



UNIVERSITAT  
POLITÈCNICA  
DE VALÈNCIA



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School of Design Engineering

Design of a shopping cart for personal use with modular compartments.

End of Degree Project

Bachelor's Degree in Industrial Design Engineering and Product Development

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ACADEMIC YEAR: 2022/2023



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# UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Escuela Técnica Superior de Ingeniería del Diseño

## **Design of a shopping cart for personal use with modular compartments**

Final Degree Project

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Degree in Industrial Design Engineering and Product  
Development

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**Tutor:** Peter Wong

Valencia, July 2023

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# 1. Report

## 1.1. Objective

Grocery shopping is a chore that most of the population has to do regularly. The objective of this project is to design and develop a shopping cart for personal use that facilitates the process of grocery shopping and allows the user to carry the groceries in an optimal way.

Finally, the resulting product must be viable in all of the different aspects. It must achieve all of the requirements and solve the problems that created the need for the product. It must be possible to manufacture through conventional processes. It must follow safety and environment guidelines. Lastly, it must also be economically viable and have a sensible production cost.

## 1.2. Scope of the project

This project will include all of the necessary phases for the design and development of a viable product, ranging from the prior investigation, user observation and market research all the way up to the detailed design and technical specifications of the product.

**Research and problem statements:** The objectives of the project are set and the scope of it is defined, followed by the user observation, the research of the product sector, the market research of existing products, as well as the investigation about the legal requirements for its manufacturing and commercialization.

This part concludes with the product specifications and the problem statements.

**Concept design:** This part of the project will represent the creative phase of the design process. It will take into consideration all of the necessary information obtained in the previous phase in order for it to be implemented in the ideation process. Different concepts will be presented through sketching for a later evaluation and comparison based on the previously established criteria. Later, one of the concepts will be chosen for further development along with the proper justification of that choice.

**Technical development:** The detailed design of the product takes place taking into account standardized parts, CMF and manufacturing processes. This also involves the technical drawings and dimensioning, the final product visualization as well as the budget.

**Project conclusions:** All of the previous parts will conclude in the different contents presented in this project: The memory, technical drawings, specifications and budget.

## **1.3. Background**

In this part, a background study is presented to better understand the context and nature of both the product typology itself and the environment where it is used. In order to do that, this project includes some insights about the behavior behind grocery shopping and later, more specifically, the history of the shopping cart as a product.

### **1.3.1. Behavior behind grocery shopping**

Grocery shopping has become a normalized and recurrent task among mostly everyone. It is safe to say that nowadays it would be difficult to find a single person who was not aware of grocery shopping. According to Darko Radic (2023), primary grocery shoppers make 1.6 shopping trips weekly. That means that in today's day and age, it becomes part of most peoples' weekly routine.

On a closer look, however, grocery shopping is not only the most convenient way for someone to get food, in a lot of cases it is almost like a ritual. Each person has their very unique way of grocery shopping, with a lot of different variables: from the supermarket they chose or the products they buy, to the path they follow or what they use to carry their groceries.

The behavior behind grocery shopping is something that must be looked at in order to better understand the context and the user so that, in the future, the proper considerations are being made when designing a product.

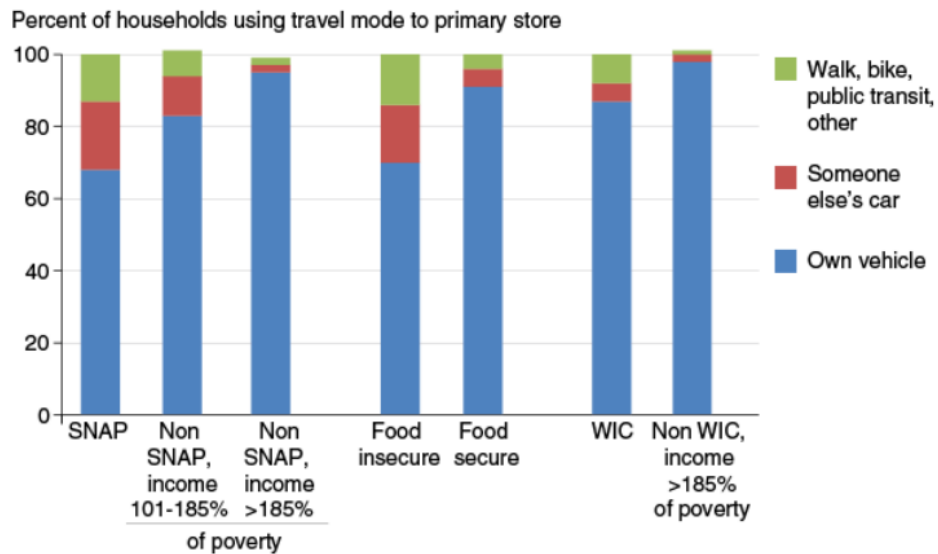
### **Equality**

Different backgrounds, incomes and lifestyles have an effect on how people do certain things and go to certain places, however, a study by Rosanna Morrison and Lisa Mancino (2015)

suggests that grocery shopping is an activity that is not heavily affected by the difference in socioeconomic status, and proves that excluding the type or quality of the products that are bought, there are other aspects that result to be very similar.

For example, the transportation modes to a primary grocery store for participants of the study did not vary a lot between those with higher incomes and the ones with lower incomes.

**About one-third of SNAP participants and food-insecure households use someone else's car or they walk, bike, or use public transit to get to the grocery store**



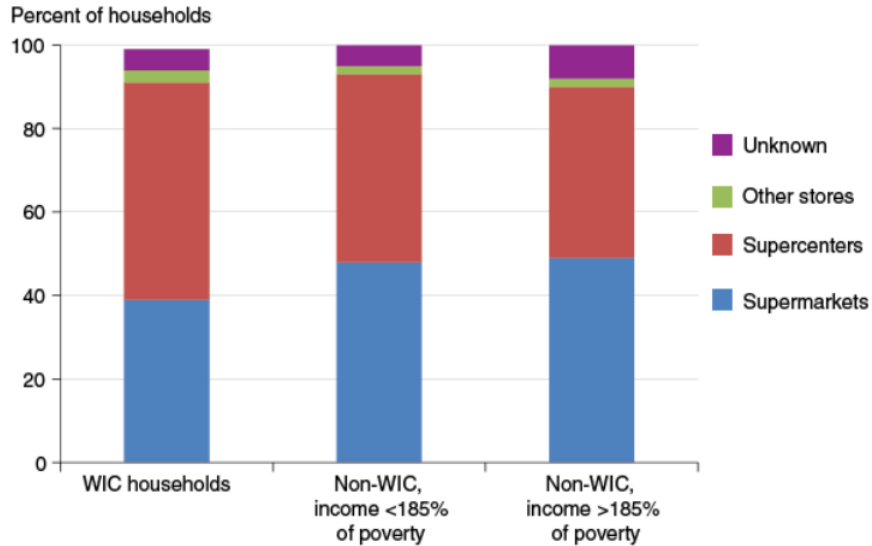
SNAP = Supplemental Nutrition Assistance Program.  
WIC = Special Supplemental Program for Women, Infants, and Children.  
Notes: Poverty refers to the Federal poverty threshold. Transportation modes used by non-SNAP households with incomes below poverty were not statistically different from those of SNAP households. Some totals do not sum to 100 due to rounding.  
Source: USDA, Economic Research Service estimates using data from the National Household Food Acquisition and Purchase Survey, collected April 2012-January 2013.

**Image 1:** Chart indicating modes of transport which participants used to go grocery shopping.

As seen in the graph, most of the participants used their own vehicle as travel mode to their primary store, and although the food secure group had a higher percentage in that section, the rest of the groups did not fall very far behind.

The next variable is a matter of location:

### WIC households seek out supercenters for their primary grocery shopping



WIC = Special Supplemental Nutrition Program for Women, Infants, and Children.  
Notes: Poverty refers to the Federal poverty threshold. Some totals do not sum to 100 due to rounding.  
Source: USDA, Economic Research Service estimates using data from the National Household Food Acquisition and Purchase Survey, collected April 2012-January 2013.

**Image 2:** Chart indicating locations where the participants went grocery shopping.

Similarly, when observed in what places the participants went to do their groceries, the study states that “Overall, roughly 44 percent of households did their primary grocery shopping at supercenters, while another 45 percent used supermarkets for their primary shopping. Just 5 percent of households did their main shopping at other retailers. For the remaining 6 percent of households, it was not possible to identify or classify their primary store”. That data is once again very similar among the different groups of participants.

The previous examples suggest that the way to go grocery shopping, as well as the places where it is done, are a common trait among many people, which may interpret this as a mostly equal task for everybody.

### Planning

“Shoppers do not go into the store and pick out food randomly. The shopping trip is the tip of the iceberg in terms of the work involved in feeding families. Food provisioning generally involves a planning phase...” (Koch, 2012)

That fragment of *A Theory of Grocery Shopping: Food, Choice and Conflict* (Koch, 2012) introduces a segment in the book where different levels of planning are explained.

One of the reasons for planning ahead what to put on the shopping list is saving money. Many shoppers make meal menus in order to both have an organized schedule, so that there is not as much time lost in preparation, and to save money by knowing exactly the products needed and not buying by impulse. Other buyers also consider health issues when planning their food list, either for them or their kids, partners, parents... Sometimes there are products that have to be bought in a specific store in order to assess medical conditions or allergies.

There have also been buyers who have changed their shopping habits due to a new, more time consuming job, moving homes or having kids. Since grocery shopping is a task that results in being versatile for most of the buyers, it allows them to fit this task into their schedule. They do not have to adapt their schedule to grocery shopping.

Many buyers have also mentioned a distinction between different shopping ways depending on the day or intention, for example, doing a “big shopping” during the weekend, buying the main items just to complement it with a “smaller shopping” throughout the week to pick up missing items, or those with a close expiration date.

### **Family**

When being in a household, grocery shopping is a task that has to take into consideration the different parts of the family, not only by adapting the food that is brought home, or the schedule of the different family members, as seen before. The shopping labor is also a chore that is negotiated, some shoppers would rather contribute by having different duties, while others take it as their responsibility because their partners might not have the skills needed or might be too impulsive. In other occasions, grocery shopping grants a position of control because the buyer, to some degree, gets to dictate what the rest of the household gets to eat.

Buyers that are part of the household also have less flexibility over grocery shopping, they experience more anxiety than the single shoppers and they tend to spend more time planning.

On a different note, many adults also make their children take part in the activity, and state that by doing that, the children also help in a chore and feel involved by pushing the cart or grabbing some punctual products like their favorite snacks.

### **Safety**

Given that grocery shopping is a common and recurring task, and that it may involve all of the components in the family unit, safety is also a key factor in this situation, and the design of some products for grocery shopping, such as shopping carts, take part of that responsibility.

In *The effects of shopping cart design and prior behavioral history on children's standing in cart seats* (Harrell, 1995), the author talks about the many injuries to children caused by falling from the shopping cart. It was found that for the children that were inside the basket, risk of injury was significantly higher in comparison to children in the cart seat or outside of the cart.

The experiment agrees on the idea that:

“...the design features found in certain styles of grocery carts, and cart seats would make it more difficult for a child to stand in the cart seat and injure himself by falling or jumping from the seat or by climbing into the basket area.”(Harrell, 1995)

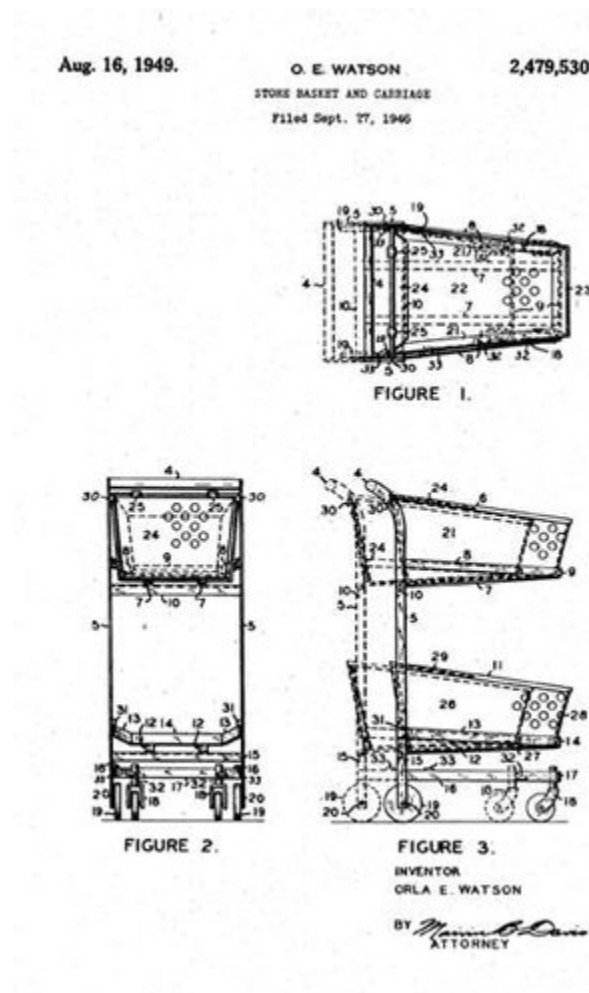
### **1.3.2. History of the shopping cart**

The origins of the shopping cart can be tracked to the late 19th century. In that era, many stores began a transition to a “self-service” business model. This shift necessitated a convenient means for customers to carry their purchases. In 1937, Sylvan Goldman, an Oklahoma City grocery store owner, recognized this need and set out to design a solution.

His idea was to make a combination of a folding chair, taking advantage of the product's functionality, and a basket on wheels, in order to be able to carry products inside. That was the first approximation to the shopping cart that we know about today. The main purpose of the invention was to remove the burden of carrying heavy groceries, so with weight being the

biggest problem, Goldman contacted a local mechanic, Fred Young, and both developed a prototype that consisted in just a wire basket on wheels with a folding seat. The invention found success very quickly, customers really appreciated the ease and comfort while shopping and it began gaining popularity, getting the attention of designers and engineers that wanted to improve its functionality and ergonomics. (Dolcini & Frazelle, 2019)

Orla Watson, a renowned industrial designer, played a significant role in this regard. She was responsible for the implementation of innovations to the design of the shopping cart, such as the child seat. She explored the maneuverability of the cart and incorporated swiveling wheels and a more ergonomic handle to enhance user comfort. (Watson, 2010)



**Image 3:** Original patent documents of Orla Watson showing design of the nesting feature.

Today's shopping carts have evolved significantly, incorporating features such as adjustable handle heights, locking mechanisms, and increased storage capacity. Designers continue to explore new possibilities, considering factors such as sustainability, smart technologies, and seamless integration with digital shopping experiences.

### **1.3.3. Conclusions**

In conclusion, grocery shopping has become a notable task for the general public, and the shopping cart is one of the many products that go unnoticed by the majority of people, while being at the same time a very important component in this universal task.

It is a perfect example of how some products are created, become ubiquitous in society and keep evolving “quietly” through generations while adapting to the needs of its users, while never being noticed or questioned by them.

## **1.4. User study**

In order to understand the behavior, problems and needs of the potential users of the product of this project a user observation has been carried out.

The user observation consisted of following a couple of persons (our test subjects) on a journey to the supermarket when they needed to go grocery shopping. By doing that, it is possible to make objective observations and gather unbiased information about the whole process.

It has been established that the information obtained by an uninvolved observation would more likely be more reliable than insides gathered from surveys or interviews.

### **1.4.1. User observation**

The case study is composed of the observation and annotation of the actions of two test subjects while grocery shopping: “Test subject #1: Diego” and “Test subject #2: Cesar”. They are presented and explained in the next part.

The first user is Diego, a 21-year-old male student going on his weekly grocery shopping. He is going into one of the supermarkets from the German origin supermarket chain “Lidl”. The



store is located in Edgware, London, UK and the user had to take a bus on a 15 minute trip in order to arrive at the destination.



**Image 3:** Test subject #1 grabbing a shopping cart.

Once at the destination, the user wants to grab a shopping cart located outside of the store in order to put the groceries there. He realizes that in order to use one of the shopping carts he must insert a coin into a slot for coins located on the cart handle. As he did not carry any coins, he was forced to ask a friend for a coin.





**Image 4:** Shopping cart of Test subject #1 left alone.

Since there are more people at the supermarket, the user has to move through the aisles taking into account the size and shape of the shopping cart in order not to hit anyone.



**Image 5:** Test subject #1 bending for a product.



On many occasions, the user has to leave the cart alone in a different location in order to go and grab something in an aisle where the access with the cart would be difficult due to the location of the product or the amount of people/ shopping carts nearby. The user had an established route through the store and whenever he had to deviate from the main path that he was following he would not take the whole cart with him and he would also leave the cart alone.



**Image 6:** Test subject #1 placing the groceries in his bag.

At this particular supermarket, there isn't much space at the checkout for buyers to organize their groceries after paying for them. That means that the user has to move towards a designated place after paying in order to arrange and store the groceries. The user puts all of the groceries in big, polyethylene bags from a home furnishings retailer, IKEA.

The second user is Cesar, a 22-year-old male student going to a Morrisons supermarket, located close to his house. He arrives there by foot. He only needs to buy some spare things that he forgot while doing his big grocery shopping.





**Image 7:** Test subject #2 grabbing a basket.

The user grabs one of the wire mesh baskets located right after the entrance of the supermarket.



**Image 8:** Test subject #2 holding a basket.

The user tries to grab the basket by the designated handle in a comfortable way





**Image 9:** Test subject #2 choosing a product.

The user has to manually carry the basket along the aisles, as well as all of the products he decides to put inside it. Due to the geometry of the basket, the user has to grab it while tilting his arm so that the basket doesn't constantly hit his leg





**Image 10:** Test subject #2 looking for a product.

While some of the products the user grabs immediately, he needs some time to decide on others. He does that while still carrying the basket.



**Image 11:** Test subject #2 leaving the full basket on the ground.



After some time standing with the basket and thinking about his decision, the user puts the basket on the ground.



**Image 12:** Test subject #2 checking out at self check out.

The user decides to use the self checkout and proceeds to manually take out all of the products and scans them one by one.



**Image 13:** Test subject #2 using his own bag and paying.

The user pays with his phone and places all of the products into a tote bag that he brought with him before taking the basket back to its original place.

### **1.4.2. Target user definition**

Following a similar demographic to the test subjects of the user observation the product of this project aims for a target user with the next features:

- Young
- Student
- Organized
- Efficient
- Responsible
- Confident
- Direct



### 1.4.3. Creation of a “persona”

Once defined the target user, a user “persona” has been elaborated as an example in order to better explain and help to visualize the type of person the product of this project would be aimed towards.

## Mark Scott

**"I'm working hard for the future I want. I don't like wasting time."**

Age: 20  
Occupation: University student  
Family: 1 sister  
Location: London, UK  
Character: The Likable Nerd

**Organized** **Calm**  
**Overthinker** **Hardworking**

### Bio

Mark is one of the top neuroscience students at Middlesex University. He spends most of his time among books, whether it is studying for an important exam or learning something new from an old encyclopedia he got from the library. He is a very focused young man that gets bored with easy tasks and tries to optimize every aspect of his life.

### Goals

- To graduate top of the class
- To get accepted to his dream job

### Frustrations

- Too much time spent on tedious tasks.
- Too many projects to manage and think about.
- If he doesn't do it, it's not well done.

### Motivation

Price	Low
Comfort	Medium
Convenience	High
Looks	Medium
Branding	Low

### Personality

Introvert	Extrovert
Analytical	Creative
Loyal	Fickle
Passive	Active

### Preferred Channels

Chrome	Medium
Mobile	High
Email	High
Traditional Ads	Low

### Brands

WUOLAH  
audible an amazon company

WIKIPEDIA Free Encyclopedia

**Image 14:** Image of a hypothetical persona designed for this project.

## 1.5. Problem statements

Taking into consideration the previous conclusions, the next step is writing down the main problem statements that derive from the user observations. They are done using “How might we” statements, a process that consists of turning challenges into questions that can be solved. The most important ones are:

- How might we create a product or a method for the user so that unlocking the shopping cart is satisfied, taking into account that the user might not have a coin with them.
- How might we create something to replace the shopping cart for the user so that the need for using the shopping cart is eliminated, taking into account that the user needs a place to carry the groceries.
- How might we create an object for the user so that grabbing a basket is unnecessary, taking into account that the user needs a place to carry the groceries.
- How might we reduce the size or change the shape of the shopping cart for the user and others around them so that the blocking of the aisle with the cart is eliminated, taking into account that the user might not want to carry the shopping cart everywhere.
- How might we improve the packing away process for the user and the cashier so that packing the products from the cash register is fast and easy is satisfied, taking into account that the cashier needs the buyer to put the groceries away fast.
- How might we facilitate putting the groceries away for the user so that they can do it in a fast and easy way , taking into account that when they get home they have to leave the bags around.
- How might we clean the handles or create our own for the user so that grabbing a clean and pleasant material is satisfied, taking into account that many people might use the same product.

- How might we help the user so that reaching the top shelf is satisfied, taking into account their height or strength.
- How might we shorten or eliminate the way to leave the carts for the user so that not walking a lot is satisfied, taking into account the places to leave the cart are far away.
- How might we organize the groceries (mostly bottles and heavy products) for the user so that a stable structure is satisfied, taking into account the products might move inside the bag.
- How might we differentiate the shopping carts for all the users so that distinguishing the carts is satisfied, taking into account they all look the same.
- How might we protect the vegetables for the users so that having clean vegetables is satisfied, taking into account the conveyor belt is dirty.
- How might we influence the movement of the cart for all the users so that having a stable device is satisfied, taking into account the carts don't have stops or working wheels.
- How might we keep the common carts clean for all the users so that having a clean cart is satisfied, taking into account the carts are dirty.
- How might we make the most out of the space for all the users so that a smooth movement among the aisles is satisfied, taking into account the space on the aisles is tight.
- How might we protect the groceries for the user so that having untouched groceries is satisfied, taking into account animals or things that can touch the food.

- How might we arrange the groceries for the user so that fitting everything in a small space is satisfied, taking into account the user needs more space.
- How might we eliminate the need for leaving a trolley away for the user so that taking less time is satisfied, taking into account that currently the user needs to put their bags and trolley away.
- How might we create a protective solution for the vegetables so that protecting the vegetables is satisfied, taking into account the user doesn't want to always use plastic bags.
- How might we design a product or a system for the user so that space usage is satisfied, taking into account that it takes a lot of space at home.

## 1.6. Market research

In this segment, the market research that has been carried out is presented. The market research consists of different personal-use shopping carts, that are similar in type to the product to be developed. They are personal shopping carts that allow the user to carry their groceries in a more comfortable and efficient way than plastic or cloth bags.

### 1.6.1. Existing personal use shopping carts

The next shopping carts are examples of the type of product that will be developed further. All of them help to understand the state of the market and allow for the comparison between them and the further establishment of requirements and preferences of the product.

#### ARIANA Lightweight 2



**Image 15:** Ariana Lightweight 2 shopping cart, Amazon.com

**Price:**

22.95£

**Dimensions:**

Hight: 95 cm

Width: 38 cm

Depth: 25 cm

**Weight:**

1.70 Kg

**Capacity:**

61L

**Materials:**

Its different parts consist of an outer frame made out of steel extruded tubing, a waterproof cloth bag and an injection molded plastic handle.

**Description:**

This shopping cart presents one of the simplest designs of the market, it is also the most recognizable model of them all. It has a big bag on a metal frame, firmly fixed with Velcro straps, where the groceries can be carried. It also has two complementary pockets, one on the front and one on the back. It can be folded flat when not used, the wheels can be easily detached and the frame, as well as the bag can be folded.

It has good reviews among the different platforms where it is sold (such as amazon and ebay) that often mention its low price, simplicity and capacity.

## Hoppa Lightweight 4



**Image 16:** Hoppa lightweight 4 shopping cart, Amazon.com

**Price:**

42.99£

**Dimensions:**

Hight: 80 cm

Width: 33 cm

Depth: 24 cm

**Weight:**

1.82 Kg

**Capacity:**

64L

**Materials:**

The cart's parts consist of an iron pipe tubing frame, a polyester microfiber material bag, and a soft padded handle.

**Description:**

The Hoppa Lightweight 4 is a personal shopping cart with four wheels that claim to “move on curbs and uneven paths very easily” and a polyester bag that fits into a square metal tubing frame.

It has a soft, height-regulated handle and the wheels can also be clicked off easily. The bag can be detached for cleaning purposes. It additionally offers a 1 year guarantee replacement service covering all manufacturing defects.

**Popolic Folding Shopping Trolley**

**Image 17:** Popolic Folding Shopping Trolley, Amazon.com

**Price:**

33.99£

**Dimensions:**

Hight: 49 cm

Width: 40 cm

Depth: 39 cm

**Weight:**

3.61 Kg



**Capacity:**

40L

**Materials:**

This model consists of a polypropylene box, rubber wheels and an aluminum alloy handle.

**Description:**

The Popolic Folding Shopping Trolley is a small, compact and resistant personal shopping cart characterized by a small rigid black box that can be folded on top of four small 360 degree wheels. It can handle 35 kg of weight. Additionally, it has an aluminum alloy handle that can be adjusted to three heights (63cm, 80cm, 102cm) with a press of a button.

Different reviews suggest that the cart is rigid but because of its small wheels it moves around inconsistently and due to its shape it lays close to the ground, which forces the user to bend over every time.

## Clax Trolley



**Image 18:** Clax Trolley, Clax.com

**Price:**

215£

**Dimensions:**

Hight: 103 cm

Width: 89 cm

Depth: 55 cm

**Weight:**

7 Kg

**Capacity:**

46L per box

**Materials:**

The frame is made out of aluminum, with a plastic handle and the boxes on top of the structure are made out of injection molded plastic. The wheels are made of rubber.

**Description:**

This is one of the most robust and premium models in the market, it consists of a big foldable frame with two compartments for the boxes that are placed on top of it. These two compartments can be folded separately in order to carry taller objects on the bottom compartment. It has two big wheels on the back and two 360 degree wheels on the front to allow

better movement, as well as a brake for the wheels. The wheels can also be detached for better storage. The polypropylene boxes are 53 x 37 x 27 cm and cannot be folded. The big majority of reviews are positive and highlight the strength and ease of use, as well as the cart being sturdy.

### **VersaCart Transit Folding Shopping Cart**



**Image 19:** VersaCart Transit Folding Shopping Cart, Amazon.com

**Price:**

84.99£

**Dimensions:**

Hight: 95 cm

Width: 57 cm

Depth: 47 cm

**Weight:**

4,08 Kg

**Capacity:**

90 L

**Materials:**

The folding bag is made out of nylon and the frame is made of steel and PVC.

**Description:**

This model consists of a foldable “ X-shape” plastic frame and a detachable nylon bag attached by straps in the middle of the frame that also has a lid to cover the groceries. It has four double wheels as seen in the image that are easy to mount and dismount.

The cart can support up to 55 kg of weight and has two separate PVC handles made to be pushed rather than pulled. The reviews of this product seem to focus a lot on the positive price-to-value of the product.

## Scout Cart



**Image 20:** Scout Cart, Amazon.com

**Price:**

369£

**Dimensions:**

Hight: 102 cm

Width: 62 cm

Depth: 63 cm

**Weight:**

13 Kg

**Capacity:**

45 L

**Materials:**

The main materials range from aluminum in the frame, steel wire with powder coat in the boxes, plastic joints and rubber wheels.

**Description:**

This very resistant model is also located at the top tier level of personal shopping carts. It has an adjustable height through its aluminum tubing, removable steel wire baskets and big 25 cm wheels at the front and 18 cm wheels at the back equipped with a parking brake. The frame can be folded without the baskets to occupy less space.

Many reviews talk positively about the maneuverability of the cart and the ease to use when going grocery shopping with a car.

**Playmarket We Go Basic**

**Image 21:** Playmarket We Go Basic shopping cart, Amazon.com

**Price:**

126£

**Dimensions:**

Hight: 97 cm

Width: 68 cm

Depth: 48 cm

**Weight:**

4.7 Kg

**Capacity:**

50 L

**Materials:**

The frame is made out of extruded aluminum, the joints are made of plastic and the fabric of the bag is waterproof.

**Description:**

The frame of this model can be folded up to 48 x 33 x 64 cm. The model is equipped with a rotating handle to regulate height that is also covered by a foam part for easy and comfortable grip, two wheels on the back and two double rotating wheels on the front. The bag located inside is easy to remove and wash and attaches to the frame with velcro. It also has a back pocket. It comes in 4 different colors: Red, black, mist and navy and has positive reviews over all.

## VOUNOT Foldable Shopping Trolley



**Image 22:** VOUNOT Foldable Shopping Trolley, Amazon.com

**Price:**

47£

**Dimensions:**

Hight: 104 cm

Width: 43 cm

Depth: 59 cm

**Weight:**

3.5 kg

**Capacity:**

35 L



**Materials:**

Metal tubing frame, nylon bag.

**Description:**

The structure of this model consists of a metal tubing frame that holds a removable waterproof shopping bag with thermal insulation. It also has a folding resting seat attached that can support a weight of 95 kg.

There are 6 wheels, 3 on each side forming a triangle in order to make climbing stairs easy. The 2 fabric bands allow taking it as a backpack. This last feature and the wheel arrangement for the stairs are the most mentioned among the reviews.

### 1.6.2. Comparative table

All of the relevant information recorded from the previous part is displayed in the table below comparing the most important aspect of each chosen model. This helps to visualize the information in an easier way.

**Table 1:** Comparison between the principal personal shopping carts in the market.

Name	Image	Price	Dimensions	Weight	Capacity	Materials	Features
ARIANA Lightweight 2		22.95£	250 x 380 x 950 mm	1.70 kg	61 L	Steel tubing and polyester	Simple design
Hoppa Lightweight 4		42.99£	800 x 330 x 240 mm	1.82 kg	64 L	Iron pipe tubing and polyester	Foam handle
Popolic Folding Shopping Trolley		33.99£	400 x 390 x 490 mm	3.61 kg	40 L	Injection molded plastic and aluminum	Most resistant

Clax Trolley		215£	1030 x 550 x 890 mm.	7 kg	46 L per box	Injection molded plastic and aluminum	Big capacity
VersaCart Transit Folding Shopping Cart		84.99£	950 x 570 x 470 mm	4 kg	90 L	Steel, PVC and nylon	Easily foldable
Scout Cart		369£	1020 x 620 x 630 mm	13 kg	45 L	Aluminum, steel wire, plastic and rubber	Highly compact
Playmarket We Go Basic		126£	680 x 480 x 970 mm	4.7 kg	50 L	Aluminum, plastic and fabric	Adjusting handle height
VOUNOT Foldable Shopping Trolley		47£	1040 x 590 x 430 mm	3.5 kg	35 L	Aluminum, plastic and fabric	Can be turned into a backpack

### 1.6.3 Conclusions

After the research, study and comparison of different models in the market it is possible to observe the elements that most of the carts have in common such as a metal structure encapsulating a fabric bag on some wheels.

However, all of the models have small exclusive features that differentiate them from the rest which allows a direct comparison and evaluation of what features are more useful and optimal for the design of a new one.

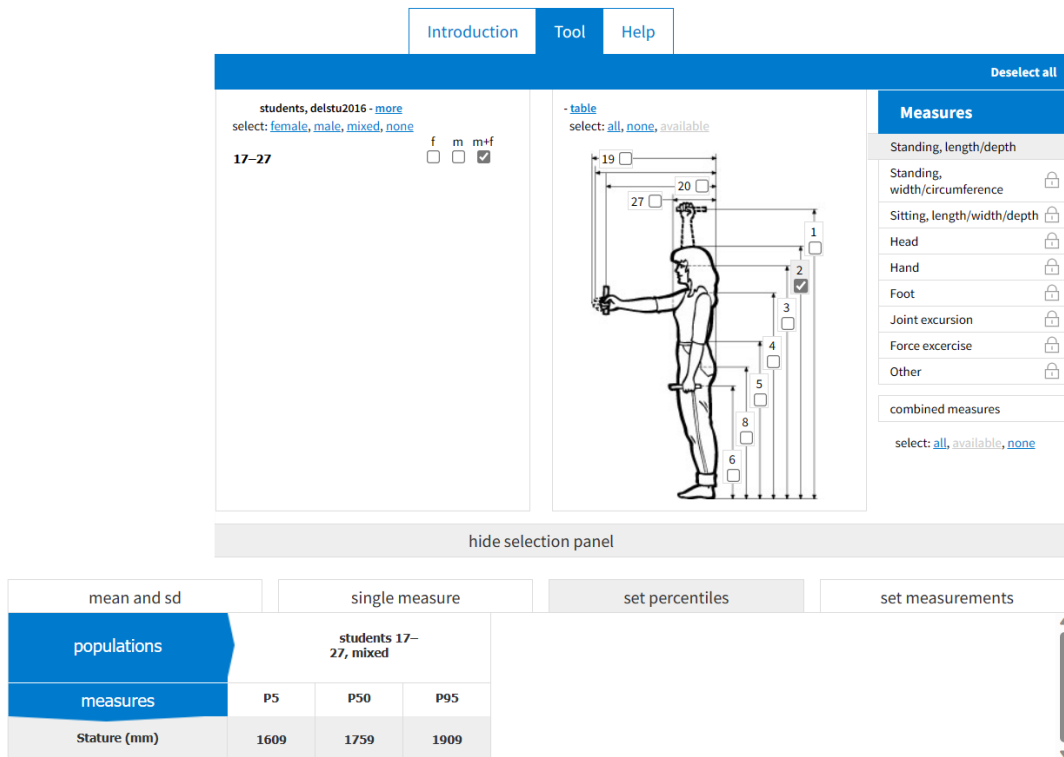
## 1.7. Ergonomics

This product will most likely have a direct physical interaction with the user. For that reason, having a look at the ergonomics of the product can be beneficial. Studying the ergonomics of the human body will make it possible to establish design requirements to consider later, in the design phase.

### 1.7.1. Product height

In the first place, considering the fact that the product is going to be moved by the user, the aim is to make that interaction as easy and safe as possible. That means that the size of the product in relation to its user must be adequate, so that the product can be used while standing up and walking.

In order to know the desired range of dimensions for the height of the product, a database has been consulted.



**Image 23:** Percentiles 5, 50 and 95 of students' height, Dined.io

While checking the Dined database it is possible to observe the 5th, 50th and 95th percentile of the stature measurements of male and female students from ages 17 to 27. Being 1609 mm the 5th percentile it is reasonable to aim for a product height no greater than that dimension.

### 1.7.2. Handle height

Since the way that the user will move the product is through an interaction with a handle, or a handle like component, it is important for that component to be located at a correct height as well.

In order to achieve that it is necessary to account for the distance from the ground to the elbow of the user while standing. Using the same database it is possible to obtain the data for the elbow height while standing.

The screenshot shows the Dined.io interface. At the top, there are navigation tabs: "Introduction", "Tool", and "Help". Below this is a blue header with "Deselect all" on the right. The main content area is divided into three sections:

- Left Panel:** Contains the text "students, delstu2016 - more" and "select: female, male, mixed, none". Below this are radio buttons for "f", "m", and "m+f", with "m+f" selected. The age range "17-27" is also displayed.
- Middle Panel:** Contains a diagram of a person standing and holding a handle. Various body measurements are indicated with numbered arrows (1-8) and checkboxes. The "5" checkbox is selected, corresponding to the "Elbow height, standing" measure in the table below.
- Right Panel:** Titled "Measures", it lists various measurement categories with checkboxes: "Standing, length/depth", "Standing, width/circumference", "Sitting, length/width/depth", "Head", "Hand", "Foot", "Joint excursion", "Force exercise", and "Other". A "combined measures" section at the bottom allows selecting "all", "available", or "none".

Below the main interface is a "hide selection panel" button. At the bottom, a table displays percentile data for the selected measure:

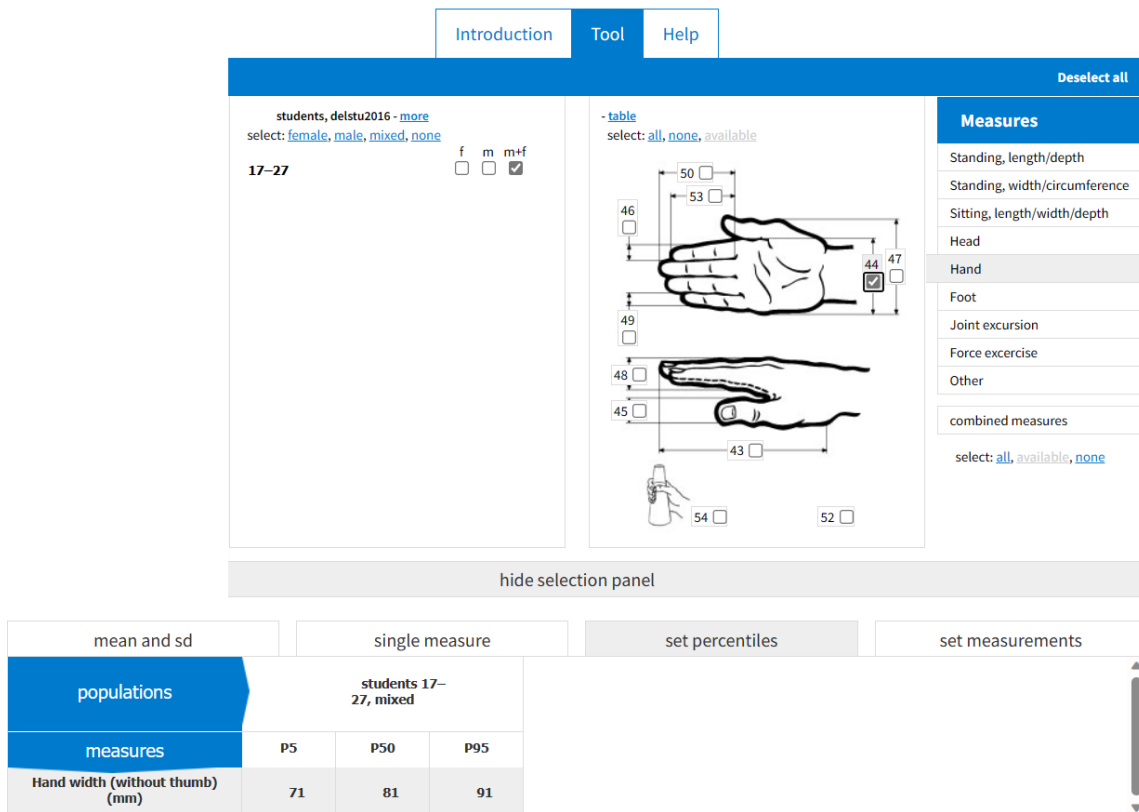
mean and sd	single measure			set percentiles	set measurements
populations	students 17-27, mixed				
measures	P5	P50	P95		
Elbow height, standing (mm)	996	1095	1194		

**Image 24:** Percentiles 5, 50 and 95 of students' elbow height, Dined.io

For this measurement, the 5th percentile is 996 mm and the 95th percentile is 1194 mm. That means that the desired handle height should fall between these dimensions.

### 1.7.3. Handle width

The handle of the product must also be wide enough to be held by both hands, to ensure better stability and more strength while moving the product.



**Image 25:** Percentiles 5, 50 and 95 of students' hand width, Dined.io

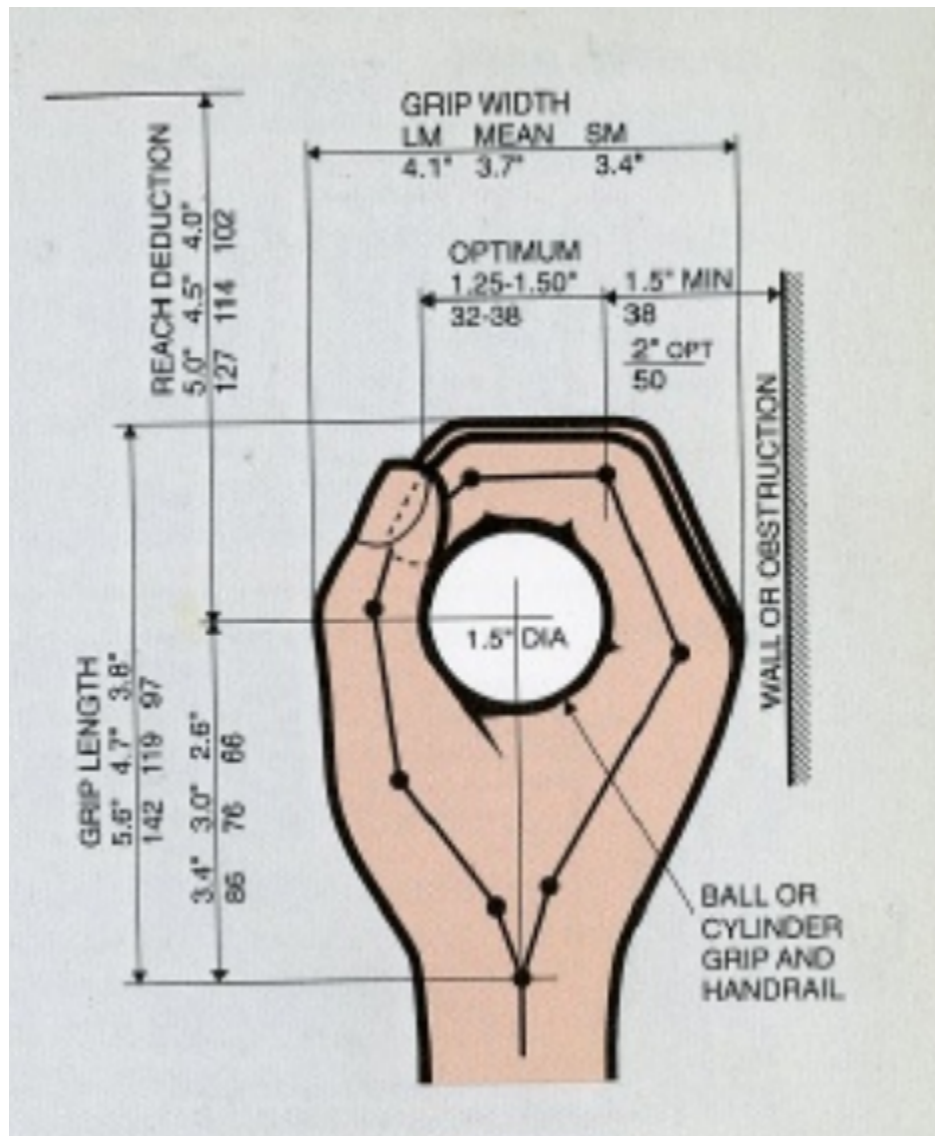
Using the same database, the data obtained shows that the 95th percentile of the measure of the width of the hand, without including the thumb, is 91 mm. If that number is multiplied by 2 (number of hands) the resultant dimension is 182 mm. That means that the handle must not be smaller than 182 mm in width.

### 1.7.4. Handle diameter

The diameter of the handle must also be taken into consideration.

Quoting Henry Dreyfuss in *The Measure of Man; Human Factors in Design* (1960):

“Hand grips should conform to use and hand motion, and all handles should feel comfortable; use rounded shapes and cylindrical grips. Thin handles cut under heavy loading. Gripping handles that are too large feels insecure.” He also provides a drawing to explain the anthropology of the hand and suitable dimensions for it.



**Image 26:** Image showing the optimal diameter for a comfortable grip, Dreyfuss, 1960

As we can see in the image above, it is stated that the optimum diameter of the grip should be between 32mm and 38 mm.

### **1.7.5. Conclusions**

By researching the anthropometry of the human body and the human hand new information has been obtained, and it will translate into ergonomic design requirements that will later condition the design process.

## **1.8. Design requirements**

Once concluded the previous segments and taking into account the information obtained from them, the product to develop must follow the next requirements and include the following features:

### **1.8.1. Usability requirements**

1. The product must be adequate to use in a closed building, specially in a supermarket.
2. The product must be adequate to use outside, on the pavement, on even and slightly uneven ground.
3. The product must be safe to use.
4. The product's size must be smaller than 100 x 50 x 80 cm.

### **1.8.2. Functional requirements**

1. The product must be able to store groceries by the user.
2. The product must make it easy to later access the user's groceries.
3. The product must be easy to move by the user.
4. The product must be easy to hold by the user.

### **1.8.3. Structural requirements**

1. The product's components must be joined in a way that will prevent them from involuntary disassembly throughout the common use of the product.
2. The product must be stable when static, it must not fall down easily or quiver.

3. The product's structure cannot cause any damage to the user.
4. The product's materials must be safe and cannot cause any damage to the user.

#### **1.8.4. Market requirements**

1. The product must be able to be commercialized in Europe.
2. The cost of the product will be within the range of the cost of the products in the market.  
That is between 25£ and 300£.
3. The product must be suitable for the middle and lower middle class.

#### **1.8.5. Formal requirements**

1. The form of the product must follow its function.
2. The product must have an intuitive visual appearance.
3. The finish of the parts that are meant to interact with the user must be pleasant to the touch.

#### **1.8.6. Ergonomic requirements**

1. The height of the product cannot be greater than 1609 mm.
2. The height of the handle should be between 996 mm and 1194 mm.
3. The width of the handle must not be smaller than 182 mm.
4. The diameter of the handle should be within the range of 32mm and 38 mm.

### **1.9. Concept design**

This segment contains all of the different parts of concept design, ranging from the different initial ideas, and the selection and development of the best ones, to the final concept further to be developed.

#### **1.9.1. Inspiration**

Taking into consideration the market research of the existing products and the field where they correspond, it is possible to observe that some of the main goals to achieve with the products are **commodity**, **ease of use** and **practicality**.



Because of this, the inspiration behind the concepts consists of simple and intuitive products that prioritize function and comfort over complexity or aesthetics.

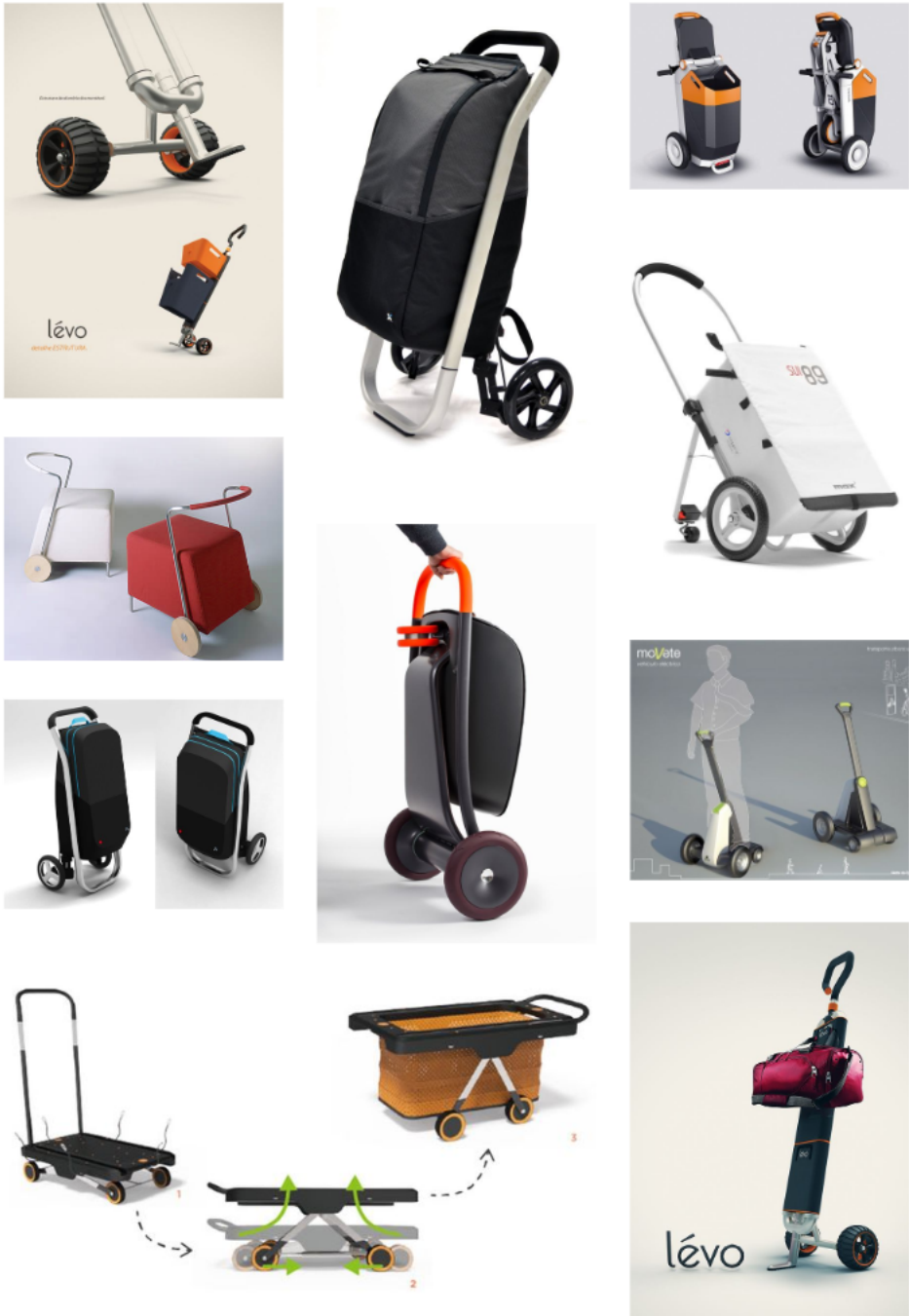


Image 27: Moodboard #1: Aesthetic inspiration



**Image 28:** Moodboard #1: Industrial inspiration

These moodboards show the structural components of shopping carts: simple shapes, combination and contrast of rigid materials like metal with cloth or plastic in the user-interaction oriented parts, a neutral color palette consisting of blacks, grays and dark tones of blue or green in contrast with yellow, red or orange parts emphasized by those bright colors. Overall an industrial type of product with some particular distinctive touches.

### 1.9.2. Concept sketching

This segment shows the initial sketching process and the first concept exploration displaying different size, geometry, function and aesthetic. This part is done in order to do a later selection and development of some of the most interesting concepts.

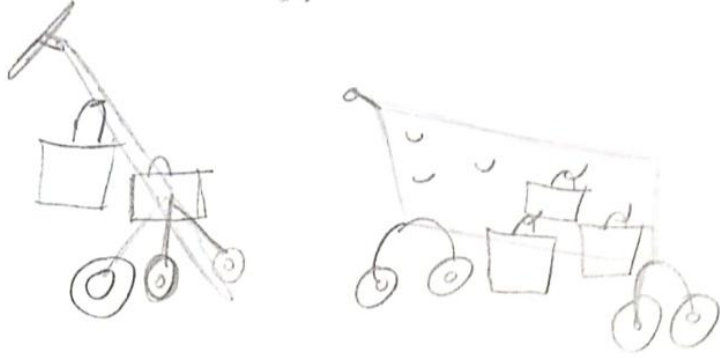


Image 29: First Sketches

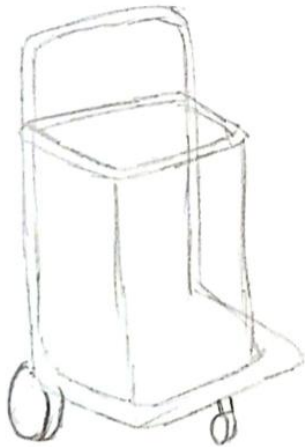
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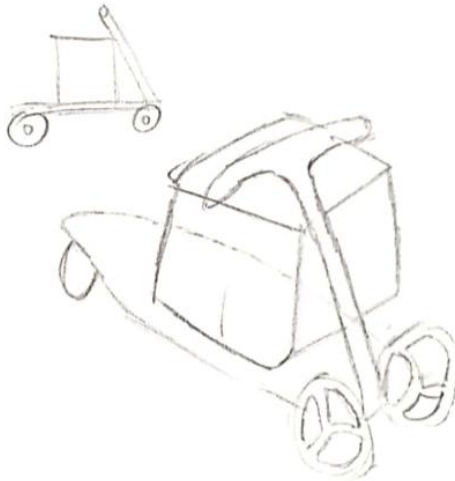
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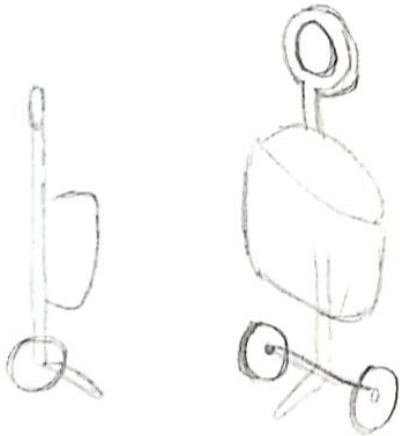
10.



11.



12.



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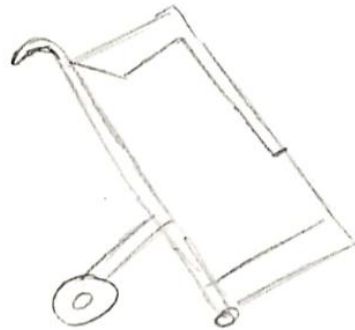
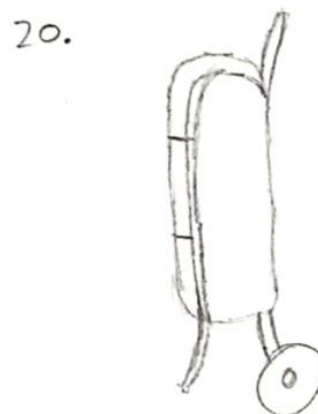
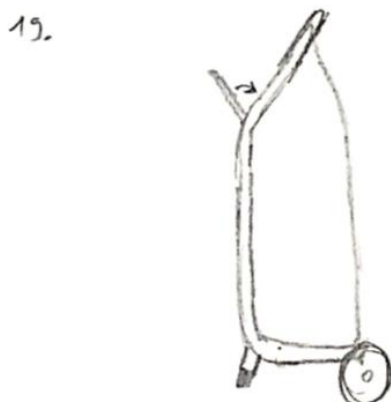
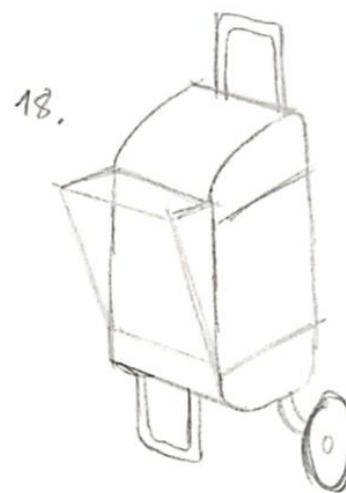
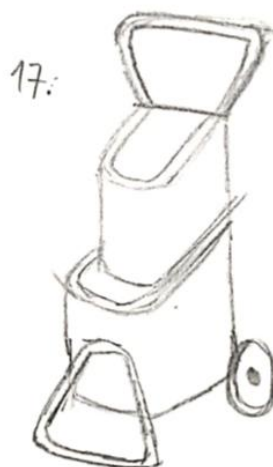
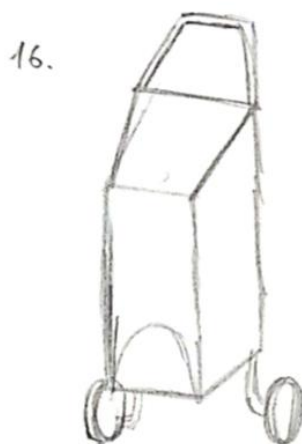


Image 30: First Sketches

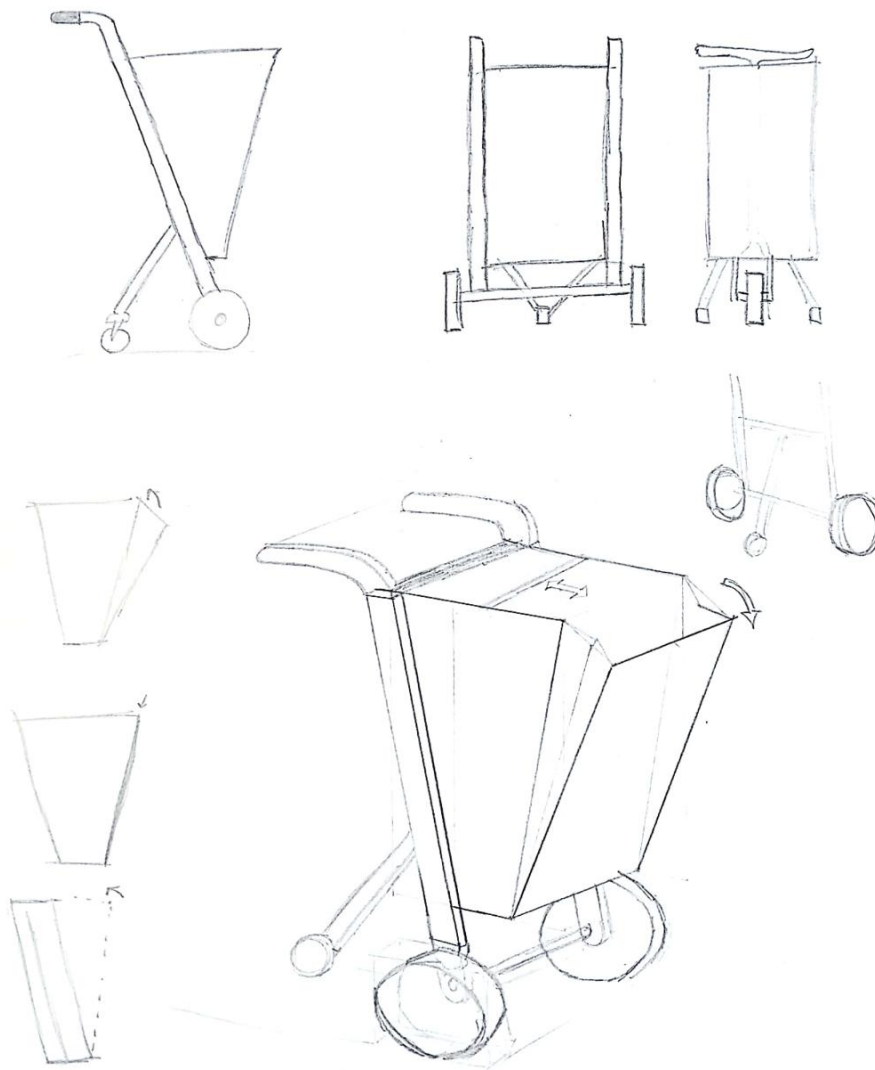


**Image 31: First Sketches**

The concepts that have been considered more interesting have been selected for further development and comparison.

### “Concept 1”

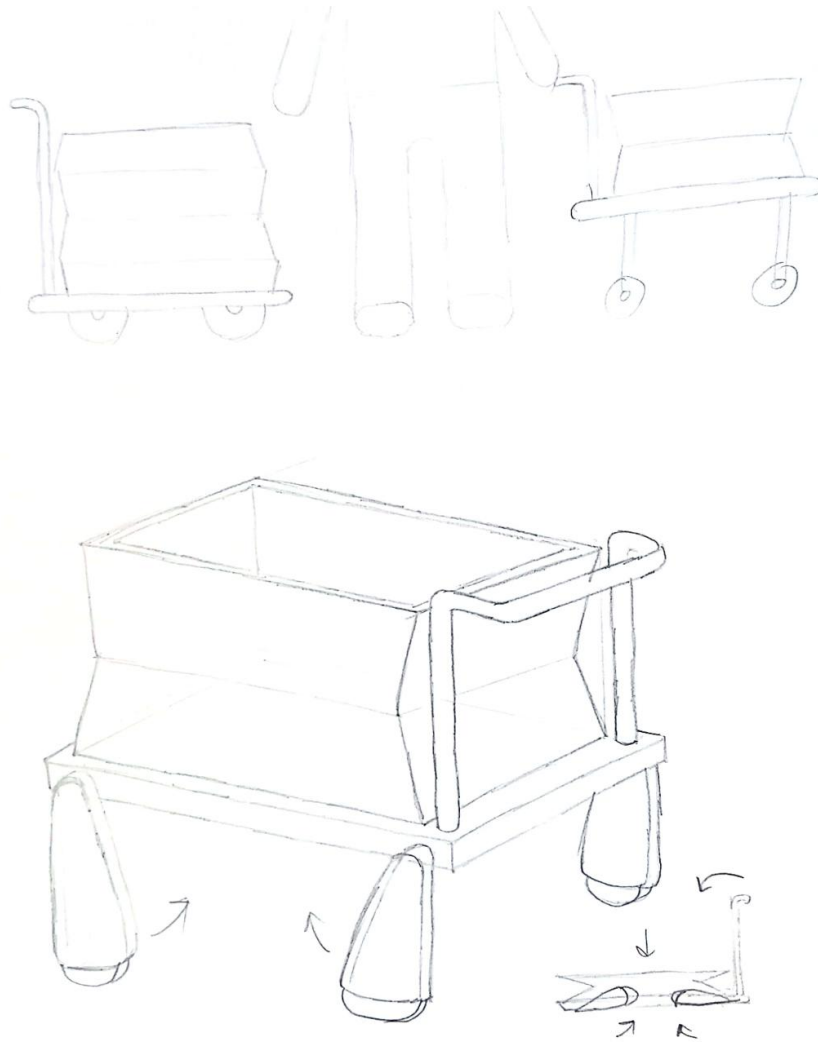
This first concept is an approach to some minor changes to the traditional shape of a personal shopping cart. It consists of a simple frame structure that would be formed by a few simple parts and could be completely disassembled into pieces and a rigid, foldable and detachable compartment located on top of the frame. The whole structure would rest on a tripod-like mount with wheels.



**Image 32:** Concept 1 sketches

## “Concept 2”

The second concept’s structure resembles a wire mesh shopping cart that can be found in most big supermarkets. It consists of a large flat base with a handle and wheels attached. Both of those components would be foldable through a rotation movement in order to make the structure as flat as possible for easy storage. On top of the base there would be a silicone box that could reduce its size to be nearly flat using an “accordion fold”.

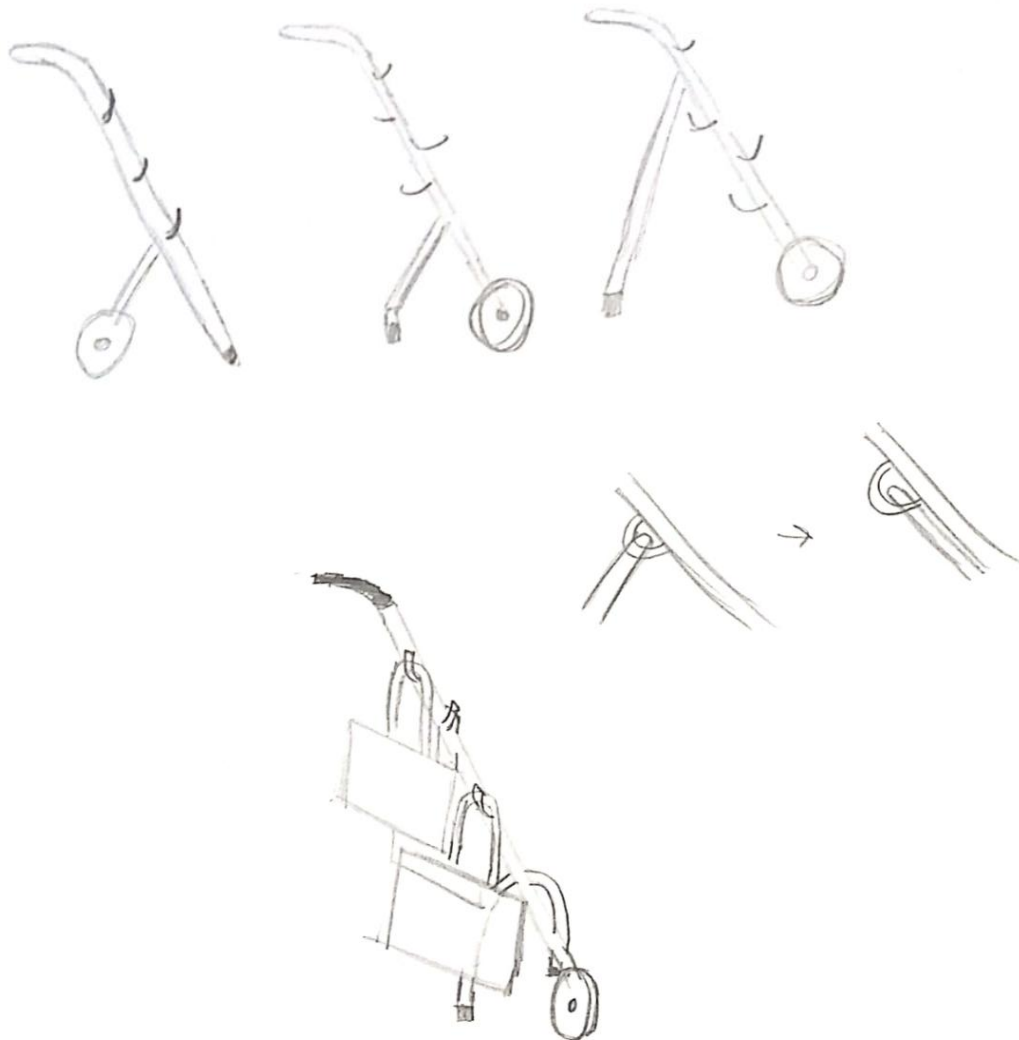


**Image 33:** Concept 2 sketches



### “Concept 3”

The third concept tries to take advantage of the normalized use of bags. It is just a metal tube with a handle, resembling a walking staff that has hooks attached facing different directions for the bags to hang into. Adding wheels would be necessary for an easy movement. This would be the smallest concept in size amongst all of them.

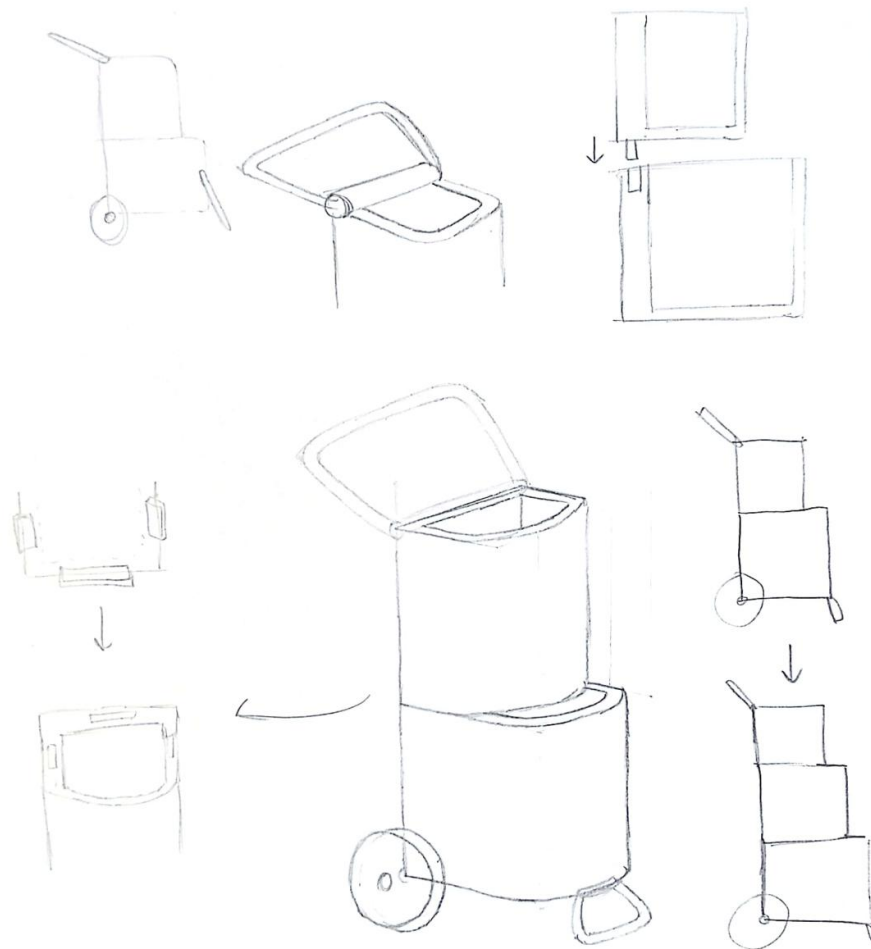


**Image 34:** Concept 3 sketches



### “Concept 4”

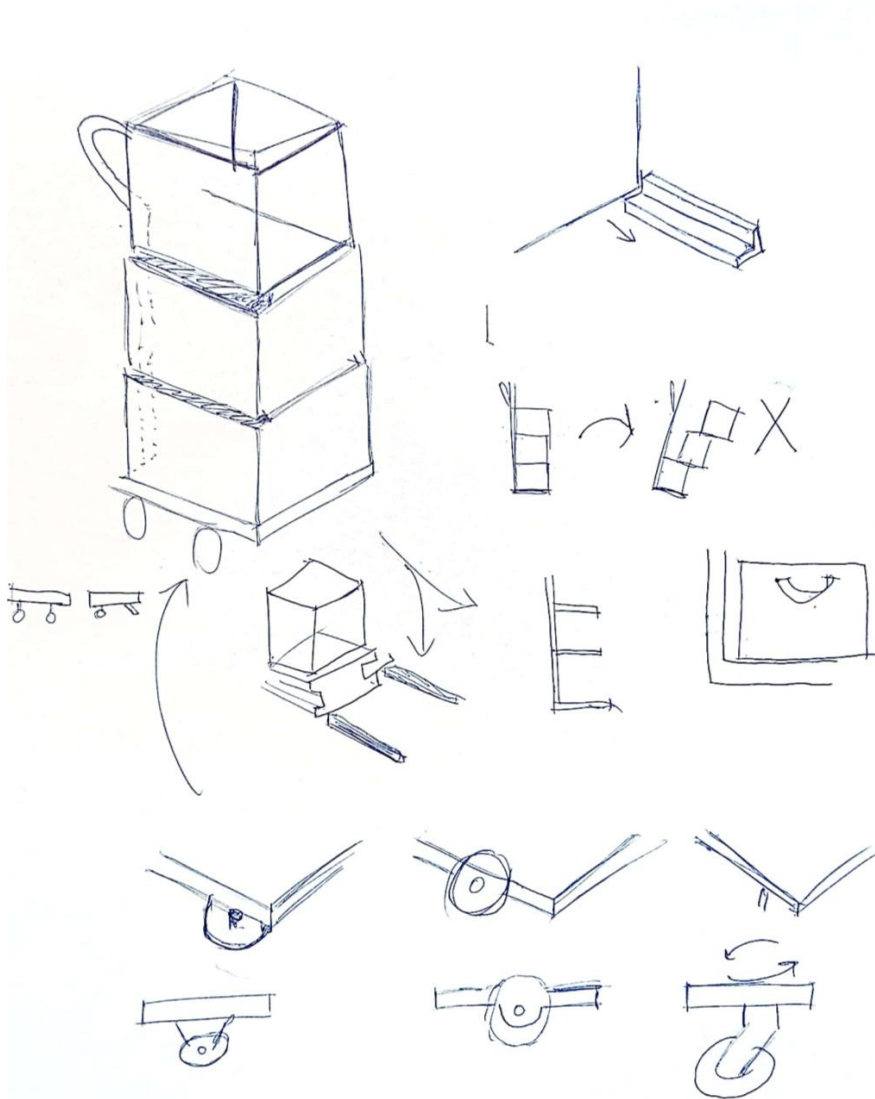
Concept number 4 is a shopping cart made of two rigid plastic containers that vary in size stacked on top of each other. The boxes, firmly attached, would move on two wheels and would have a metal rim at the front to act as a break, and a metal rim working as a handle that could also rotate to achieve desired height. The cart would be modular, allowing for a third plastic container to be attached to the top if necessary.



**Image 35:** Concept 4 sketches

### “Concept 5”

The fifth concept shares some features with the previous concepts. In this case, the structure is also made out of a base with wheels that can be folded. However, the frame that ends with the handle and is attached to the base has three sets of rails attached in order for 3 rigid boxes to slide into them. The boxes would be foldable and easy to remove.



**Image 36:** Concept 5 sketches

### 1.9.3. Concept evaluation

From the five previous concepts, the most interesting concept has been selected through the evaluation of different criteria: Innovation, practicality, compactibility, visual appeal and viability.

For each of the concepts, all of the different criteria have been given a mark ranging from 1 to 5, with 1 being the lowest and 5 the highest mark.

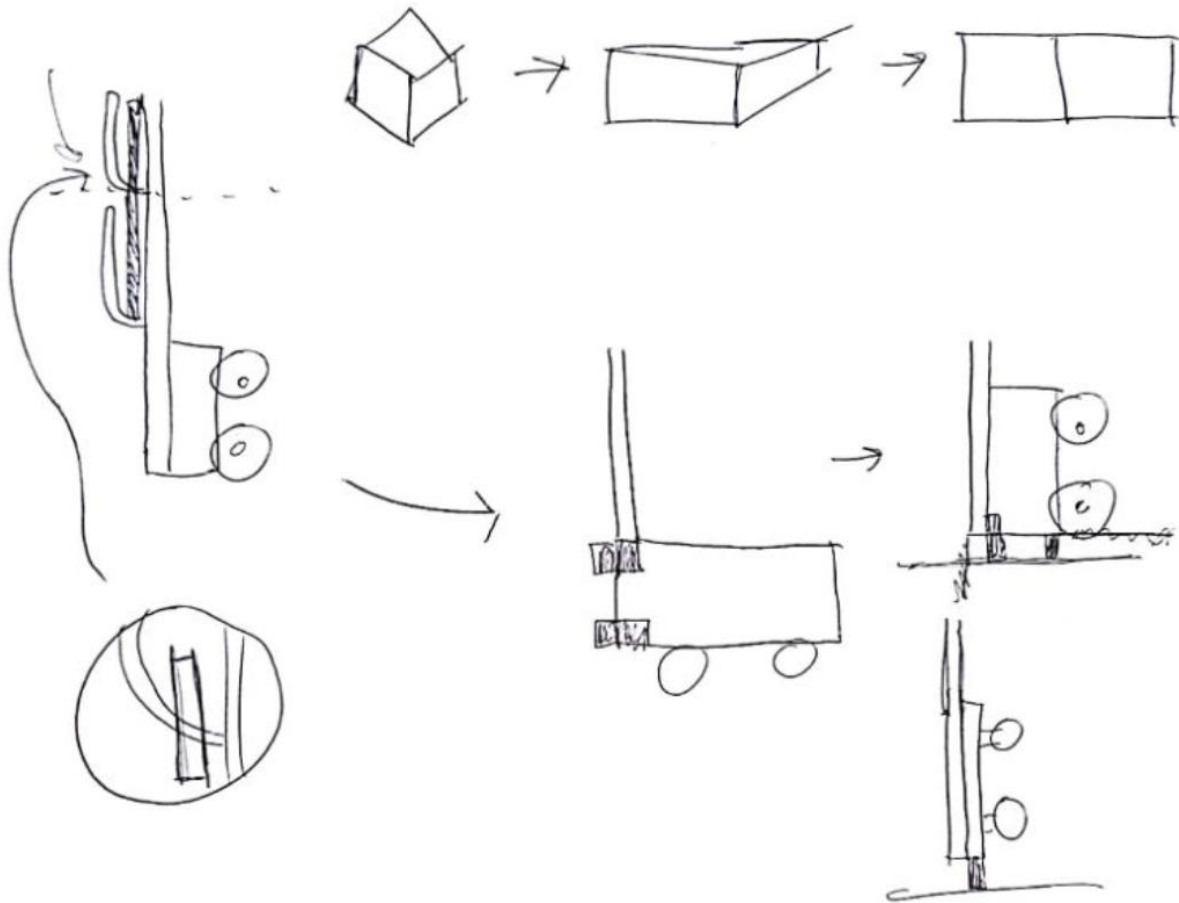
**Table 2:** Selection of the most optimal concept.

Concepts	Innovation	Practicality	Compact- ibility	Visual appeal	Viability	Total
C1	1	3	4	4	5	17
C2	2	2	3	3	3	13
C3	4	3	4	2	4	17
C4	3	4	1	4	3	15
C5	3	5	4	3	4	<b>19</b>

The results obtained by the table above conclude that the most optimal concept to be developed is “Concept 5” because of it having a high mark in many different criteria and the highest combined mark.

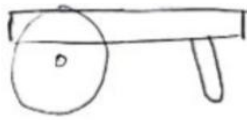
### 1.9.4. Concept development

From the concept selected in the previous section, the main idea has been developed as well as the different components that would form the product:

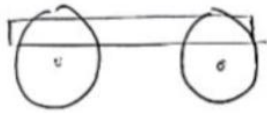


**Image 37:** Concept development sketches: Folding

The main components of the cart would be the base that would be a flat platform with wheels, a couple of tubes or long parts joining the base with the handle and foldable rails attached to them. The boxes on top of the rails will be able to be folded and attached to the folded rails.



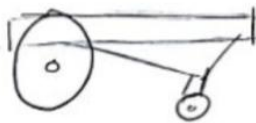
- Easiest
- Brake
- Not agile
- Resembles a "cheap trolley"



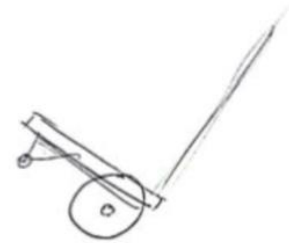
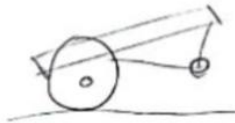
- Good for cobblestones
- Not agile



- Bad for cobblestones
- Agile



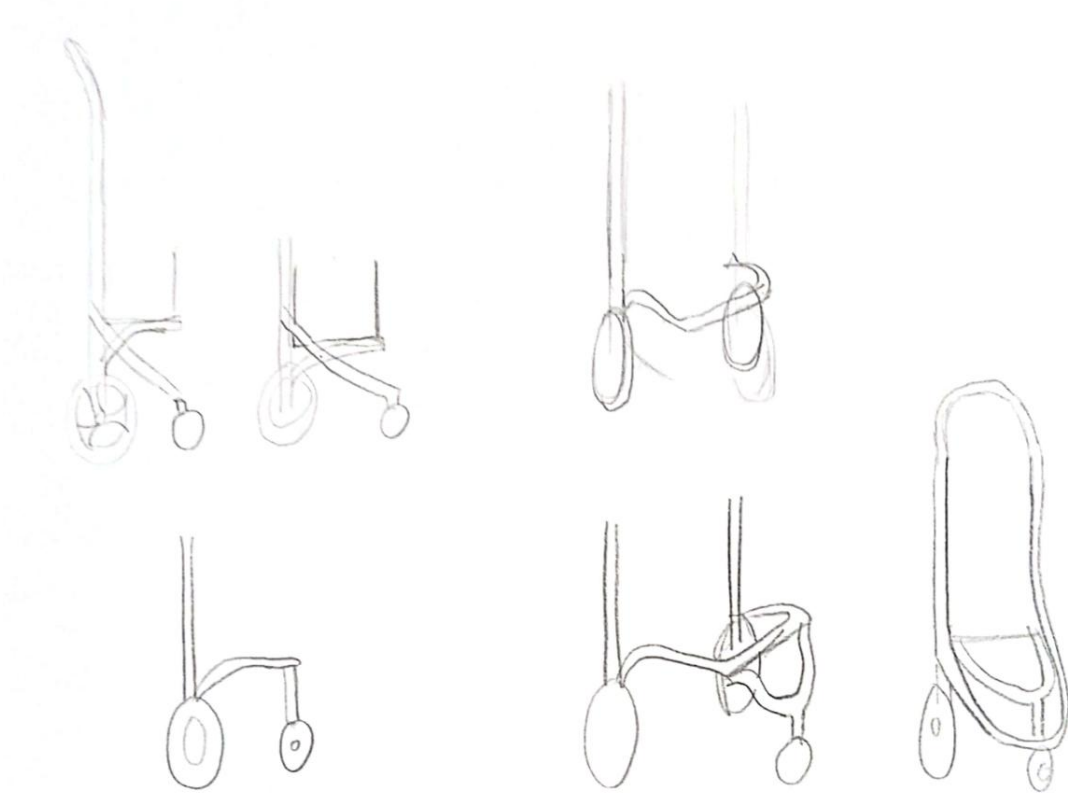
one or  
two)



No brake

Image 38: Concept development sketches: Wheels

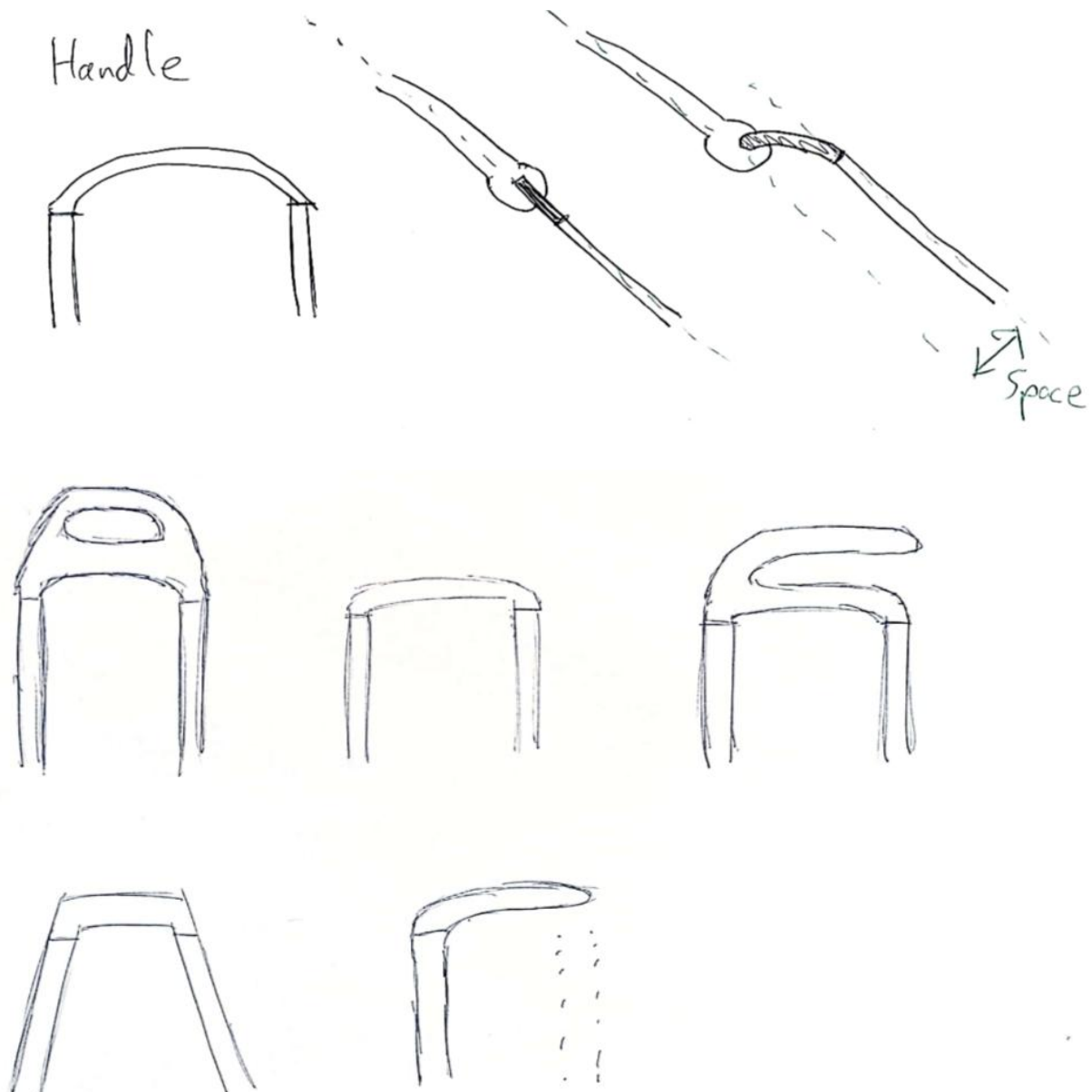
Looking at the information obtained in the market researched, it was established that the wheels were an important component of the shopping cart. Therefore, some options have been considered regarding the size, type, number and positioning of the wheels. The final decision resulted in two big wheels at the back and one small rotating wheel at the front. This combination is the most effective in order to overcome major obstacles and uneven paths on the way to the supermarket (with the big wheels) and having a great maneuverability and control over the shopping cart throughout the narrow aisles of the supermarket (with the small rotating wheel).



**Image 39:** Concept development sketches: Frame

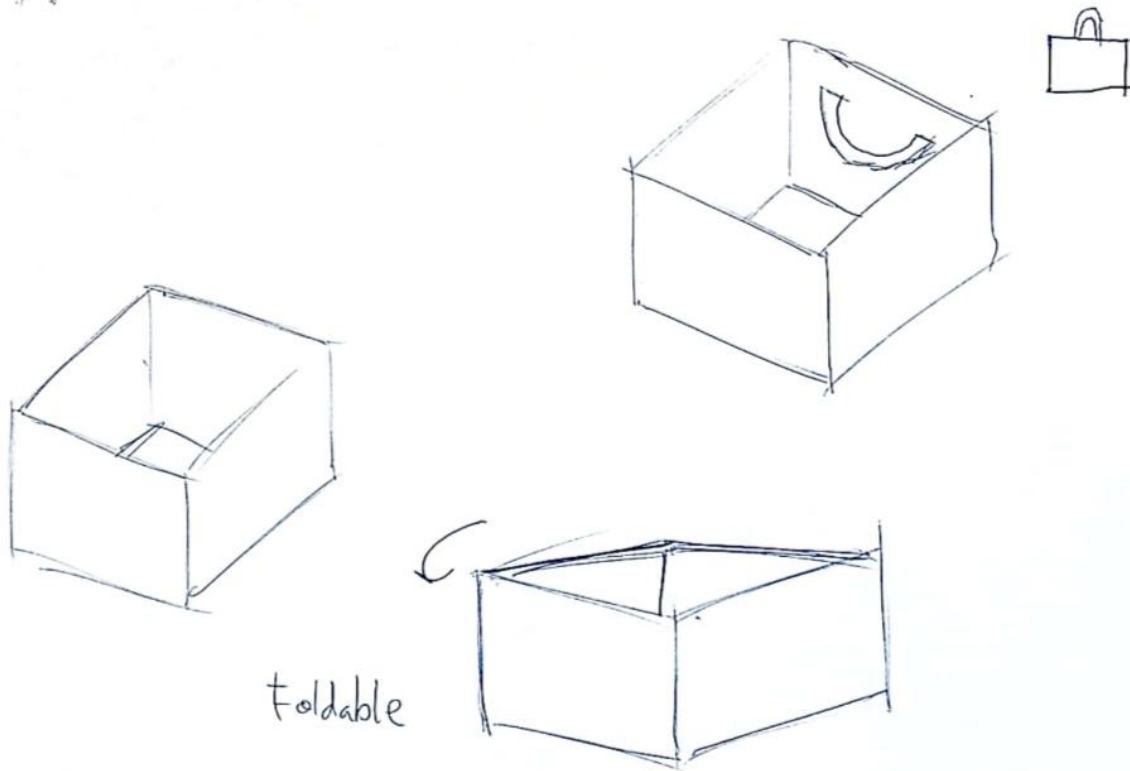
The decision about the wheels led to the further exploration of the wheel positioning and attachment to the main frame. Another idea was to join the base and the vertical component into one main frame that could be folded to increase structural stability and minimize component parts.





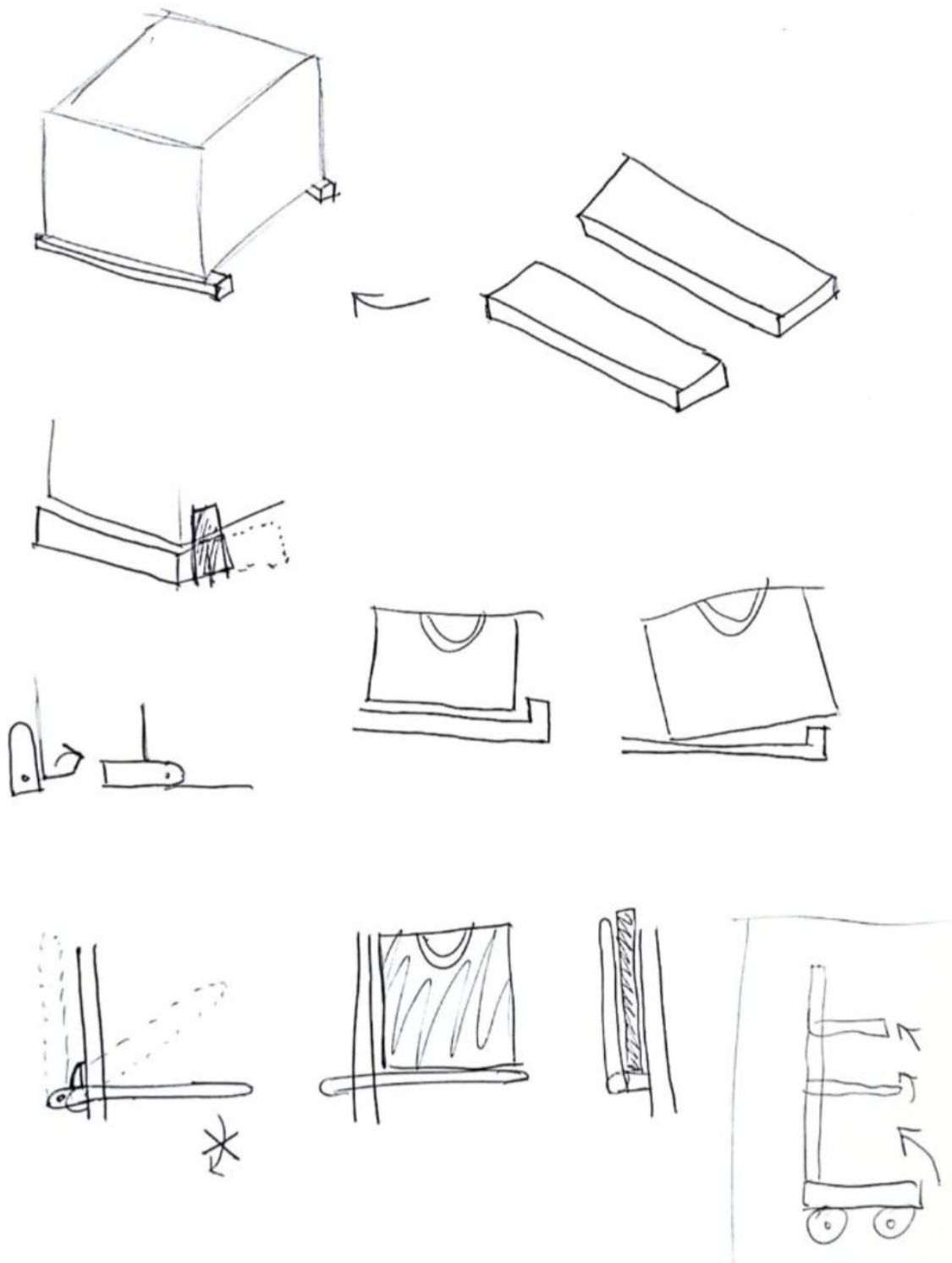
**Image 40:** Concept development sketches: Handle

The handle and its shape have also been briefly considered. This part will have a major importance in the ergonomics of the product explained in the future.



**Image 41:** Concept development sketches: Compartments

The first idea for the compartments was to use thin, premade boxes that could be folded and stored, attaching them later to a different part of the folded shopping cart.



**Image 42:** Concept development sketches: Rails

Finally, there would be three pairs of rails (one per box) attached to the frame for the boxes to be placed onto. The rails would fold upwards and would be stopped to fold downwards with a stop mechanism. One of the first ideas was to fold the rails in a way that the folded boxes could be attached.

### **1.9.5. Concept development in CAD**

In order to visualize the shape, size and proportions, some concept development has also been made in CAD software, more specifically in SOLIDWORKS.



**Image 43:** First concept approach in CAD

As seen in the image, the structure of the shopping cart consists of a solid frame with three rim-like parts that substitute the previously mentioned “rails” for a better attachment to the box. The small wheel would be placed at the bottom part of the frame, at the front, attached to it.

### **1.9.6 Justification of chosen concept**

The concept that has been chosen has been compared to the other options and has achieved the highest mark in the evaluation process. It solves many of the problems encountered, meets the design requirements and is similar to the products that the user might be used to.

Furthermore, the concept has some notable features such as:

**Size:** The shopping cart stores the groceries vertically, not horizontally. That provides greater freedom of movement inside of the building. Being foldable is also convenient for storage purposes.

**Capacity:** Storing the groceries vertically will also allow a bigger space for storage.

**Modular structure:** it allows to separate the groceries in different compartments and permits carrying only those compartments without the need to always move the whole shopping cart.

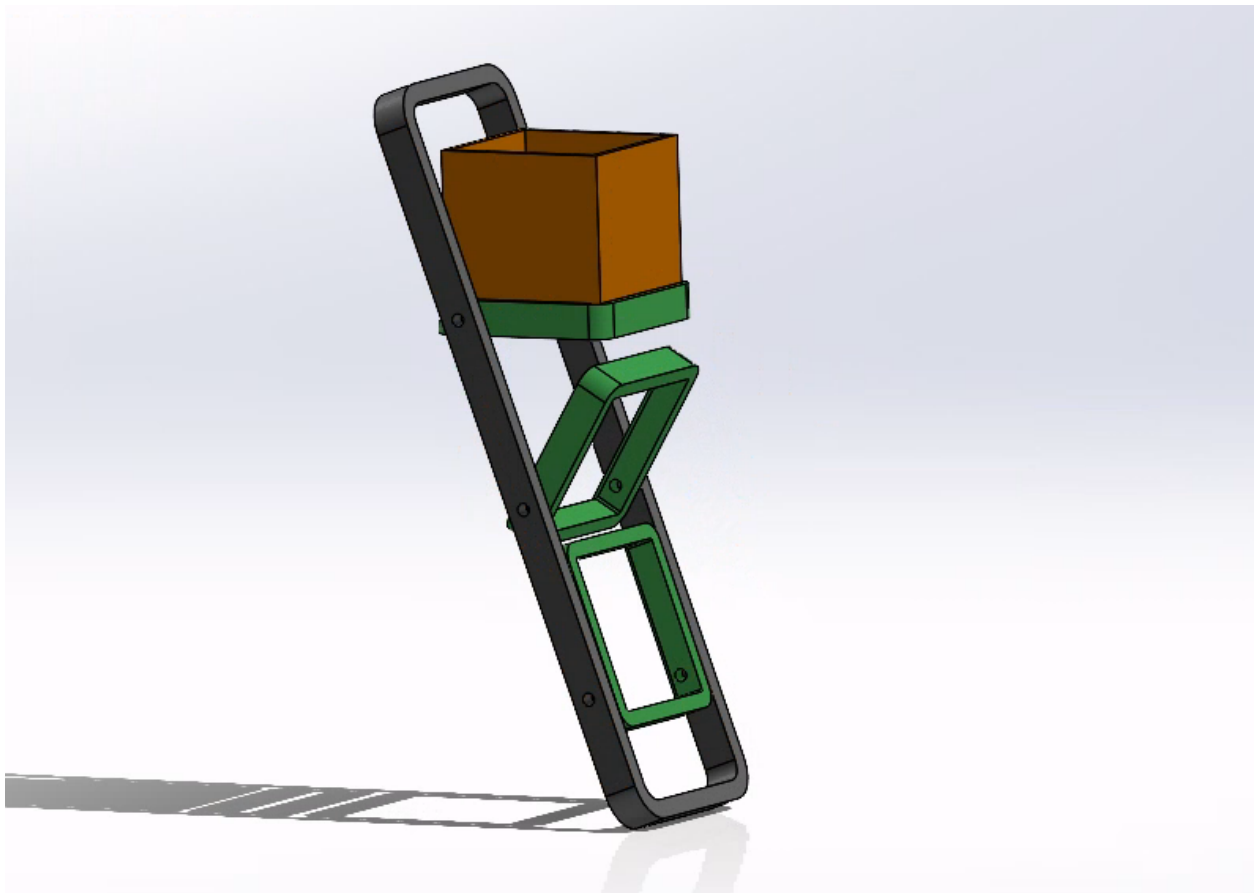
**Practicality:** The design allows the user to easily place the groceries inside, and access them afterwards without the need to store them in any other place throughout the shopping period.

## 1.10. Detail design

Following the previous section, once established the general structure of the product, all of its different components have been developed in this segment.

### 1.10.1. Frame

The initial idea for the development of the frame was to have an injection molded plastic frame, it would be square with rounded edges. There would be 3 identical rims where the boxes would be located.



The rims would be attached to the frame and would be able to rotate in order to fold themselves with the frame making the folded product linear and easier to store.



Using a model of a person as a reference, the size and proportions had been checked and the wheels had been added, initially to one of the rims. A problem encountered was the component to join the back wheel with the bottom rim. It would have to have a complex shape in order not to collide with the frame.





Later, the frame evolved from being completely linear to having a ledge both at the top, in order to make a better grip for the user, and at the bottom, in order to support the bottom rim. In this case, due to the bottom ledge, the smaller wheel would have to be attached directly to the main frame.

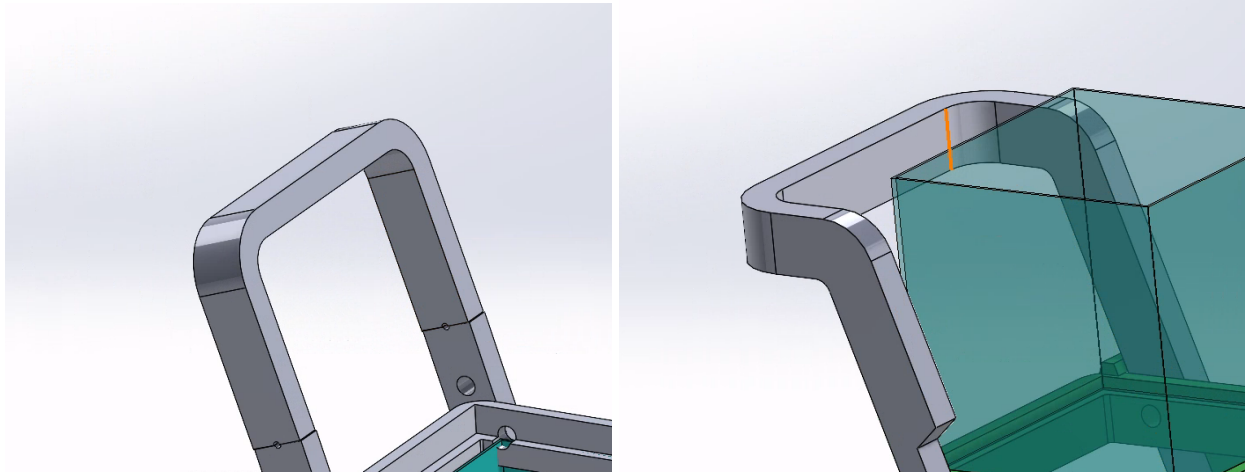


After thinking about the product while folded, a decision was made to take a step back and return to a more linear design in order to occupy less space when the product is folded. However, a small ledge has been kept at the bottom part in order to solve the back wheel attachment stated previously.

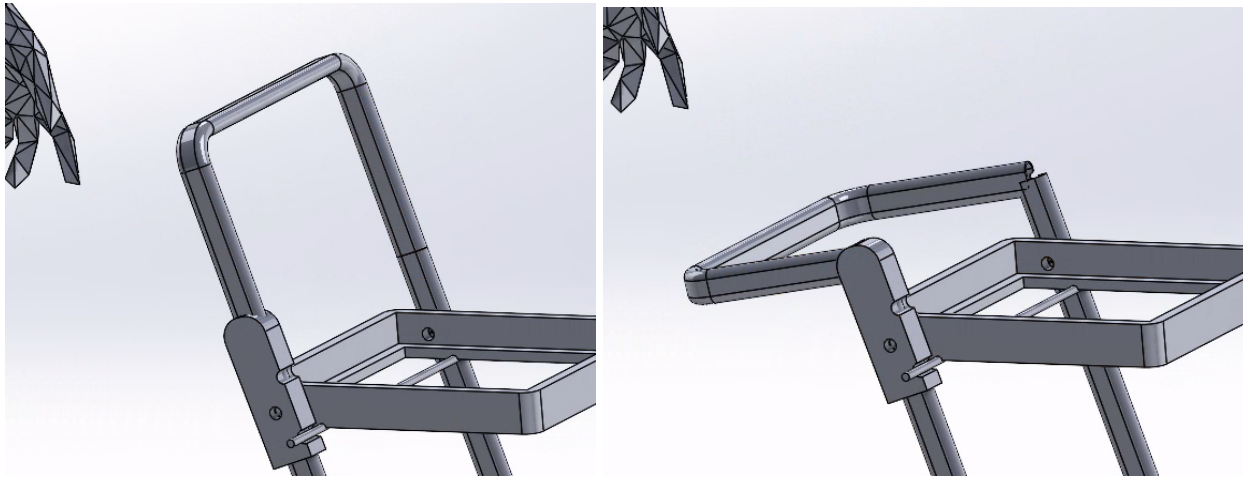
Another major decision was considering a change in material: while injection molded plastic would be more versatile and allow more shape complexity, after observing products with a similar structure, it was noted that most of their frames were made of tubed steel or aluminum. Tubed metal is more resistant, cheaper, and has standardized dimensions for manufacturers to follow. This change meant a design of a new piece to attach the rims to the frame.

### 1.10.2. Handle

The first idea for the handle was for it to be a static part of the main frame, only to be later covered in a comfortable material to grip.

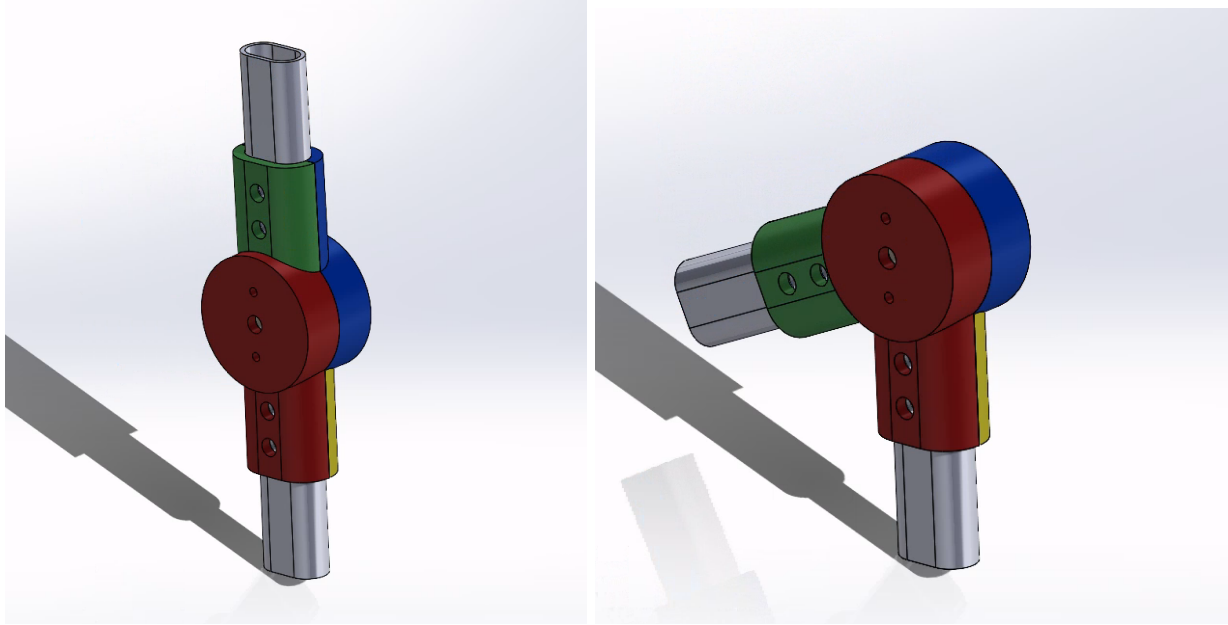


In these designs the handle would be completely fixed.

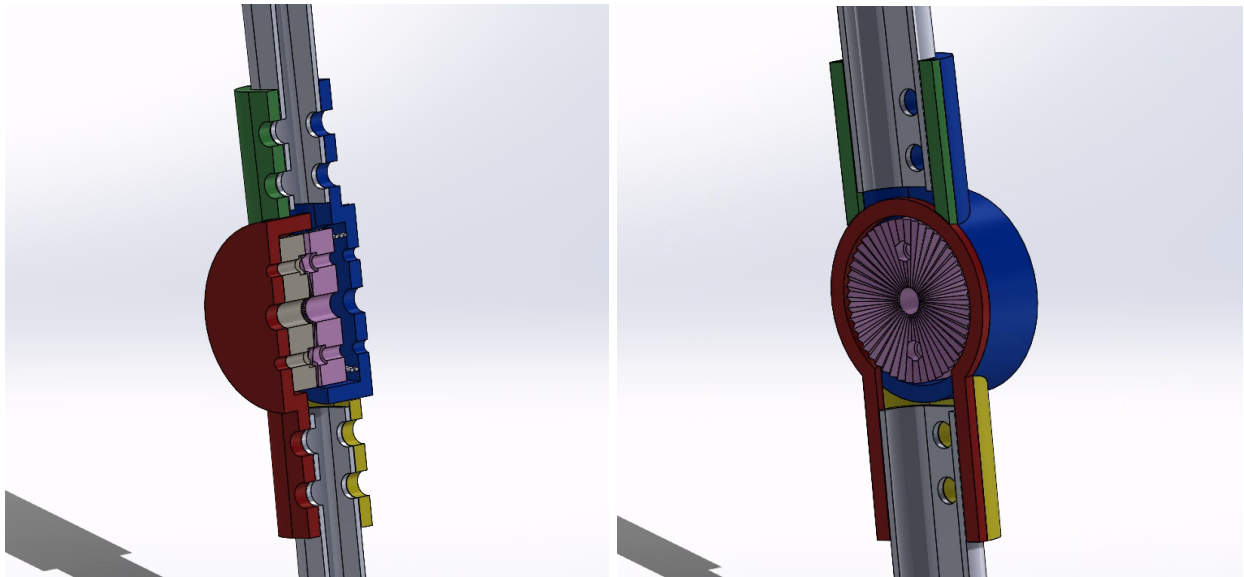


When the next step in the design process resulted in the change of the frame material to metal tubing, it allowed for it to be split and, with the use of another component, to be rotated.

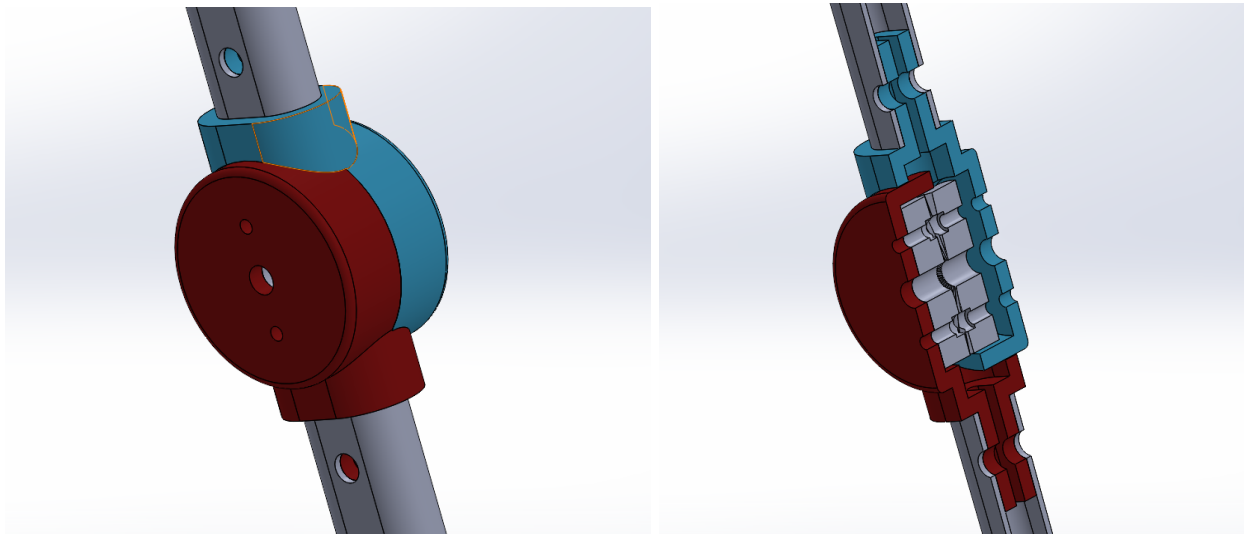
Ergonomically speaking, rotating the handle gives a greater range of handle height, which transforms into a more versatile and comfortable interaction with the user.



In order to be able to rotate the handle in a smooth way while locking it into a set position a rotating mechanism has been designed.



The rotating mechanism consists of four outer pieces that are attached to the metal tubing frame and form a capsule that holds two dented disks that snap together when pushed against each other with a spring. When force is applied to rotate the handle, the discs are separated until they snap back to the next closest position. The user can keep rotating the handle and stop at the desired position.

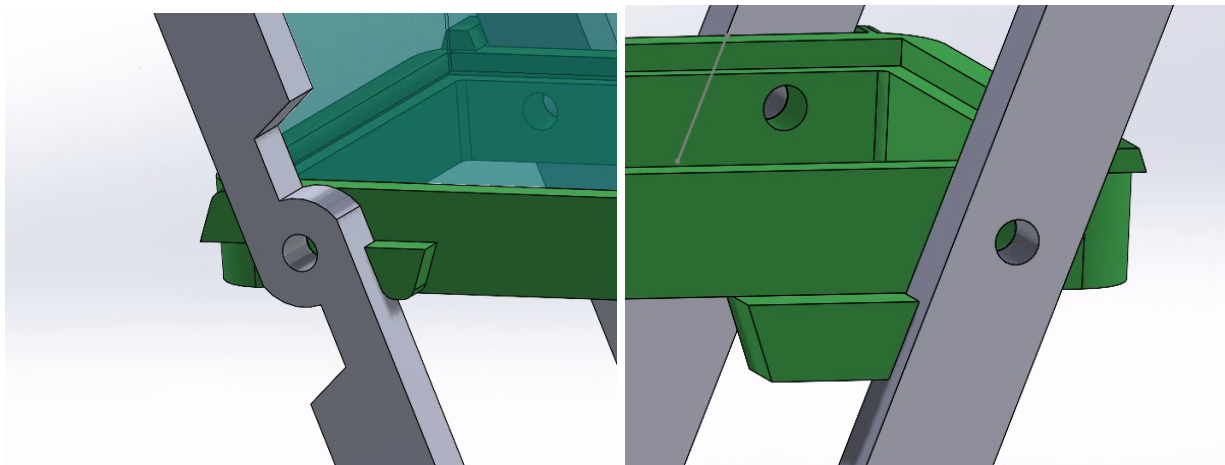


In order to reduce the size of the mechanism, the attachment to the metal tubing changed from exterior to interior.

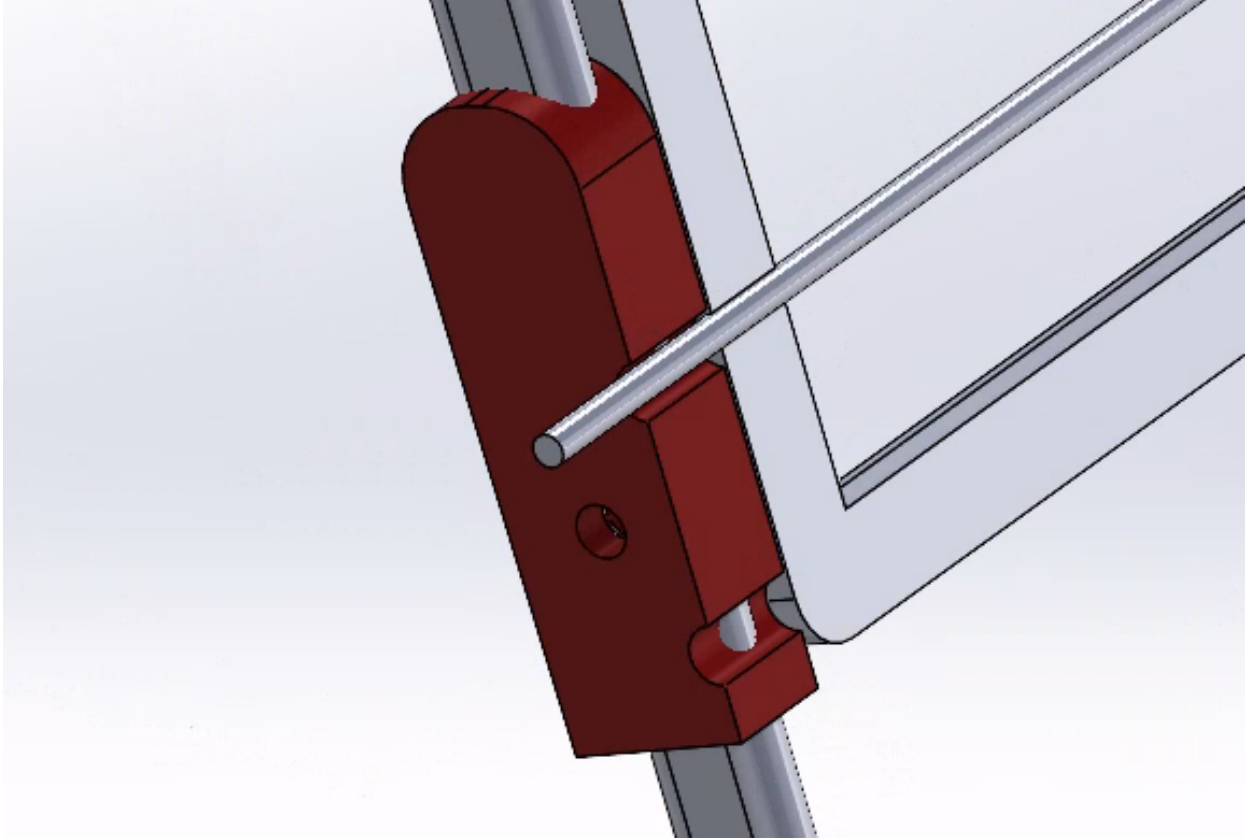
The design also reduced the number of parts to two components that are technically just two units of one component, with the second being rotated 180 degrees in two axes.

### 1.10.3. Joints

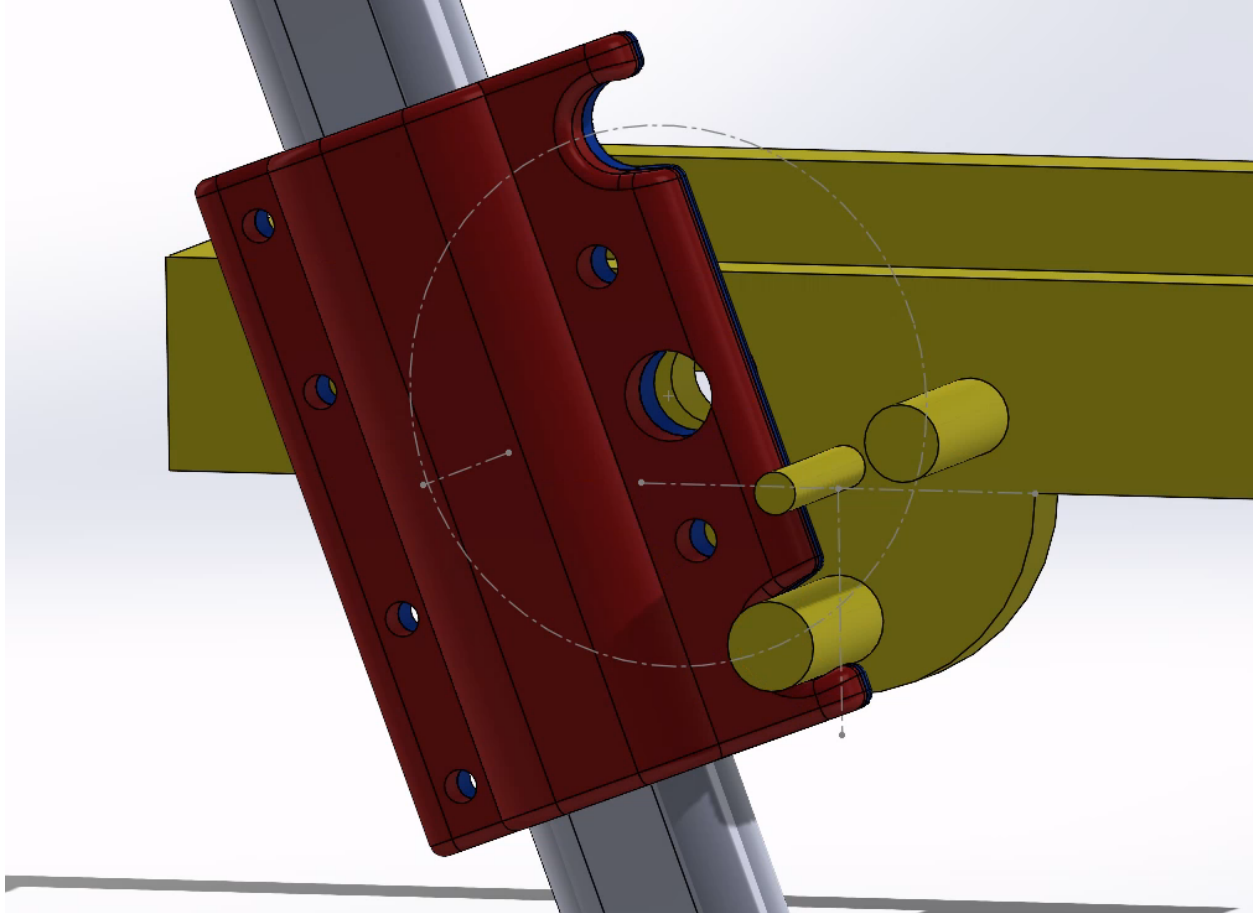
At the beginning, the first concept was to attach the rims directly through the frame. Different ideas were explored:



However, the proposed solutions either compromised the strength of the frame or were just not viable to manufacture.

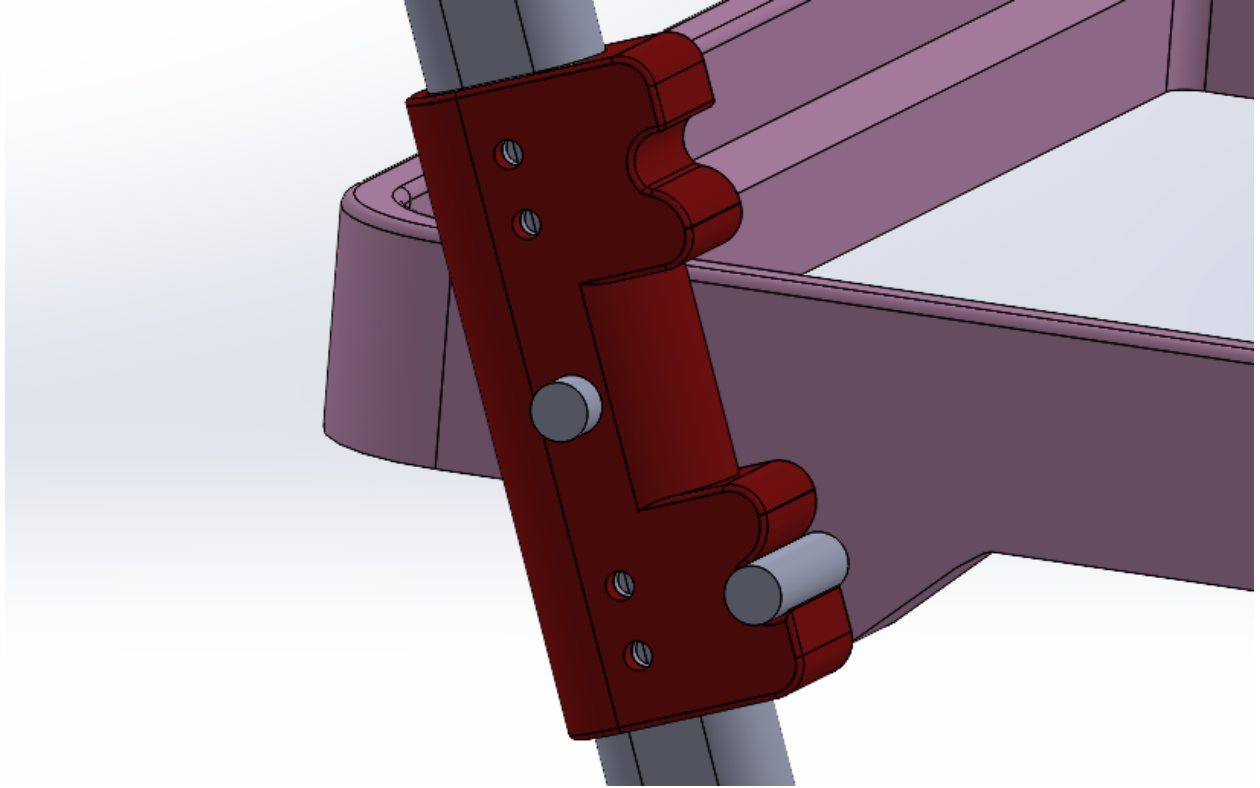


When the frame changed to metal tubing, the design of a new piece was necessary. That piece would have to hold the rims and allow them to be locked into position.



Another option of the joint was explored, in order not to make modifications on the metal tubing. However, that decreased the fixation with the frame and moved the rotation axes to a difficult position for the rims to fold.





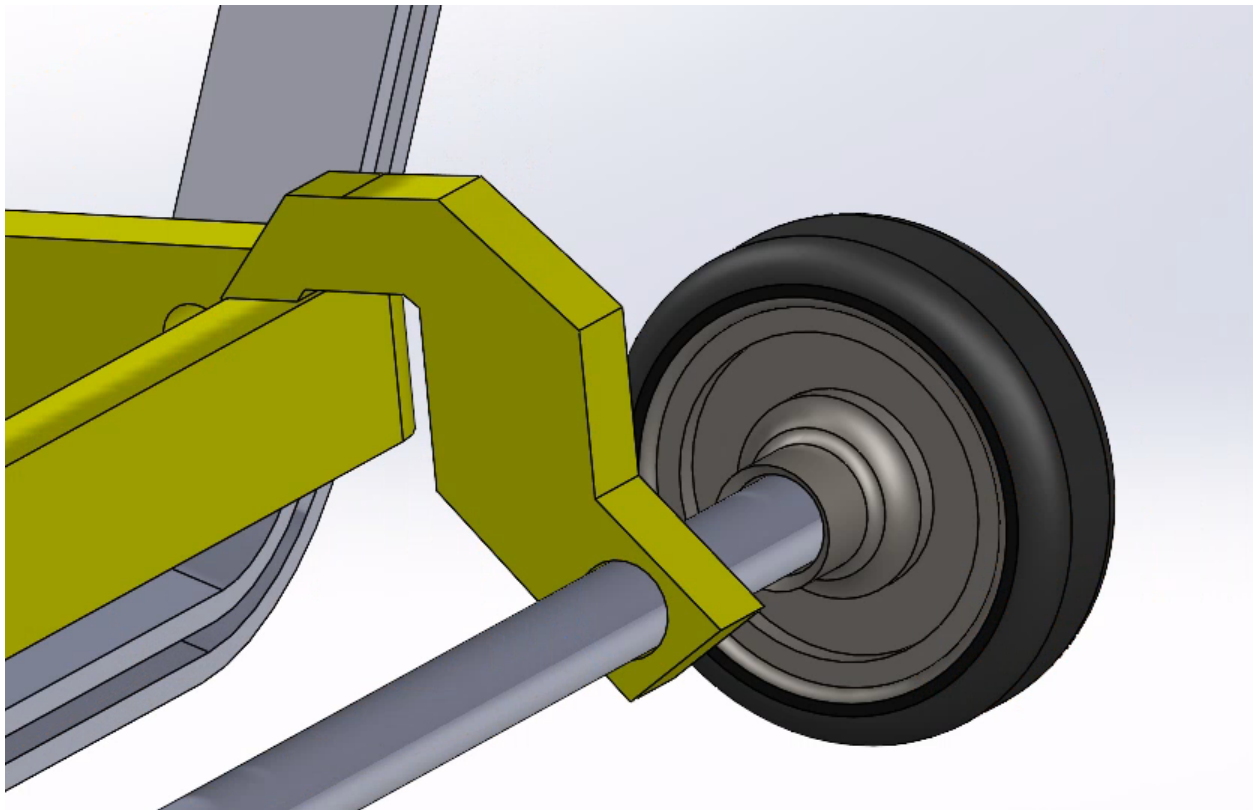
The final design of the joint is attached directly to the metal tubing frame, it also joins the frame with the rims and allows rotation. Furthermore it has two gaps for the pins of the rims to lock into.

#### 1.10.4. Wheels

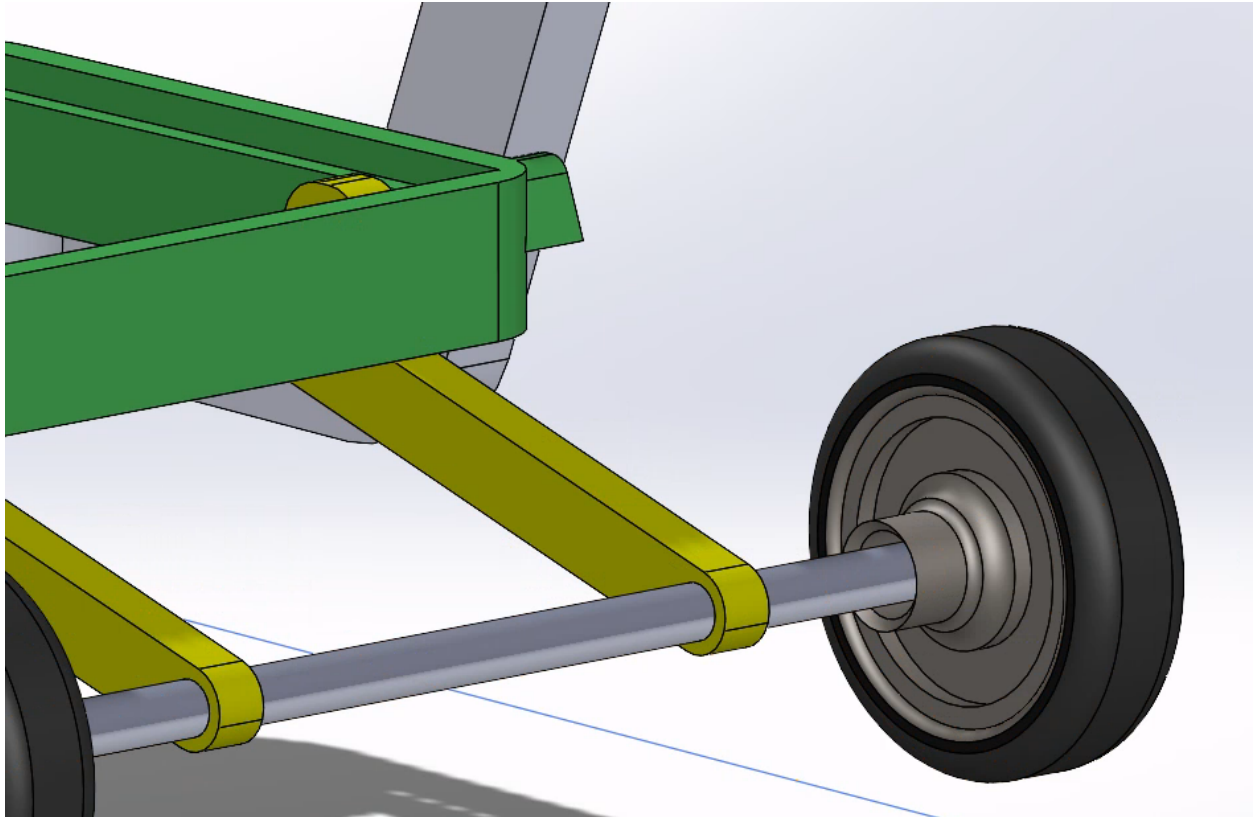
Although the wheels in this project are decided to be outsourced components, the attachment of the wheels to the structure of the product has also had to be designed.

##### Big wheels

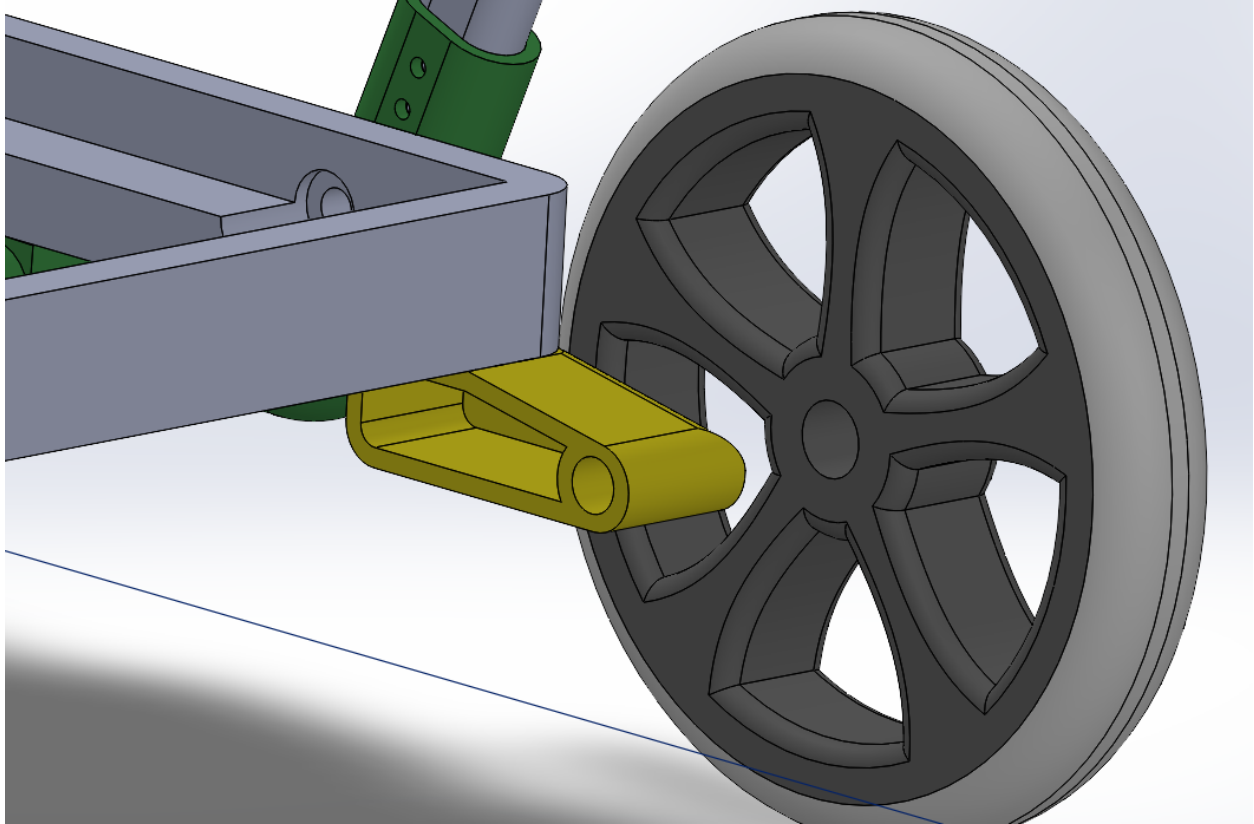
The attachment piece for the big back wheels has evolved through different stages shown below:



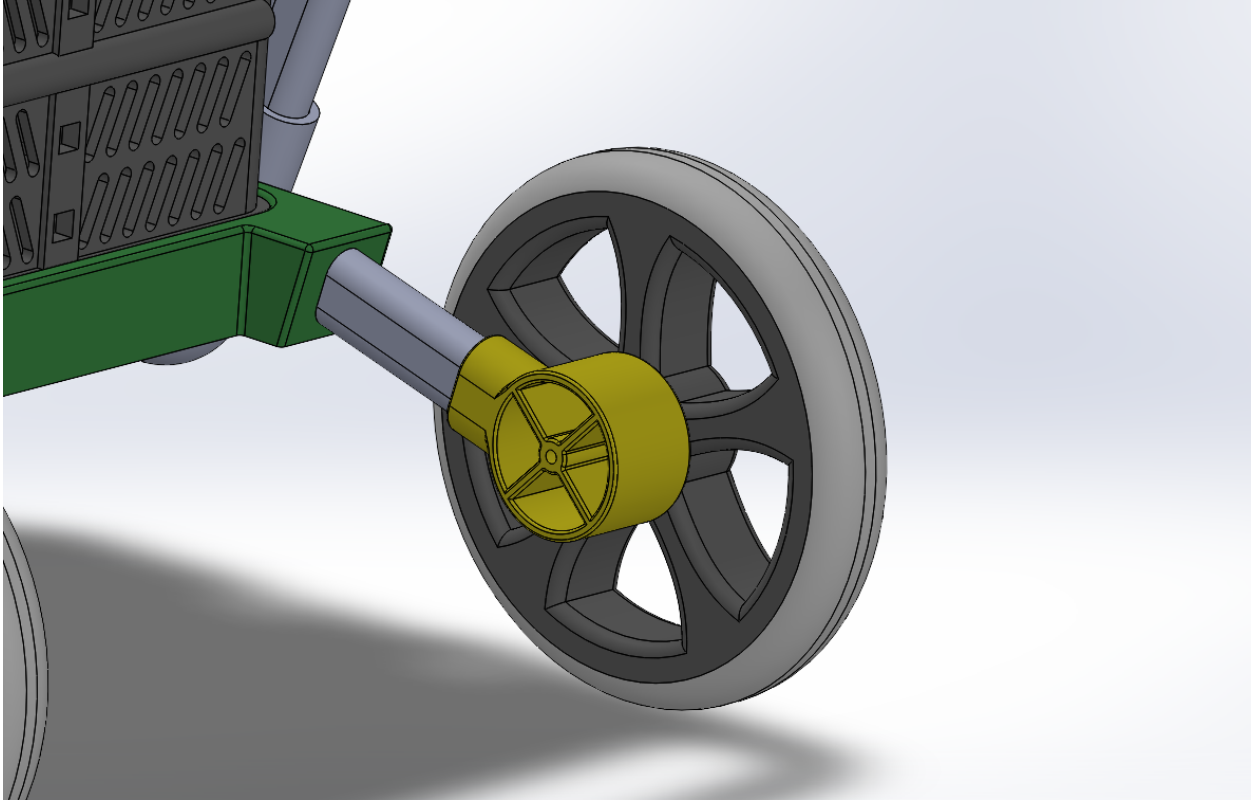
The first approach was to make the joining component part of the rim, in one piece, having a gap in order to avoid collision with the initial linear frame.



With the change of the frame, the gap was no longer necessary. A decision was made to make the joining part a different component in order to make the design of the rim more viable



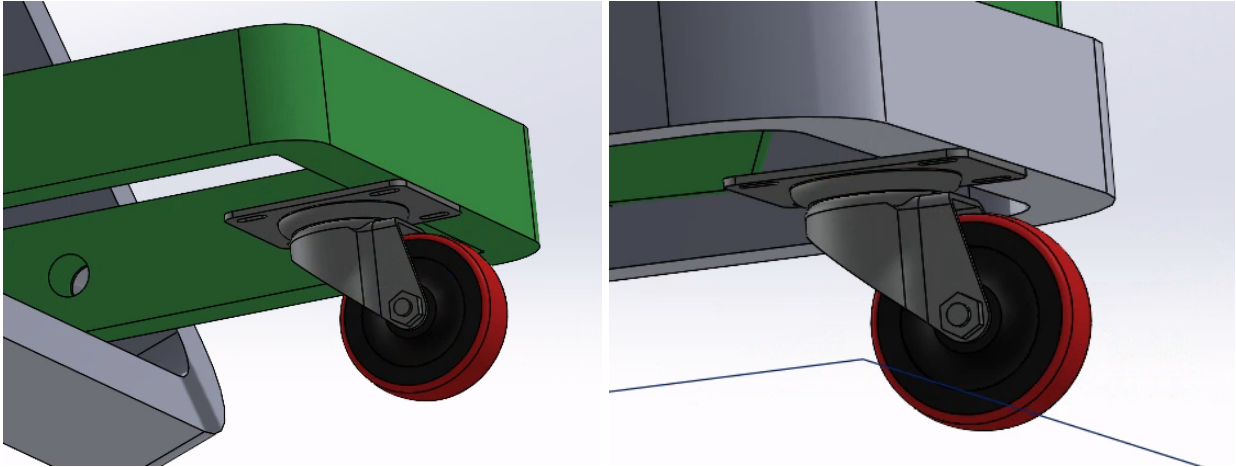
The piece to join the wheel to the rim developed to a small plastic component attached to the bottom of the rim.



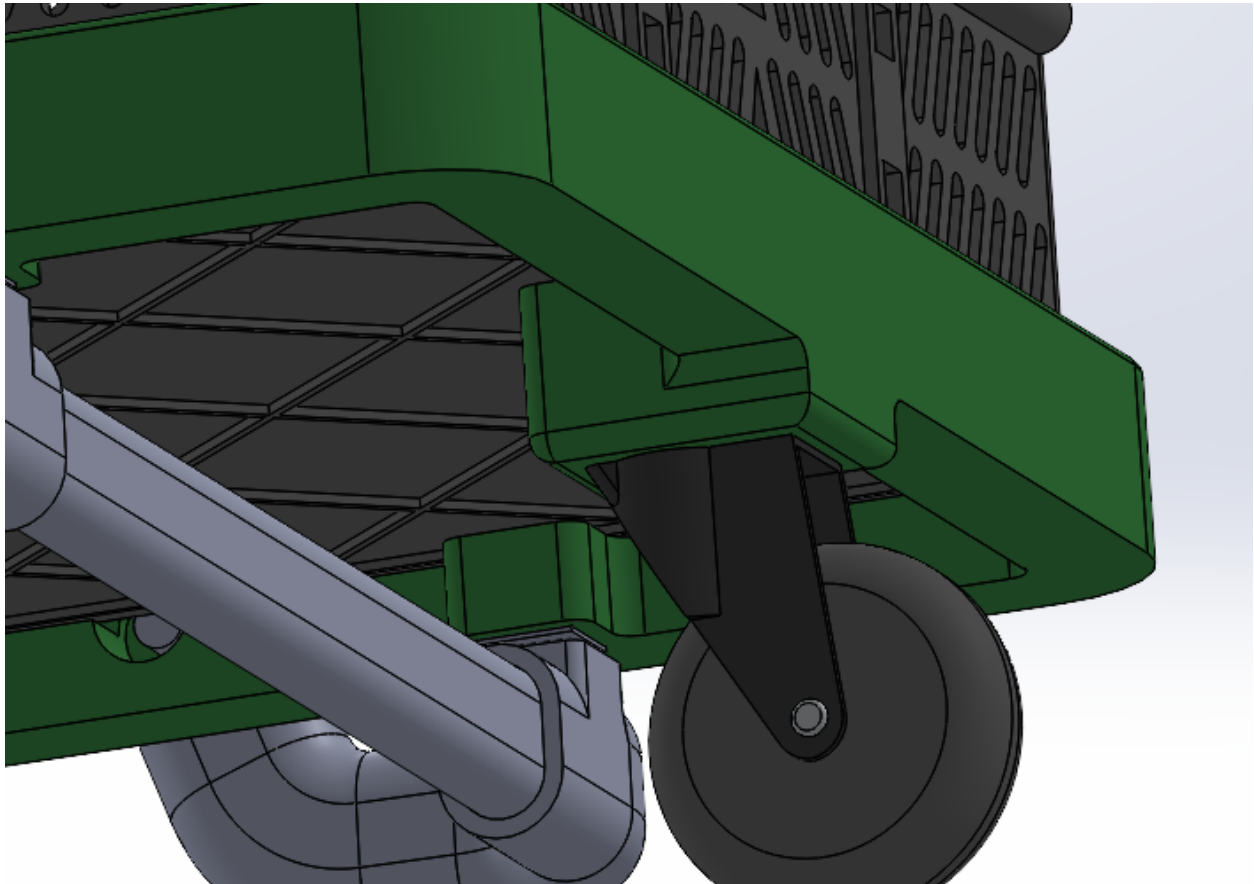
Finally, the piece has been adapted to be attached to the wheel and joined to the bottom rim by a piece of tubing.

**Small wheel**

The attachment of the small front wheel resulted easier, but it still was significant among some design decisions:



At the beginning, the small wheel was meant to be attached to the bottom rim of the product. Later, when the frame was extended, the small wheel was supposed to be directly attached to the frame.



After changing the frame material, and all the way up until the final result, it was necessary to go back to the first setting and attach the small wheel to the bottom rim.

### 1.10.5. Compartments

The initial idea for the compartments was to use premade, light square boxes that could be placed onto the rims and easily removed and carried if needed.

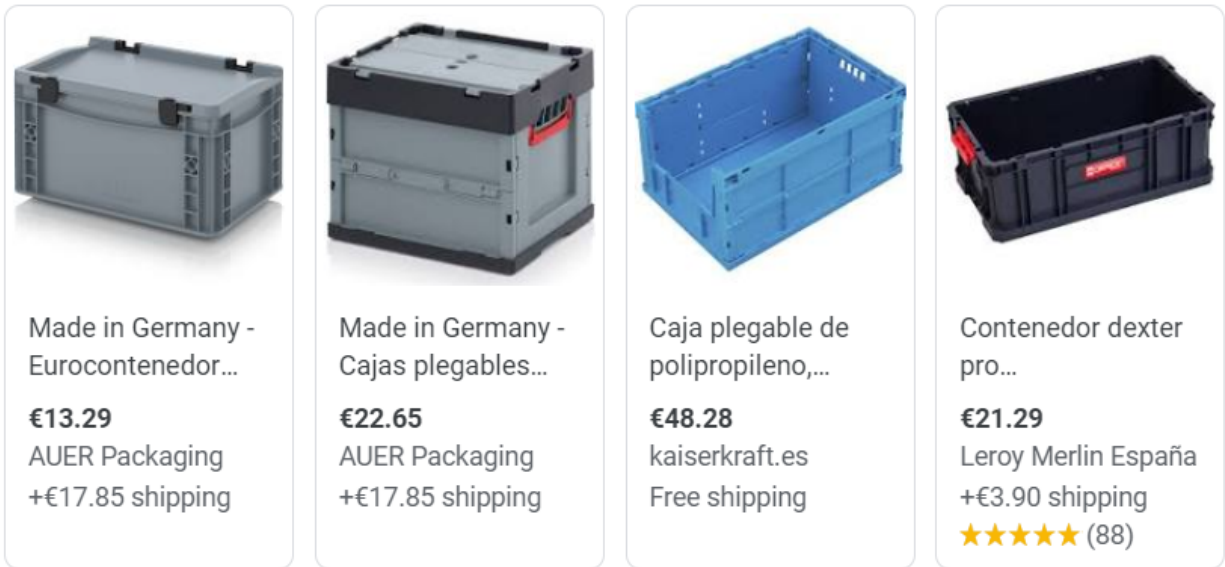


**Image 44:** DRÖNA box, Ikea

The “DRÖNA” box from Ikea was the initial best candidate. With its dimensions being 320 x 320 x 320 mm it would provide a lot of capacity optimizing the space, without being too big or uncomfortable to carry.

Despite it being a good option at first, its way of folding was not compatible with the folding direction of the rims in the product, which meant that the boxes would always have to be detached before folding the shopping cart and stored separately. That is why a decision was made to look for a more compatible type of box that could fold while staying attached to the shopping cart.





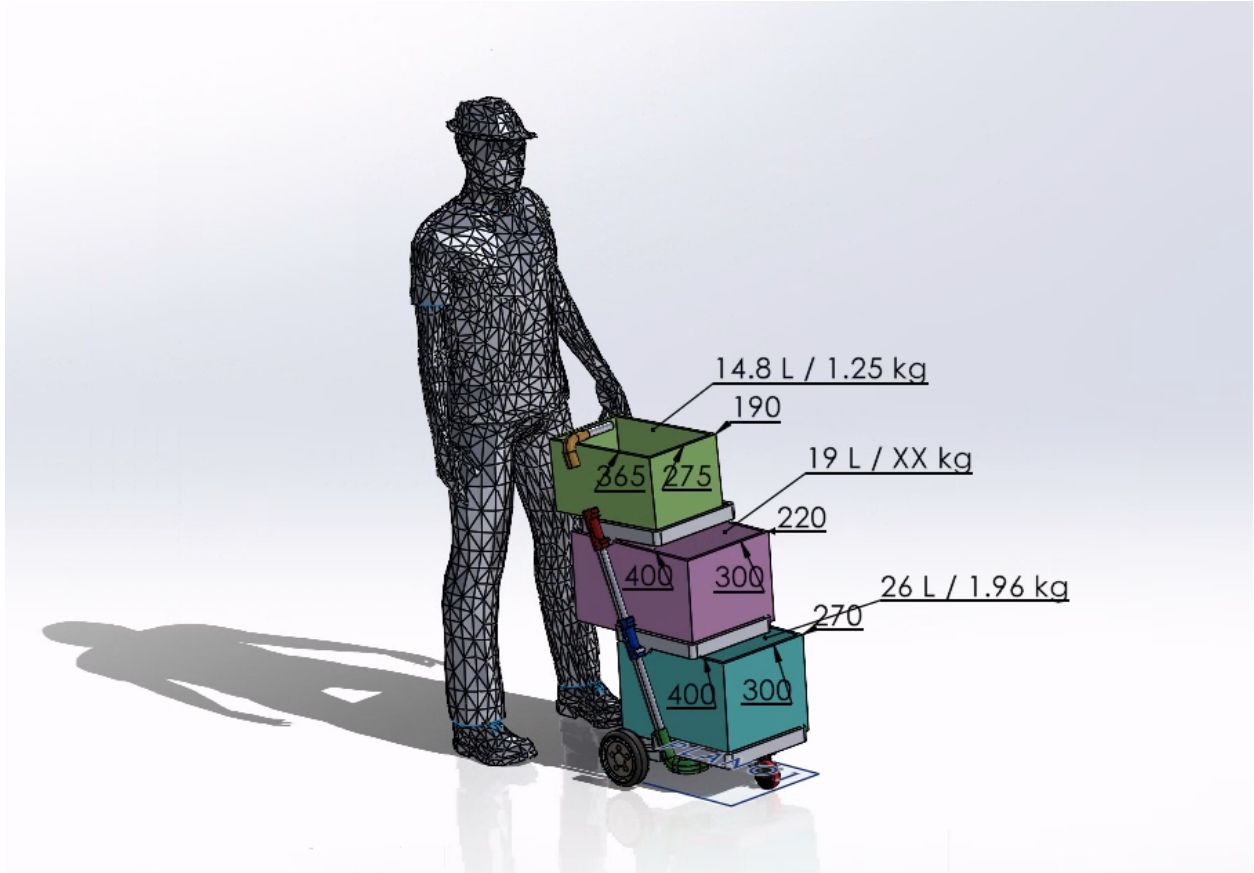
**Image 45:** Industrial plastic crates, Google search

While looking for robust and stable boxes that could be folded vertically (and be collapsed from top to bottom) it was noted that most of the options looked too industrial and resembled more industrial crates rather than shopping baskets.



**Image 46:** Plastic foldable baskets, Aliexpress.com

The final decision resulted in the baskets above, while being sturdy and folding like crates, their design resembles a traditional shopping basket. The decision to choose the optimal compartments is also important due to the fact that the rims where these boxes will be placed are going to be designed around them.



(image of this thing)

Noting that the box model was available in three different sizes, three quick models had been made in CAD to better understand the proportion.



**Image 47:** Prototypes of various box sizes

Finally, some basic prototypes have been made out of cardboard to test the possible sizes and the interaction with the user.



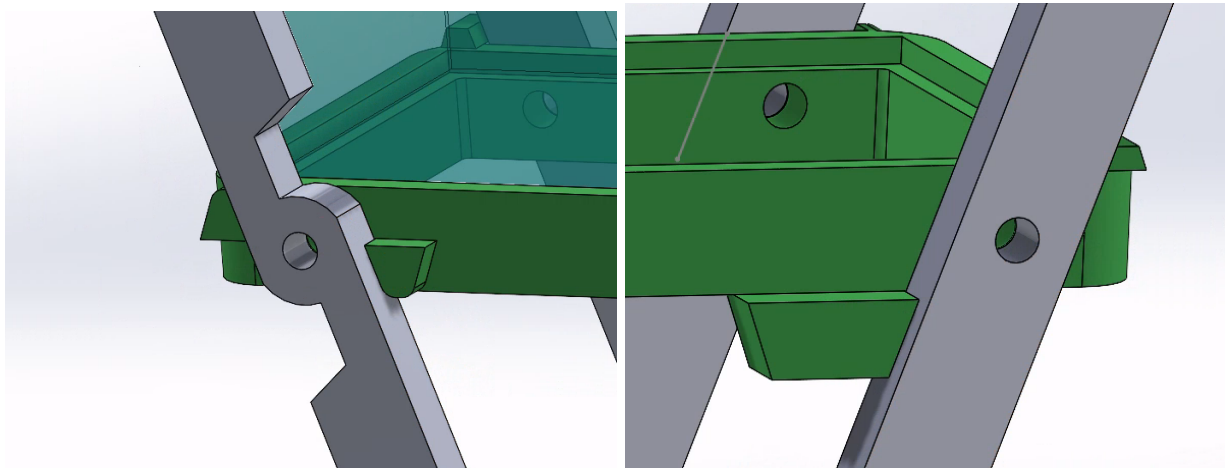


**Image 48:** Prototypes of various box sizes filled with groceries

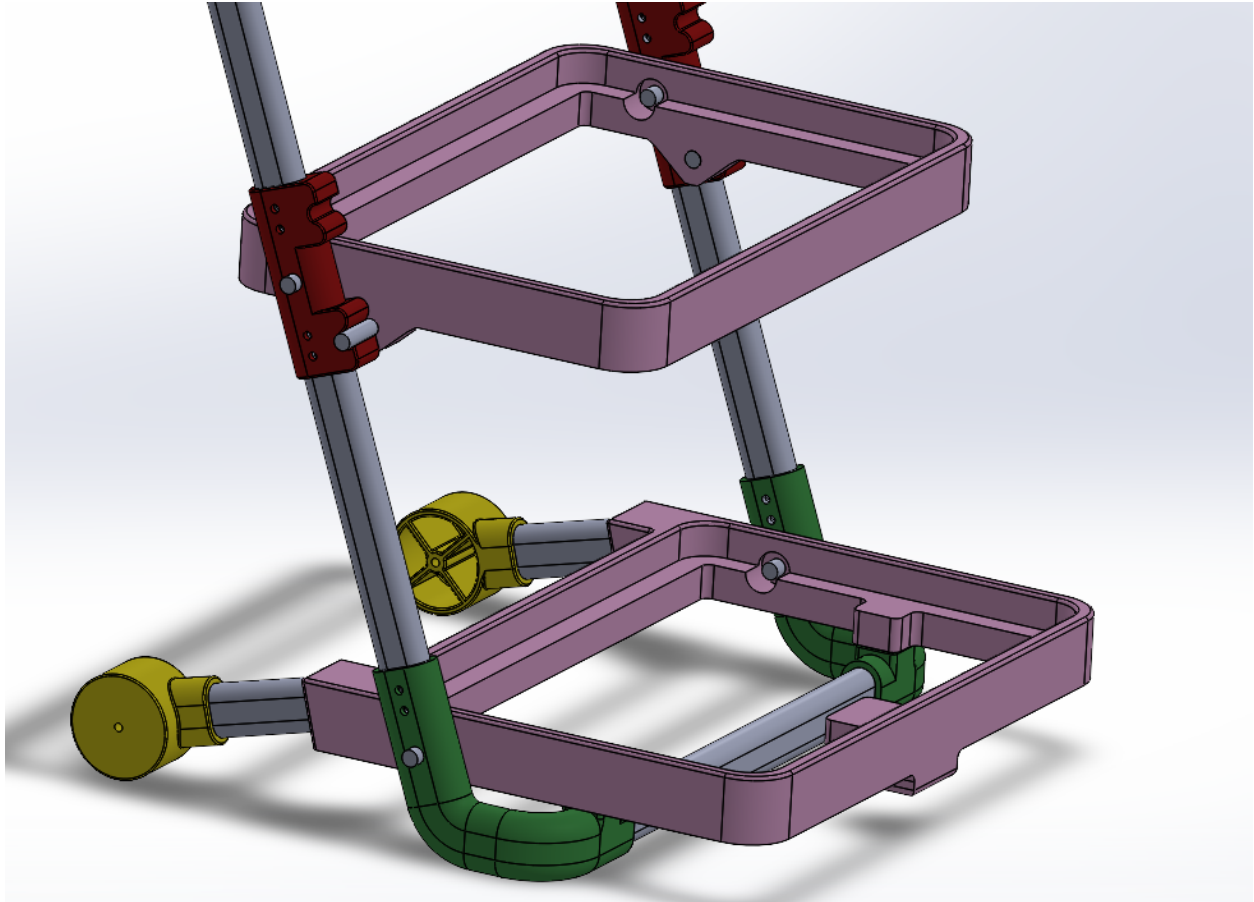
These prototypes were also useful to prove that the size of the chosen boxes would have enough capacity to carry a big range of groceries.

### 1.10.6. Rims

The design of the rims didn't undergo many changes throughout its design process, the main feature to keep in mind was its size, since it was completely dependent on the chosen box.

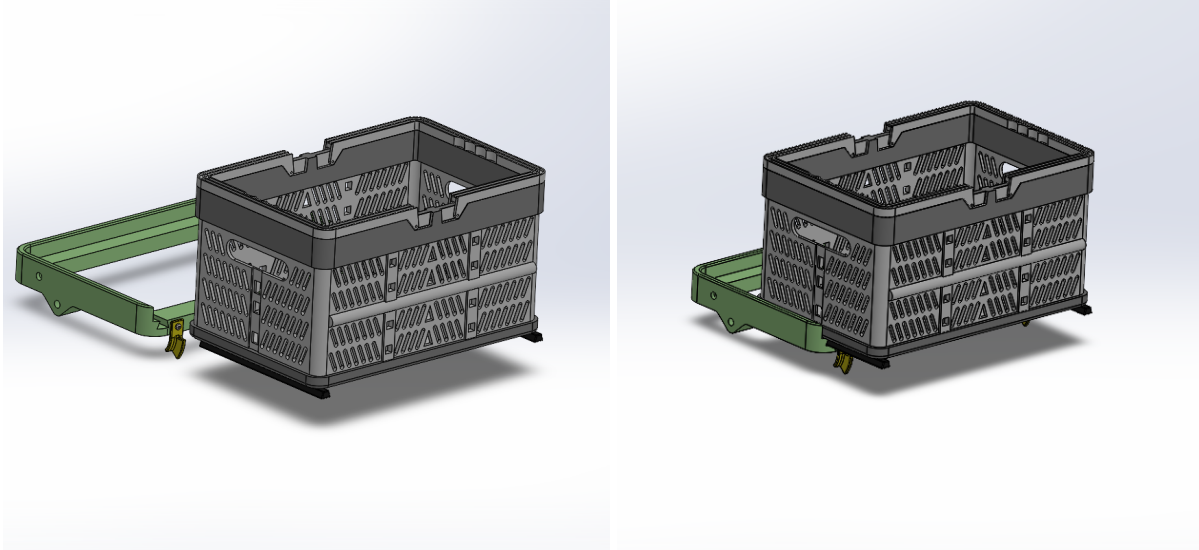


As seen before, the geometry of the rims was supposed to also be part of the joint and rotation mechanism. However, with the design of a specific component for that function, the design of the rims could remain simple.



Another initial objective was to make all three rims equal in order to facilitate the manufacturing process and reduce costs. Unfortunately, due to the complexity of the bottom rim and the need for attaching all three wheels to it, the end design will have two different models of rim, two units of the first model and one unit (the bottom one) of the second model.





Finally, being able to securely attach the baskets to the rims and thus making it possible to fold the whole structure without the need of detaching the baskets was one of the biggest challenges in this project.

However, a solution was found taking advantage of the manufacturing process and material of the rim, it was possible to create a cavity in order to later attach a couple of rails to the baskets in order for them to slide it. In order to prevent the baskets from sliding out, a couple of flaps were designed in order to lock the rails into place.

## 1.11. Final result

The result of the design process of this project is NOBAG, a personal, foldable shopping cart with modular compartments. It has two types of wheels which make the cart sturdy, yet maneuverable, a rotating handle to adjust its height and both the rims where the baskets are located and the baskets themselves are foldable for better storage.

### 1.11.1. Rendering



**Image 49:** Final product render



**Image 50:** Collection of product renders

### **1.11.2. Conclusions**

The design of this product combines many features and ideas that have been implemented in order to form a complete and useful design. It also served as a good example of a project that requires constantly thinking about many different factors, solving problems, creating solutions and being able to implement them.

The project resulted in a practical, industrial solution to problems that myself and many others faced in a very basic, every day activity.

## 2. Scope statement

### 2.1. Objective

The objective of this document is to propose and act as an explanatory guide for the conditions necessary to follow for the definition, production and conformation of the product presented in the memory.

Given the different segments presented before the product, in addition, must be profitable in its productive aspect and thus offer possibilities of development in series, taking into account costs of manufacturing, distribution, assembly etc. The accuracy of this section is imperative for its correct development. In case of inconsistency between the memory and the scope statement, the latter will prevail as the valid option.

### 2.2. General regulation

Below are listed some of the general standards that the manufacturing and distribution of this product would have to follow.

#### 2.2.1. General standards

**European Standard EN ISO 9001:** This standard establishes the criteria for a quality management system, which can be implemented by manufacturers to ensure consistent quality in shopping cart production.

**European Standard EN ISO 9004:** This standard provides guidelines for performance improvement, which can be implemented by manufacturers to improve the quality in shopping cart production.

**European Standard EN ISO 14001:** This standard specifies the requirements for an environmental management system, which can help manufacturers minimize the environmental impact of shopping cart manufacturing processes.

**European Standard EN 755:** This standard covers the technical conditions for aluminum and aluminum alloys extruded profiles, including tubing. It specifies dimensions, tolerances, mechanical properties, and other relevant characteristics.

**European Standard EN 755-1:** This standard provides general specifications for aluminum and aluminum alloys extruded profiles, including tubing. It covers aspects such as terminology, symbols, and general requirements for extruded profiles.

**European Standard EN ISO 294-1:** This standard addresses the general requirements for injection molding of thermoplastics. It covers aspects such as material selection, machine specifications, and processing conditions.

### **2.2.2. Standards regarding shopping carts and like products**

**European Standard EN 1929-1:** This standard specifies safety requirements and test methods for shopping carts, including aspects related to stability, structural integrity, and braking systems.

**European Standard EN 1929-2:** This standard provides guidelines for the ergonomic design of shopping carts, focusing on aspects such as handle height, grip comfort, maneuverability, and ease of use.

**European Standard EN 1929-3:** This standard covers the performance and safety requirements for shopping cart castors, including dimensions, load capacity, and durability.

**European Standard EN 1929-7:** This standard outlines guidelines for the design and construction of shopping cart handles, ensuring strength, ergonomics, and ease of use for consumers.

**European Standard EN 1929-8:** This standard covers the requirements for shopping cart signage and labeling, including safety instructions, load capacity markings, and warnings.

**European Standard EN 1929-9:** This standard provides guidance on the materials used in shopping cart construction, addressing aspects such as corrosion resistance, durability, and environmental impact.

**European Standard EN 1929-10:** This standard focuses on the testing and performance requirements for shopping cart wheels, including rolling resistance, wear resistance, and noise emissions.

**European Standard EN 1929-11:** This standard provides guidelines for the testing and performance requirements of shopping cart handles, including strength, durability, and resistance to bending or deformation.

**European Standard EN 1929-13:** This standard addresses the requirements for shopping cart nesting and stacking, including dimensions, stability, and ease of handling during storage or transportation.

**European Standard EN 1929-14:** This standard specifies guidelines for shopping cart maintenance, including recommendations for cleaning, lubrication, inspection, and replacement of components.

**European Standard EN 1929-15:** This standard outlines the requirements for shopping cart load capacity, including maximum weight limits, load distribution, and stability under various loading conditions.

**European Standard EN 1929-16:** This standard focuses on the design and construction requirements for shopping cart accessories, such as baskets, dividers, or hooks, ensuring proper attachment and functionality.

**European Standard EN 1929-20:** This standard covers the guidelines for the packaging and labeling of shopping carts during transportation, including recommendations for packaging materials, handling instructions, and stacking limits.



## 2.3. Technical conditions


This segment explains the technical conditions of the project.

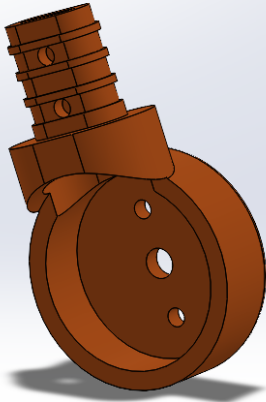
Below can be found a list of all of the components, their CMF and manufacturing processes, as well as their assembly.

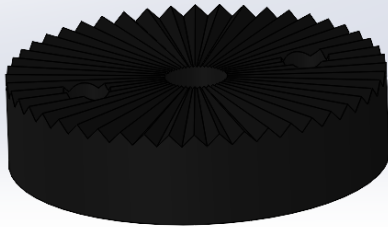
### 2.3.1. Plastic components

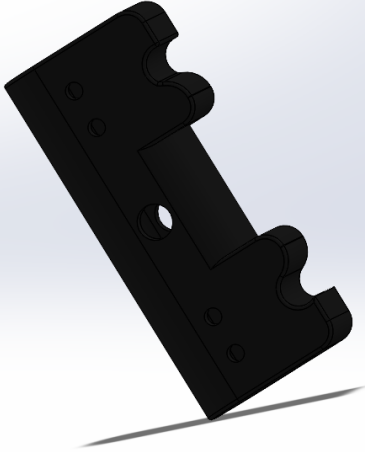
The following components all share the material and manufacturing process, that is why they are all listed below, in this section.

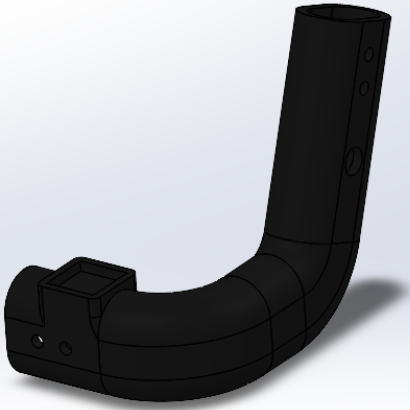
**Table 3:** Specification sheet of the plastic designed components

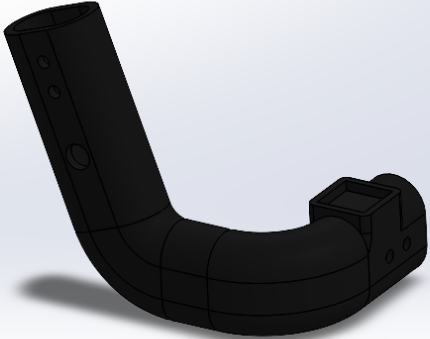
Handle Joint	Part #1	Specifications:	
		Quantity	2
		Mass	44g
		Color	Black
		Material	Polypropylene
		Finish	Smooth
		Manufacturing	Injection molding
		<b>Description:</b>	
		<p>Piece situated at the handle that resembles a bent tube. Its function is joining the main metal tubing with the horizontal handle metal tubing.</p> <p>There is only one piece used twice in opposite directions</p>	

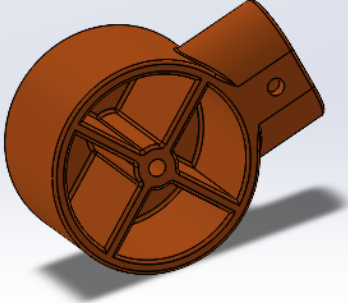
Handle case	Part #2	Specifications:	
		Quantity	4
		Mass	40g
		Color	Orange
		Material	Polypropylene
		Finish	Smooth
		Manufacturing	Injection molding
		<b>Description:</b>	
<p>A piece that serves as a rotating axis for the handle, it is attached to the metal tubing. Joining two of these components in opposite directions permits joining the metal tubing from the handle and the rest of the structure. It also encapsulates the rotating mechanism.</p>			

Handle disk	Part #3	<b>Specifications:</b>	
		Quantity	4
		Mass	19g
		Color	Black
		Material	Polypropylene
		Finish	Smooth
		Manufacturing	Injection molding
		<b>Description:</b>	
<p>Cylindrical disk that is inside of the handle case.</p> <p>It has holes in order to fix the part properly.</p> <p>With two of these components facing each other, a spring and the correspondent bolts it is possible to assemble the rotating mechanism.</p>			

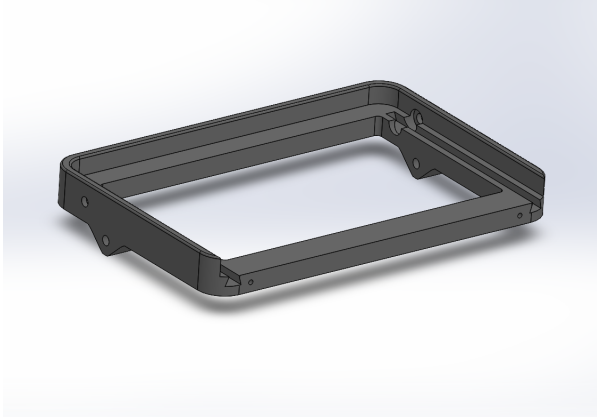
Joint	Part #4	Specifications:	
		Quantity	4
		Mass	55g
		Color	Black
		Material	Polypropylene
		Finish	Smooth
		Manufacturing	Injection molding
		<b>Description:</b>	
<p>A piece responsible to attach and hold in place the rims.</p> <p>It attaches to the main metal tube and its geometry permits pressure locking the rims in two positions: folded and unfolded.</p>			

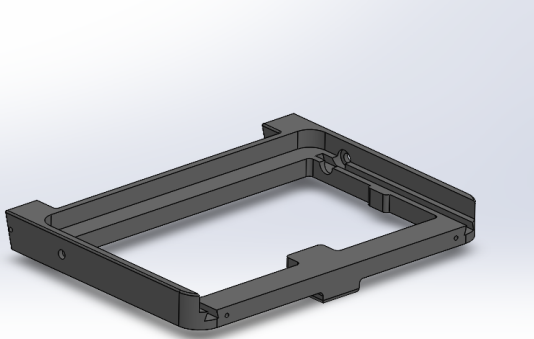
<b>Bottom left joint</b>	Part #5	<b>Specifications:</b>	
		Quantity	1
		Mass	80g
		Color	Black
		Material	Polypropylene
		Finish	Smooth
		Manufacturing	Injection molding
		<b>Description:</b>	
<p>Similarly to the previous component, it attaches the bottom rim to the main frame. This part, however, is also responsible for joining the main tubing with the bottom one and has a compartment where a neodymium magnet is located.</p>			

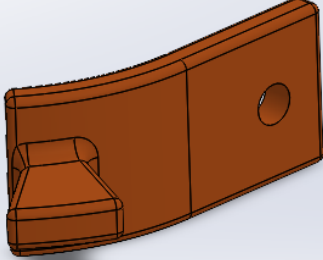
<b>Bottom right joint</b>	Part #6	<b>Specifications:</b>	
		Quantity	1
		Mass	80g
		Color	Black
		Material	Polypropylene
		Finish	Smooth
		Manufacturing	Injection molding
		<b>Description:</b>	
<p>It is the same component as the last one, but this one is mirrored in order to be located on the other side.</p>			

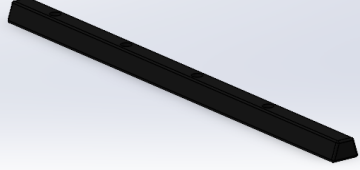
<b>Back wheel joint</b>	Part #7	<b>Specifications:</b>	
		Quantity	2
		Mass	62g
		Color	Orange
		Material	Polypropylene
		Finish	Smooth
		Manufacturing	Injection molding
		<b>Description:</b>	
<p>This component is responsible for attaching the back wheels to the metal tubing that is consequently attached to the bottom rim.</p> <p>There are two of them, one per each back wheel.</p>			



<b>Top rim</b>	Part #8	<b>Specifications:</b>	
		Quantity	2
		Mass	962g
		Color	Grey
		Material	Polypropylene
		Finish	Smooth
		Manufacturing	Injection molding
<b>Description:</b>			
<p>This component holds the baskets in place, it has specific cavities for the boxes to slide in. It is attached to the main frame and can fold to two different positions.</p> <p>There are two units of this component, the top rim and the middle rim.</p>			

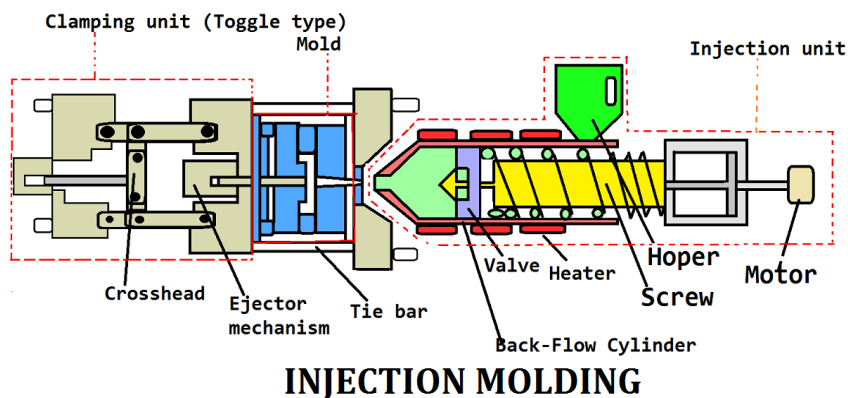
<b>Bottom rim</b>	Part #9	<b>Specifications:</b>	
		Quantity	1
		Mass	1080g
		Color	Grey
		Material	Polypropylene
		Finish	Smooth
		Manufacturing	Injection molding
		<b>Description:</b>	
<p>A similar component to the previous one. This one, however, is adapted to have two magnets that secure the rim with the bottom joints and has a special geometry to join the front wheel and the tubing for the back wheels.</p>			

Flap	Part #10	Specifications:	
		Quantity	6
		Mass	4g
		Color	Orange
		Material	Polypropylene
		Finish	Smooth
		Manufacturing	Injection molding
		<b>Description:</b>	
<p>Little pieces that prevent the rails and the rails of the baskets from sliding out of the rims involuntarily.</p> <p>When rotated they allow for the attachment and detachment of the baskets.</p>			

Rail	Part #11	Specifications:	
		Quantity	6
		Mass	25g
		Color	Black
		Material	Polypropylene
		Finish	Smooth
		Manufacturing	Injection molding
		<b>Description:</b>	
Small long components attached to the bottom of the baskets in order to slide them and attach them into the rims.			

### Manufacturing process

All of the components above would be manufactured through polymer injection molding. This process consists of heating and melting materials such as plastics, and then sending them to a mold where they are cooled to form the designed shape.

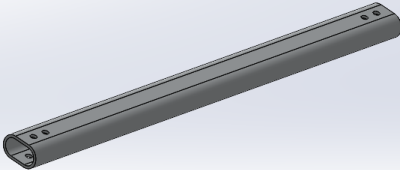


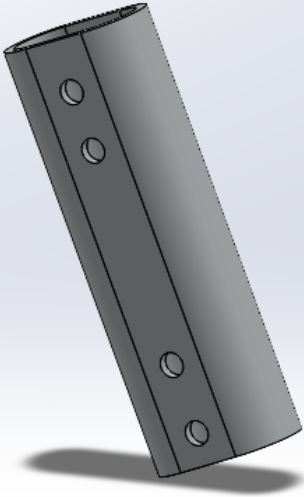
**Image 51:** Drawing of injection molding process, [themechanicalengineering.com](http://themechanicalengineering.com)

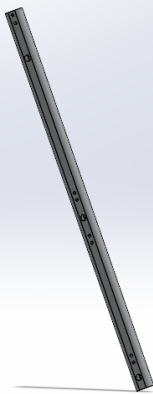
### 2.3.2. Metal tubing components

The following components are part from extruded metal tubing.

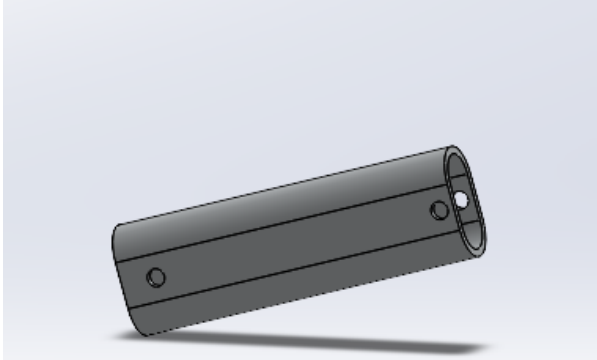
**Table 4:** Specification sheet of the metal tubing designed components

Top tube	Part #12	<b>Specifications:</b>	
		Quantity	2
		Mass	59g
		Color	Grey
		Material	Aluminum
		Finish	Smooth
		Manufacturing	Drilling
		<b>Description:</b>	
<p>A piece of extruded aluminum that serves as a handle. The same piece is also used for the bottom part of the frame</p>			

<b>Short tube</b>	Part #13	<b>Specifications:</b>	
		Quantity	2
		Mass	13g
		Color	Grey
		Material	Aluminum
		Finish	Smooth
		Manufacturing	Drilling
		<b>Description:</b>	
<p>A short piece of extruded aluminum that joins the rotating mechanism to the rest of the handle.</p>			

<b>Main tube</b>	Part #14	<b>Specifications:</b>	
		Quantity	2
		Mass	103g
		Color	Grey
		Material	Aluminum
		Finish	Smooth
		Manufacturing	Drilling
		<b>Description:</b>	
<p>A long piece of extruded aluminum where the joints are located, it finishes at the bottom joint.</p> <p>The two tubes form the majority of the frame and are attached by the joints to the rims.</p>			



<b>Wheel tube</b>	Part #15	<b>Specifications:</b>	
	Quantity	2	
	Mass	16g	
	Color	Grey	
	Material	Aluminum	
	Finish	Smooth	
	Manufacturing	Drilling	
	<b>Description:</b>		
A piece of extruded aluminum that joins the bottom rim to the back wheel joint. It is a connection between the back wheels and the rest of the structure.			

**Manufacturing process**

All of the components above use standardized aluminum tubing as a base, the only manufacturing processes to carry out would be cutting the tube and drilling 5 mm holes.



**Image 52:** Images of processes of cutting and drilling aluminum tubing, [simplifiedbuilding.com](http://simplifiedbuilding.com)

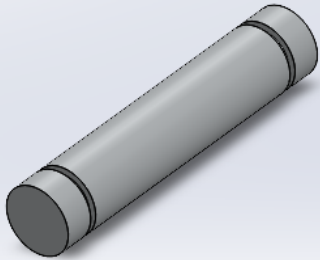
Both of those actions can be done manually with a couple of inexpensive tools: A handsaw and a drill.

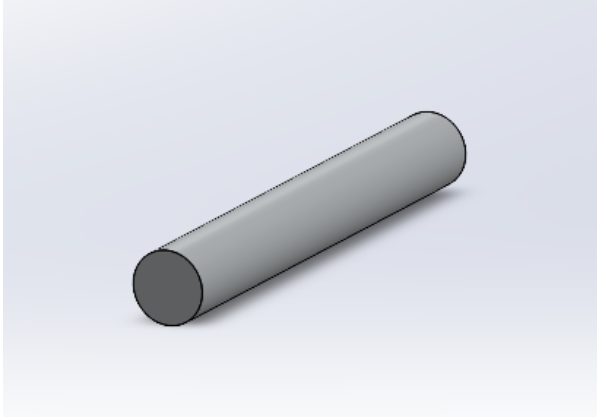


**Image 53:** Images of selected hand saw and drill for post processing, amazon.com

### 2.3.3. Steel pins

**Table 5:** Specification sheet of the designed Steel pins

Rotation pin	Part #16	Specifications:	
	Quantity	6	
	Color	Grey	
	Material	Stainless Steel	
	Finish	Smooth	
	Manufacturing	Extruding	
	<b>Description:</b>		A small cylindrical metal part that acts as an axis for the rims to fold and unfold.

<b>Stop pin</b>	Part #17	<b>Specifications:</b>	
	Quantity	4	
	Color	Grey	
	Material	Stainless Steel	
	Finish	Smooth	
	Manufacturing	Extruding	
	<b>Description:</b>		A small cylindrical metal part that locks the rims in the two possible positions.

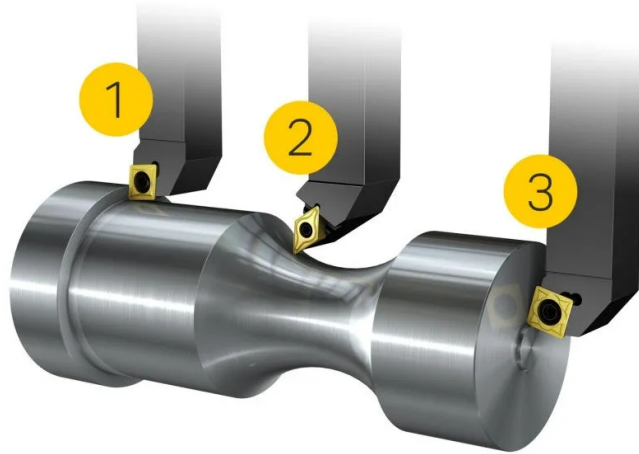
**Manufacturing process**

The two types of pins would be made out of 10 mm stainless steel rods and they would be cut and the groves would be made through external turning. The cutting would be done manually with a RATIO 5146 10mm rod cutter from Rehabilitaweb.com



**Image 54:** Image of selected RATIO 5146 10mm rod cutter, rehabilitaweb.com

The turning process would be outsourced to an external company.





**Image 55:** Image of turning process, sandvik.coromant.com)

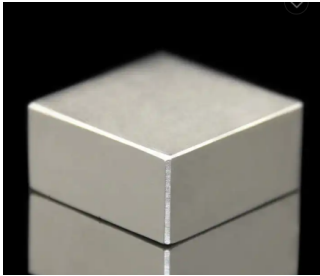
### 2.3.4. Outsourced components


Even though the next components will be acquired and not manufactured exclusively for this project, below are some specifications of the most important outsourced components.

**Table 6:** Specification sheet of the outsourced components.

Rotating wheel	<b>Supplier</b>	Foshan Changchun Casters Co., Ltd.
	<b>Specifications:</b>	
	Color	Black and gray
	Materials	Polyurethane, Steel
	Dimensions	118 x 75 x 34 mm
	Load Capacity	30 kg

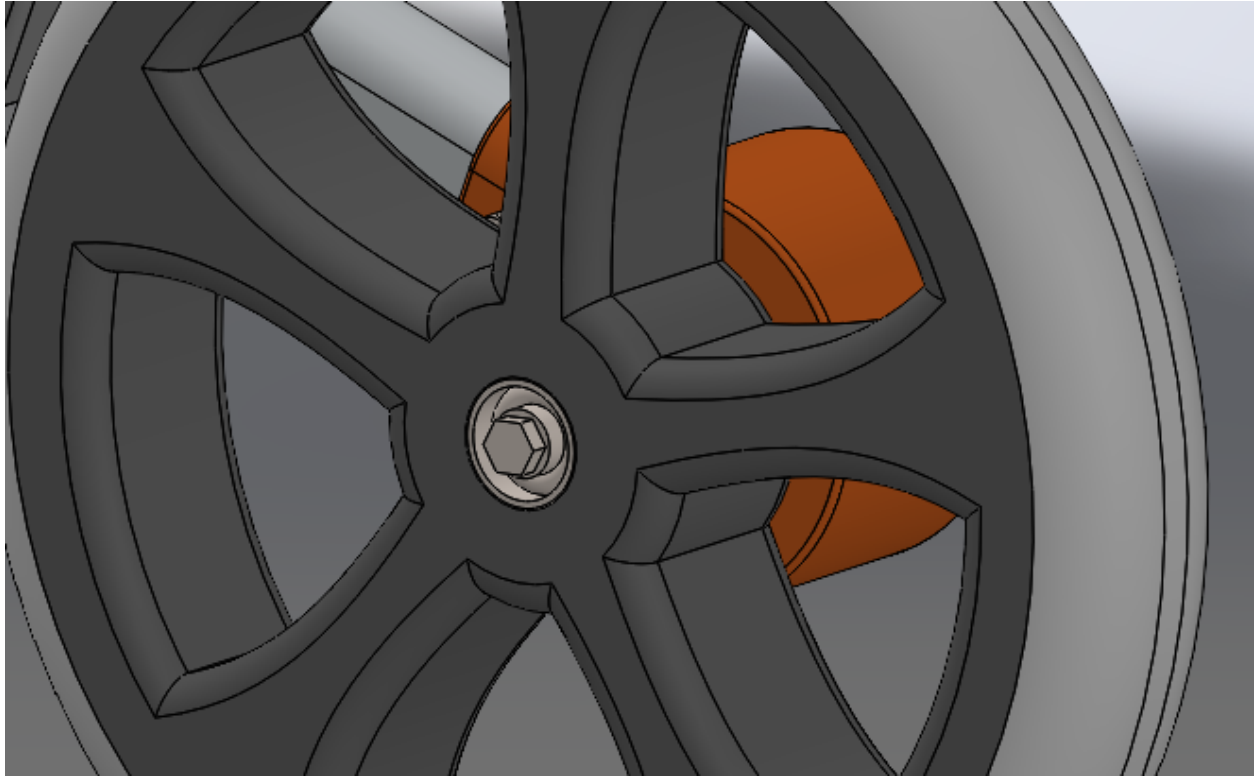
Back wheels	Supplier	ALWAYSME KidsCar Store Ltd.
	<b>Specifications:</b>	
	Color	Black and white
	Materials	Polyurethane, Rubber
	Dimensions	200 x 200 x 35 mm
	Load Capacity	80 kg

Magnets	Supplier	Shenzhen Topmag Technology Co., Ltd.
	<b>Specifications:</b>	
	Color	Grey
	Materials	Neodymium
	Dimensions	20 x 20 x 5 mm
	Magnet Certificate	ISO9001 : 2008, SGS

Baskets	<b>Supplier</b> Jieyang Jiqing Plastic Co., Ltd.	
	<b>Specifications:</b>	
	<b>Color</b>	Grey, white
	<b>Materials</b>	Polypropylene
	<b>Dimensions</b>	250 x 380 x 200 mm
	<b>Capacity</b>	17 L

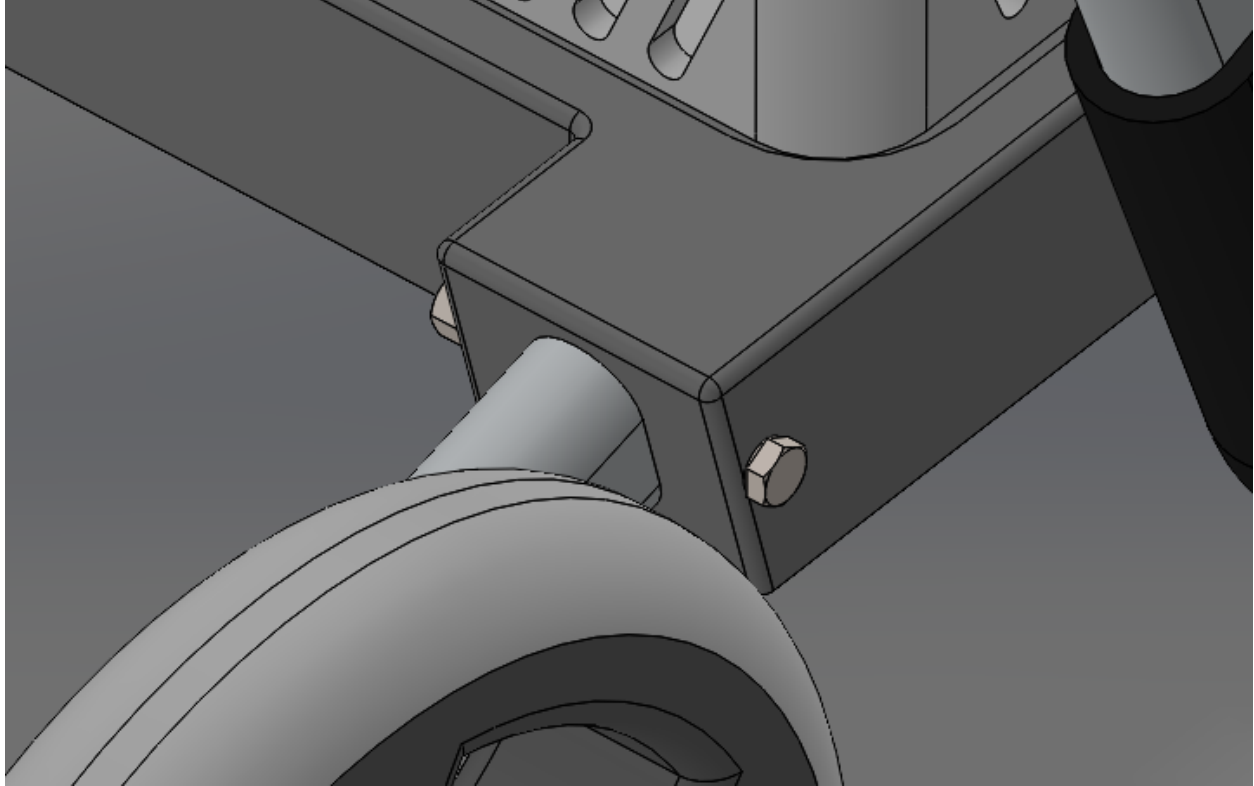
### 2.3.5. Assembly

All the different parts of the product would be assembled into one product using different types of screws and bolts:

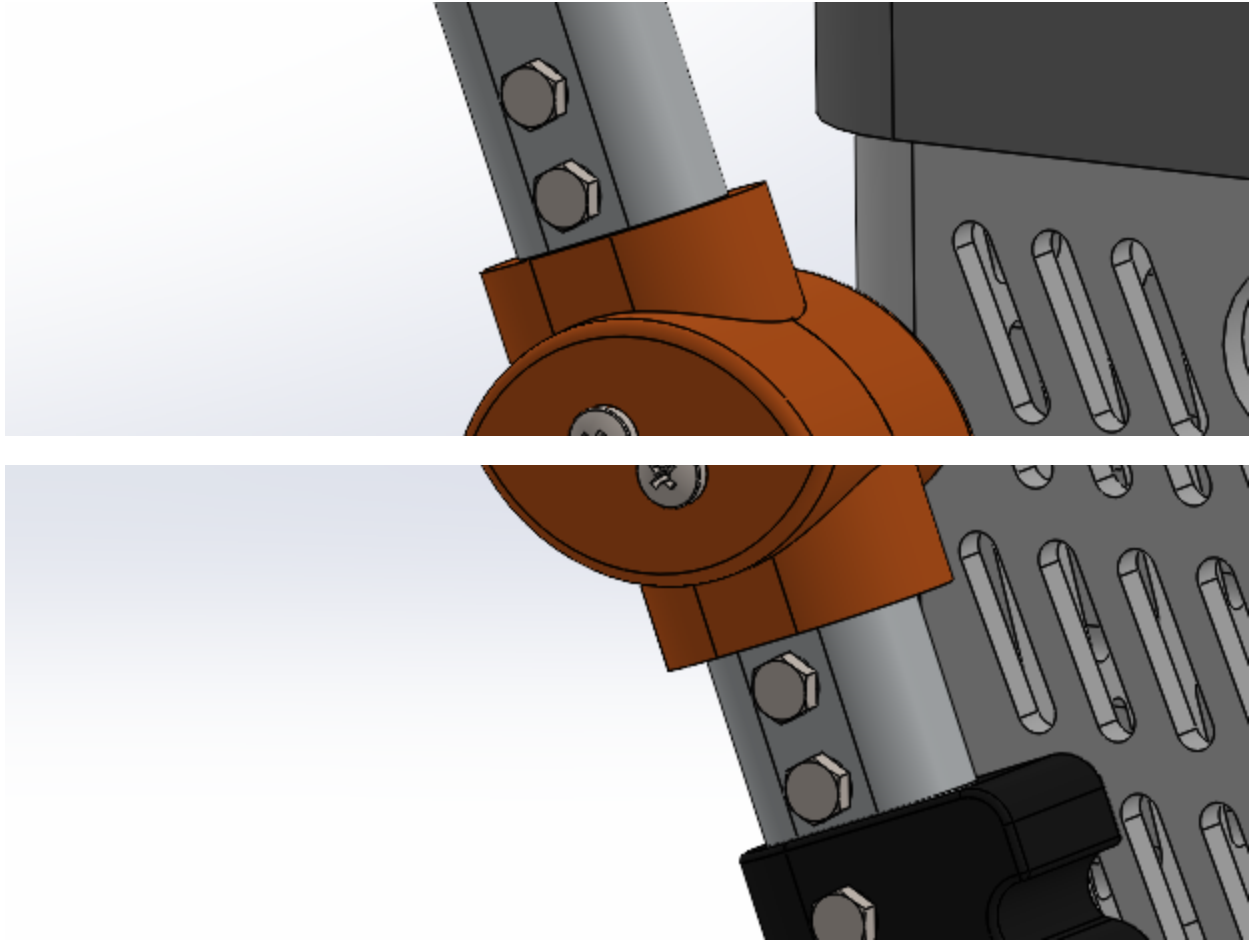


Two M5 80 mm bolts would secure the back wheels in place.

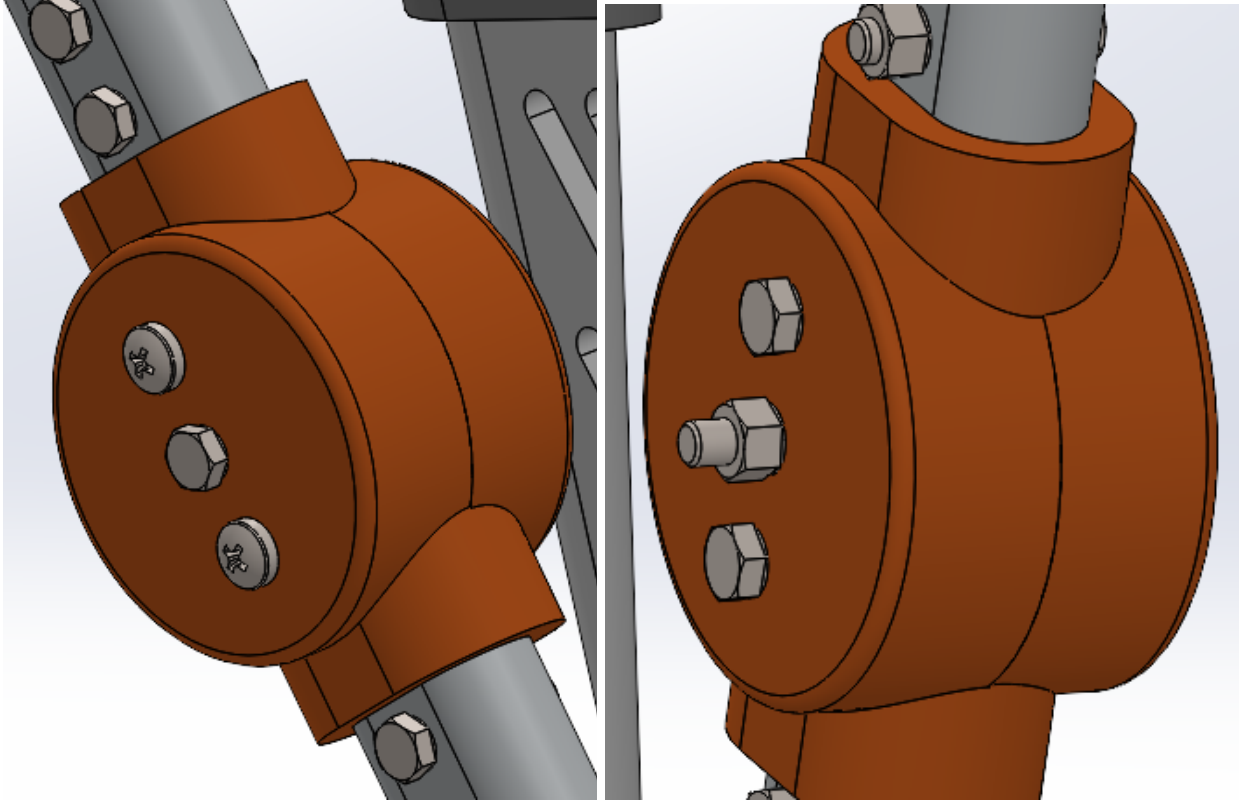




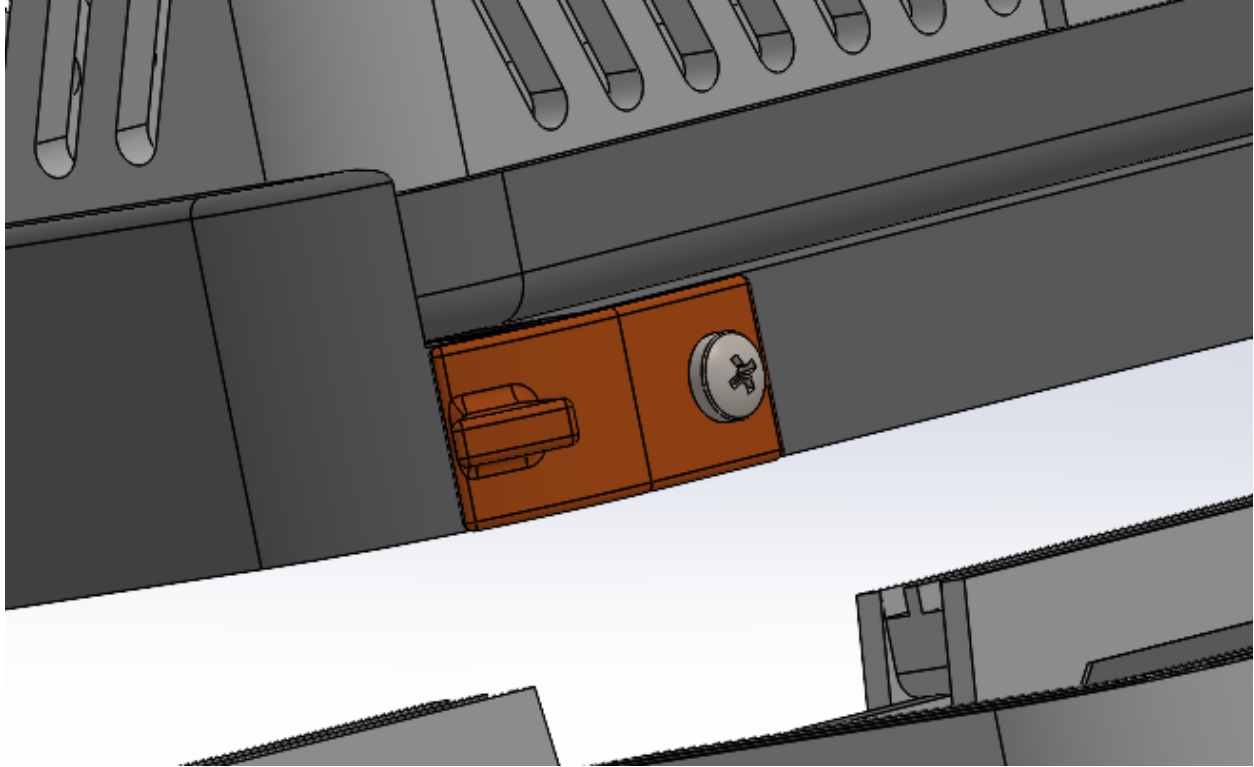
The back tubing would be joined with the bottom rim with two M5 50 mm bolts type DIN EN 24014.



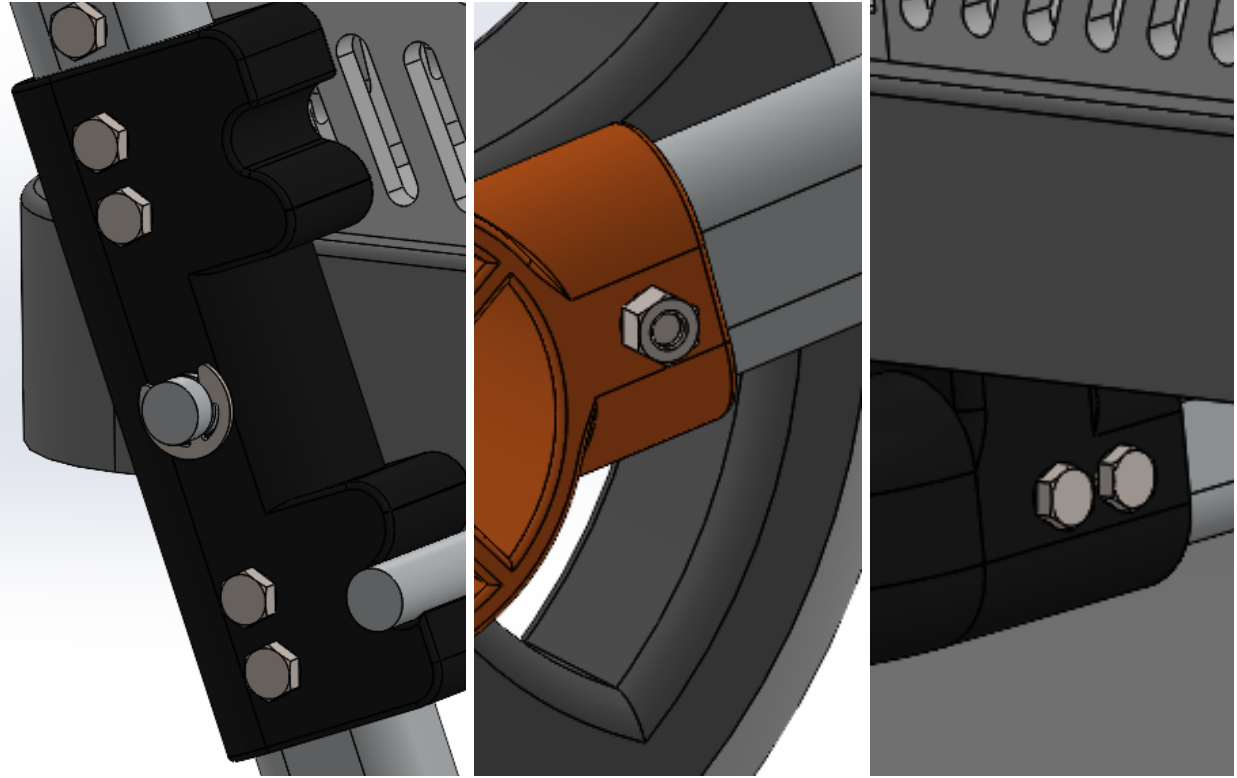
The case of the rotating mechanism would be attached to both the main tubing and the handle tubing with four M5 25 mm bolts type DIN EN 24014.



The union between the two handle cases and the disks would be made with a M5 50 mm bolt type DIN EN 24014. The discs would be secured with two M5 30 mm bolt type DIN EN 24014 for the back and two M5 16 mm screws type ISO 7045 from the front.



The same screws are used to attach the three rims with the flaps, as well as for the basket rails.

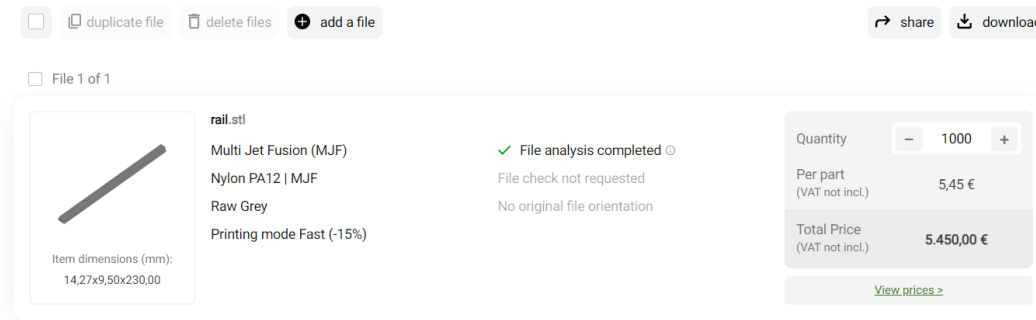


Finally, the rest of the components like the joints, bottom joints, handle joints... would be secured using M5 30 mm bolts type DIN EN 24014.

## 3. Budget

### 3.1. Designed components


This part of the budget explains and sums up the costs of all of the components that have been designed. In order to obtain an approximate manufacturing cost of the injection molded components an online quote has been received from the manufacturing website Weerg.com.

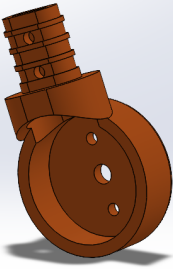


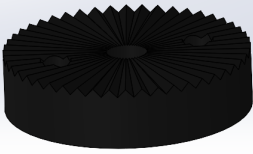
**Image 56:** Example of manufacturing quote given by Weerg.com

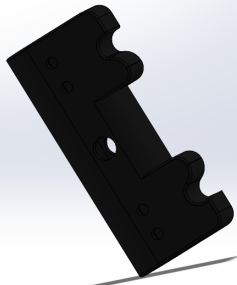
#### 3.1.1. Individual designed component cost


**Table 7:** Cost sheet of the designed components.

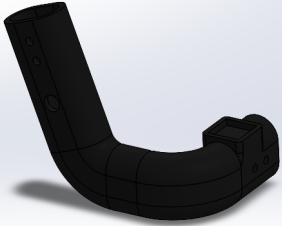
Handle joint	Supplier	Weerg .Inc
	Quantity	2
	Mass	44g
	Material	Polypropylene
	<b>Price per unit (quote from Weerg.com)</b>	<b>£9.90</b>

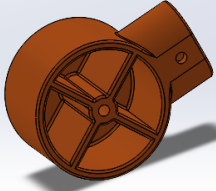
<b>Handle case</b>	Supplier	Weerg .Inc
	Quantity	4
	Mass	40g
	Material	Polypropylene
	<b>Price per unit (quote from Weerg.com)</b>	<b>£9.09</b>

<b>Handle disk</b>	Supplier	Weerg .Inc
	Quantity	4
	Mass	19g
	Material	Polypropylene
	<b>Price per unit (quote from Weerg.com)</b>	<b>£4.33</b>

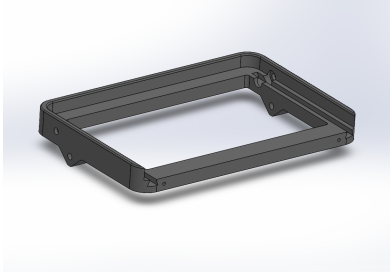
<b>Joint</b>	Supplier	Weerg .Inc
	Quantity	4
	Mass	55g
	Material	Polypropylene
	<b>Price per unit (quote from Weerg.com)</b>	<b>£12.55</b>

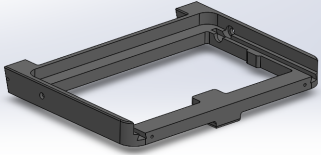
<b>Bottom left joint</b>	Supplier	Weerg .Inc
	Quantity	1
	Mass	80g
	Material	Polypropylene
	<b>Price per unit (quote from Weerg.com)</b>	<b>£19.28</b>

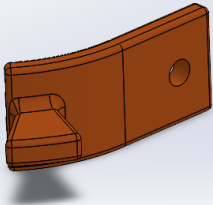
<b>Bottom right joint</b>	Supplier	Weerg .Inc
	Quantity	1
	Mass	80g
	Material	Polypropylene
	<b>Price per unit (quote from Weerg.com)</b>	<b>£19.28</b>

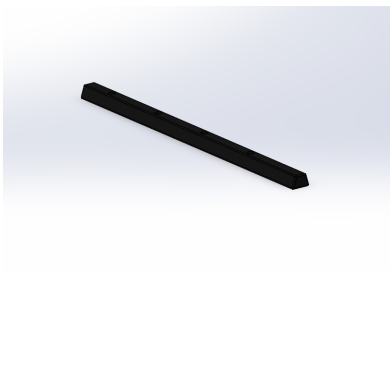
<b>Back wheel joint</b>	Supplier	Weerg .Inc
	Quantity	2
	Mass	62g
	Material	Polypropylene
	<b>Price per unit (quote from Weerg.com)</b>	<b>£14.01</b>




<b>Top rim</b>	Supplier	Weerg .Inc
	Quantity	2
	Mass	962g
	Material	Polypropylene
	<b>Price per unit (quote from Weerg.com)</b>	<b>£117.38</b>

<b>Bottom rim</b>	Supplier	Weerg .Inc
	Quantity	1
	Mass	1080g
	Material	Polypropylene
	<b>Price per unit (quote from Weerg.com)</b>	<b>£140.03</b>

<b>Flap</b>	Supplier	Weerg .Inc
	Quantity	6
	Mass	4g
	Material	Polypropylene
	<b>Price per unit (quote from Weerg.com)</b>	<b>£1.03</b>

<b>Rail</b>	Supplier	Weerg .Inc
	Quantity	6
	Mass	25g
	Material	Polypropylene
	<b>Price per unit (quote from Weerg.com)</b>	<b>£4.82</b>

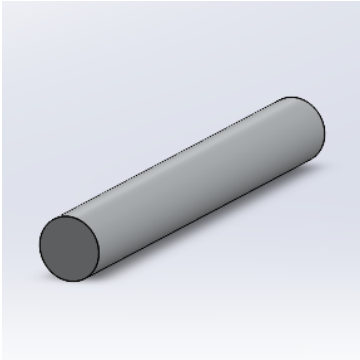
<b>Top tube</b>	Supplier	Anshan Zhongjida Industry Co., Ltd.
	Quantity	2
	Material needed	59 g
	Material cost	£4.24/1000g
	<u>Material cost per unit</u>	<u>£0.25</u>
	Tool 1 cost	£8.96
	Tool 2 cost	£17.14
	<u>Tooling cost per unit 1</u>	<u>£0.01</u>
	<u>Tooling cost per unit 2</u>	<u>£0.01</u>
	<b>Price per unit</b>	<b>£0.27</b>

<b>Short tube</b>	Supplier	Anshan Zhongjida Industry Co., Ltd.
	Quantity	2
	Material needed	13 g
	Material cost	£4.24/1000g
	<u>Material cost per unit</u>	<u>£0.06</u>
	Tool 1 cost	£8.96
	Tool 2 cost	£17.14
	<u>Tooling cost per unit 1</u>	<u>£0.01</u>
	<u>Tooling cost per unit 2</u>	<u>£0.01</u>
	<b>Price per unit</b>	<b>£0.08</b>

<b>Main tube</b>	Supplier	Anshan Zhongjida Industry Co., Ltd.
	Quantity	2
	Material needed	103 g
	Material cost	£4.24/1000g
	<u>Material cost per unit</u>	<u>£0.43</u>
	Tool 1 cost	£8.96
	Tool 2 cost	£17.14
	<u>Tooling cost per unit 1</u>	<u>£0.01</u>
	<u>Tooling cost per unit 2</u>	<u>£0.01</u>
	<b>Price per unit</b>	<b>£0.45</b>

<b>Wheel tube</b>	Supplier	Anshan Zhongjida Industry Co., Ltd.
	Quantity	2
	Material needed	16g
	Material cost	£4.24/1000g
	<u>Material cost per unit</u>	<u>£0.07</u>
	Tool 1 cost	£8.96
	Tool 2 cost	£17.14
	<u>Tooling cost per unit 1</u>	<u>£0.01</u>
	<u>Tooling cost per unit 2</u>	<u>£0.01</u>
	<b>Price per unit</b>	<b>£0.09</b>

<b>Rotation pin</b>	<b>Supplier</b>	<b>LinBo Store</b>
	Quantity	6
	Material needed	300 mm
	Material cost	£1.73
	<u>Material cost per unit</u>	<u>£0.29</u>
	Tool lifespan	4000 uses
	Uses needed	5 uses
	Tool cost	£52.27
	<u>Tool cost per unit</u>	<u>£0.06</u>
	<u>Post processing cost per unit</u>	<u>£0.09</u>
	<b>Price per unit</b>	<b>£0.44</b>

<b>Stop pin</b>	Supplier	LinBo Store
	Quantity	4
	Material needed	300 mm
	Material cost	£1.73
	<u>Material cost per unit</u>	<u>£0.43</u>
	Tool lifespan	4000 uses
	Uses needed	3 uses
	Tool cost	£52.27
	<u>Tool cost per unit</u>	<u>£0.06</u>
	<b>Price per unit</b>	<b>£0.47</b>

### 3.1.2 Combined designed component cost

**Table 8:** Table of combined component cost.

<b>Component #</b>	<b>Component name</b>	<b>Quantity</b>	<b>Price per unit</b>	<b>Total cost</b>
#1	Handle joint	2	£9.90	£19.8
#2	Handle case	4	£9.09	£36.36
#3	Handle disk	4	£4.33	£17.32
#4	Joint	4	£12.55	£50.20
#5	Bottom left joint	1	£19.28	£19.28
#6	Bottom right joint	1	£19.28	£19.28
#7	Back wheel joint	2	£14.01	£28.02

#8	Top rim	2	£117.38	£234.76
#9	Bottom rim	1	£140.03	£140.03
#10	Flap	6	£1.03	£6.18
#11	Rail	6	£4.82	£28.92
#12	Top tube	2	£0.27	£0.54
#13	Short tube	2	£0.08	£0.16
#14	Main tube	2	£0.45	£0.90
#15	Wheel tube	2	£0.09	£0.18
#16	Rotation pin	6	£0.44	£2.64
#17	Stop pin	4	£0.47	£1.88
<b>Total cost:</b>				<b>£606.45</b>





## 3.2. Outsourced components


This part of the budget explains and sums up the costs of all of the outsourced components.

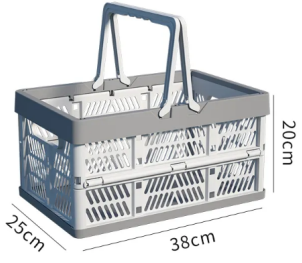
### 3.2.1. Individual outsourced component cost


**Table 9:** Cost sheet of the outsourced components.


Rotating wheel	Supplier	Foshan Changchun Casters Co., Ltd.
	Quantity	1
	Supply Ability	100000 Units/ Month
	Minimum order	100
	Minimum price	£34.62
	Price per unit	<b>£0.35</b>


Back wheel	Supplier	ALWAYSME KidsCar Store Ltd.
	Quantity	2
	Supply Ability	N/S
	Minimum order	1
	Minimum price	£3.19
	Price per unit	<b>£3.19</b>


<b>Magnet</b>	Supplier	Shenzhen Topmag Technology Co., Ltd.
	Quantity	4
	Supply Ability	3000000 Units/ Month
	Minimum order	100
	Minimum price	£38.47
	Price per unit	<b>£0.38</b>


<b>Basket</b>	Supplier	Jieyang Jiqing Plastic Co., Ltd.
	Quantity	3
	Supply Ability	10000 Units/ Month
	Minimum order	36
	Minimum price	£45.14
	Price per unit	<b>£1.26</b>


<b>Spring</b>	Supplier	Shenzhen Nailida Hardware Products Co., Ltd.
	Quantity	2
	Supply Ability	20000000 Units/ Month
	Minimum order	100
	Minimum price	£4.62
	Price per unit	<b>£0.05</b>


<b>M5 L30 Bolts</b>	Supplier	Screwfix Direct Ltd
	Quantity	38
	Supply Ability	N/A
	Minimum order	100
	Minimum price	£5.49
	Price per unit	<b>£0.05</b>


<b>M5 L25 Bolts</b>	Supplier	Accu Limited Company
	Quantity	8
	Supply Ability	N/A
	Minimum order	200
	Minimum price	£30.00
	Price per unit	<b>£0.15</b>


M5 L50 Bolts	Supplier	Leroy Merlin España S.L.U
	Quantity	4
	Supply Ability	N/A
	Minimum order	50
	Minimum price	£8.41
	Price per unit	<b>£0.17</b>

M5 L80 Bolts	Supplier	Amazon.com, Inc.
	Quantity	2
	Supply Ability	N/A
	Minimum order	10
	Minimum price	£7.57
	Price per unit	<b>£0.76</b>

M5 L16 Screws	Supplier	Amazon.com, Inc.
	Quantity	34
	Supply Ability	N/A
	Minimum order	50
	Minimum price	£8.29
	Price per unit	<b>£0.17</b>

<b>8 mm Rivet</b>	Supplier	VueloVerde.com
	Quantity	12
	Supply Ability	N/A
	Minimum order	15
	Minimum price	£0.45
	Price per unit	<b>£0.03</b>

<b>M5 Nuts</b>	Supplier	Guangdong Jingyi Technology Co., Ltd.
	Quantity	52
	Supply Ability	1000000 Units/ Month
	Minimum order	1000
	Minimum price	£38.47
	Price per unit	<b>£0.04</b>

<b>Foam sheet</b>	Supplier	Guangdong Jingyi Technology Co., Ltd.
	Quantity	1
	Supply Ability	N/A
	Minimum order	60
	Minimum price	£11.48
	Price per unit	<b>£0.19</b>

### 3.2.2 Combined outsourced component cost

**Table 10:** Table of combined outsourced component cost.

Component name	Quantity	Price per unit	Total cost
Rotating wheel	1	£0.35	£0.35
Back wheels	2	£3.19	£6.38
Magnets	4	£0.38	£1.52
Baskets	3	£1.26	£3.78
Springs	2	£0.05	£0.10
M5 L30 Bolts	38	£0.05	£2.08
M5 L25 Bolts	8	£0.15	£1.20
M5 L50 Bolts	4	£0.17	£0.67
M5 L80 Screws	2	£0.76	£1.51
M5 L16 Screws	34	£0.17	£5.63

8mm Rivets	12	£0.03	£0.36
Nuts	52	£0.04	£2.00
Foam sheet	1	£0.19	£0.19
<b>Total cost:</b>			<b>£25.77</b>

### 3.3 Assembly cost

Taking into account the approximate time of assembly and a minimum wage worker the cost of assembly is as follows:

**Table 11:** Table of assembly cost.

Workers	Operation	Cost/hour	Hours	Total cost
1	Rod cutting	£8.91*	0.03	£0.26
1	Tube cutting	£8.91	0.03	£0.26
1	Tube drilling	£8.91	0.33	£2.94
1	Assembly	£8.91	1	£8.91
<b>Total cost:</b>				<b>£12.38</b>

\*minimum wage in the UK

### 3.4. Total final cost

The total final cost combines the designed components cost, the outsourced components cost and the assembly cost in the table below.

**Table 12:** Table of total final cost.

Type of cost	Total cost
Designed components total cost	<b>£606.45</b>
Outsourced components total cost	<b>£25.77</b>
Assembly total cost	<b>£12.38</b>
<b>Total cost:</b>	<b>£644.60</b>

Taking into account the initial target user, the project's budget appears to be significantly more expensive than expected. The biggest costs seem to be related to the size of the two main components and the customizability of all of them, which suggests that a way to optimize the product could be modifying some of the designed components or trying to reduce its number.



## 4. Planimetry

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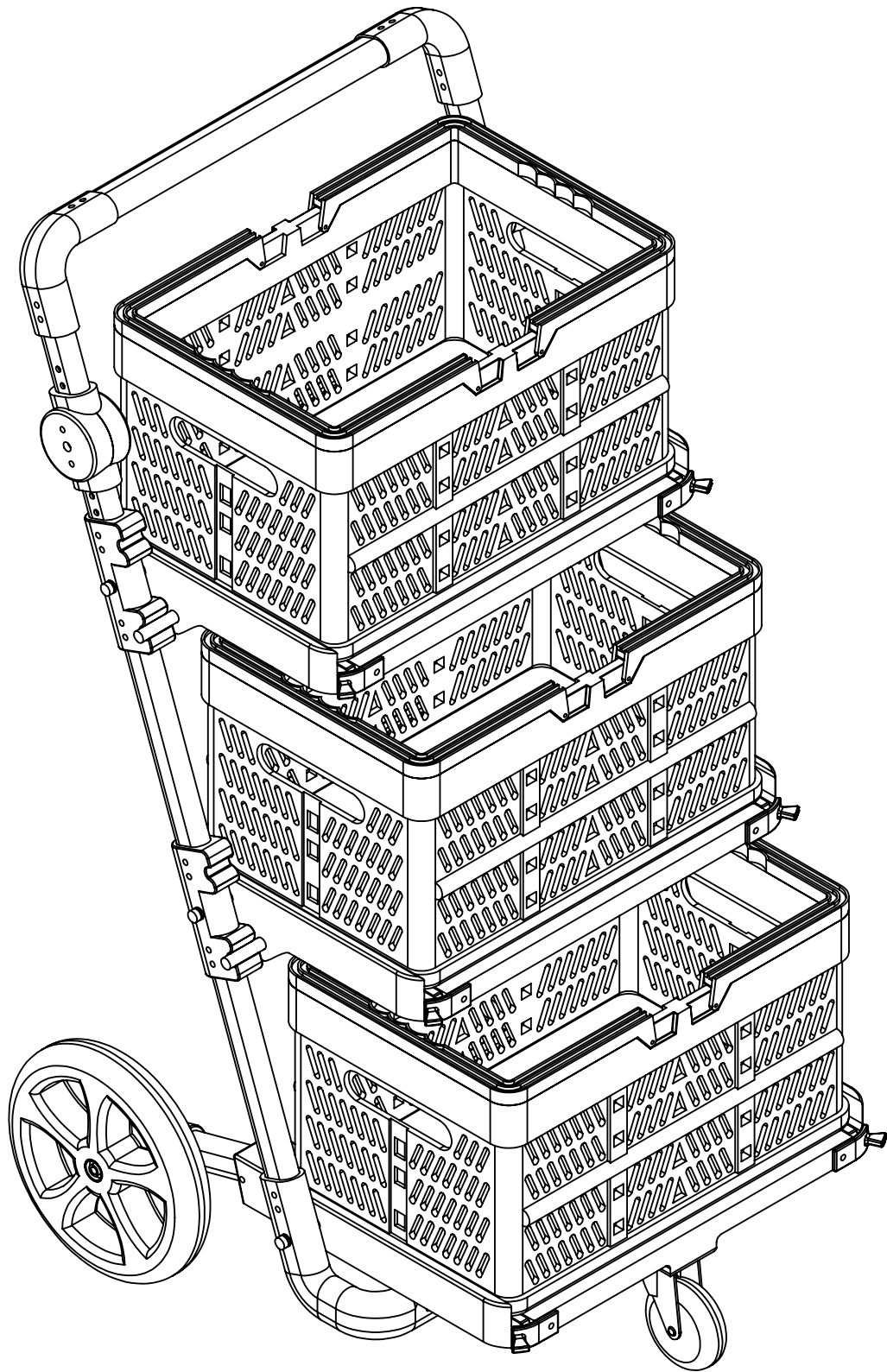
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PLEASE REPORT ERRORS AND OMISSIONS

REMOVE ALL BURRS AND SHARP EDGES

DO NOT SCALE PRINT

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**Middlesex  
University  
London**

Drawn:	Checked:	Scale 1:5	Tolerance:
Title: Isometric		Sht. 1 of 1	mm [in]
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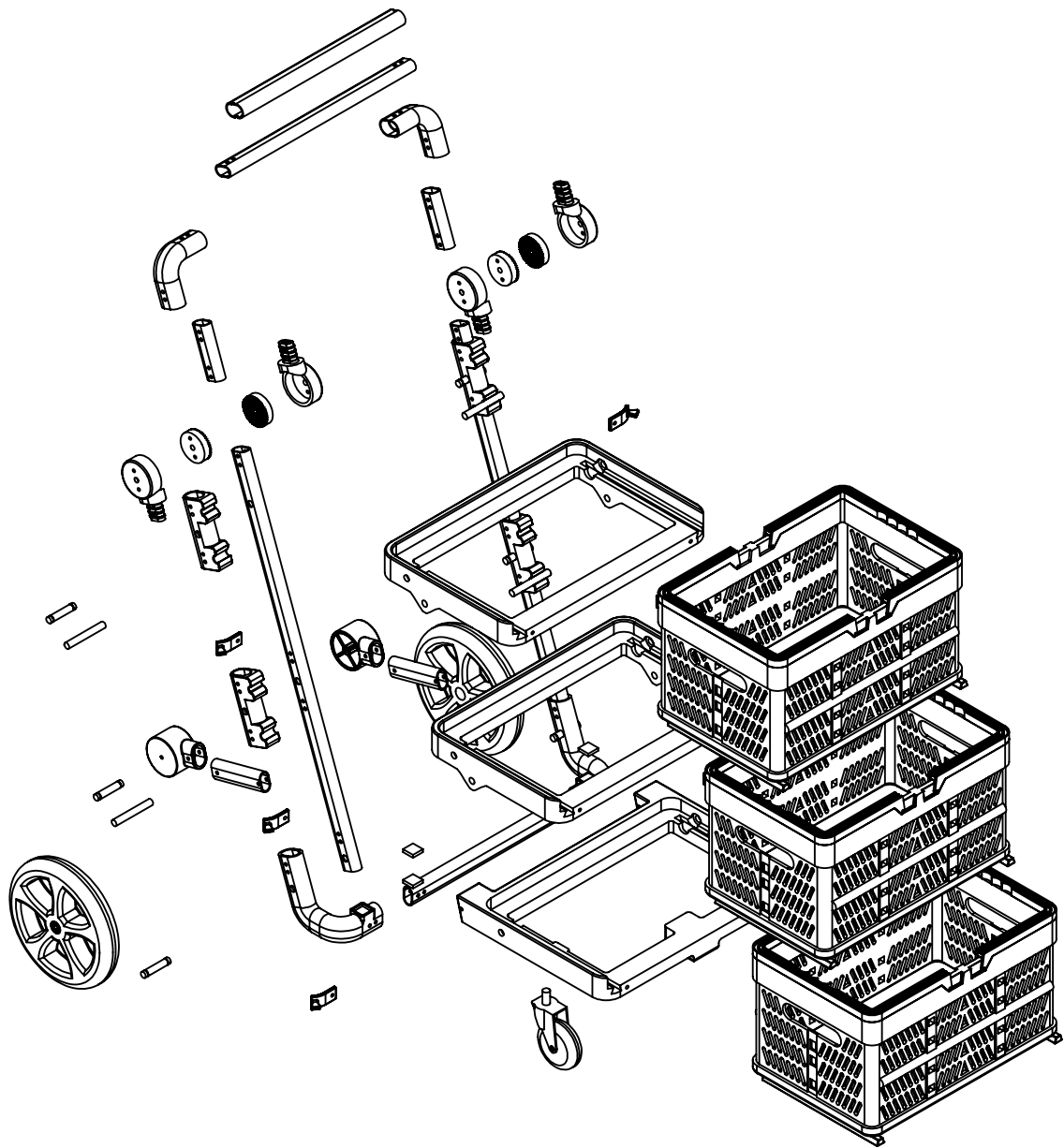
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**Middlesex  
University  
London**

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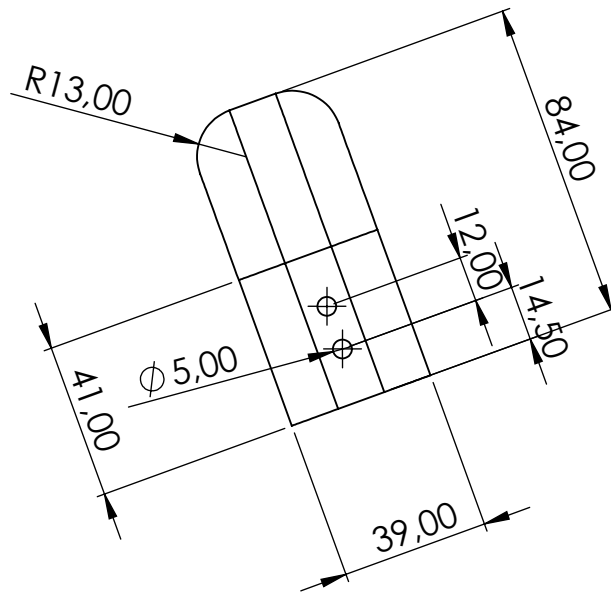
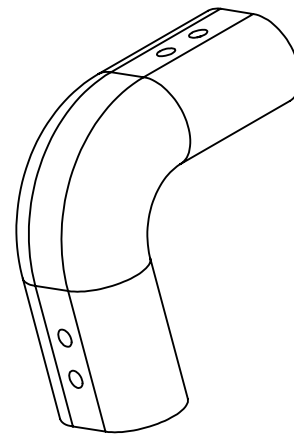
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Drawn:	Checked:	Scale 1:2	Tolerance:
Title: Handle Joint		Sht. 1 of 1	mm [in]
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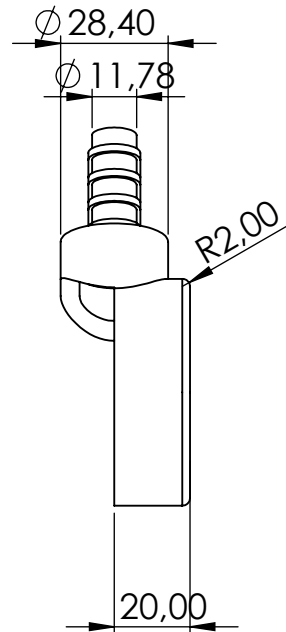
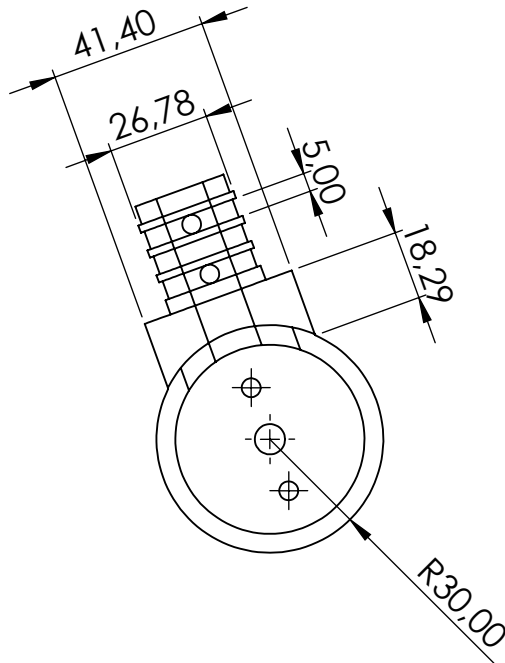
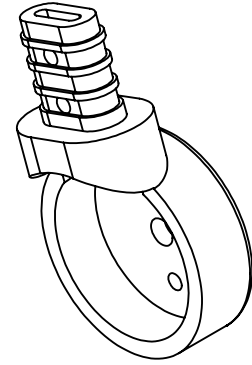
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PLEASE REPORT ERRORS AND OMISSIONS

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Drawn:	Checked:	Scale 1:2	Tolerance:
Title: Handle Case		Sht. 1 of 1	mm [in]
		No. A4	

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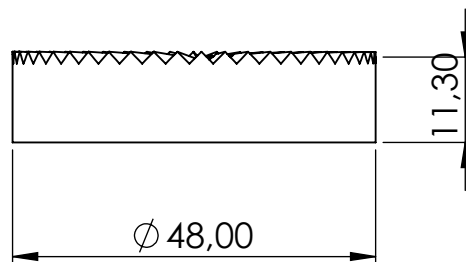
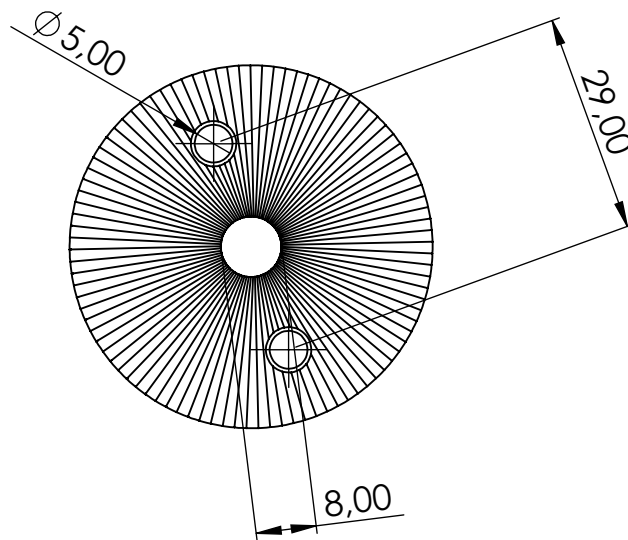
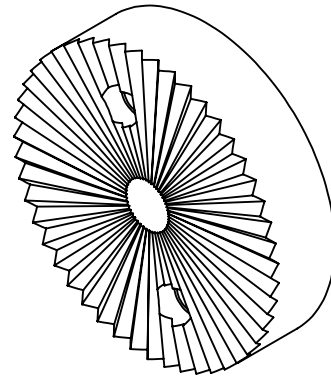
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PLEASE REPORT ERRORS AND OMISSIONS

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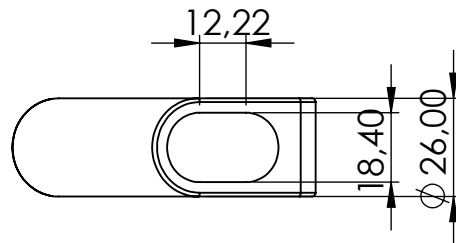
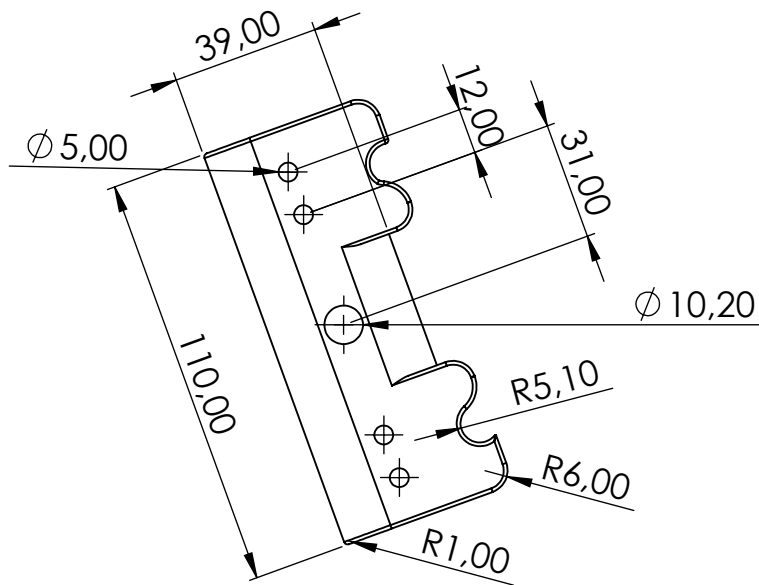
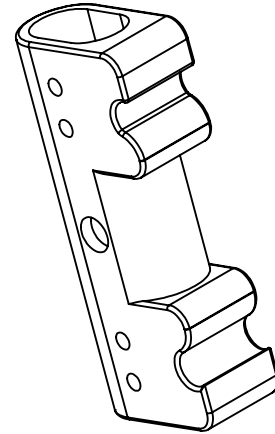
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PLEASE REPORT ERRORS AND OMISSIONS

REMOVE ALL BURRS AND SHARP EDGES

DO NOT SCALE PRINT

Material:	Finish:	Colour:
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**Middlesex  
University  
London**

Drawn:	Checked:	Scale 1:2	Tolerance:
Title: Joint		Sht. 1 of 1	mm [in]
		No. A4	

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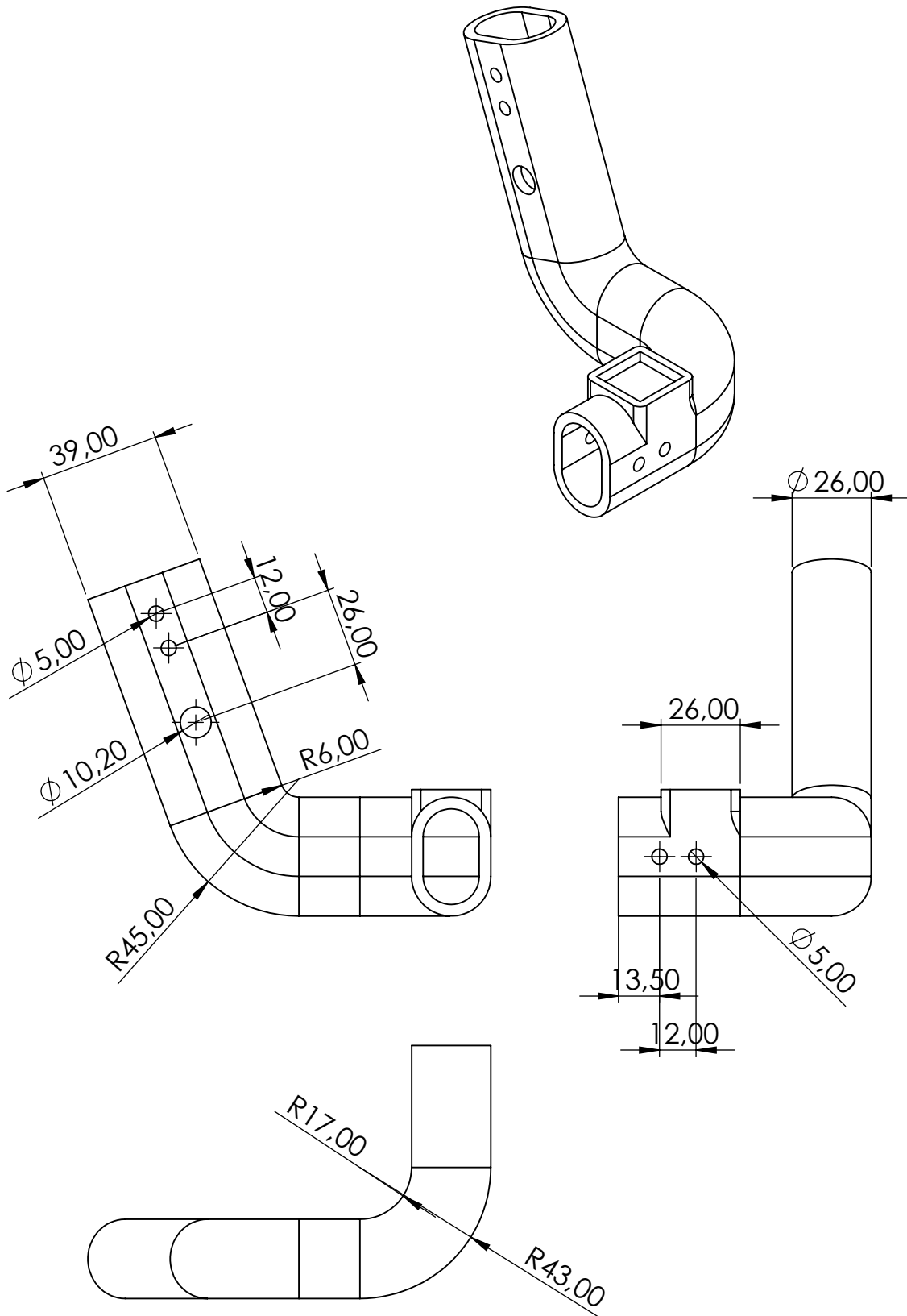
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PLEASE REPORT ERRORS AND OMISSIONS

REMOVE ALL BURRS AND SHARP EDGES

DO NOT SCALE PRINT

Material:			Finish:			Colour:		
Revisions:								
Drawn:		Checked:		Scale 1:2		Tolerance:		
Title: Bottom Left Joint				Sht. 1 of 1		mm [in]		
				No. A4				



**Middlesex**  
**University**  
**London**



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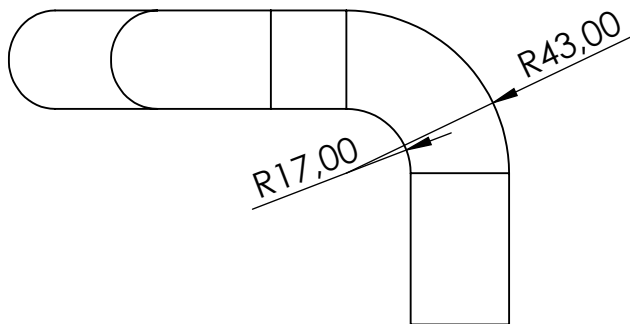
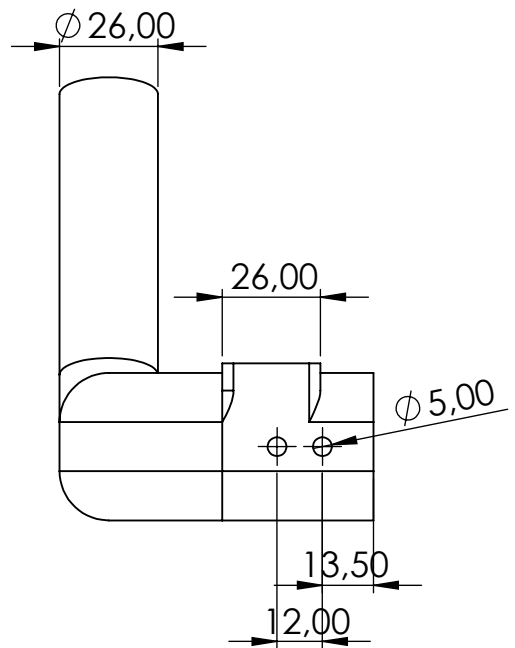
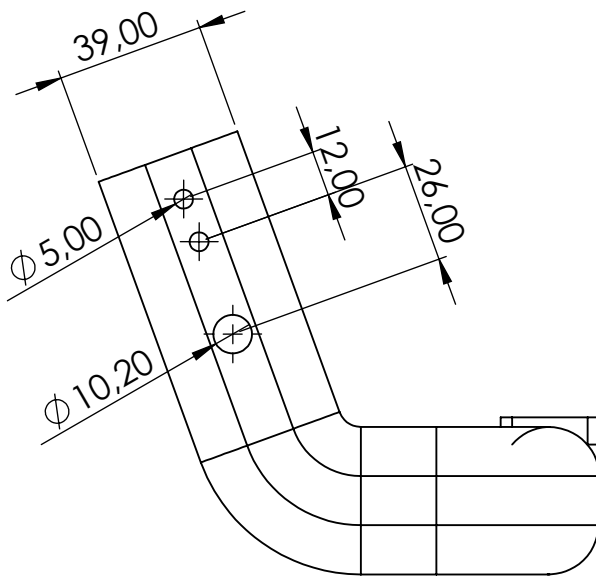
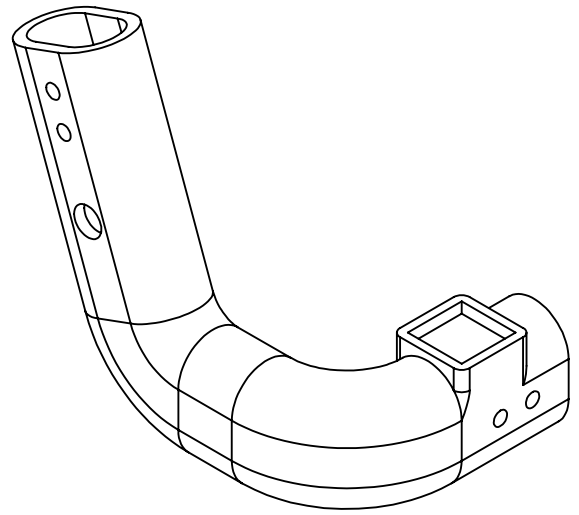
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PLEASE REPORT ERRORS AND OMISSIONS

REMOVE ALL BURRS AND SHARP EDGES

DO NOT SCALE PRINT

Material:	Finish:	Colour:
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Revisions:									
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Drawn:	Checked:	Scale 1:2	Tolerance:
Title: Bottom Right Joint		Sht. 1 of 1	mm [in]
		No. A4	

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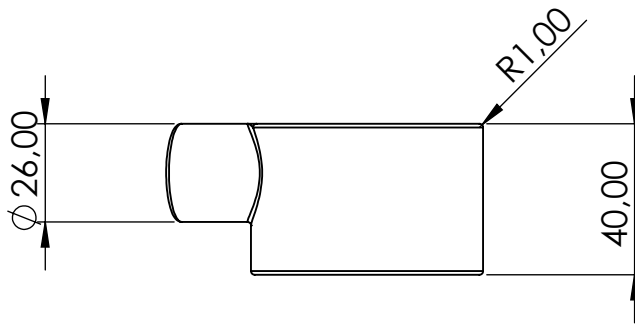
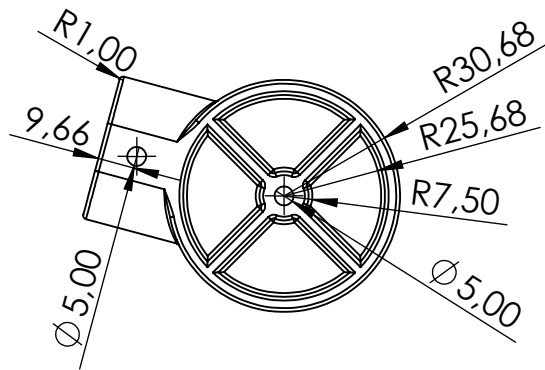
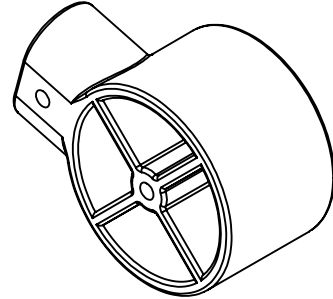
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PLEASE REPORT ERRORS AND OMISSIONS

REMOVE ALL BURRS AND SHARP EDGES

DO NOT SCALE PRINT

Material:	Finish:	Colour:
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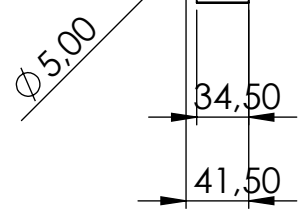
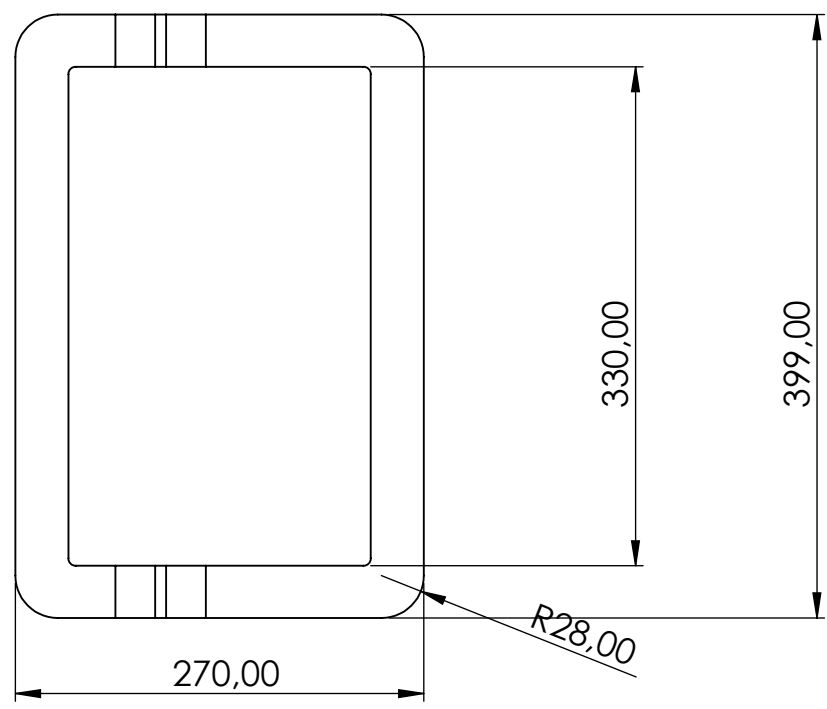
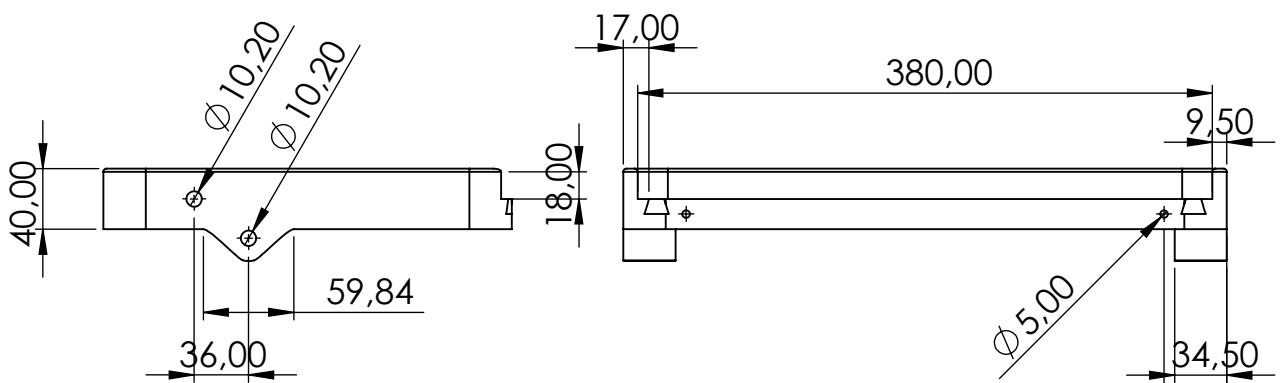
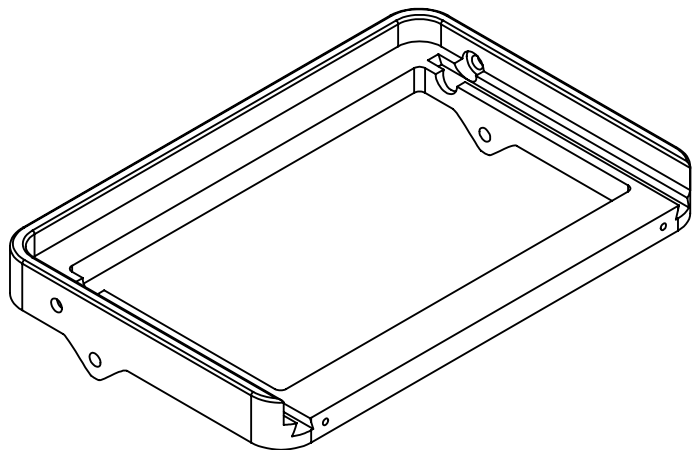
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Drawn:	Checked:	Scale 1:2	Tolerance:
Title: Back wheel joint		Sht. 1 of 1	mm [in]
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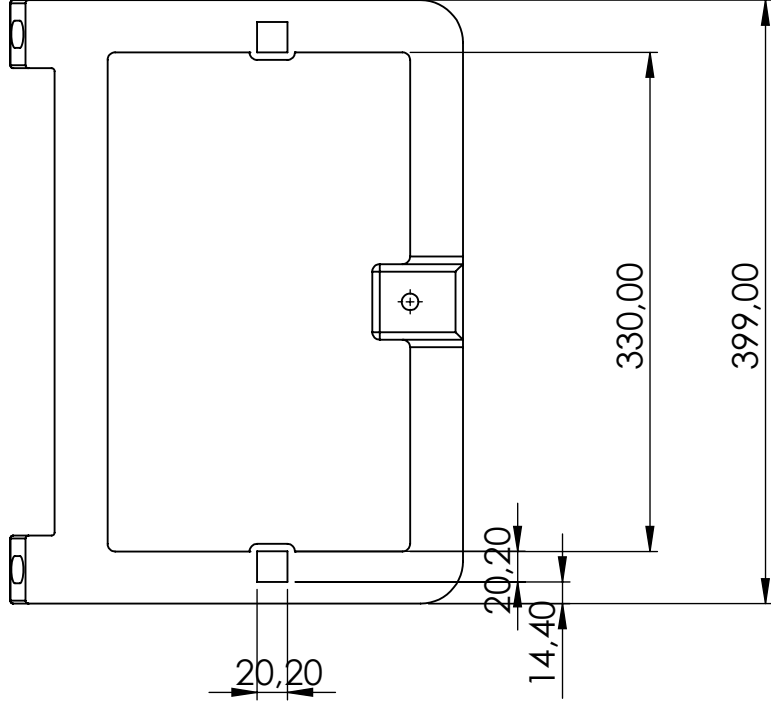
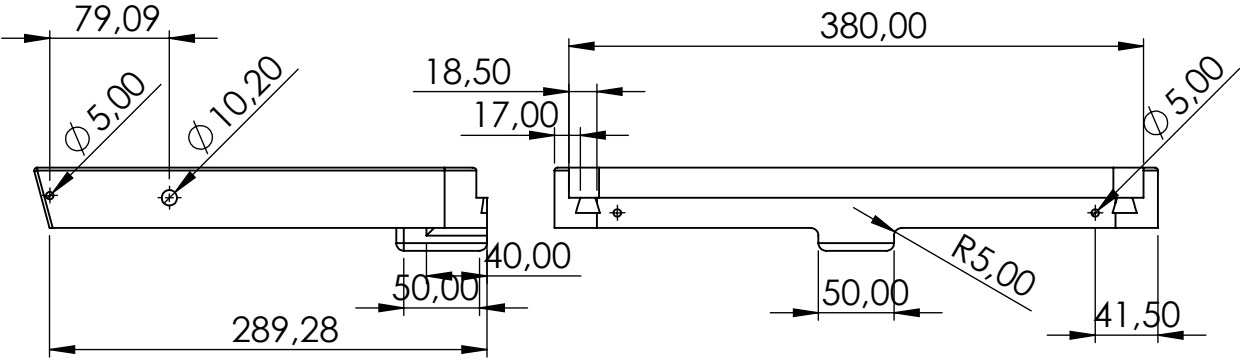
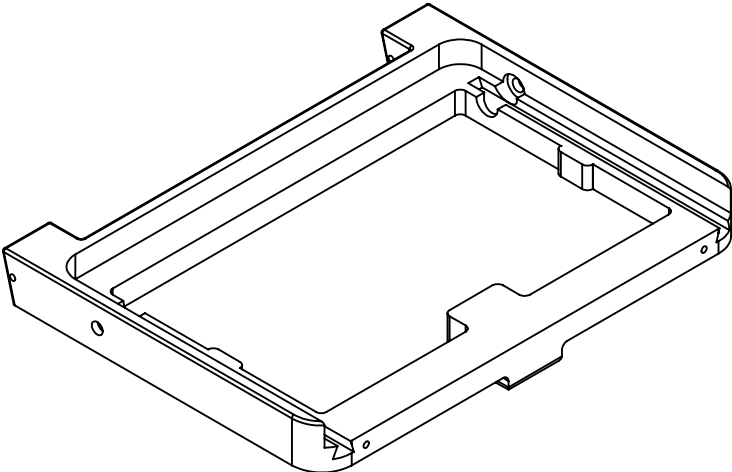
PLEASE REPORT ERRORS AND OMISSIONS REMOVE ALL BURRS AND SHARP EDGES DO NOT SCALE PRINT

Material:			Finish:			Colour:		
Revisions:								
Drawn:		Checked:		Scale 1:5		Tolerance:		
Title: Top rim				Sht. 1 of 1		mm [in]		
				No. A4				



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PLEASE REPORT ERRORS AND OMISSIONS REMOVE ALL BURRS AND SHARP EDGES DO NOT SCALE PRINT

Material:	Finish:	Colour:
Revisions:		



Drawn:	Checked:	Scale 1:5	Tolerance:
Title: Bottom rim		Sht. 1 of 1	mm [in]
		No. A4	

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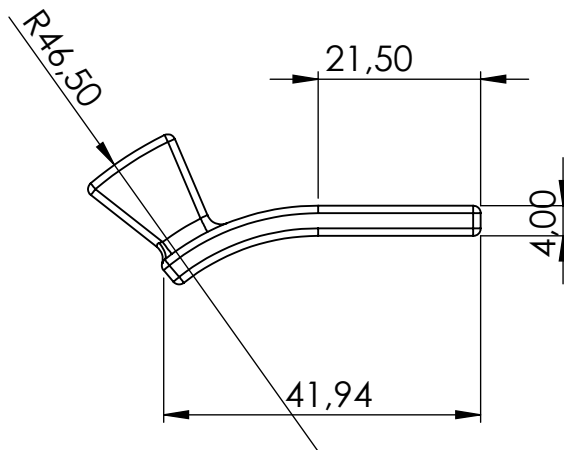
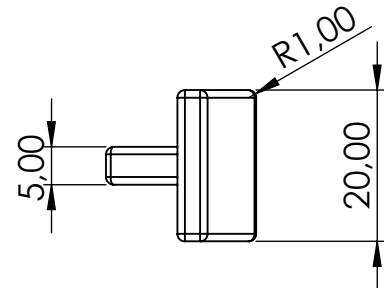
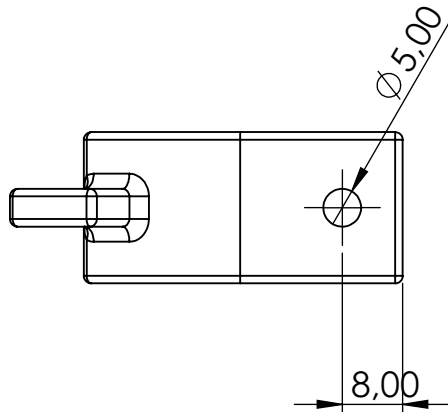
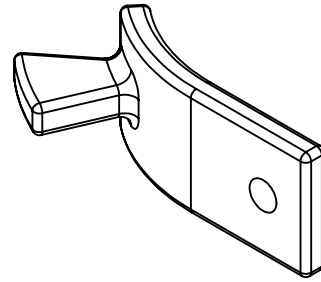
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PLEASE REPORT ERRORS AND OMISSIONS

REMOVE ALL BURRS AND SHARP EDGES

DO NOT SCALE PRINT

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Drawn:	Checked:	Scale 1:1	Tolerance:
Title: Flap		Sht. 1 of 1	mm [in]
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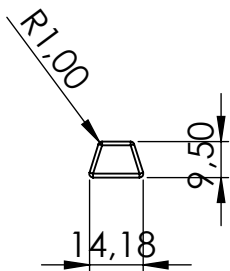
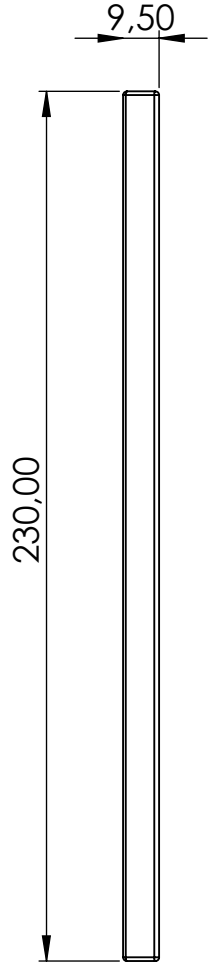
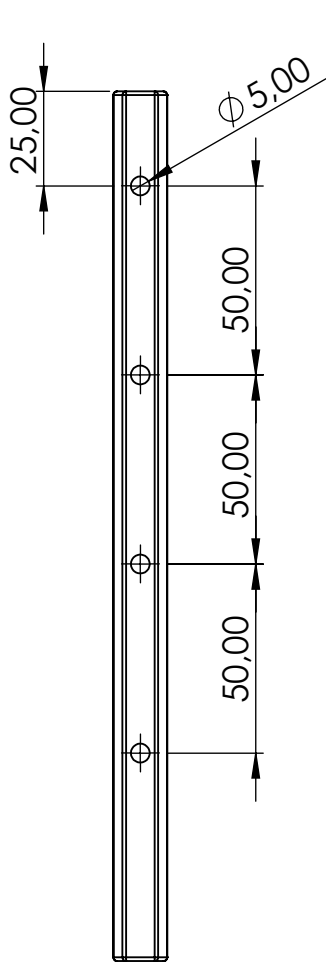
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PLEASE REPORT ERRORS AND OMISSIONS REMOVE ALL BURRS AND SHARP EDGES DO NOT SCALE PRINT

Material: Finish: Colour:

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Drawn:	Checked:	Scale 1:2	Tolerance:
Title: Rail		Sht. 1 of 1	mm [in]
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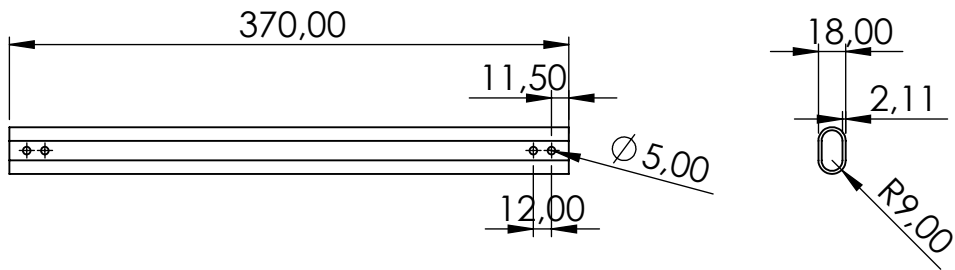
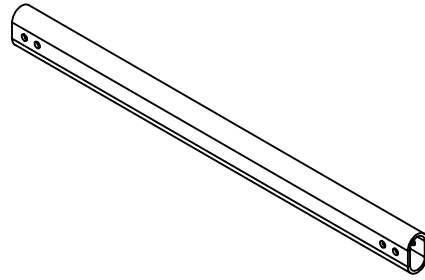
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PLEASE REPORT ERRORS AND OMISSIONS

REMOVE ALL BURRS AND SHARP EDGES

DO NOT SCALE PRINT

Material:	Finish:	Colour:
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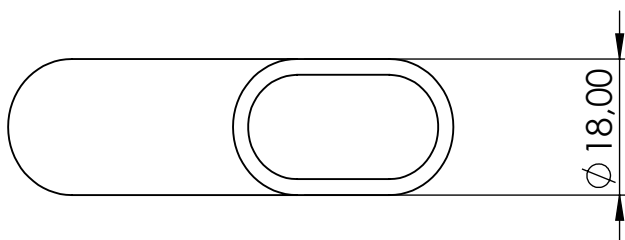
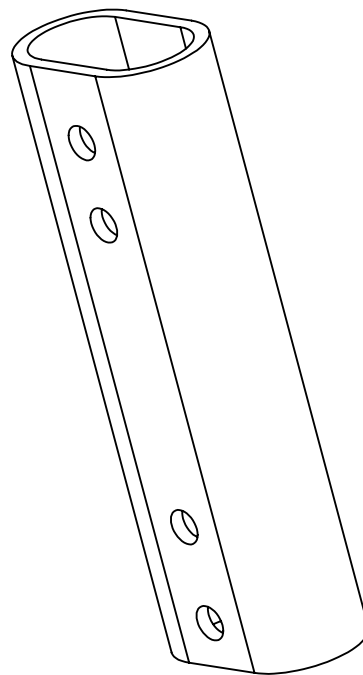
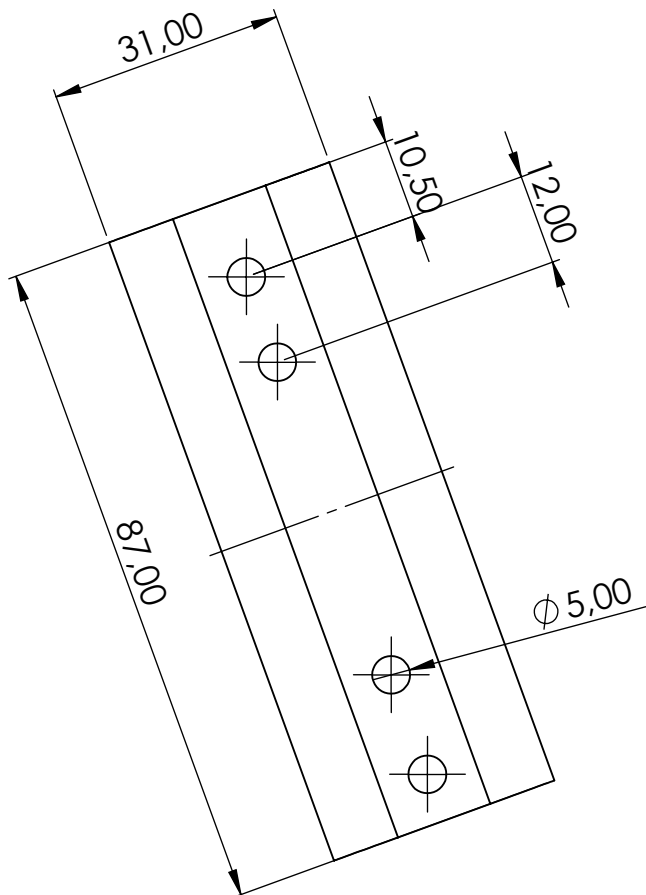
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Drawn:	Checked:	Scale 1:5	Tolerance:
Title: Top tube		Sht. 1 of 1	mm [in]
		No. A4	

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PLEASE REPORT ERRORS AND OMISSIONS

REMOVE ALL BURRS AND SHARP EDGES

DO NOT SCALE PRINT

Material: Finish: Colour:

Revisions:



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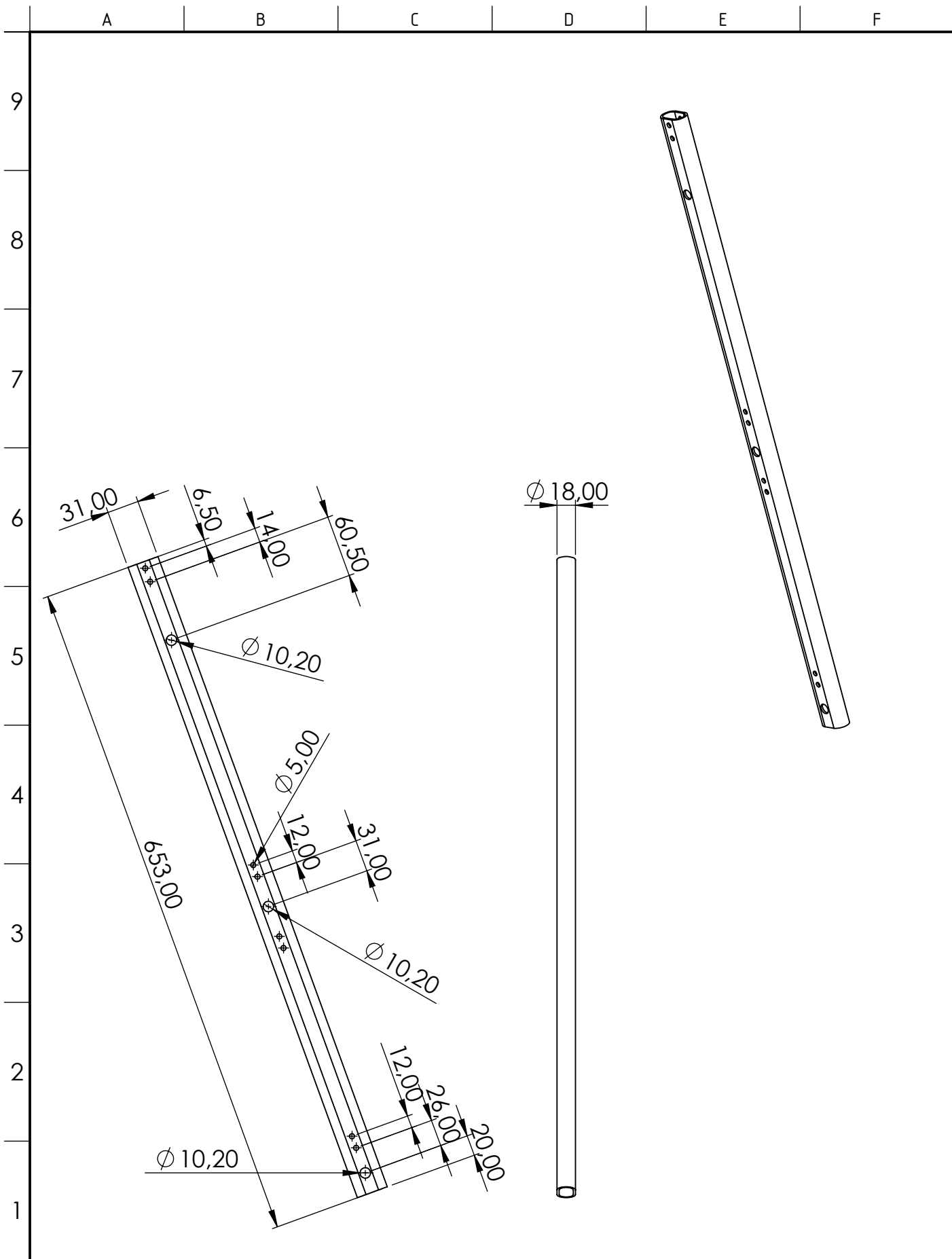
Drawn: Checked: Scale 1:1 Tolerance:

Title: Sht. 1 of 1 mm [in]

Short tube

No. A4







PLEASE REPORT ERRORS AND OMISSIONS

REMOVE ALL BURRS AND SHARP EDGES

DO NOT SCALE PRINT

Material:			Finish:			Colour:			
Revisions:									
			Drawn:		Checked:		Scale 1:5		Tolerance:
			Title: Main tube		Sht. 1 of 1		mm [in]		
			No.		A4				

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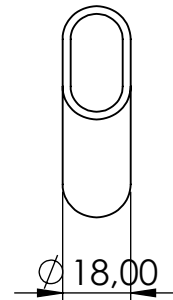
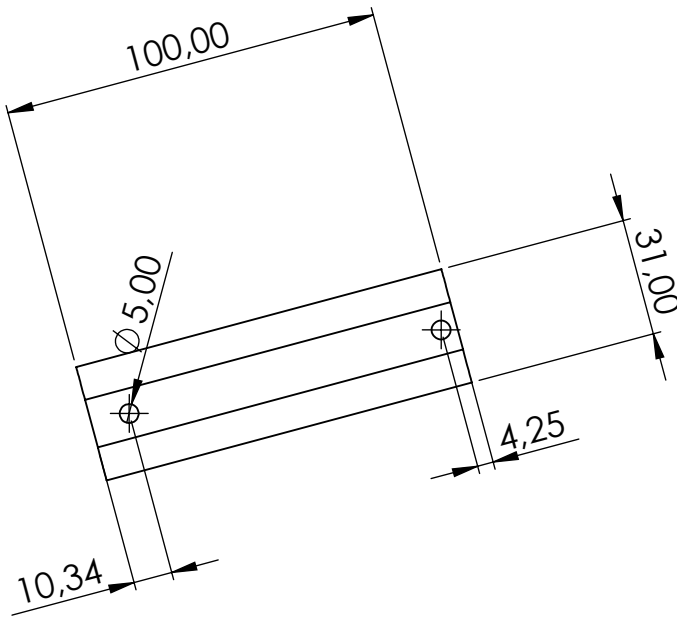
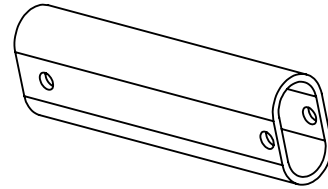
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PLEASE REPORT ERRORS AND OMISSIONS

REMOVE ALL BURRS AND SHARP EDGES

DO NOT SCALE PRINT

Material:	Finish:	Colour:
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Drawn:	Checked:	Scale 1:2	Tolerance:
Title: Wheel tube		Sht. 1 of 1	mm [in]
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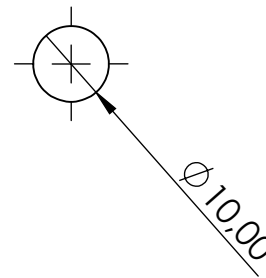
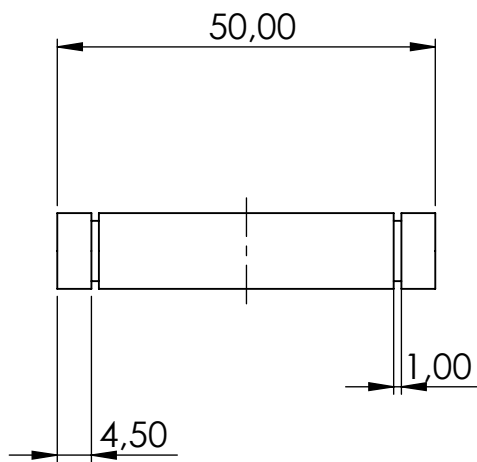
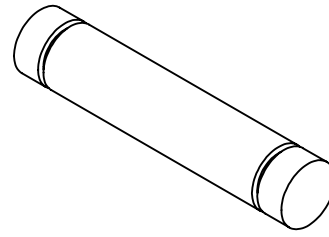
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PLEASE REPORT ERRORS AND OMISSIONS

REMOVE ALL BURRS AND SHARP EDGES

DO NOT SCALE PRINT

Material:	Finish:	Colour:
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Drawn:	Checked:	Scale 1:1	Tolerance:
Title: Rotation pin		Sht. 1 of 1	mm [in]
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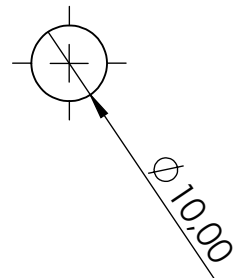
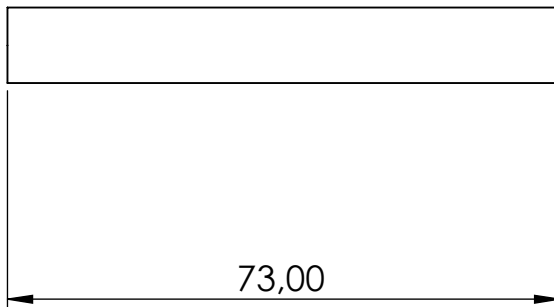
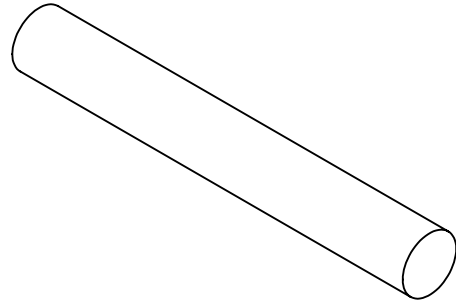
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PLEASE REPORT ERRORS AND OMISSIONS

REMOVE ALL BURRS AND SHARP EDGES

DO NOT SCALE PRINT

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Drawn:	Checked:	Scale 1:1	Tolerance:
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Title: Stop pin	Sht. 1 of 1	mm [in]	
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No. A4
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## 5. Bibliography

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