong and sell it for our target price range.

1. User Friendly
1.1 Easy to load and unload
1.2 Easy to operate
1.3 Safe
2. Portability
2.1 Light-weight
2.2 Collapsible
2.3 Able to fit through standard doors
3. Durability
3.1 Strong
3.2 Easy maintenance
C.1 Carry heavy loads
4. Price
4.1 Cheap
C.2 $40-50

Figure 1. AHP Pairwise Comparison Chart to Determine Weighting for Main Objective Categories

This is our AHP table. It compares the two qualities of our product and tells which one is more important. If the second quality we are comparing the first one to has a greater importance it has a whole number of a scale from one to ten. The second quality would then get the reciprocal of that number in the area where those two qualities are compared. You figure out the weight by taking the percentage of all the totals combined. This is important because you find the real importance with each quality.

	User Friendly	Portability	Durability	Price	Total	Weighing
User Friendly	1.00	5.00	9.00	0.25	15.25	0.42
Portability	0.20	1.00	3.00	4.00	8.20	0.23
Durability	0.11	0.33	1.00	6.00	7.44	0.21
Price	4.00	0.25	0.17	1.00	5.42	0.15

Figure 2. AHP Pairwise Comparision Chart to Determine Weighting of User Friendly Sub-Objectives

For this table we compared the qualities and changes we could change from our four major categories of change to each.

	Easy to load & unload	Easy to operate	Safe	Total	Weighing
Easy to load & unload	1.00	0.20	0.17	0.37	0.02
Easy to operate	5.00	1.00	2.00	8.00	0.50
Safe	6.00	0.50	1.00	7.50	0.47

Figure 3. AHP Pairwise Comparison Chart to Determine Weighting of Portability Sub-Objectives

For this table we compared the qualities and changes we could change from our four major categories of change to each.

	Light weight	Collapsible	Able to fit through standard door	Total	Weighing
Light weight	1.00	3.00	0.50	4.50	0.30
Collapsible	0.33	1.00	3.00	4.33	0.29
Able to fit through standard door	5.00	0.33	1.00	6.33	0.42

Figure 4. AHP Pairwise Comparison Chart to Determine Weighting of Durability Sub-Objectives

For this table we compared the qualities and changes we could change from our four major categories of change to each.

	Strong	Easy maintenance	Carry heavy loads	Total	Weighting
Strong	1.00	4.00	2.00	7.00	0.47
Easy maintenance	0.25	1.00	0.20	1.45	0.10
Carry heavy loads	0.50	5.00	1.00	6.50	0.43

Figure 5. AHP Pairwise Comparison Chart to Determine Weighting of User Price Sub-Objectives

For this table we compared the qualities and changes we could change from our four major categories of change to each.

	Cheap	$40-50	Total	Weighting
Cheap	1.00	1.00	2.00	0.50
$40-50	1.00	1.00	2.00	0.50

Table 3. Weighted Hierarchal Customer Needs List Obtained from Survey

After creating the AHP pairwise comparison charts to determine the weighting of each sub-objective we out them into a more organized chart where it shows each category and the sub-objectives and the weight of each sub-objective in the main objective.

1. User Friendly (0.42, 0.42)
    1.1 Easy to load and unload (0.084, 0.2)
    1.2 Easy to operate (0.21, 0.5)
    1.3 Safe (0.1974,0.47)
2. Portability (0.23,0.23)
    2.1 Light weight (0.069, 0.3)
    2.2 Collapsible (0.0667, 0.29)
    2.3 Able to fit through standard doors (0.0966, 0.42)
3. Durability (0.21, 0.21)
    3.1 Strong (0.098, 0.47)
    3.2 Easy maintenance (0.021, 0.1)
    C.1 Carry heavy loads
4. Price (0.15, 0.15)
    4.1 Cheap (0.075, 0.5)
    C.2 $40-50

3.0 Revised Problem Statement

Our initial problems we faced in this project were what materials to use, what will be moved with this product, all while keeping the price affordable. After collecting the research from our consumer survey, we have decided to focus on the user friendliness of the product, which includes focusing more on safety, ease of use, size & strength of the product, and also keeping the price within 40 to 50 dollars.

4.0 External Search

For our external search, we sent out a survey to our parents and their companies to receive feedback on what the customer wants. We also researched other products on the market that were similar to our project. Within our survey we asked the customers if they could think of any similar products as well. We also looked up different materials to get an idea of what we want to use for our final design.

4.1 Dissection and/or Experimentation

For this project, we had no products available to us to dissect. Instead we used our external research and benchmarking to collect data. We also tested our wooden prototype and found that it can hold all four of our team members, which is about 550 pounds. We also did the calculations to support the choices in material. These calculations will be presented in section 8.1 Material and Material Selection.

4.2 Patent Search

This chart shows all of the patents we found that might interfere with the designs we were creating. The patents are broken down into different categories so we can easily distinguish different functions that we may incorporate into our final design.

Table 4. Art-Function Matrix for Child Car Seat

FUNCTION		**ART**			
	Dolly	Table	Hand Truck	Desk Transport	Stackable Dolly
Moving large objects	US 6386560 US 6955368		US 20120286483		
Expandable		EP 2229843A2 US 6994032	EP 2465746A2		
Moving				US 3768676	
Easy Storage					US 6979005

4.3 Product Archaeology

See attached page.

4.4. Benchmarking

This table was set up to compare four different types of dolly's, one from Ace Hardware, two from Lowe's and one from The Home Depot. The features of each dolly are located on the left side of the table, while each type of dolly is located at the top of the table. Each product is rated on a scale from one to five with five being the best possible score. Next to each score there is a short description of the specific feature of that dolly.

Table 5. Benchmarking of Four Products

Feature	Ace Mover's Dolly-2 Pack	Harper Steel Convertible Hand Truck	CONTICO Resin Dolly	Milwaukee800 lb. Capacity 2-in-1 Convertible Hand Truck
Size	18"x30"x5.5"(2)	49"x19"x23"(5)	6.25"x17.25"x17.25"(1)	17.5"x49.25"x21.25"(4)
Product Weight	N/A(0)	38 lb.(3)	5 lb.(5)	32 lb.(4)
Aesthetics	Red carpet ends	Black finish	Black finish	Gray finish
Materials	Red carpet ends, hardwood frame(Chinese oak or birch), heavy-duty steel swivel caster wheels.(3)	Steel frame, solid rubber wheels(5)	Resin body, plastic wheels(1)	Heavy Duty metal frame(4)
Price	$47.98(4)	$134.00(2)	$17.49(5)	$84.97(3)
Ease of Use	Very easy(4)	N/A(0)	N/A(0)	Fairly easy(3)
Weight Capacity	850 lb.(4)	900 lb.(5)	250 lb.(1)	800 lb.(3)

4.5 Design Target

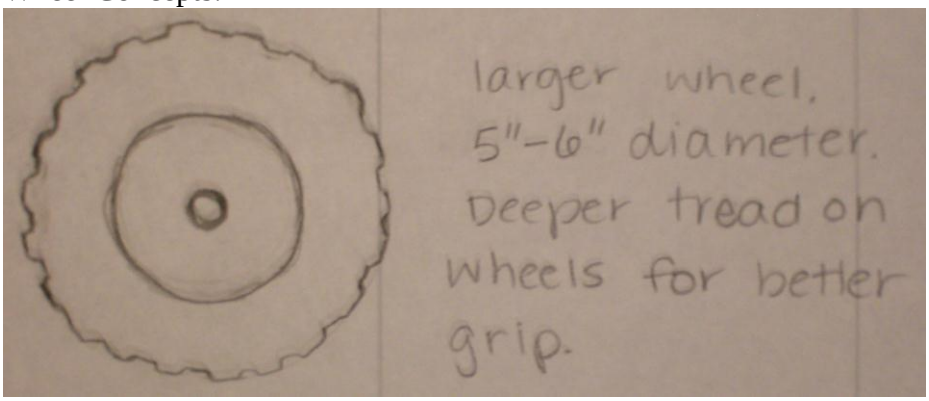
From out external search we discovered that there are many other products that are similar to ours. We also found many patents on specific features that we wanted to incorporate into our final design. In our external search we also saw how customer needs have changed the flatbed dolly over time to better fit customer's everyday needs. We were also able to see different price ranges of other competing companies' products.

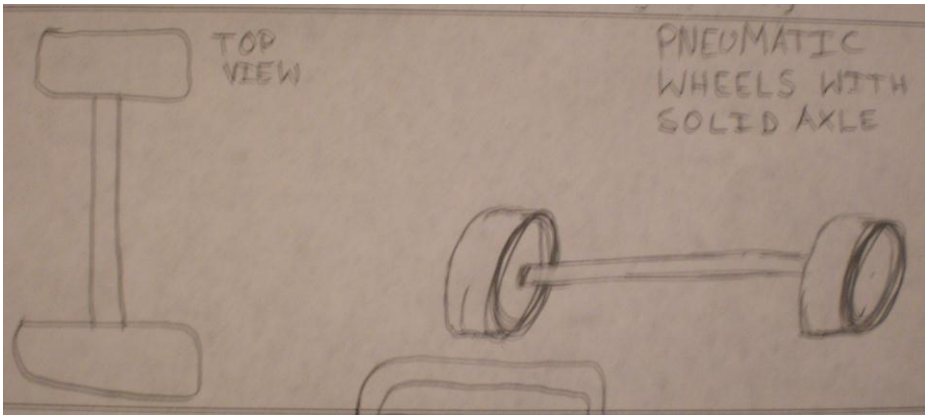
5.0 Concept Generation

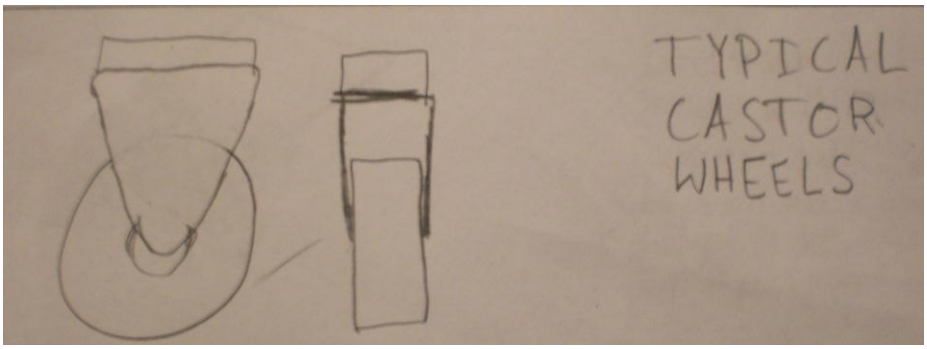
When coming up for different concepts for our wheels on everything product, we first made a plan. In our plan we listed down materials that we thought would be light-weight and very strong and able to carry a lot of weight. For our resources we had listed iPads/iPhones, our four brains, and the online book. For our plan we had planned out

that we would first think of ideas individually, exchange ideas, plan a concept, and then finally draw and write out possible designs. There were three criteria we had concepts for: wheels, platform and ramp, and handles.

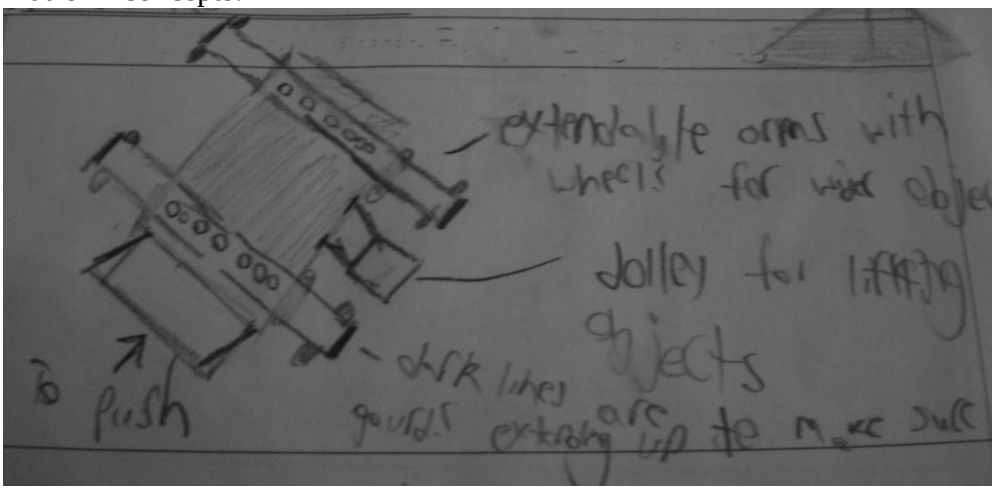
Wheel Concepts:

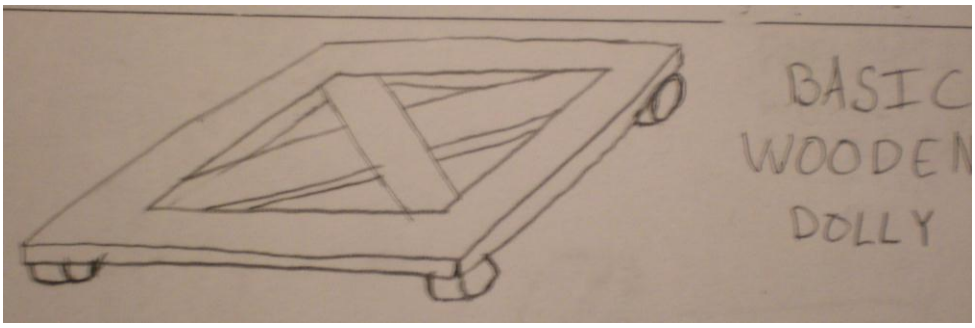


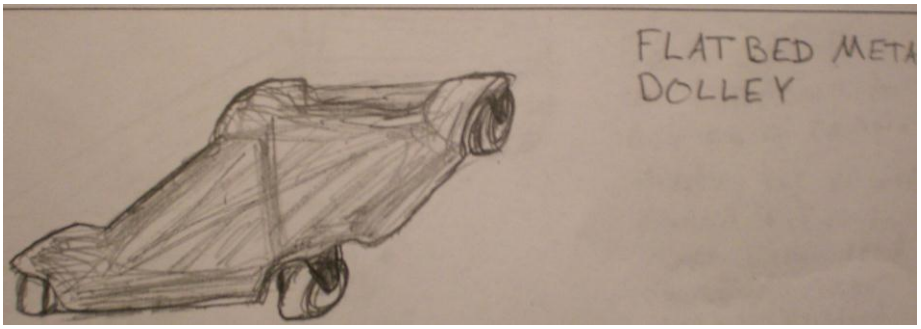


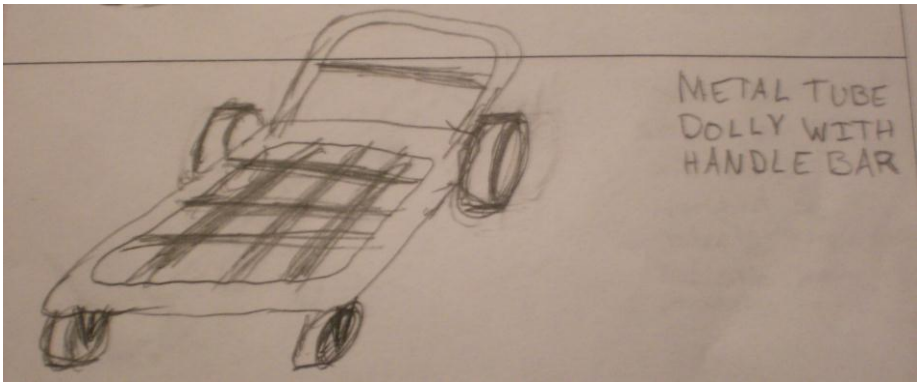


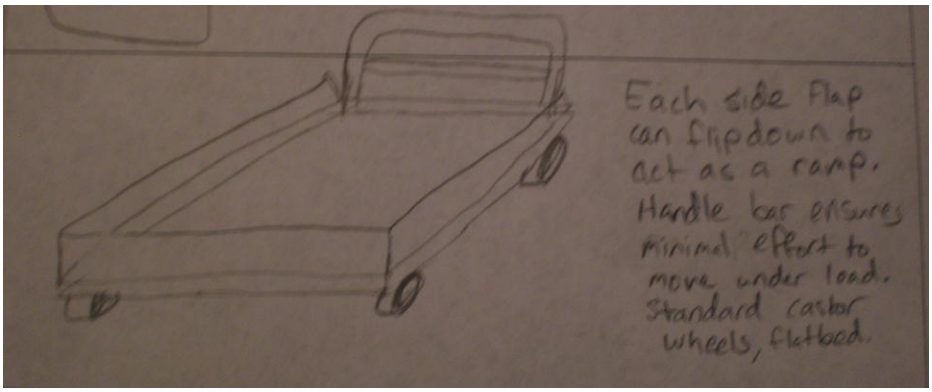
Platform concepts:

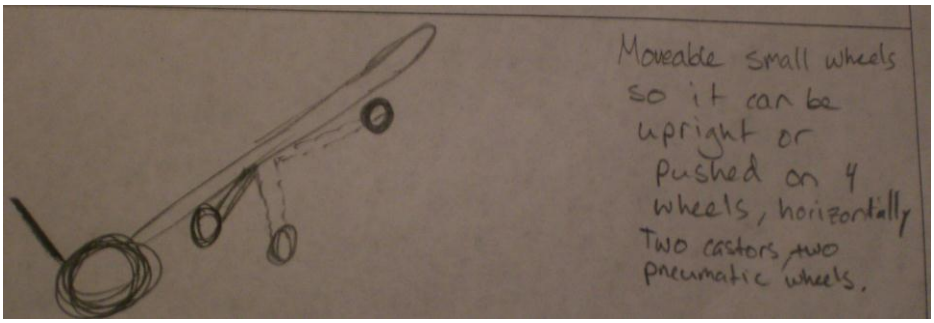


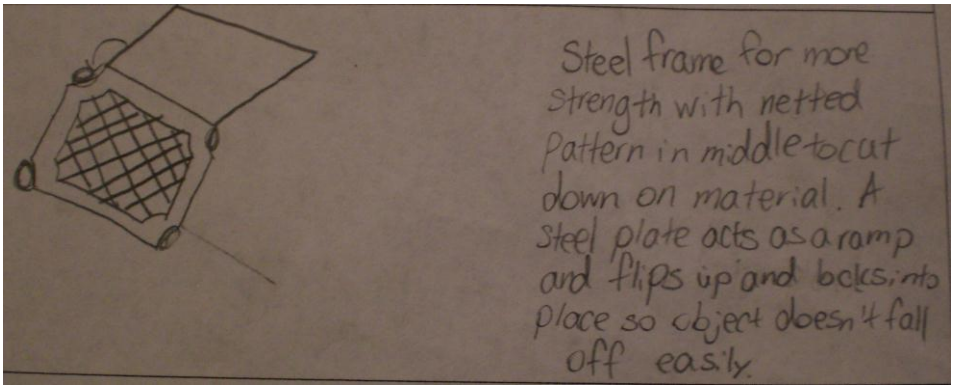




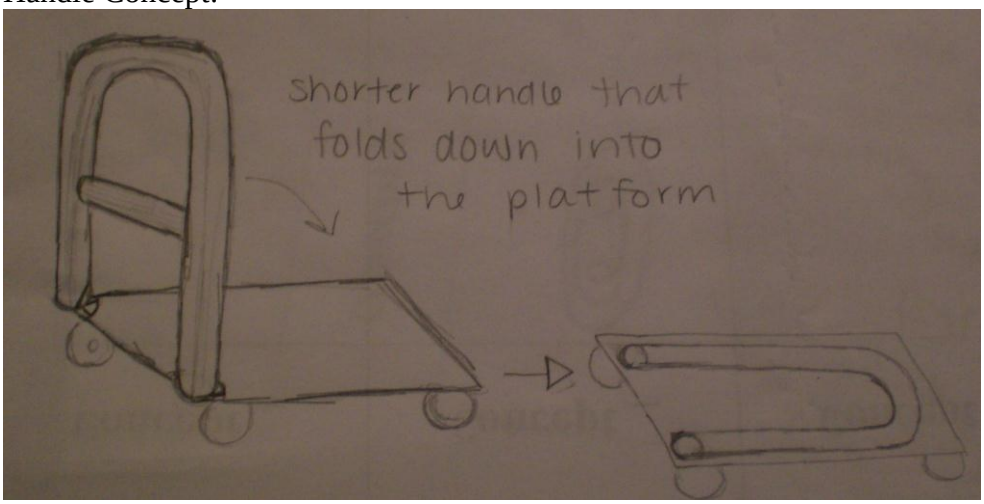

METAL TUBE
DOLLY WITH
HANDLE BAR


Each side Flap
can flipdown to
act as a ramp.
Handle bar ensures
minimal effort to
move under load.
Standard castor
wheels, flatbed.


Moveable small wheels
so it can be
upright or
pushed on 4
wheels, horizontally
Two castors, two
pneumatic wheels.


Steel frame for more
strength with netted
pattern in middle to cut
down on material. A
steel plate acts as a ramp
and flips up and locks into
place so object doesn't fall
off easily.

Handle Concept:



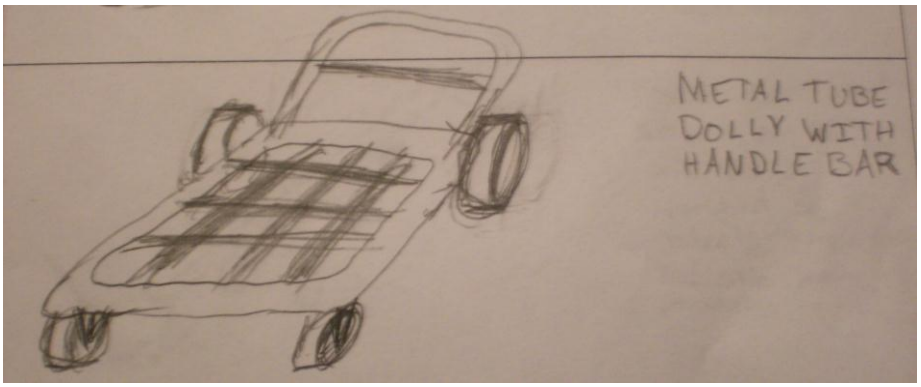
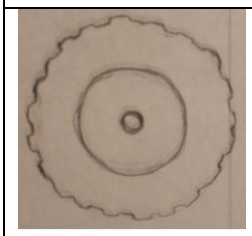
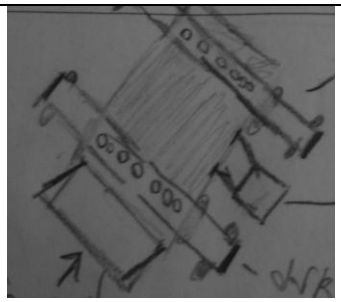
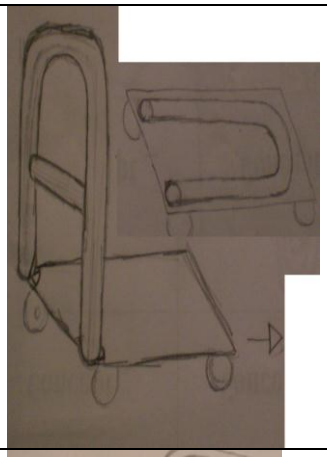
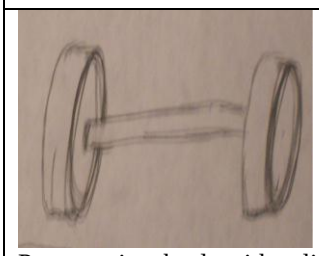
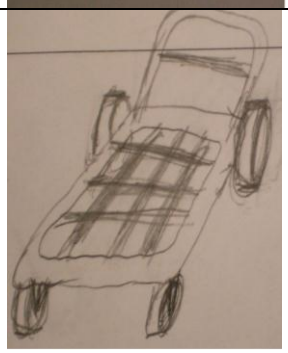
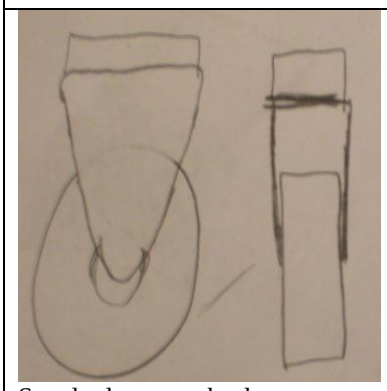
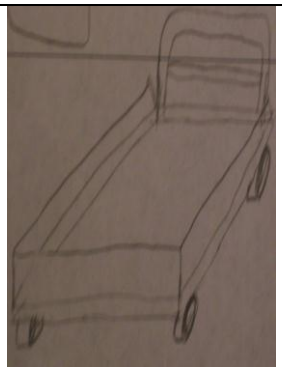
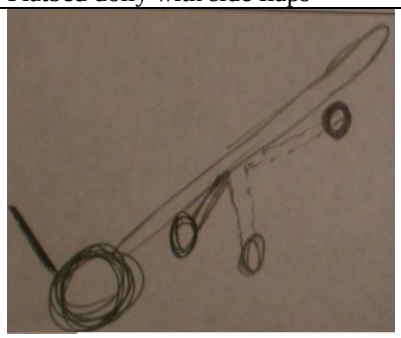
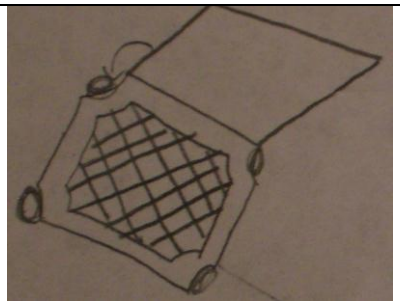


Figure 6. Morphological chart

Our morphological chart was made by narrowing down our concepts based on our consumer needs survey. In each category we have the concept and a sketch based on each idea.

Wheels	Platforms	Handles
 Big wheels with treads		
 Pneumonic wheels with solid axle.	Basic wooden dolly	 Standard handle bars
 Standard caster wheels	Flatbed metal dolly	

	 Metal tube dolly	
	 Flatbed dolly with side flaps	
	 Convertible	
	 Metal frame with ramp that locks into place	

6. Concept Selection

After narrowing down our concepts based on our customer needs survey, we made a morphological chart. After making a morphological chart we made Pugh Charts for each of the main categories. When making Pugh Charts we made two iterations to confirm which of the concepts we ranked first among the other concepts.

Pugh Charts
Table 6. Wheels Pugh Chart

We made two Pugh Charts to confirm that the top ranked concept was truly the best concept that we used for the wheels on our product.

Iteration 1:

Criteria	Size	Weight	Cost	Strength	Sum	Rank
Relative Weight	0.33	0.33	0.33	0.33		
Concepts						
Big wheels w/ tread	-1	-1	-1	+1	-0.66	3
Pneumonic wheels w/ solid axle	-1	-1	0	+1	-0.33	2
Standard caster wheels	0	0	0	0	0	1

Iteration 2:

Criteria	Size	Weight	Cost	Strength	Sum	Rank
Relative Weight	0.33	0.33	0.33	0.33		
Concepts						
Big wheels w/ tread	0	-1	-1	0	-0.66	3
Pneumonic wheels w/ solid axle	0	0	0	0	0	2
Standard caster wheels	+1	+1	+1	0	1.00	1

Table 7. Platform Pugh Chart

We made two Pugh Charts to confirm that the top ranked concept was truly the best concept that we used for the platform on our product.

Iteration 1:

Criteria	Size	Weight	Cost	Strength	Sum	Rank
Relative Weight	0.14	0.14	0.14	0.14		
Concepts						
Flatbed with extendable sides	0	0	0	0	0	1
Basic wooden dolly	-1	-1	+1	-1	-0.29	3
Flatbed metal dolly	-1	-1	0	0	-0.29	3
Metal tube dolly	-1	0	0	0	-0.14	2
Flatbed dolly with side flaps	-1	0	0	0	-0.14	2
Convertible flatbed/upright	0	0	-1	-1	-0.29	3
Metal frame w/ ramp that locks into place	-1	0	0	0	-0.14	2

Iteration 2:

Criteria	Size	Weight	Cost	Strength	Sum	Rank
Relative Weight	0.14	0.14	0.14	0.14		
Concepts						
Flatbed with extendable sides	+1	0	0	0	0.14	1
Basic wooden dolly	-1	+1	+1	-1	0	2
Flatbed metal dolly	0	-1	-1	0	-0.29	3
Metal tube dolly	0	0	0	0	0	2
Flatbed dolly with side flaps	0	-1	-1	0	-0.29	3
Convertible	0	-1	-1	0	-0.29	3
Metal frame w/ ramp that locks into place	0	0	0	0	0	2

Table 8. Handle Pugh Chart

We made two Pugh Charts to confirm that the top ranked concept was truly the best concept that we used for the handles on our product.

Iteration 1:

Criteria	Size	Weight	Cost	Strength	Sum	Rank
Relative Weight	0.5	0.5	0.5	0.5		
Concepts						
Standard handle bars	0	0	0	0	0	2
Handle that folds down into platform	+1	0	0	0	0.5	1

Iteration 2:

Criteria	Size	Weight	Cost	Strength	Sum	Rank
Relative Weight	0.5	0.5	0.5	0.5		
Concepts						
Standard handle bars	-1	0	0	0	-0.5	2
Handle that folds down into platform	0	0	0	0	0	1

7. Concept Improvement through Creativity Methods

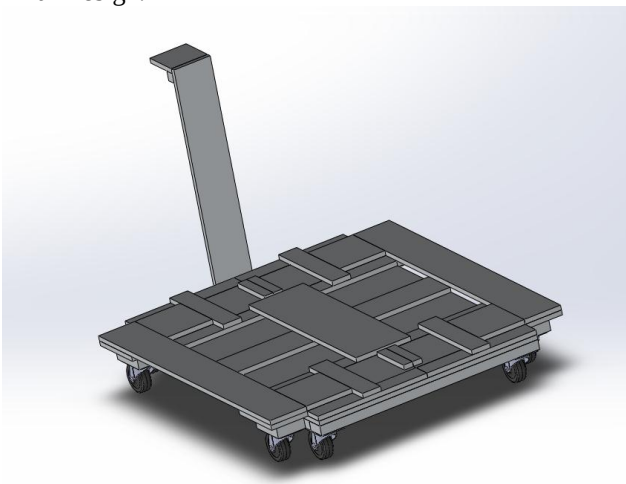
Below is our TRIZ chart that we created to find more creative ways to improve our product. The areas that needed to be improved included the stability of the object, the strength, and the reliability.

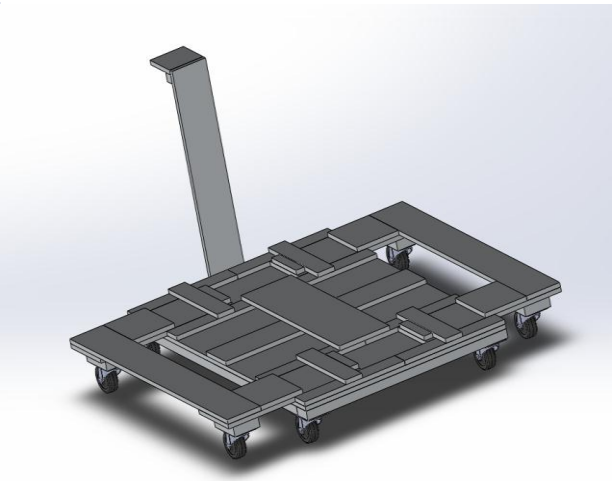
Table 9. TRIZ Chart for Dolly

Feature to Improve	Contradiction	Principles	Design Solutions for Principles
13-Stability of object	37-Complexity of Control	35-Physical or Chemical properties 22-Blessing in disguise (Harm to Benefit) 39-Inert environment 23-Feedback	35-make platform slightly flexible so it bends and all the wheels are touching the ground. 39-make the material a type of metal that does not rust or corrode easily.
14-Strength	31-Harmful side effects	15-Dynamisn 35-Physcial or Chemical properties 22-Blessing in disguise (Harm to Benefit) 2-Separation or extraction	15-add springs so the design becomes more flexible and achieves dynamicity. 2-remove extra set of wheels.
27-Reliability	25-Waste of time	10-Preliminary action 30-Flexible films or membranes 4-Asymmetry	30-cover the platform with a thin flexible membrane so it adjusts as the dolly platform does but keeps the objects from moving around on top. 4-change shape to make it easier to maneuver and go around tight corners.

8.0 Final Design

Final Design:





The final design of the dolly is significantly different than the design of many other basic dollies. The first and most noticeable change is the ability for the dolly to expand in width. Our final design has four arms that extend from the main body of the dolly to increase its surface area. This allows the dolly to carry and transport a range of different sized objects. Instead of the average two big wheels on a dolly, our dolly has eight wheels to increase its carrying capacity. Because of the addition of the wheels, it is able to carry a heavier load than a dolly with fewer wheels. The dolly has several layers of material in order to allow pieces to slide in and out and secure these pieces from falling off of the dolly. The material the dolly is made of is aluminum alloy 6061. This is because this material is corrosive proof, light weight, strong and durable. This metal is also produced in North America, which allows the dolly to be advertised as a made in America product.

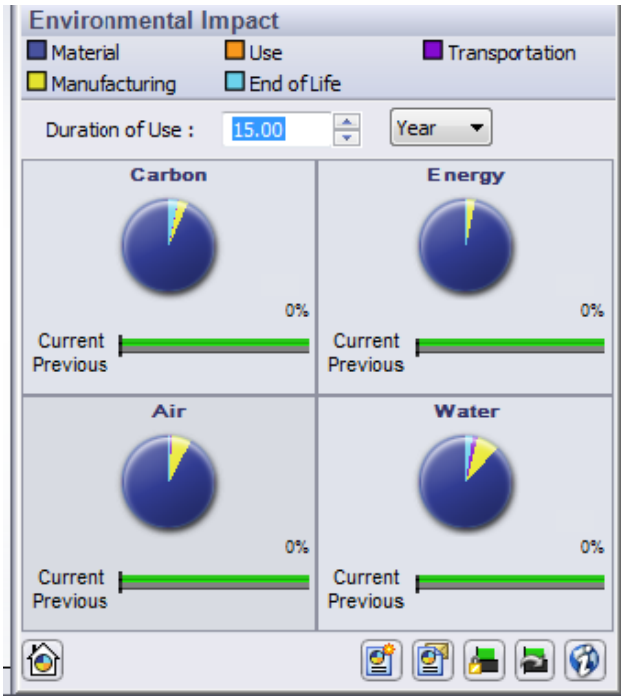
8.1 Materials and material selection

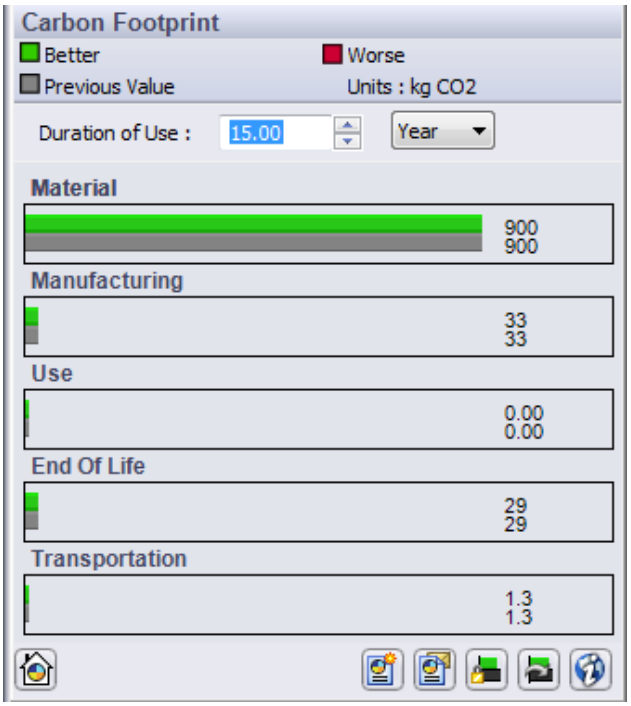
We chose to go with Aluminium 6061 for our material because of the properties that it possesses and that it is produced here in North America. Aluminium 6061 is very resistant to corrosion even when the surface is abraded. This metal also performs well under high pressure and is weldable.

Figure 7. Decision Matrix for Material

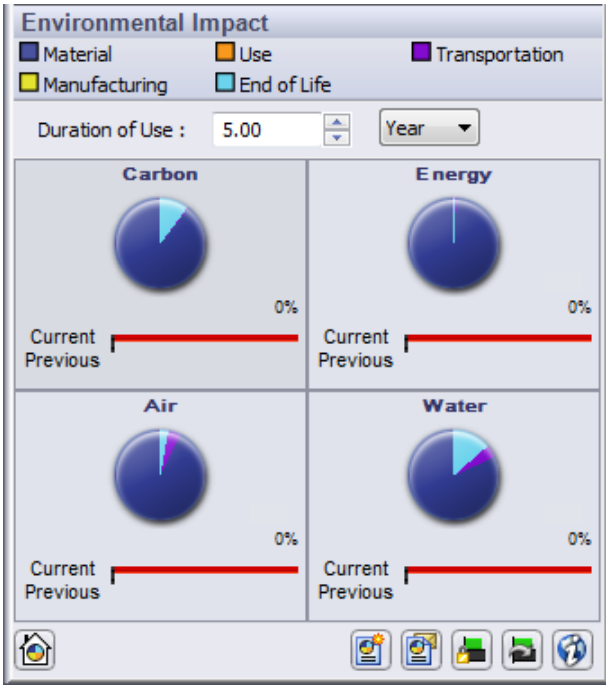
Criteria	Ey (psi) 10^3	Norm.	E (psi) 10^3	Norm.	d (lb/in^3)	Norm.	Total
Weights	0.5	0.5	0.2	0.2	0.3	0.3	
Aluminium 6061	8	0.18	10000	0.34	0.1	0.43	0.29
Lexan 9334	9	0.2	330	0.01	0.043	1	0.42
Steel 1010	44.2	1	29000	1	0.28	0.15	0.75

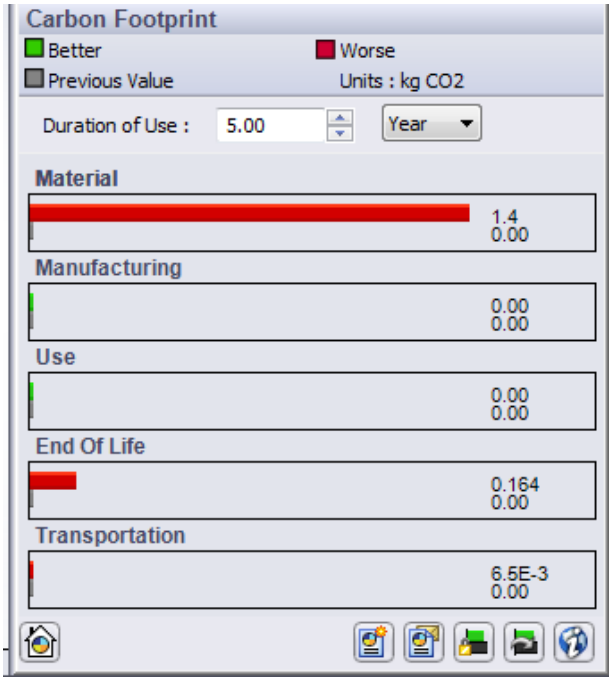
Sustainability for the cart (without caster wheels):





Sustainability for caster wheels:





8.2 List of Materials

The table below is a list of all the materials that would be needed in order to create the dolly. The total price for the cart is also listed in this table.

Table 6. List of required materials and components

Qty	Description	Catalog Number	Vendor	Total Cost
8	2" Swivel Grey Wheel w/ brake	235587	Lowe's	$34.24
36	¼-20 x ½ inch Round-Head Machine Screws	72353	Lowe's	$6.58 (50 pack)
1	½ x 36 x 48 inches Aluminum 6061 Alloy	6061	Network Metals Inc.	$332.49
	Total Cost			**$373.31**

Table 7. Contact information for suppliers of required Materials

Lowe's lowes.com 104 Valley Vista Drive State College, PA 16803 (814) 321-9130	Network Metals Inc. networkmetalsinc.com 7402 Mount Joy Drive Suite C Huntington Beach, CA 92648 (714) 654-6181

8.3 Cost & Life Cycle Cost

Since our dolly is made out of aluminium alloy 6061 it will be very weather resistant and won't corrode. It is also a very strong metal so it will stay in good condition because of these qualities that it possesses. Assuming that the dolly is used often (about two times a week), is well taken care of (stored in dry, clean areas) and doesn't have constant pressure on the tires, the bed of the dolly should last about 15 years. The caster wheels won't be able to last as long so they will need replaced about every five years. The wheels are relatively cheap to and easy to replace so there isn't much maintenance that needs to be done for the dolly.

9.0 How Does It Work & Conclusions

Overall, we believe our dolly was a success. We were able to create a product that was easy to use and store but that also became large enough to move a refrigerator. The product is safe to use, having the locks on the wheels to keep the dolly from moving on slanted ground and also by having a design that didn't allow the extendable arms to be completely pulled off. We believe that we were able to fulfil the customer's needs for this product. Since the aluminium alloy 6061 is manufactured here in North America, it wouldn't be difficult to find a company that would be willing to produce this dolly. It's a fairly simple design that won't be too tough to manufacture.

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Appendix

Questions from survey:

- Are you a male or female?
- How old are you?
- What is your profession? Please be specific.
- What types of items would you be moving with this product?
- How much would you be willing to pay for a product like this?
- How portable would you want this item to be? Weight, size, shape, etc. Please be specific.
- Do certain physical features appeal to you. If they do, which ones and why?
- How often do you think you will be using this product.
- Do you know of any products similar to this, if there are can you name any?
- On a scale from 1 to 10, 10 being the highest, how often do you think you will use this product?