ESCUELA TÉCNICA SUPERIOR DE INGENIERÍA (ICAI)
MASTER EN INGENIERÍA INDUSTRIAL (MII)

ERGONOMIC ADAPTABLE STROLLER ADD-ON MECHANISM FOR RUNNING

Autor: Alfonso Delgado Navarro

Director: Jean-Michel Dhainaut

Madrid

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EL DIRECTOR DEL PROYECTO

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Agradecimientos

En primer lugar agradecer enormemente la paciencia infinita y la gran ayudada que me han brindado mis directores, Víctor y Jean-Michel.

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Entidad colaboradora: ICAI – Universidad Pontificia Comillas

RESUMEN DEL PROYECTO

1. Introducción

El motivo principal que me ha impulsado a realizar este proyecto ha sido el de poder combinar los conocimientos de ingeniería, adquiridos durante toda mi carrera académica, con los conocimientos de negocio, obtenidos durante este último año en Estados Unidos.

El proyecto surge principalmente por la idea de una estudiante de fisioterapia, que después de haber realizado un estudio de la biomecánica del cuerpo humano, se dio cuenta de que existía un grave problema en la técnica de carrera de los usuarios que salían a correr con carritos de bebes.

Por lo tanto, gracias a este estudio y a las herramientas de diseño de las que disponemos hoy en día, se va a intentar diseñar un mecanismo que cumple con todas las necesidades de los clientes potenciales.

2. Objetivos

El principal objetivo de este proyecto va a ser desarrollar un producto que, a la vez que se satisfacen una serie de requisitos biomecánicos, se van a cumplir con ciertas restricciones técnicas y económicas preestablecidas.

Otro de los objetivos principales va a ser conseguir reducir el peso del diseño final, ya que va a ser un factor determinante en nuestra línea de negocio. Por otra parte, se intentará

analizar los precios de diferentes materiales para, siempre y cuando se asegure la integridad del mecanismo, conseguir un mecanismo que genere un mayor margen de beneficios económicos. Finalmente, se intentará imprimir el prototipo en 3D, para poder evaluar el correcto funcionamiento del mecanismo final.

3. Metodología

En primer lugar, se van a analizar cuáles van a ser las necesidades básicas de los clientes. Para ello, se va a salir a la calle ("Get out of the building"), con el objetivo de conocer de primera mano, cuál es la situación actual del producto a estudiar y cuál es el impacto que tiene en la sociedad de hoy en día. Todo este proceso se va a llevar a cabo mediante entrevistas personales con los clientes potenciales, en las que se preguntaran cuáles son sus necesidades básicas y los problemas a los que se enfrentan con el producto actual. Una vez que se tenga una base de todas estas necesidades, se analizarán y clasificarán para agruparlas en función de su impacto para los usuarios.

El siguiente paso será analizar cuáles van a ser las especificaciones de producto, que servirán como base para su desarrollo. Una vez que se tengan todas y cada una de estas especificaciones se agruparán en una matriz QFD para analizar cuál de ellas va a tener más impacto en nuestro producto y cuál va a ser prescindible.

En tercer lugar, se ha llevado a cabo un análisis de mercado, que va a combinar un análisis del tamaño en el que se lanzaría nuestro producto, con cuales son los competidores directos actuales. Esta información, servirá de base para poder estimar el tamaño del primer lote de ventas. Para llevar a cabo este estudio de mercado, se va a comenzar analizando la evolución de la natalidad en Estados Unidos, que es la base fundamental de nuestro estudio. Posteriormente, se investigará la variación en el número de usuarios que practican esta moda de "jogging" a lo largo de los últimos años, para conocer si nuestro producto tiene mercado en el largo plazo, o simplemente se trata de una moda pasajera. El análisis de competidores nos servirá como guía para conocer cuáles son las características de sus productos, y lo que es más importante para nuestro análisis económico, cuál es el precio de mercado en el que se mueven estos productos.

Posteriormente, y con el objetivo de conocer cómo quedaría la estructura de nuestra empresa ficticia, se va a aplicar el "Business Model Canvas" a nuestro modelo de negocio. De esta manera, se va a conocer entre otras cosas, cuales son los segmentos de clientes, los principales canales de marketing y las principales fuentes de ingresos. Estas variables son fundamentales para hacernos una idea de cuáles serían las dimensiones de la empresa.

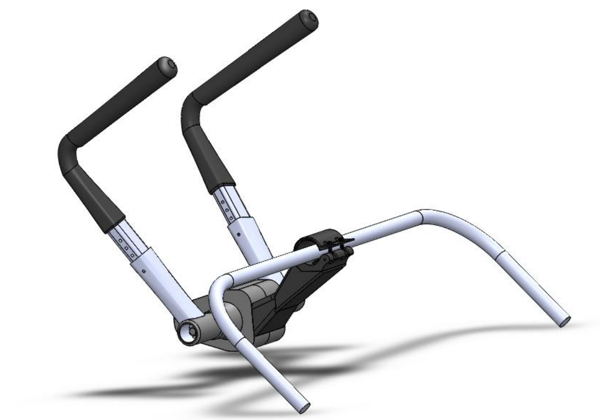
Una vez definidas cuales son las partes intangibles del proyecto, es momento de pasar a diseñar el modelo físico, siempre respetando los criterios de diseño y seguridad. En un primer momento se ha decidido diseñar un modelo básico, para poder hacer las principales estipulaciones de cómo quedaría nuestro producto final. Con el objetivo de mejorar el diseño inicial, se realizarán los cambios pertinentes definidos anteriormente. El diseño final recogerá todos estos cambios, a la vez que se mejorará su imagen. Finalmente, en el apartado de diseño, se ha llevado a cabo una simulación de cómo sería el movimiento de nuestro mecanismo, que será el indicador de si nuestro producto simula correctamente la biomecánica del cuerpo humano.

Lo siguiente que se ha analizado, ha sido la resistencia a esfuerzos de las diferentes piezas que componen el mecanismo final. Esto se ha realizado con el objetivo de cerciorar que nuestro mecanismo es seguro en todo momento. Para ello, se ha decidido analizar el escenario crítico en nuestro sistema, para asegurar que las piezas resisten las tensiones y no llegan a deformase bajo ninguna circunstancia.

Finalmente, con el objetivo de obtener un precio final de venta para nuestro producto, se ha realizado un estudio de cuáles serían los materiales idóneos para resistir los esfuerzos anteriormente presentados. Con estos datos y conociendo los métodos de fabricación para cada una de las piezas, se ha podido estimar cual sería el precio de fábrica de cada una de las piezas y el del conjunto del mecanismo. De esta manera, se ha podido predecir la viabilidad de este nuevo producto en los próximos 20 años.

4. Resultados

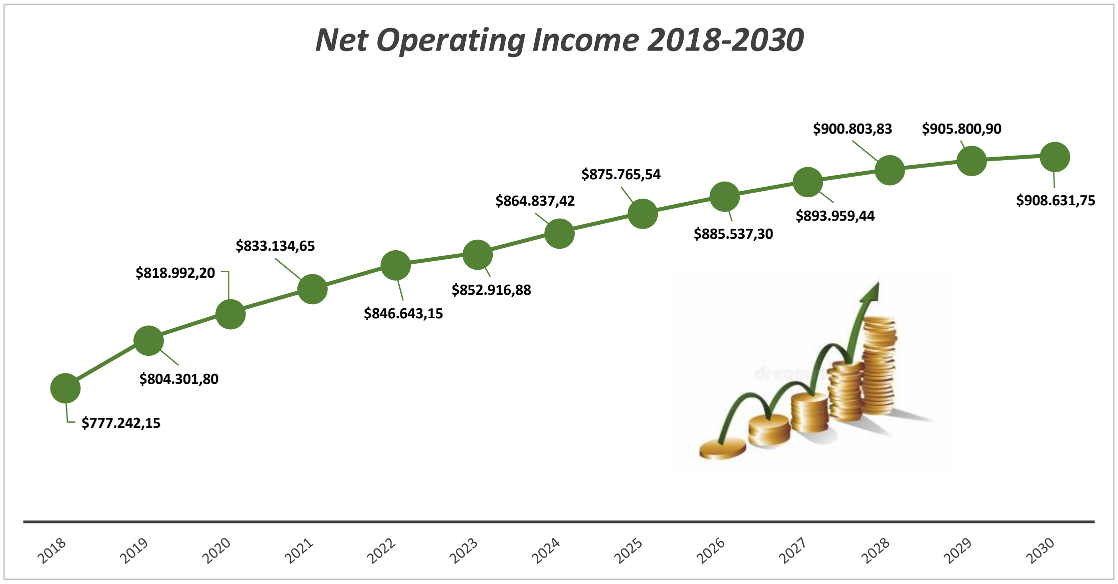
El diseño final que se ha obtenido después de todos los modelos planteados se muestra a continuación.



Como se puede observar, este diseño cumple con las principales prioridades de los clientes, que en nuestro caso eran: diseño robusto al mismo tiempo que se utilizan materiales ligeros; ajustable a cualquier carrito del mercado; los materiales aseguran la integridad física del sistema; diseño bonito; precio asequible comparados con sus competidores directos.

De la misma manera, como se ha comentado anteriormente, la mayor complejidad que presentaba nuestro sistema era ser capaz de simular correctamente el movimiento natural del ser humano al correr. Por lo tanto, a continuación se muestra una comparativa de cómo sería la trayectoria que seguiría la mano de un corredor con la que sigue la mano de una usuaria de una elíptica.

En cuanto a la viabilidad del proyecto, considerando un precio de mercado de $199.99 y un lote inicial de unidades de 10,000 unidades, se han obtenido los siguientes resultados.



5. Conclusiones

Como conclusión de este proyecto, se puede decir que nuestro diseño cumple perfectamente con los diferentes requisitos que los clientes potenciales habían indicado en las entrevistas.

Por otra parte, cabe destacar que el peso es uno de los principales problemas que presenta nuestro diseño, ya que prácticamente pesa lo mismo que el propio carrito. Todo esto, hace que el sistema llegue a ser inestable. Una solución rápida, podría ser añadir un cierto peso en la parte del carrito, que consiga eliminar dicho desequilibrio. Pero, por otra parte, esta medida, haría que aumentara la fuerza de empuje que el usuario tendría que realizar, incrementando el nivel de tensiones internas en nuestro mecanismo.

Por lo tanto, se puede decir que, de cara a futuro se debería de trabajar más en la parte de la optimización de material, ya sea consiguiendo materiales más ligeros capaces de resistir dichas tensiones, o usando por ejemplo optimización topológica, para reducir la cantidad de material existente.

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Author: Delgado Navarro, Alfonso

Director: Dhainaut, Jean-Michel

Collaborating entity: ICAI – Comillas Pontifical University

ABSTRACT

1. Introduction

The main reason that has driven me to carry out this project has been to be able to combine the knowledge of engineering, acquired during my academic career, with the business knowledge obtained during this last year in the United States.

The project arises mainly by the idea of a student of physiotherapy, who after having made a study of the biomechanics of the human body, realized that there was a serious problem in the run technique of users who went out with strollers.

Therefore, thanks to this study and the design tools that we have today, we tried to design a mechanism that meets all the needs of potential customers.

2. Objectives

The main objective of this project will be to develop a product that, while satisfying a series of biomechanical requirements, will comply with certain pre-established technical and economic restrictions.

Another of the main objectives will be to reduce the weight of the final design, since it will be a determining factor in our market segmentation. On the other hand, an attempt will be made to analyze the prices of different materials in order to get, as long as the integrity of the mechanism is ensured, a mechanism that generates a greater margin of economic benefits.

Finally, we will try to print the prototype in 3D, in order to evaluate the correct functioning of the final mechanism.

3. Methodology

First, we will analyze what will be the basic needs of customers. To do this, we will ask directly our customers ("Get out of the building"), with the aim of knowing on first hand, what is the current situation of the product to study and what is the impact that has on today's society. All this process will be carried out through personal interviews with potential customers, in which we will ask them what are their basic needs and the problems they usually face with the current product. Once that a base of all these needs is created, we will analyze and classify them in different groups according to their impact.

The next step will be to analyze what the product specifications will be, which will serve as a basis for our product development. Once we have each and every one of these specifications we will group them in a QFD matrix to analyze which of them will have more impact on our product and which of them will be dispensable.

In third place, a market analysis has been carried out, which will combine an analysis of the size in which our product would be launched, with which are the current direct competitors. This information will serve as a basis for estimating the size of the first batch of sales. To carry out this market study, we will begin by analyzing the evolution of the birth rate in the United States, which is the fundamental basis of our study. Subsequently, we will investigate the variation in the number of users who practice this "jogging" fashion over the last few years, to know if our product has a market in the long term, or simply it is a passing fad. The analysis of competitors will serve as a guide to know what are the characteristics of their products, and what is more important for our economic analysis, which is the market price at which these products move.

Subsequently, and with the aim of knowing how the structure of our fictitious company would be, the "Business Model Canvas" will be applied to our business model. In this way, it will be known among other things, which are the customer segments, the main marketing channels and the main sources of income. These variables are fundamental to get an idea of what the dimensions of the company would be.

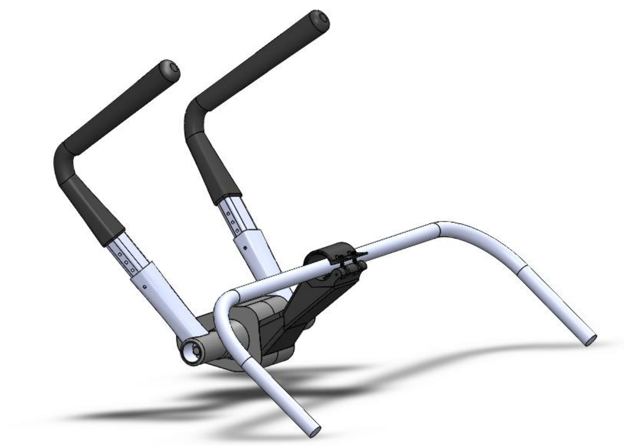
Once the intangible parts of the project have been defined, it is time to move on to design the physical model, always respecting the design and safety criteria. At first it was decided to design a basic model, to be able to make the main stipulations of how our final product would look. In order to improve the initial design, the relevant changes defined above will be made. The final design will collect all these changes, while its image will be improved. Finally, in the design section, a simulation of what the movement of our mechanism would de bone, which will be the indicator of whether our product correctly simulates the biomechanics of the human body.

The next thing that has been analyzed has been the resistance to stress of the different pieces that make up the final mechanism. This has been done in order to ensure that our mechanism is safe at all times. For this, it has been decided to analyze the critical scenario in our system, to ensure that the pieces resist the tensions and do not become deformed under any circumstances.

Finally, in order to obtain a final sale price for our product, a study has been made of what would be the best materials to withstand the efforts previously presented. With these data and knowing the manufacturing methods for each of the pieces, it has been possible to estimate what would be the manufacturing price of each of the pieces and the whole mechanism. In this way, it has been possible to predict the viability of this new product in the next 20 years.

4. Results

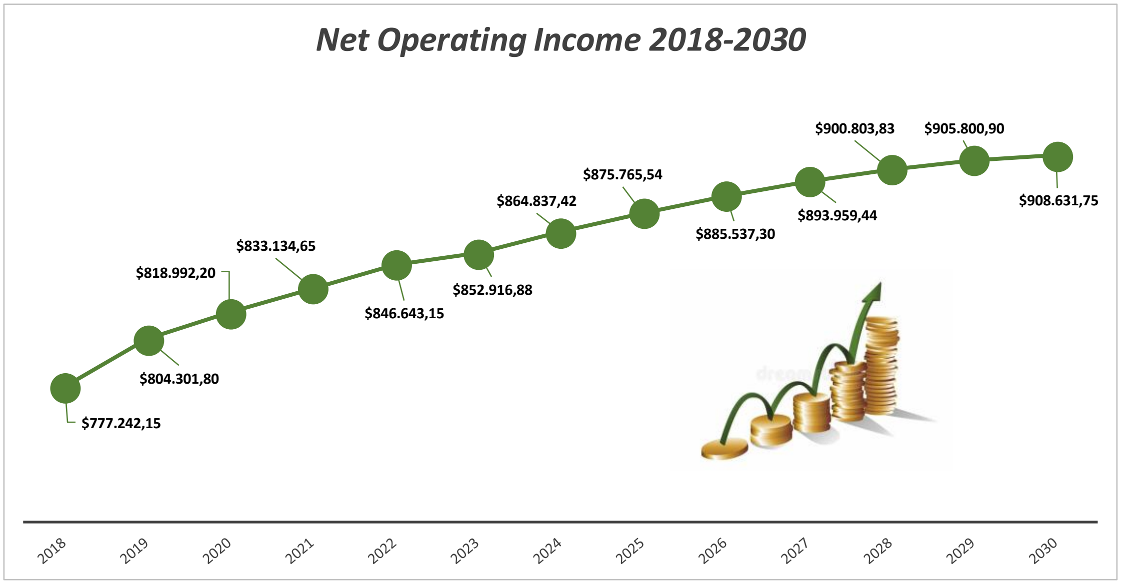
The final design that has been obtained after all the proposed models is shown below.



As can be seen, this design meets the main priorities of the customers, which in our case were: robust design while using lightweight materials; adjustable to any market stroller; the materials ensure the physical integrity of the system; nice design; affordable price compared with its direct competitors.

In the same way, as previously mentioned, the greatest complexity that our system presented was being able to correctly simulate the natural movement of the human being when running. Therefore, following it is a comparison of what the trajectory of the hand of a runner would be like, compared with the hand of a user of an elliptical.

Regarding the feasibility of the project, considering a market price of $ 199.99 and an initial batch of units of 10,000 units, the following results have been obtained.



5. Conclusions

As a conclusion to this project, it can be said that our design perfectly meets the different requirements that potential clients had indicated in the interviews.

On the other hand, it should be noted that weight is one of the main problems that our design presents, since it practically weighs the same as the stroller itself. All this causes the system to become unstable. A quick solution could be to add a certain weight in the part of the stroller that manages to eliminate this imbalance. But, on the other hand, this measure would increase the pushing force that the user would have to perform, increasing the level of internal stresses in our mechanism.

Therefore, it can be said that, in the future, more work should be done on the part of material optimization, either by obtaining lighter materials capable of resisting said stresses, or using for example topological optimization, to reduce the amount of existing material.

MEMORY

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1. *State of the Art*

The first children's car was built by the architect William Kent in the year 1733. This stroller was created as a gift for the family of the Duke of Devonshire. The first model was characterized because it had to be pushed, either by a horse or a goat. (AulaFacil, n.d.)

A century later, around 1840, this invention began to become fashionable among the citizens of the United Kingdom, since the trawlers were replaced by a kind of handlebar so that the parents themselves were able to push the stroller.

It was in 1889 when the first predecessor car was developed to the multi-purpose systems that we know today. This model consisted mainly of:

- A large cradle, which was the central part of the model. This cradle offered the possibility of placing the child in two positions, looking at the person pushing or in the direction of the march.
- The aforementioned handlebar
- Four large wheels placed in each of the corners

However, these first models were only accessible to people of high purchasing power, therefore it was not until 1920, when these models became accessible to the majority of the middle class.

Throughout all these years, the main objective of the product developers has been to improve certain factors such as: safety, suspension, brakes, chassis, all with the aim of improving the performance and viability of these products.

Nowadays, it is very rare to see a couple pushing one of these traditional cars. What is most often observed are strollers that go one step beyond traditional ones, known as polyvalent systems. These multi-purpose systems are made up of the same parts as the traditional ones, but there is a big difference between them. These new models offer the possibility of exchanging the room in which the baby is transported, being able to adjust it according to the basic needs of the client. This means that the cradle can be adjusted and changed depending on the weight, age and height of the baby. Other advantages offered by these systems, is the possibility of folding the chassis, making it a smaller stroller and greatly facilitating its transport.

Another of the designs that set the trend in the 70s was the one of Owen Maclaren. In 1965 this designer brought to market the well-known "buggy". The main ideas that he wanted to impose in his new model, were to get a lighter stroller and suitable for daily transport. These models are suitable for short walks around the city, roads and streets practically without any type of inclination, since the damping is practically null.

Also on the other hand, we find the famous 3-in-1 systems. These systems offer the advantage of having the typical removable cradle, but at the same time, they offer the seat service for the car.

Finally, the strollers that will be relevant to our study are the famous "Jogger". These new models arise with the aim of satisfying the different needs presented by the clients, since they demanded: to be able to exercise (whether running or walking) at the same time as they were taking a walk with their children.

In 2015, a new runner fashion emerged in the United States, which consisted of going out to run with baby strollers. Thanks to this fashion, fathers and mothers who love running did not have to stop practicing their favorite sport due to having a baby. The problem that has presented this fashion during the last years is that most conventional strollers were not adaptable to do this type of exercise, therefore it was necessary to buy a specific "jogger" model. These new sports cars are characterized by: (LBDC, 2015)

- ❖ **A particular structure**: these tricycles are characterized by having two wheels in the rear, while unlike conventional models, they have a single wheel in the front. Regarding the front wheel, it has to be bidirectional, with the aim of facilitating the natural turn and that this is comfortable for the user.
- ❖ **Large wheels**: the wheels have to be large enough to support the high speeds at which the cart will be subjected. Another characteristic that must have the system that surrounds the wheels is that the system has to have a good cushion.

- **Unique handlebar:** it is important that there is a single handlebar instead of two laterals. This favors the stability of the stroller by pushing it with a single hand. In this way, both arms can be alternated, being able to rest every so often.
- **Bag**: is an essential requirement for any cart. Any of these models must have incorporated a bag in which certain fundamental elements can be stored, such as water, food, shelter elements, that is, any accessory that the baby may need during the journey. Another fundamental requirement of these bags is that they have to be large enough to ensure that the baby is continuously protected from the sun's rays.
- **Rope fastening:** any sports car has to have a harness that is tied at one end to the stroller and that it is continuously tied to the corridor at the other end. In this way we are able to ensure that the stroller is in the user's domain at all times.
- **Braking system:** Many of these strollers, include an emergency brake on the handlebar, although this is not mandatory. In many cases, this brake helps stop the cart slowly. What is essential is the presence of a parking brake. It is also highly recommended that the jogger strollers have a locking system for the front wheel. In this way, the user ensures that the stroller will not leave the path at any time.

Once defined the characteristics that are going to present the strollers object of study, it is important to ask the reason why we are going to realize this project. When users use these types of strollers it can be shown that the adaptation system is completely created to ensure the baby's safety, but at any time the designers thought about the comfort and position of the user (apart from putting a more ergonomic handlebar than another). It is common to observe these runners exercising simply by holding the stroller with one hand, which is translated in a muscle overload in the part of the body that is used. Others, however, decide to hold the handlebar with both hands, adapting a very uncomfortable position for carrying out the exercise.

Therefore, going out to run with your baby to a park or while participating in a race is going to suppose a completely different experience to which we were accustomed. All these movements will be based on the adaptation of your running technique, they will completely change the biomechanics of your body. This means that you will move from moving your arms freely with the natural movement of the body to having to be constantly holding a handlebar.

In order to improve and optimize the training, while avoiding health problems, the user must adapt the following changes to their career technique: (Panea, 2015)

- **The posture**: it is essential to keep the body straight, while looking forward with the head high. The position of the body has to be a relaxed position, never forcing a rigid position, since you end up overloading certain parts of the body.
- **The arms**: the arms are going to be the connecting part between the body of the user and the stroller, therefore there must always be some hand that holds the handlebar. This implies muscle overloads as explained above, so it is recommended to alternate both arms to avoid this imbalance.
- **The hands**: first of all it is the safety of the baby, therefore the runner has to be prepared to react to any unforeseen event. It is important that the runner holds the handle firmly, but never squeezing too much since it is not good that the user is constantly stressed.
- **The tread**: it is important to adapt the position of the body to make sure that the tread continues with the front part of the foot, as if it were running naturally.
- **The run:** The run must be harmonious, this harmony will be achieved through practice and training.
- **Do not lose the correct position:** it is important to try to maintain the correct position throughout your exercise. What usually happens is that you start correctly but as the tiredness is appearing, always tends to adapt a more comfortable position, tilting the trunk and even reaching to drag the feet.

As you can see there are many factors that will take part in the adaptation to this new technique. Therefore, the following question arises: why not design a mechanism that ensures the correct position of the user at all times? That is going to be the basis of the project, to create a system that by means of the natural movement of the man, the user is able to push his baby in the same way as before, always worrying about the safety of the baby.

The technique that will adapt to our mechanism will be that of the elliptical. The elliptical of any conventional gym perfectly simulates the natural movement of the arms. Therefore, the object of study of this project will be to look for an adaptation mechanism that manages to combine the mechanism of an elliptic with the function of pushing a stroller. To do this, several design programs will be used. Another factor to consider is the strength analysis of the different pieces to be studied, since it is essential to ensure the perfect performance of the product at all times. As final part of the project, we will try to print the prototype in 3D to analyze the possibility of taking it to the Market.

2. Identification of opportunities

All development behind a new product, comes after the idea of creating a mechanism that covers certain costumers' needs. Every opportunity is based on meeting the needs of the clients, either through new discoveries or improvement of current systems. Within the opportunities we can classify 3 large groups: (Ulrich)

- **Horizon 1**: based on constant improvements of the current product (reduction of the total cost of manufacturing, adaptation of mechanisms)
- **Horizon 2:** they are next generation products, that is, markets that are not yet fully discovered.
- **Horizon 3**: they are totally new products for the Market that represent a great risk for the company.

In our case, our product would be within a horizon 1, since as it has been said previously it is an adaptation of two world-known systems (stroller and the Elliptical System) to a single system.

Dependent of the horizon in which we find ourselves, the needs and solutions offered by the company vary enormously.

3. Identification of clients' needs

In the process of identifying the needs of the client we can distinguish 5 clearly differentiated steps:

Step 1: We have to collect undiscovered customer data

The most effective way to carry out this search is to directly address the end users of this product. In this way, we are able to know directly what is the current situation of the product and what could be the possible improvements. For this it is important to carry out a series of interviews, through which we can obtain a point of view that completely resembles reality. All these questions are going to be related and focused on knowing what are the main advantages and disadvantages of the current product and what would be the main improvements that the users themselves would make We have decided to directly interview certain persons. As a summary of all the interviews we can say that customers agree with the advantages that jogging strollers offer, especially with the ease of adapting to all types of terrains, while fully ensuring the safety of the baby. However, they agree that at the beginning it was difficult for them to adapt the new race technique, since it completely changes the biomechanics of their position. Therefore, they point out that a mechanism that adapts the position and the natural movement of the human being to the stroller would end with all the inconveniences.

Step 2: Interpret the data

Every word and comment from the interviewers counts. Behind any "why not", "how" probably the answer to all our questions is hidden. Therefore, it is important to take note of everything they say and examine their words step by step.

Step 3: Organize the results that we obtain in a hierarchical way

It is always important to have a good list of needs with which we can start working. Once they are all completely defined, it is important to classify them in a hierarchical way. This hierarchy is usually divided into several types of needs, from primary needs to secondary needs.

Below, Figure 1 shows what would be the main needs of the clients and which would be the most relevant. With a star, the needs that concern most customers are marked.

	The mechanism is safe
*	The safety of the baby comes first
*	The stability of the cart has to be the same
*	The reaction time has to be the same
	The mechanism simulates the natural movement of the run
*	The back and shoulders are in their correct position
**	The run is comfortable
	The mechanism has a nice and adjustable design
*	Good materials
**	Nice design
***	Ergonomic for all types of users

Figure 1. Principal Costumer Needs

❖ **Step 4:** Determine the importance of the different needs

Once the primary and secondary needs have been established, it is important to move on to the numerical assessment of each of them. For this we can use two different methods: go to the group of developers or re-interview users to decide which of these needs are most important. Therefore, through another survey we can know which of the functions are undesirable and which are of critical importance for our mechanism. As a summary of these new responses, we can say that all users agree that safety is the critical importance factor, ultimately leaving the final design of the product. In the following classification you can see the product characteristics that matter most to customers, rated with a 5, and those that matter least for customers, rated with a 2.

1. The function is undesirable
2. The function is not important
3. It would be nice to have that function
4. The function is highly desirable
5. The function is of critical importance

5	The mechanism is safe
4	The mechanism simulates the natural movement of the run
3	The mechanism has a nice and adjustable design
2	Nice design
3	Ergonomic for all types of users

Figure 2. Importance of the different needs

❖ **Step 5:** Reflect on the results

Once we have all the results of our surveys, it is important to reflect on the results obtained. It is important to realize what we have learned from these interviews that we did not know before. Have any of the results surprised us? It is also important to self-criticize our work and to realize if we have contacted and interviewed the correct users. In our case we can say that we were surprised that the design was not so important for users. Instead, we knew from the start that security was vital to this mechanism. As for the users interviewed, we can say that they are people who have a single child between about 2-3 years of age, therefore we still think that this is the perfect client.

4. Product specifications

Many times the needs of clients leave too much room for imagination and have a very subjective interpretation. Therefore, these needs are important to imagine how the product is going to be, but they are not very useful in terms of design specifications. We can define product specifications as what the product has to be and what it has to do. Therefore, breaking down the needs presented by our clients a little we have:

Number		Need	Importance
1	Mechanism	Improves the position of the body	5
2	Mechanism	Ensures baby's safety	5
3	Mechanism	It allows to adjust the height	3
4	Mechanism	It is light	4
5	Mechanism	Nice design	2
6	Mechanism	Good materials	3
7	Mechanism	Maintains the direction characteristics of the stroller	4
8	Mechanism	It is adjustable for different types of jogging strollers	4
9	Mechanism	It is very easy to install	4
10	Mechanism	Easy to clean	3
11	Mechanism	It has a long lifespan	4
12	Mechanism	Affordable price	4

Figure 3. Break-down of Customer Needs

Once you have the needs of the clients, it is important to analyze the objective specifications. This type of specification is the goal set by the product developers, but usually they are very difficult to reach together. These specifications are what would make the difference in the market, in case our product was an improvement of existing products or a totally new product. To carry out this process of changing an existing product, it is important to follow the following steps:

Step 1: Prepare a list of metrics

The relationship between customer needs and metrics is essential to develop good objective specifications. It consists of the transformation of the needs of the clients that is something totally subjective to something that is totally measurable. To do this, we have to create a new list, which shows what the metric specifications of our design will be.

Number of metrics	Number of need	Metrics	Units
1	1,7	Measures of the elliptical	mm
2	2	Rigidity of the mechanism	KN/m
3	3	Handlebar measurement	mm
4	3	Handlebar angle	mm
5	3	Elongation of the handlebar	mm
6	4	Total weight	kg
7	5	Nice design	Subjective
8	6	Resistance to stress	KN
9	7	Same references	mm
10	8	Grip measurements to the stroller	mm
11	9	Tiempo reducido de instalacion	s
12	10	Corrosion time	s
13	11	Standard durability tests	s
14	12	Reduced cost	$

Figure 4. List of Metrics

Once we have defined the main needs of the clients and the main metrics to use, it is time to create our Quality Function Development (QFD) matrix. The rows of the matrix will correspond to the needs, while the columns will refer to the metrics. Therefore, to identify what is the relationship between the two we will make a mark in each of the cells that we think there is a relationship. The matrix will determine the degree to which the product meets the client's needs.

			Metrics													
			1	2	3	4	5	6	7	8	9	10	11	12	13	14
			Measures of the elliptical	Rigidity of the mechanism	Handlebar measurement	Handlebar angle	Elongation of the handlebar	Total weight	Nice design	Resistance to stress	Same references	Grip measurements to the stroller	Tiempo reducido de instalacion	Corrosion time	Standard durability tests	Reduced cost
Needs	1	Improves the position of the body	*													
	2	Ensures baby's safety		*												
	3	It allows to adjust the height			*	*	*									
	4	It is light						*								
	5	Nice design							*							
	6	Good materials								*						
	7	Maintains the direction characteristics of the stroller	*								*					
	8	It is adjustable for different types of jogging strollers										*				
	9	It is very easy to install											*			
	10	Easy to clean												*		
	11	It has a long lifespan													*	
	12	Affordable price														*

Figure 5. Quality Function Development (QFD)

5. *Market Study*

Once we know what the customers' needs will be and to what extent they will affect our product, it is important to determine the current size of the market we are targeting and what is our expectation in the future. In the same way, it is vital to know how many competitors we have and what services they offer.

Let's start with analyzing the current situation of the market, how is the growth of people who start to do this activity, how the number of stroller sales has evolved and how many brands are present in the market.

The first thing we are going to do is analyze how the situation of the birth rate in the United States is evolving, since this will determine the number of sales of strollers that will be carried out in the coming years. Figure 6 shows how the number of births has evolved in recent years, from the year 2000 to 2016. (Statista, 2016)

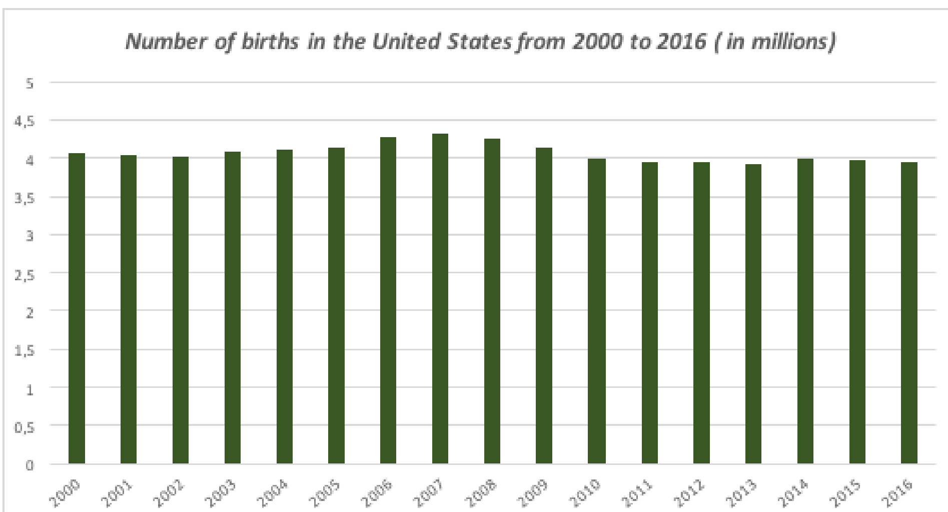


Figure 6. Number of births in the United States from 2000 to 2016 (in millions)

Once we have this data, we will try to analyze if there is any kind of trend in recent years. In this way we will be able to determine which could be our volume of sale from here to the next years. To do this, with this data we are able to determine a forecast, by which we will be able to estimate the number of births approximated from here to a period of 10 years. Once we have this data and the graph that shows the evolution in the number of runners in recent years, we will be able to draw a reasonable estimate. The results obtained by this estimation are shown in the following figure. In the same way, in Appendix A the data of the forecast can be observed in more detail.

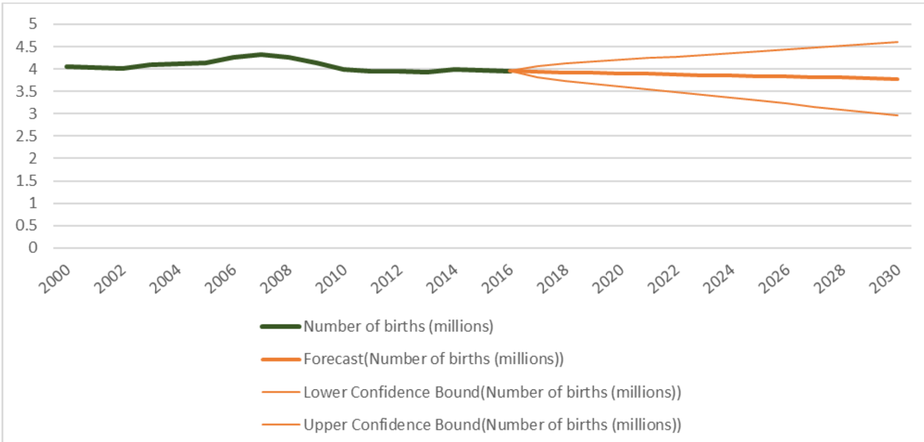


Figure 7. Forecasting number of births

As can be seen in Figure 7, the number of births in the United States will be stable, around 4 million newborns per year. The next step will be to analyze the growth in the number of people who go out to run during these last years, in order to estimate the total number of final users. Figure 8shows the evolution in the number of runners in the last 10 years. (Statista, 2017)

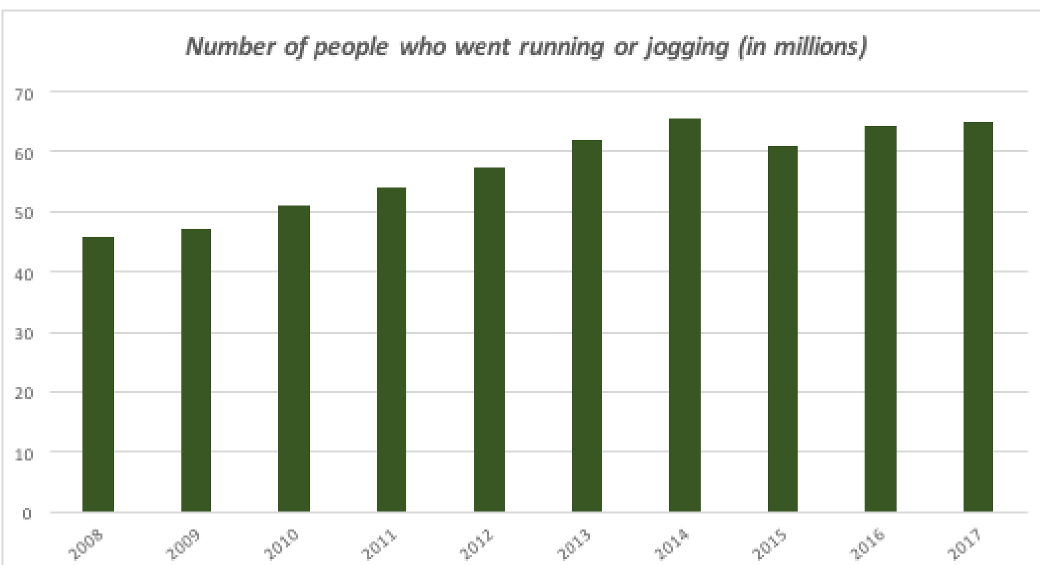


Figure 8. Number of people who went running or jogging (in millions)

As you can see in the previous figure since 2008, the number of people who decide to go out for a run has increased considerably. This increase can be associated with the new fashions that revolve around practicing the activity of going out to the street to run. During the last years, running has become a social phenomenon, beyond a sporting activity. All this is reflected in the amount of competitions that can be found in any corner of the world, all of them aimed at encouraging the practice of exercise. Next, Figure 9 shows how the number of participants in these competitions has changed (half marathons, marathons, ironman ...) due to this social phenomenon. (Kan, 2017)

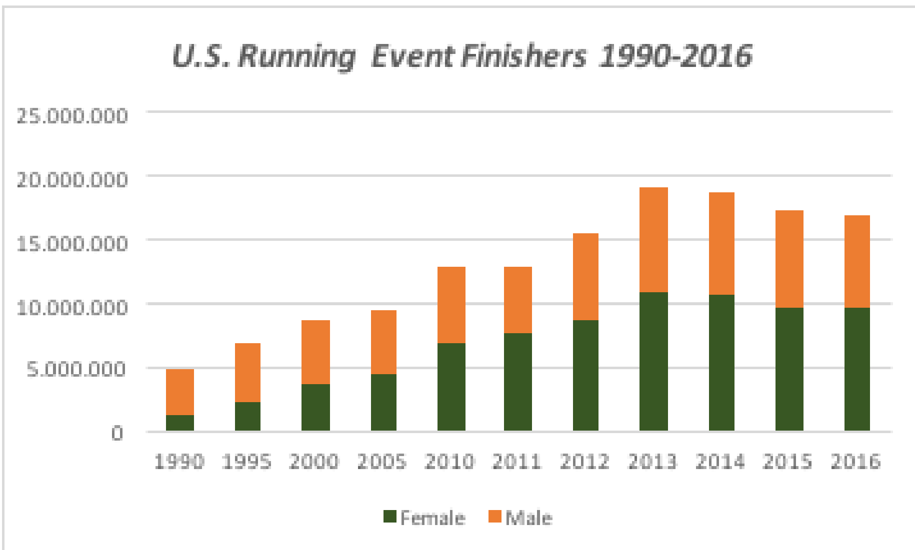


Figure 9. U.S. Running Event Finishers 1990-2016

As can be seen in 2016, the number of runners who were able to finish the race were around 17 million. This number has multiplied by three in the last 20 years. One of the reasons is the one that we have commented previously, the fashion of running. Around the world there exist, especially marathons, which are known worldwide by all these fans and which are home to nearly 50,000 people willing to run for 42 km. Among the most famous, we can find from Athens, known as the most classic, to New York, known as the most media. Below is a list of the most known marathons worldwide and with their respective number of participants. It is important to note that most of these events limit the number of participants, in order to control each part of the route.

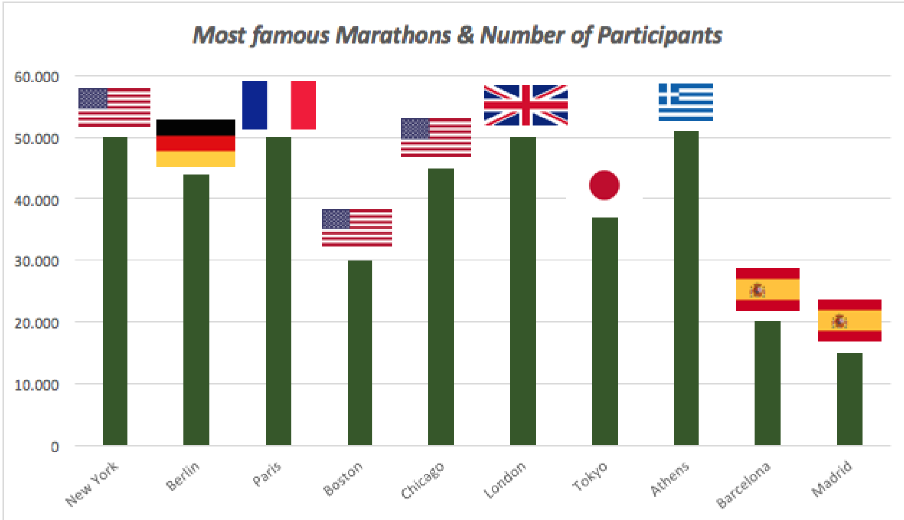


Figure 10. Most famous Marathons & Number of Participants

This number of participants can give an idea of the size of this market. Once explained the fundamental reason why the number of runners has increased in recent years, we have to do as before a forecast of what will be the number of runners that will be by 2030. Therefore, based on the results of the previous years and in the respective trends, the results obtained are shown in Figure 11. In the same way, as in the previous simulation, the most detailed data are found as Appendix A.

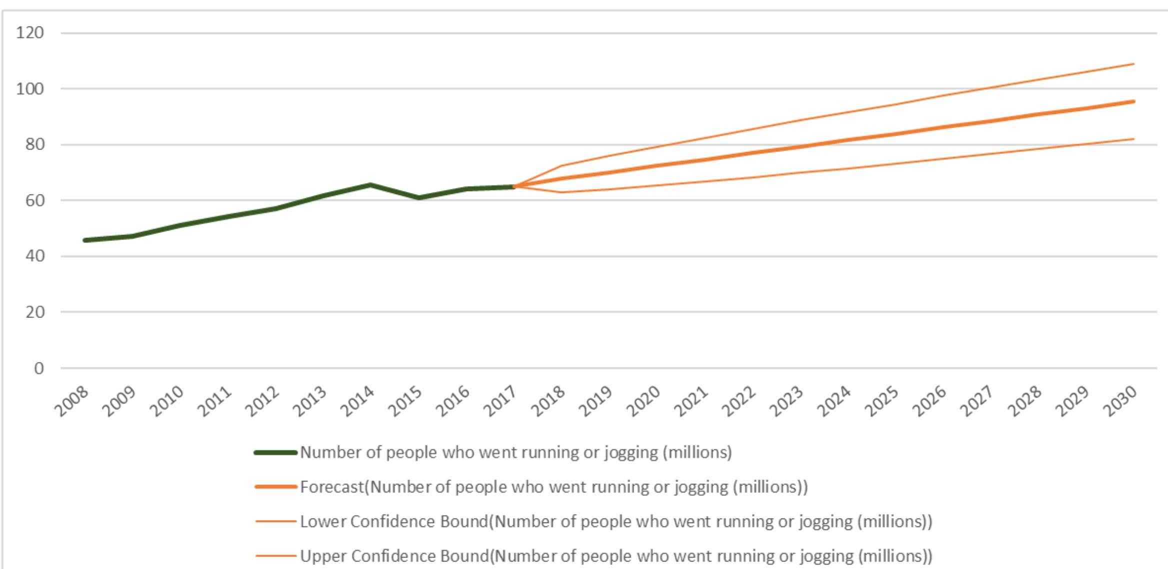


Figure 11. Forecasting number of people who went running or jogging (in millions)

In the same way that the number of runners worldwide has increased considerably, the number that does it using strollers has increased proportionally. This number of users will be the object of our study. It should be noted that in many of these competitions, the strollers are not allowed due to the possible dangers they could cause. However, in the same way the number of marathon events has increased considerably in recent years, so has the running competitions with strollers. These competitions take place mainly in the United States and in Europe and bring together a large number of participants. Therefore, we can say that our mechanism would be directed to all these competitors.

Finally and after having studied in depth the runners market we can say that it is an emerging market, which has a great sales potential. Therefore, I believe that thanks to all the events that are moving social networks and the great impact they have on users, it is a great business opportunity.

Once we have the future projection of the number of users that could present our product, being a mechanism that is going to adapt to another existing product in the market, it is important to analyze how this market is. Especially what we want to get out of this analysis is a conclusion in reference to the shape of the stroller handlebar. With this information we will be able to design the adaptation mechanism between our mechanism and the stroller. Therefore, the first thing that will have to analyze will be which were the most sold and the best qualified strollers. In this study, it will also be interesting to analyze what is the price of each of these strollers, since it will be a decisive factor in the future when it comes to having a price reference. Below are the strollers that are best considered during the last year.

Range	Price ($)	Characteristic
1	359.99	High-Rise Hero
2	879.99	Splurge Worthy
3	499.99	All-Terrain Ride
4	216	Well-Rounded Pick
5	999	Luxurious Versatility
6	599.95	Nap Champ
7	299.99	Jogger Light
8	262.03	Tried & True Travel System
9	349.99	Easy Install
10	529.99	Functional Favorite

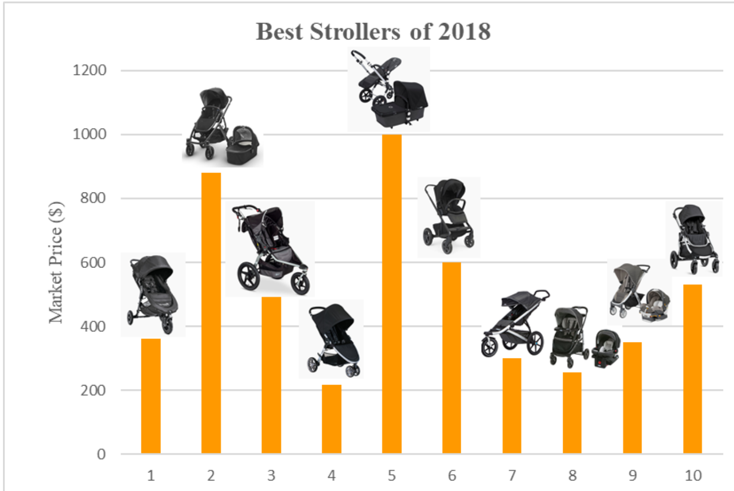


Figure 12. Best Strollers 2018

Once we have an idea of which characteristics present the most sold strollers in recent years, we must focus more on what will be of our direct interest. In this case, we decided to analyze which were the most sold jogging strollers in the last year. In this study it has been decided to add both the total weights of the product, and the maximum weights of the babies that can be transported in this type of strollers. The results we have obtained are shown below.

Range	Price ($)	Characteristic	Stroller Weight (lbs)	Age Range (max lbs)	Total Weight
1	369.99	No-Effort Push	25	75	100
2	109.99	For Casual Runners	26	50	76
3	189.99	Fast to Flatten	30	50	80
4	449.99	Best for Multiple Users	29	75	104
5	429.99	Handsome Hybrid	28	75	103
6	399.95	Bringing the A Game	23	75	98

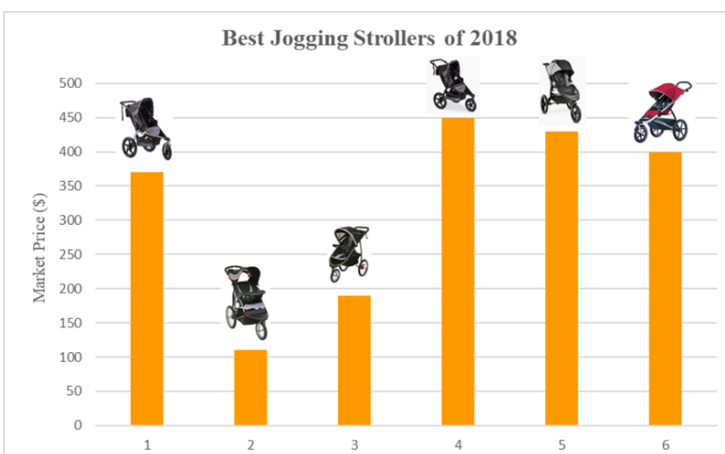


Figure 13. Best Jogging Strollers of 2018

The main conclusions that we can draw from this latest study is that today most strollers presented in the market are characterized by having a single elongated horizontal handle, instead of two shorts placed at the ends. This greatly simplifies our design, since by a common clam we will be able to connect our mechanism to the horizontal handlebar of the stroller.

6. Competitors Analysis

In the current market, our mechanism would have three clearly direct competitors differentiated by their product. The first one would be the mechanism that Walmart sells in its large stores. This adapter consists of two bars that are connected directly to the handlebar. The manufacturers define their product it as:

- Easy to install
- Adjustable for wheelchairs
- Sure

Below a picture of the product is attached.

Figure 14. Walmart's product

After having read the opinions of the users and having seen their promotional video I consider that this product is much more directed to people who are in a rehabilitation. It is a suitable system for someone who is sitting in a wheelchair and needs to exercise the upper body. As for using it in strollers, I think it does not meet the conditions of simulating the natural movement of the human body when running, since as shown in his promotional photo the arms would be in a much more open position than normal. The price of this article, is around $ 178.85 according to the website of Walmart. (Walmart, n.d.)

The second product would be the elliptical stroller. The designers define this product as a mechanism composed of two fundamental elements: the stroller and the transmission mechanism of the elliptical movement. This mechanism is formed by two pedals that move up and down, moving together the stroller. The user can decide if he wants to use the mechanism or instead use the stroller as normal. Below a picture of this mechanism can be shown.

Figure 15. Elliptical Stroller

Once read the opinions of this product, most focus on the insecurity of this mechanism, because in case of an unexpected situation the user reaction time would be much greater than in a normal situation. Many others also criticize the weight of this mechanism and explain that it is not practical. We can say that this mechanism is more similar to what our product is trying to satisfy. The price of this mechanism is around $ 1,250. (Abbott, 2018)

Finally, we have the jogalong stroller. Designers define it as the only jogging stroller that can be considered ergonomic, since it perfectly simulates the natural motion of the arms while the user is running. The system is practically the same as that of an elliptical, what makes it different is the incorporation of a series of brakes to the final part of the handlebar. Below is a photo of the stroller with the mechanism.

Figure 16. Jogalong Stroller

As you can see the mechanism will perfectly simulate the natural run of the user. The problem with this product is that it is included in the stroller. Therefore, the price increases greatly. In addition, this system is not adjustable for different heights, so as you can see in their promotional video, it is not very ergonomic for those of a certain height. In the same way, as we have said before, this mechanism will not be able to adapt to any type of stroller, therefore it does not meet one of our main customer needs. (Jogalong, n.d.)

After having made an analysis of competitors, we can make clear what are the specifications that we will want for our product and which are not.

7. Business Model Canvas

The business model canvas was developed by Akex Osterwalder and Yves Pigneur in 2010, making it a relatively new tool. Although it is a recent business tool, it has a large number of benefits for users who want to implement it in their businesses.

- ❖ It is a very practical tool, since it ends up making variations in any of the parts as you analyze the company.

  It is a very simple business model that simply has nine boxes to fill out. The filling of these boxes is done in a very intuitive way, without needing great knowledge in the study area.
- ❖ It is a good tool for teamwork. Many companies usually print a large business model canvas and hang it on any wall of their office. In this way, any worker, with a pen or placing a posit, can fill part of the business model canvas. It is a very dynamic way of listening to the opinions of workers and giving them the opportunity to work directly on a project.
- ❖ Once you have all the boxes filled, it is a very visual tool. It gives you the opportunity to analyze your company from a global point of view. This gives the opportunity to entrepreneurs to analyze possible failures that may exist between the different needs of customers, services offered by your product, channels ... etc.

To begin filling in the business model canvas, we must start doing it on the right side, that is, on the external part of the company. This part refers to the market in which our product would enter. This technique has its logic, because before knowing the interiors of our company, it is important to know the market in which it is going to operate, which will be the clients and their main needs. Another point that is vital in this part of the right is the part of the financing, which will be the different sources of income that your company will receive.

Once the business model canvas has been defined in a global way, we will analyze each of the boxes to see which elements fit in each one of them. (Prim, n.d.)

7.1. *Customer Segment*

It is about the customers to whom our product is directed. Normally these clients tend to be a segment of the population, who have certain common characteristics, such as needs or behaviors. As a company, it is very difficult for your product to meet the needs of the entire market, so it is important to focus on a certain group of potential customers and ignore those that are not.

In our case, the customer segments are clearly defined. They will be those people who are parents of young children, who love sports and love sharing them with their family. Therefore, they are going to be runners who have a jogging stroller or who are interested in buying it.

7.2. *Value Proposition*

The value proposition summarizes why customers want to buy the product. It is the value added by the company through the sale of said product. Basically, they coincide with the main needs and requirements of the customers. These needs can be qualified in two large groups: quantitative and qualitative needs. The value proposition of our company is going to look like this:

- **Performance:** manages to satisfy needs of customers that were previously not satisfied, such as improving the position of the upper body.
- **Adjustable:** the system has a mechanism that allows the user to adjust the height of the handlebar, offering facilities for both large and small. The long rubber handlebar also makes it ideal, to be able to grab it anywhere.
- **Price:** the price compared to its competitors will be more economical, trying to make it affordable for all types of public.
- **Innovative:** by adapting the technique of the elliptical, our mechanism will ensure the correct position at all times of the user, while he enjoys full freedom to perform his preferred activity.

- **Safe:** it is a totally safe mechanism and that in case of an unforeseen event it offers the same reaction time as a conventional cart. The most important thing for the clients is to ensure the baby's safety at all times.
- **Compatible:** our mechanism is compatible for any stroller, since it adapts directly to the handlebar. Therefore, it is not necessary to buy any type of special cart to use this system.
- **Easy to install:** due to its easy hook mechanism, it can be fitted to any cart simply by adjusting two handles. This also allows it to work with trolleys that have different thicknesses.
- **Lightweight:** the product will use the lightest possible materials but always satisfy the strength analysis. It is important that the mechanism is light, so that the user can transport it easily.

7.3. Channels

Channels are the sources by which the company will publicize its product and its different services. The channels of our company are going to be the following:

- **Word of mouth:** essential for this type of products. The activity of going for a run to the street or to any park is usually done in a group, so a good impression to the first users will be key for the success of our company.
- **Social media**: the creation of promotional videos that will be published on Facebook, Instagram and Snapchat.
- **Fairs:** these types of events, are privileged places that offer a great opportunity to present your product to the most direct customers. Therefore, attending sports fairs or running & jogging is an ideal setting to publicize the product.
- **Website:** through the website you can make known the description of the product, the different services offered. Also through this channel you can hang a video that explains the operation of the mechanism and its correct movement.
- **Competitions:** in this type of events, especially those that bring together a large number of people, are the best showcase to promote your product. Therefore, going

to one of these competitions can originate the success of your company, making itself known.

7.4. Customer Relationships

It is based mainly on the existing relationship between the company in question and the potential customers. In our case, we are going to have direct / personal relationships with customers as well as automated ones.

- **Personal Assistance**: our idea is to give a personalized service to the client. In case the user has any question, the website will have an email, which will answer questions in a period less than 24 hours. Also, in order to avoid easy questions to answer, the product will come incorporated with a video in which the functioning of our mechanism will be fully explained.
- **Self-service**: the system will be automated in such a way that the client who wants to buy our product, will only have to go to the website and select the product. All this process will be done without the need of a direct contact with any of the workers of the company.
- **Membership:** the idea has been thought of organizing a group of runners in each of the most representative cities of each country. In this way, fans of these sports can participate in common activities, without ever having to appear in championships.

7.5. Revenue Streams

They make reference to the sources of income that the company receives from different clients. In our case we will have different revenue streams.

- **Electronic Payments:** the main revenue streams of our company will be the direct payments that customers will make through the Website.
- **Directs Payments**: another of the ideas is, at the same time that the product is presented at fairs and competitions, to keep a small stock so that in case there is a user interested in buying the product at the moment, units will be available.

- **Annual Subscription**: as explained above, one of the objectives of this company is to create a platform where different runners who are fans of running with their children can interact. Therefore, although it is lower compared to the other types of revenue streams, money will also be received for parts of the membership fee.

7.6. *Key Resources*

They are the fundamental pieces to make the company work. Without these necessary assets the company is not able to make any profit. The key resources can be: physical, intellectual or financial.

- **Physical:** in our case, most of the space will be occupied by warehouses and factories where our product is made. Also our company will hire a courier company to distribute all orders.
- **Intellectuals:** the company will have its brand associated with this product.
- **Financial:** all sources of finance needed by the project, especially bank loans.

7.7. *Key Activities*

They are defined mainly as the activities that the company has to comply with. Around these activities it can found all the other elements that we have studied previously. Therefore, we can say that it will be the cornerstone of our business. In our case, our main activity will be related to the production and design of a new product.

7.8. *Key Partnerships*

It is based on the relationships that the company has with its own suppliers and with the different associated companies. In general, companies that belong to the same sector and are not direct competition, usually establish mutual relations, in order to optimize both businesses. Since neither the company nor the product exist, this part may be considered a bit subjective. Despite this, our intention is to get the following relationships.

- **Allied companies:** mainly companies that base their products on sports products. In this way, we could be able to introduce our product in one of its advertising campaigns.
- **Relationship with the suppliers**: since we want to obtain the best product in the market, we will try to keep certain suppliers that are loyal to the brand, that are able to ensure the quality of the product at all times.
- **Distribution companies:** we must have a company in charge of logistics and distribution of all our products. Due to our market size. We cannot have our own transportation company that can supply the product to any customer anywhere in the world. Therefore, it will always be more profitable to rent the services of any of these companies.

7.9. Cost Structure

The cost structure, as its name suggests, structures the different costs associated with the company once it starts to develop its product. Within the costs, we can find costs of all kinds, such as direct or indirect costs. The costs that we are going to have are going to be the following ones.

- **Fixed costs:** in relation to the fixed amounts of money that the company is obliged to pay, we will have: expenses associated with the sale of the office building where we establish our neuralgic operations center; salaries of each of the workers of the company; electricity and water services; amortization; insurance that companies are required to pay.
- **Variable costs**: this type of costs will be more related to the production of our product. In this case we will be able to find: total cost of materials; shipping service expenses; overtime due to demand peaks. As you can see each of these expenses is related to the number of sales that occur throughout the year.

8. Design specifications

At the time of beginning with the design, we have to collect the maximum amount of possible information of all the specifications that we have defined in the previous stages. Once we have the information of all these specifications and the problems presented by our most direct competitors, we are ready to begin with the definition of the product in broad strokes. Summarizing in a few concepts, we can say that our strategy will be based on creating our product with the following characteristics.

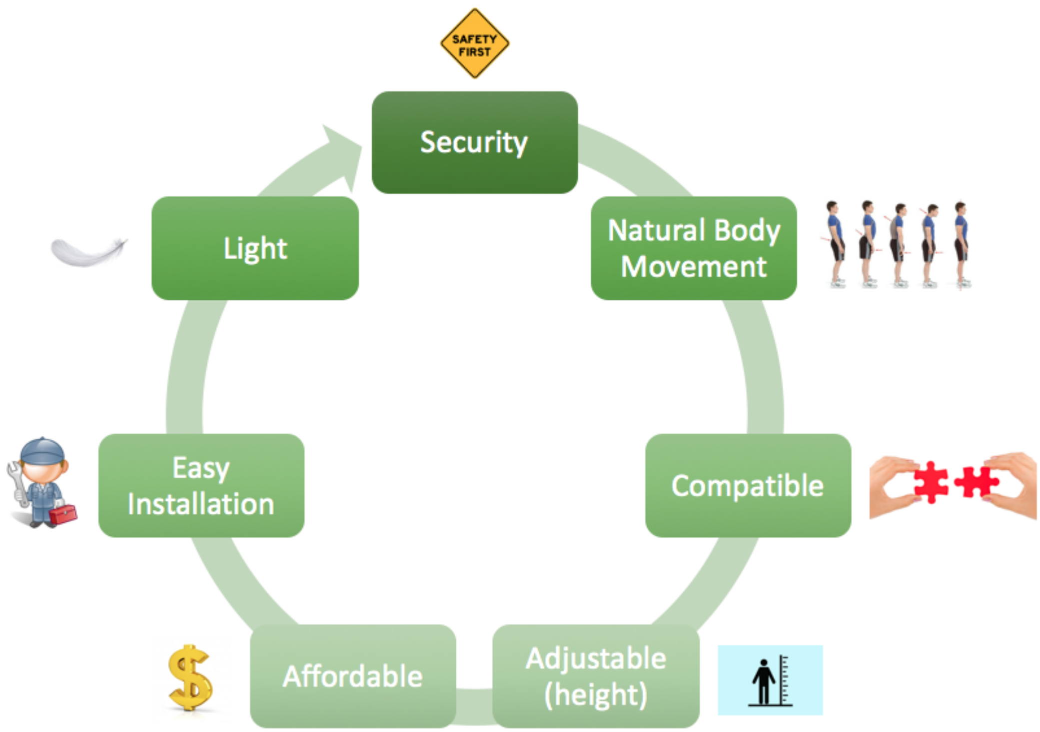


Figure 17. Principal Costumers' needs

8.1. Concept design

We must start by analyzing and using creativity to shape the first idea of our product. In this section there are several techniques that can be very useful for the development of any product.

- The generation of ideas is always important when developing a new idea, having several alternatives on the table and not focusing on a single one.
- Clearly define what the applications of our product will be. As a first design, it is essential to focus on a single design with a single application, the most essential one. Later you can go making changes that improve the design of the product for example.
- Designate what will be the resources that the company has to get this product to market. These resources are going to be both direct and indirect. The development time is going to be a determining factor in this type of products.
- Define what will be the technologies that we will use during the process. In the same way, it is vital to know what our direct suppliers could be.
- There are different tools that can be used during this process. Brainstorming is one of the most famous techniques in development stage. It is essential to know the opinion of each member of the development team. Therefore, a meeting in which the sketches and outlines are the center of the conversation, is essential for the correct course of the design. Economic-financial analyzes also play a very important role in this process. A good analysis of the market, the trends of current societies and long-term benefits can be vital when making this product a reality.

8.2. Design in detail

Once we have all the sketches and schemes it is time to formally define what the final product will be like. In the same way, it is going to be important the different technical specifications for its later production. In this part of the process, the interactions between the product developers and the rest of the departments, such as the engineering department, begin to appear. In our case we are going to use a 3D modeling software, SolidWorks. Thanks to this work tool we will be able to translate all the sketches into real pieces, in which it will be easier to analyze possible failures. It is important to realize several designs in case we do not have a totally pre-established design. In this way, we will be able to obtain at the end of the process that will be the sum of the advantages of each of the designs. Below you can see how our design has varied until the final design.

8.2.1. First design

For this first design, we try to directly simulate the operation of an elliptical. To do this, we designed two completely symmetrical handles that simulated the movement of an elliptical. Both handlebars end in a common handle found in the market, so that their purchase would be easier when manufacturing process. These two supports were directly connected to a central axis that was going to be the element that supported all the forces. As for the link between the systems and the stroller was a piece that joined both systems and was attached to a clamp. In the same way as the handle, it has been tried to look for clamps that are easily to access in the current market. Below, the first design is shown.

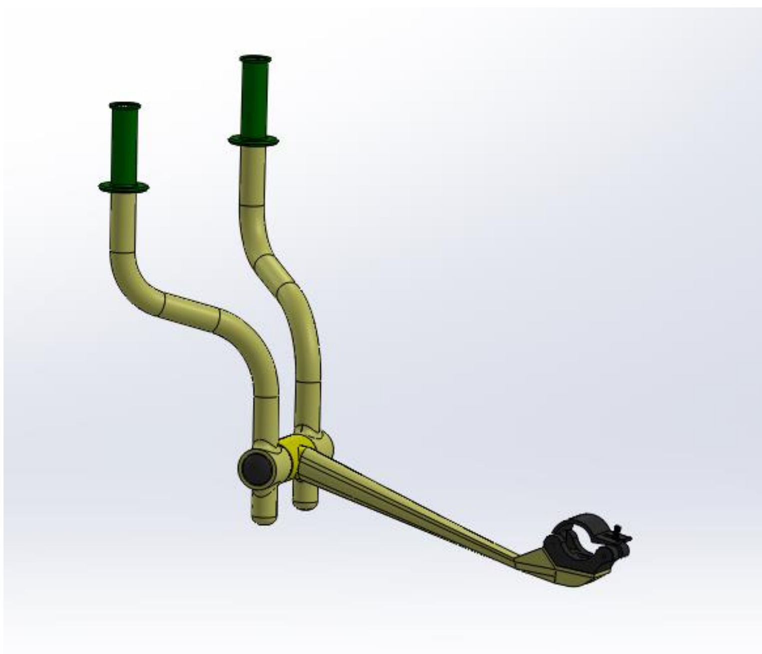


Figure 18. First design

As you can see in this figure, the system does not present the robustness that we were looking for our product. After an analysis of forces, we concluded that this model was not a valid model for our product.

8.2.2. Second design

In order to improve the stability of our system, it was decided to place two connecting bars with the cart instead of one. Another application that emerged during this design phase, was to think of some way by which the user could rest and continue walking without using our system. The solution that was applied in this design was to relax both handlebars so that they were hanging. Once these were floating, we would have to join them to a piece that is on top of each of the clamps. Therefore, when observing the system with the handlebars attached to the clamps, one could see how the handlebars rested perfectly on the handlebar of the stroller. With the idea of continuing to walk even if we had our system coupled, it had been decided to add two new handles that would serve as new handlebars.

As it happened to us in the previous model, the piece that connected the system with the stroller suffered too much stress. One of the solutions could be to reduce its length and increase its thickness, in order to ensure its perfect operation.

Other disadvantages of this system was that it was not compatible with all types of users, since it was restricted to a certain height. Then, you can see how the final assembly of the second design was.

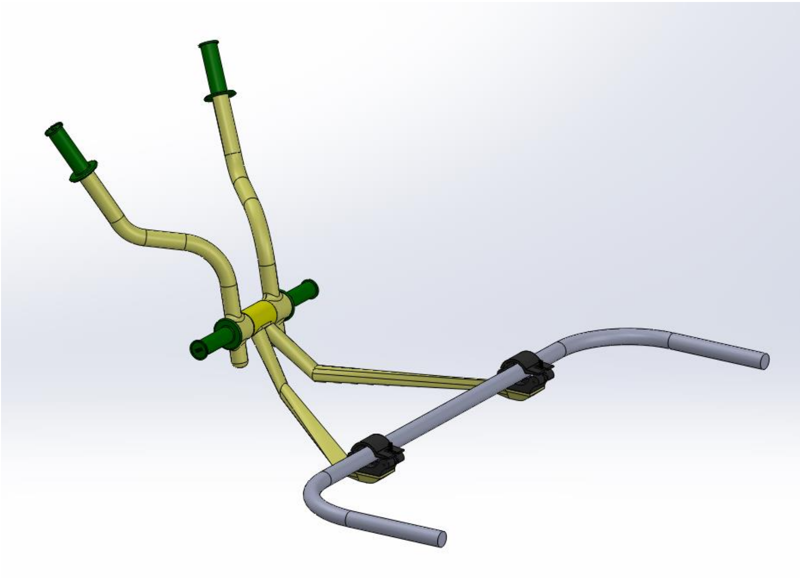


Figure 19. Second design

8.2.3. Third and last design

In order to improve all the problems presented by the previous models, it was decided to go to the gym to take again the real measurements of a conventional elliptic. After measuring the arc that both handlebars created, it was decided to reduce the distance between the mechanisms to the stroller to the maximum, always ensuring that at no time could the stroller be impacted. Therefore, as can be seen in Figure 20, the union will be made with a single piece. This piece is going to have twice the thickness of the previous ones and will be attached to the stroller by a double length clamp. In this way, we ensure the stability of the user perfectly, while at the same time ensuring the stability of the stroller.

In terms of adapting the mechanism to all types of users, it has been decided to apply two significant changes:

- Place a rubber handle that covers practically the entire part of the joint. Applying this change, we simulate perfectly the functioning of an elliptical of any gym, in which the user can grab the system in the way that is most comfortable.
- We have decided to put adjustable bars between the handlebars and the central part of the system. Thanks to this new incorporation, the runner can adjust up to a difference in height of 20 cm.

With these two additions, our design is compatible with people in a large range of heights. It is also important to emphasize that this design practically has the same measures as a normal elliptical, therefore its operation should be the same. Next Figure 20 shows how the design of the final model would look.

In order to optimize the material of our mechanism to the maximum, it has been decided to place a hole in the central part. This hole also gives the user the possibility to place any object that he will need during his exercise.

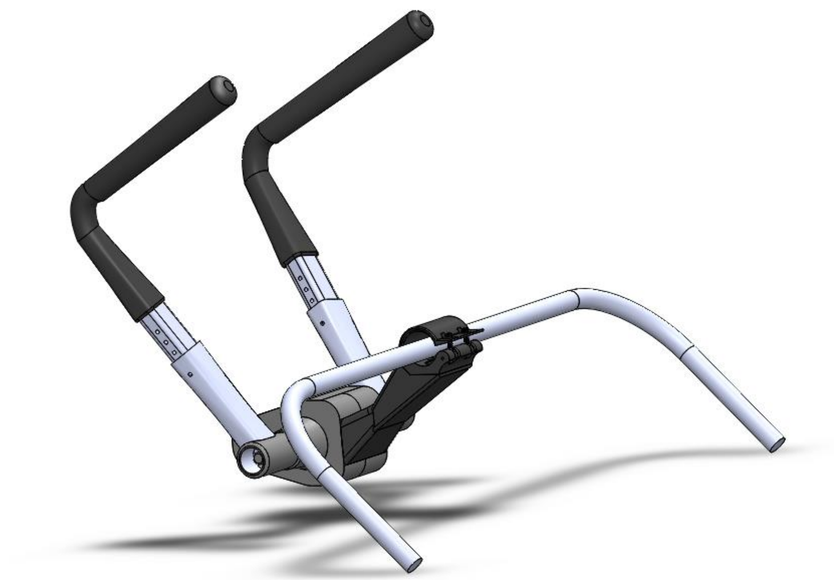


Figure 20. Third and last design

8.3. Validation

The form that we are going to use to evaluate the correct functioning of our mechanism will be simulating the path of a point of the handle of our system, to later compare it with what it would have in a conventional elliptical. In order to perform this we are going to place a rotary motor in each one of the handlebars that simulate the natural movement of the human body. The engine associated with the right handlebar will present the following configuration.

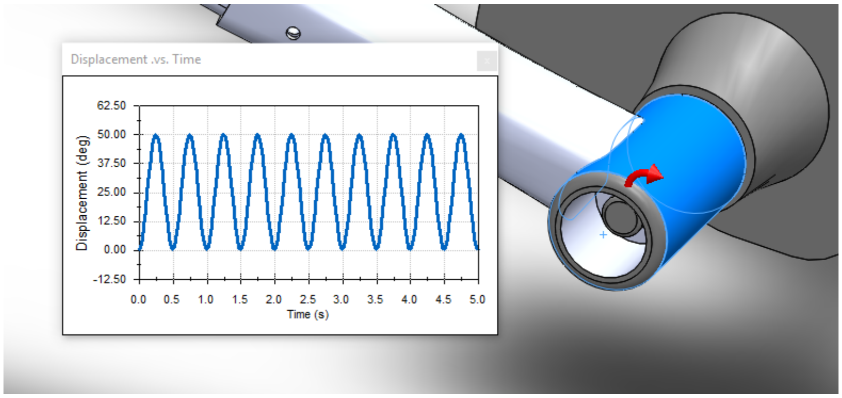


Figure 21. Right Handlebar Engine

As we can see in the graph, the mechanism will go from the resting position (zero degrees) to a final position of 50 degrees. These data have been selected based on the trajectory usually traveled by the arm of a normal person who practices this type of exercise.

In the same way, the left handlebar motor has been implemented as shown below.

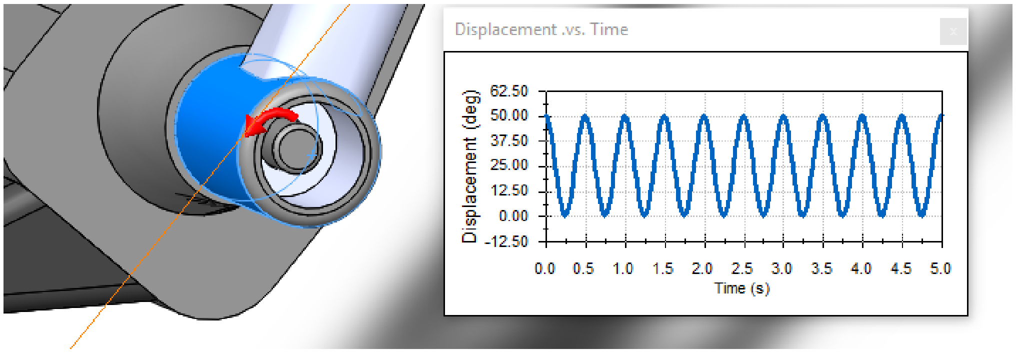


Figure 22. Left Handlebar engine

The only difference presented by this engine compared to the previous one, is that the rest position of this starts at 50 degrees. Using this 180 degree phase, it facilitates the visualization of how a person's movement would be if they were using both handlebars. As happens in reality, at the ends of the trajectories, both arms are in opposing positions.

Once both movements are defined, you can calculate what the trajectory of any point on the handlebar will be. This point to symbolize the center of mass of the user's hand. Therefore, the final trajectory that we obtain is the following.

Figure 23. Trajectory

The trajectory that we obtain with a normal elliptical can be seen below in Figure 24.

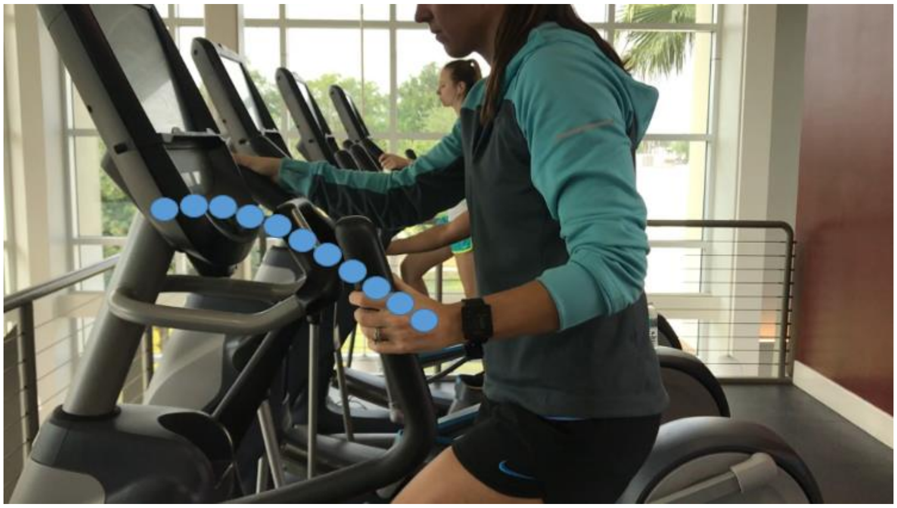


Figure 24. Real trajectory

Finally, it can be seen that both trajectories are practically the same. This means that our design simulates perfectly the natural movement of the human being when running. In the same way, through these simulations we have seen that our design complies with each and every one of the previous specifications. The next step to finish the validation, would be to print the final design in 3D and directly prove the correct functionality of the mechanism with different types of users.

9. Force Analysis

In order to carry out the analysis of the force applied to our mechanism, we will have to calculate which is going to be the force that the person does when pushing the mechanism. For this, we will have to analyze what forces are going to be present in our stroller. In this case we will have the following forces:

1. Stroller´s weight
2. Normal force
3. Frictional force
4. Pushing force

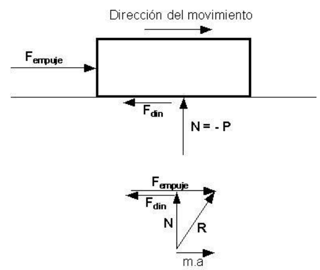


Figure 25. Free body diagram

9.1. Stroller´s weight

The weight of the different market strollers is easy to find in the different specification tables of each of the models. The following are the five most sold models in 2018 with their respective weights, both in lbs. and kg. (Spurrier, 2018)

Stroller´s Name	Price ($)	Pros	Cons	Weight (lbs)	Weight (kg)
Thule Urban Glide 2	450	Top scores for run-ability and maneuverability, easy to use, high quality	Harder to transport and stow as it doesn't self-stand	**24,4**	**11,0676448**
BOB Revolution Flex	500	Easy to run with, responsive turning, high quality	Won't self-stand when folded, difficult to lift and carry	**27,3**	**12,3830616**
Thule Glide 2	450	High quality, lightweight, easy to fold and use	Harder to turn in small spaces	**24,4**	**11,0676448**
Burley Solstice	400	Top score for ease of use, simple fold, large storage, runs straight	Heavier weight, bulky fold, difficult to lift and stow	**27,4**	**12,4284208**
Bumbleride Speed	550	Easy to push and turn, compact for small spaces	Doesn't track as straight, harder to adjust harness	**26,6**	**12,0655472**

Figure 26. Weight of the most famous strollers in 2018

As it can be shown in the table above, the average weights of the jogging strollers are usually between an interval of 24.4 to 27.4 lbs. Therefore, in our case we will choose the maximum value that we have found in the market, in order to analyze the most critical scenario (27.4 lbs. / 12.42 kg).

9.2. Normal Force

In this case, we are going to assume that the landscape that we are going to analyze is smooth practically, since normally the runners will perform the exercise on essentially smooth surfaces or with a small inclination. Therefore, as previously seen in the free body diagram, the normal force is directly affected by the force of the weight. In the case that there was a small inclination in the way it would be necessary to multiply said force by the cosine of said angle, that as it has been explained previously, in our case it is going to be considered zero.

$$N = m * g \tag{1}$$

$$N = 12.42\, kg * 9.8\, m/s^2 \tag{2}$$

$$\boldsymbol{N = 121.72\, N} \tag{3}$$

9.3. Frictional Force

Within the friction forces there are two types depending on the state of the body to be studied. We can find a body that is moving with constant speed or a body that is totally at rest. For each of these states, there is a type of friction force, dynamic and static respectively. (sc, s.f.)

9.3.1. Dynamic Frictional Force

This is the case of the body that is in motion with a constant speed (acceleration equal to zero). The applied force F will be equal to the friction force present in the ground. As previously explained, a practically smooth surface will be assumed, so that the force will finally be proportional to the normal, that is, to the weight.

Regarding the coefficient of dynamic friction, it has been decided to use the coefficient that refers to the relationship between rubber and cement (dry), since it is the most restrictive of all rubbers. (Formación, 2015)

	μ_k
Rubber-Concrete (dry)	0,8

Figure 27. Dynamic Friction Coefficient

Therefore, the force of dynamic friction that will present our stroller model will be:

$$F_r = \mu_k * N \quad (4)$$

$$F_r = 0.8 * 121.72\ N \quad (5)$$

$$\boldsymbol{F_r = 97.37\ N} \quad (6)$$

$$F - F_r = 0 \quad (7)$$

$$\boldsymbol{F = 97.37\ N} \quad (8)$$

It is important to note that when the body slides, the friction force is totally independent of the speed of the block.

9.3.2. *Static Frictional Force*

When there is no relative movement between the bodies there is also a frictional force, known as static. As the body is at rest it has zero acceleration, so if we apply the force diagram to our system, we have again the pushing force equal to the force of friction, in this case static. For the calculation of this new friction force we have to apply the coefficient of static friction.

	μ_s
Rubber-Concrete (dry)	1

Figure 28. Static Frictional Coefficient

Therefore, the static friction force that our stroller model will present will be:

$$F_r = \mu_s * N \quad (9)$$

$$F_r = 1.0 * 121.72\ N \quad (10)$$

$$\boldsymbol{F_r = 121.72\ N} \quad (11)$$

$$F - F_r = 0 \quad (12)$$

$$\boldsymbol{F = 121.72\ N} \quad (13)$$

The maximum friction force in our system is obtained when the block in question begins to slide towards the direction of displacement.

9.4. Pushing Force

Once the body is in motion, the pushing force can be increased depending on the acceleration that the user wants to give to the system. According to a study, the maximum acceleration reached by a pedestrian in case of an emergency is 1.44 m/s^2. Comparing this acceleration, with the acceleration that Usain Bolt reaches in the first meters of its races that is usually around 3.09 m/s^2, we can estimate that the average acceleration of a runner with a stroller can be around 2 m/s^2. (Grewolls, 2014) (Allain, 2012)

With these data, it is going to be calculated what would be the maximum force that the user would have to give, in case that the maximum acceleration that has been estimated previously was reached. This data will be relevant for the subsequent study of forces.

When the body is moving with a variable speed, that is to say with a constant acceleration, it has that the pushing force is:

$$F = m * a + F_{\text{r-k}} \tag{14}$$

$$F = 12.42\,kg * 2\frac{m}{s^2} + 97.37N \tag{15}$$

$$\boldsymbol{F = 122.21\ N} \tag{16}$$

Below is a graph showing all the points previously studied.

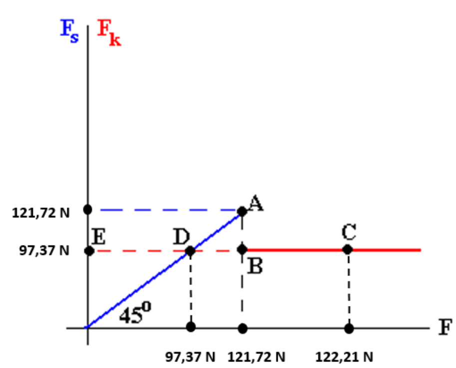


Figure 29. Force evolution

- ***A:*** From the origin of coordinates to point A the system is at rest (without acceleration). From point A and thereafter is when the body's slide occurs, the friction force reaches its maximum value. It is also important to note that the angle of the line is 45 degrees. During all this trajectory the pushing force is the same as the friction force, since as explained above, the acceleration is zero.
- ***B:*** Point B corresponds to the moment in which the body begins to slide, acting in this case as friction force, the dynamic.
- ***C:*** In case the pushing force increases, the body starts to accelerate. In this case the only force that opposes the movement will be the force of dynamic friction. This acceleration will increase until its maximum values are reached.
- ***D:*** The point D is reached when the applied force F decreases to such a point that it reaches the value of the dynamic friction force. At this point the acceleration is reached equal to zero, that is, the body moves with constant speed.

Finally, once all the forces that are going to appear in our system have been defined, it is time to study how our mechanism is going to react to the impact of the total pushing force.

9.5. Force Analysis SolidWorks

Through SolidWorks Design Software, it is possible to analyze which will be each of the tensions present in our mechanism once the estimated thrust force is applied. To do this, we will be analyzing each of the different assemblies to see what will be the critical points of each of the modules. Initially, an alloy steel material will be used, since it is the material predefined by SolidWorks. Later on, several scenarios will be analyzed with different types of materials, in order to optimize the manufacturing price of the mechanism.

9.5.1. Connector

This part is the one that connects the mechanism of movement of the arms with the part of the stroller. In this case, it has been decided to fix the fastening part to the stroller, since we want it to be the one that remains fixed and stable every time. In the case of applied force, it has been decided to apply it to the back part of the assembly, since the pushing force will be applied from that part.

The following figure shows how the result of the Von Mises stresses would be in each of the nodes of the system, once we apply each and every one of the constraints.

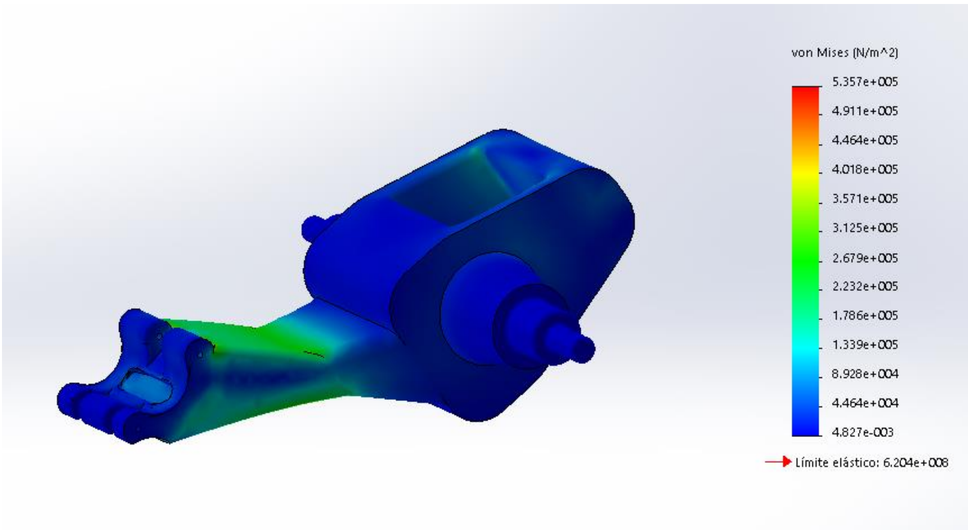


Figure 30. Stress Analysis - Connector

As expected, the part of the system that suffers the most stress is the one that acts as a connector between the central axis and the clamps of the stroller. The maximum tension is reached at the following node.

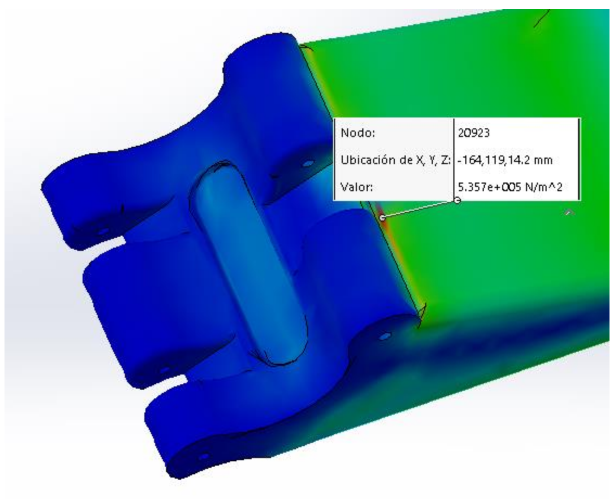


Figure 31. Node that suffers the most stress – Connector

9.5.2. Common Part

Now, the part that is common in our system will be analyzed, both for the left side and for the right side of our mechanism. In this case, it has been decided to keep the internal face that connects to the connector as a fixed point. In the case of forces, it has been decided to apply them on the internal face of the pin, in this way we are able to simulate what would be the force that the height regulator would apply to our system.

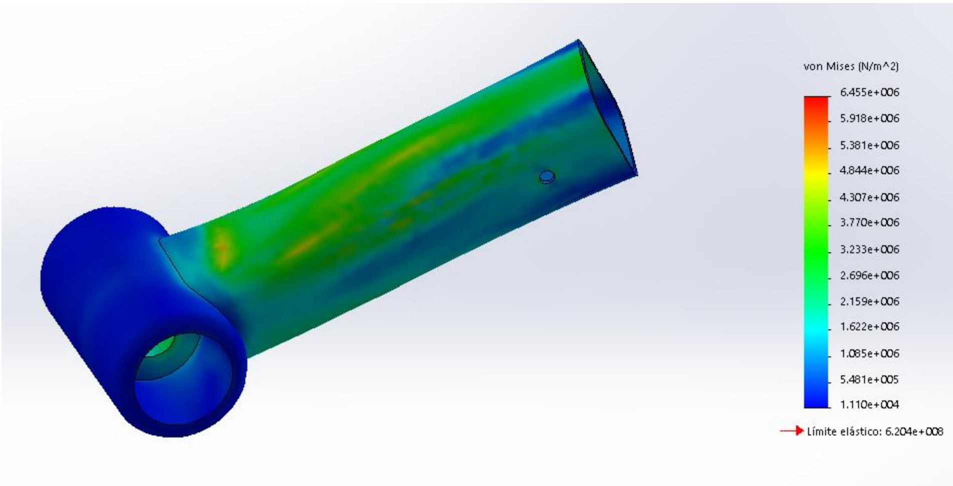


Figure 32. Stress Analysis – Common Part

In this scenario, it can be seen how the point that suffers the most is the internal face where the height regulator would be located. The maximum tension occurs in the following node and has a value of:

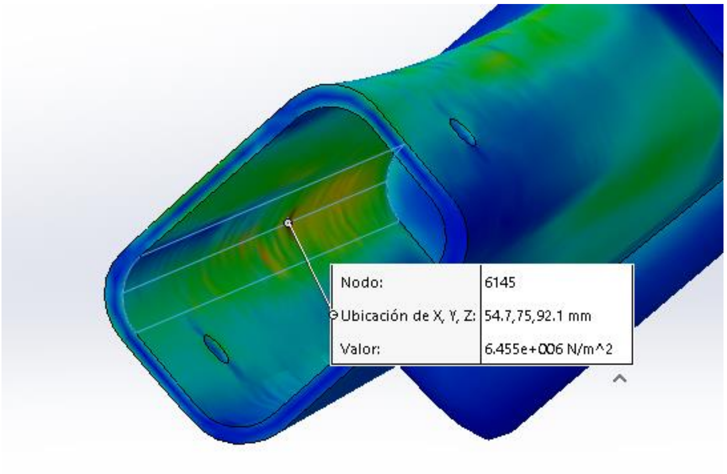


Figure 33. Node that suffers the most stress – Common Part

9.5.3. Left Arm / Right Arm

The next system to be analyzed will be the left arm, which by symmetries will be the same as that of the right arm. In this case it has been decided to fix the face on which we used to apply the forces. In the case of the forces, it has been decided to apply them to the part of the curvature of the handle, since as a common rule it will be where the user has his main support during the maximum time of his exercise. In the case of the value of the force, it has been decided to apply the amount previously calculated (122.21 N), since the user will apply this force in each of the supports, each time he/she makes one of his movements.

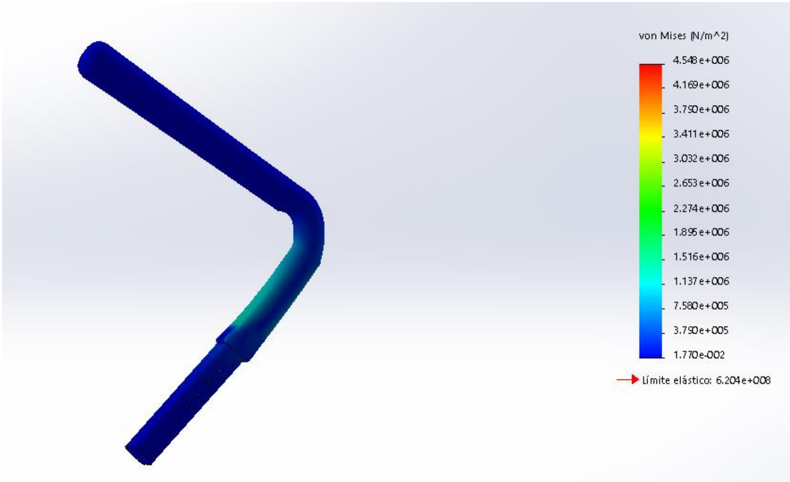


Figure 34. Stress Analysis – Left/Right Arm

In this case it can be seen how the maximum tension can be found in the internal point of connection between both pieces. Below you can see its location and value.

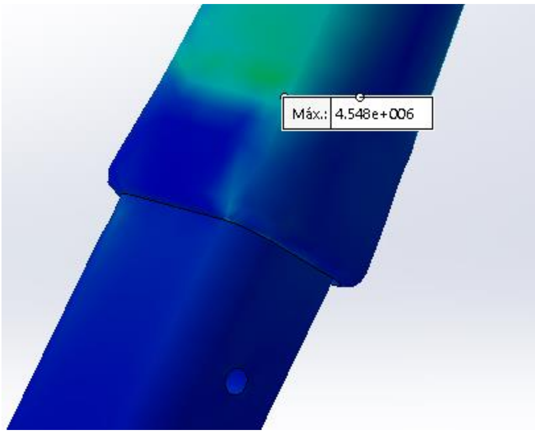


Figure 35. Node that suffers the most stress – Left/Right Arm

9.5.4. Analysis of Results

Once the results of each the analysis have been calculated, it is important to compare them, so that it can be defined which is the point that suffers the most or moves in each of the scenarios. Below is a comparative table in which the tensions, displacements and unit deformations of each of the sets are observed.

	Force Analysis		
	Tension (N/m^2)	**Displacement (mm)**	**Unit Deformations**
Connector	5,375E+05	1,810E-03	1,696E-06
Common Part	**6,455E+06**	1,126E-02	**2,037E-05**
Left Arm / Right Arm	4,548E+06	**1,591E-02**	1,14E-05

Figure 36. Critical Values

As can be seen in the table above, the set that suffers the least in all the scenarios is the connector. This is a good sign for our mechanism, since it indicates that there is less danger, being the piece closest to the stroller. However, as for the comparative of the common part and the different arms, it can be said that both suffer practically the same. In the case of the common part, it is observed that the tension and the unit deformations present higher values than the rest of the scenarios. However, the piece that suffers the greatest deformation is the one associated with the arms of the mechanism, since due to its structure and design it presents a greater facility to deformation.

Finally, if these results are compared with the specific characteristics of the material that we are using (alloy steel), it can be said if the mechanism would be capable of supporting these efforts. In our case, when using alloy steel, we have the following characteristics.

Alloy Steel		
Property	**Value**	**Units**
Elastic Modul	2,10E+11	N/m^2
Poisson Coeficient	0,28	N/D
Density	7700	kg/m^3
Elastic Limit	**620422000**	N/m^2

Figure 37. Initial Material

In our scenarios the maximum tension that was obtained according to the Von Mises analysis was 6.455E + 06, which compared to the elastic limit is much lower. Therefore, it can be said that our mechanism will not undergo any kind of permanent deformation, keeping our system integral at all times. The next step will be to try to analyze the cost of each of the pieces, choosing that material that maximizes our benefits, while ensuring the integrity and security of the system.

10. Weight Analysis

Being a mechanism that will be used to exercise, it is important to get a material that maximizes its weight. Reducing a kilogram, can suppose a great improvement in our system, since our mechanism does not have to suppose an extra effort to the user in order to realize his activity. To do this, with the aim of having a light product, we will try to make an analysis of the different scenarios, changing only the materials of each of the pieces of our model. Another of the main reasons why our mechanism has to be light, is because it has to be easy to transport.

To start, we will analyze the current weight of each of the pieces with the material that had been previously preselected (alloy steel). Then, the results will be interpreted to see which piece result in the most material, in order to optimize our mechanism to the maximum. Therefore, it will be evaluated thanks to the function that SolidWorks offers to evaluate the physical properties of each of the elements. Then the next table shows each of the weights.

	Total Mass and Volume of the Mechanism		
	Density (g/mm^3)	Mass (g)	Volume (mm^2)
Stroller-Mechanism	0,0077	6.255,21	812.365,54
Central Axis	0,0077	19.340,76	2.511.786,70
Common Part (1)	0,0077	1.588,10	206.247,09
Common Part (2)	0,0077	1.588,10	206.247,09
Height Regulator (1)	0,0077	2.324,97	301.943,80
Height Regulator (2)	0,0077	2.324,97	301.943,80
Left Handle	0,0077	5.998,32	779.003,23
Right Handle	0,0077	5.998,32	779.003,23
Clamp_Part 1	0,0077	1.194,99	155.192,98
Clamp_Part 2	0,0077	548,35	71.213,89
Clamp_Part 3 (1)	0,0077	21,96	2.851,92
Clamp_Part 3 (2)	0,0077	21,96	2.851,92
TOTAL		47.206,01	6.130.651,19

Figure 38. Total Mass and Volume of the Mechanism

As can be seen in the previous figure, the total weight of our mechanism if we use alloy steel would be approximately 47.2 kg. This amount compared to the 12.42 kg we had estimated as the average weight of a jogging stroller, it is huge. Therefore, we would not comply with our main objective, that was ensuring the integrity of the stroller at all times, since the system as a whole would be totally unstable.

In order to study which are the heaviest parts for our system, it has been decided to evaluate the following graph.

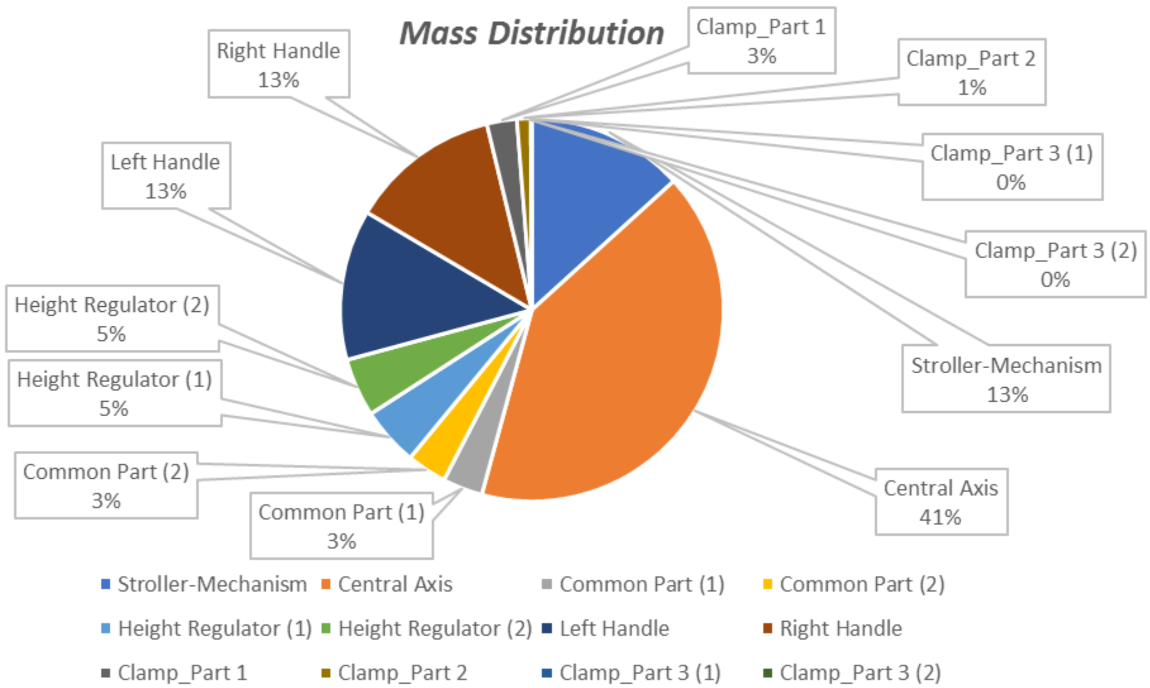


Figure 39. Mass Distribution

As we can see in the previous graph, the central part is the one that weights the most for the mechanism, since it is the most voluminous. The same happens with the stroller-mechanism as with both handles. Therefore, these pieces are the ones that we are going to try to optimize to the maximum, until achieving a more adequate weight to the weight of the stroller.

In the same way, we will try to use materials that are more similar to reality. For example, in the case of both handles it will be decided to apply a material similar to rubber. Applying this material will also favor the ergonomics of the piece. On the other hand, in the case of the clamps, an attempt will be made to select a material that adapts to the market options that exist already today. Finally, in the case of the central axis, the stroller-mechanism, the height regulator and the common parts, a resistant material will be used, but it will have a much lower density than the alloy steel.

10.1. Clamps

In order to choose the material of the clamps, it will be decanted by the same material that is used in the systems of clamps of the common GoPro. According to the technical specifications of all supports, extensors, adapters ... etc., polycarbonate (PC) is always used in its manufacture. The only polycarbonate that exists in the material gallery of SolidWorks is high viscosity polycarbonate. This material has the following characteristics. (Belén, 2015)

	Properties				
	Elastic Module (N/m^2)	Poisson Coefficient	Cutting Module (N/m^2)	Density (kg/m^3)	Traction Limit (N/m^2)
PC High Viscosity	2.320.000.000,00	0,39	829.100.000,00	1.190,00	62.700.000,00

Figure 40. Properties of Clamp_Part 1 and Clamp_Part 2

In the case of the screws, it has been decided to use AISI 316L Stainless Steel, which is usually the material used for all types of screws. This material has the following technical characteristics.

	Properties				
	Elastic Module (N/m^2)	Poisson Coefficient	Cutting Module (N/m^2)	Density (kg/m^3)	Traction Limit (N/m^2)
AISI 316L Acero Inoxidable	200.000.000.000,00	0,265	82.000.000.000,00	8.027,00	485.000.000,00

Figure 41. Properties of Clamp_Part 3

Once all the pieces that are going to participate in the set of clamps have been defined, we can calculate what the resulting total weight would be and compare it with the previous one.

	Clamp			
	Material	Density (g/mm^3)	Volume (mm^2)	Mass (g)
Clamp_Part 1	PC High Viscosity	0,00119	155192,98	184,6796462
Clamp_Part 2	PC High Viscosity	0,00119	71213,888	84,74452672
Clamp_Part 3 (1)	AISI 316L Acero Inoxidable	0,008027	2851,82254	22,89157953
Clamp_Part 3 (2)	AISI 316L Acero Inoxidable	0,008027	2851,82254	22,89157953
TOTAL (g)	315,207332	567%		
Previous amount (g)	1.787,25			

Figure 42. Total weight of an individual clamp

Therefore, as can be seen in the case of the clamp, it has been possible to reduce the weight of the assembly by more than 500%, obtaining a final weight of 315 grams.

10.2. Handles

In the case of handles, it has been decided to apply a type of rubber. The rubber used is going to be the BUTYL, since it is the one that is usually used in this type of industry, especially for the manufacture of bicycle handles. This type of material offers some ergonomics for the user, since it offers very good adhesion, even in case of rain. Also due to its malleability, it tends to adapt to the shape of the hand of the runner, greatly facilitating the comfort at the time of realizing the activity. The densities that present in general the different types of rubber tend to be much lower than those presented by steel. In this case, BUTYL rubber has a density value equal to 1159.2 kg/m^3.

Once we have the value of the density of the new material, we can directly calculate what would be the total weight that both handles would present.

	Handles			
	Material	Density (g/mm^3)	Volume (mm^2)	Mass (g)
Left Handle	Rubber BUTYL	0,0011592	779.003,23	903,0205419
Right Handle	Rubber BUTYL	0,0011592	779.003,23	903,0205419
TOTAL (g)	1.806,04	664%		
Previous amount (g)	11.996,65			

Figure 43. Total weight of a handle

Finally, in the case of handles can be seen in the previous table that we are able to save almost 600% of the initial weight. With rubber as material, a final weight has been obtained, considering both handles, of 1.8 kg.

10.3. Stroller-Mechanism/Central Axis/Common Part/Height Regulator

As it has been demonstrated previously with the analysis of forces, these pieces are the ones that are going to suffer the greatest stresses, therefore they have to present high values of traction and elastic limits. SolidWorks offers a wide range of materials to choose from, so we will mainly try to compare the weight of these materials related to their resistance to effort. It has also been thought to analyze what is the typical material that it is used in the manufacture of bicycle frames, since what is being sought is a light and resistant material, so that the bicycles present the perfect design characteristics. Most conventional bicycles are made of aluminum, in particular of an aluminum known as aluminum 6061-T6 or aluminum 7005. There are many discussions in which they compare the characteristics and technical specifications of these two materials, to know which of them is better in bicycle manufacturing processes. In our case, it has been decided to choose aluminum 6061-T6 for two basic reasons: the 7005 aluminum alloy cannot be found in the SolidWorks library; Normally, the higher the number of the alloy, the greater it is the density of mass and as always we are looking to decrease the weight of the mechanism to the maximum, therefore we will choose the one with the lowest density. (Bike-Advisor, 2012)

	Stroller-Mechanism/Central Axis/Common Part/Height Regulator			
	Material	Density (g/mm^3)	Volume (mm^2)	Mass (g)
Stroller-Mechanism	Aluminum 6061 T-6	0,0027	812.365,54	2.193,39
Central Axis	Aluminum 6061 T-6	0,0027	2.511.786,70	6.781,82
Common Part (1)	Aluminum 6061 T-6	0,0027	206.247,09	556,87
Common Part (2)	Aluminum 6061 T-6	0,0027	206.247,09	556,87
Height Regulator (1)	Aluminum 6061 T-6	0,0027	301.943,80	815,25
Height Regulator (2)	Aluminum 6061 T-6	0,0027	301.943,80	815,25
TOTAL (g)	11.719,44	285%		
Previous amount (g)	33.422,11			

Figure 44. Total weight Stroller-Mechanism, Central Axis, Common Part and Height Regulator

As it can be seen in the previous figure, the weight in this case is not reduced in percentage (285%) as it was reduced in the previous cases, since we are talking about the most resistant and heavy material. Finally, it can be said that the final weight of our global mechanism will be around 13-14 kg.

11. Manufacturing processes

In total, a total of 10 pieces were designed and validated in SolidWorks. With the intention of accelerating and facilitating the manufacturing process, it has been decided to design certain pieces with the objective that they apply to any of the arms. In this way with a simple rotation of 180 degrees will be valid for both positions. This greatly simplifies the logistics and the storage of the pieces. These pieces are going to be the pieces that we have defined in our design as connectors.

For the manufacturing processes in question, it has been decided to use different methods, depending on the characteristics of each of the pieces. These methods to use are the following

11.1. Machining

The basic principle of machining is to eliminate material or parts of the piece that we want to manufacture. This process is carried out with the aim of realizing the different operations to reach the expected final result. Different machining techniques can be found within the machining:

- Cutting: cutting one or more cutting points within a single piece
- Traditional:
  - Turning
  - Grinding
  - Drilling
- Non-traditional
  - Electro erosion
  - CNC machining
  - Water jet cutting

The traditional methods are usually made with rotating mechanisms with a cutting blade (of a material harder than the piece to be cut) that is rotating at high speed, eliminating the shavings of the piece, getting the desired shapes and sizes. The big difference with traditional processes is that in these processes there is a CNC machining center, which fully automates the machining of a part.

The materials that are usually used in these processes are steel or plastic materials, although due to its versatility, we can even use wood or stones. The determining factors that must be controlled at all times during this type of process are: the speed of rotation and the depth of cut. (Grumeber, s.f.)

Therefore, depending on the characteristics that have been defined previously, the piece that best suits this type of process is the height regulator. Below are all the machining operations that would be needed to reach the final product.

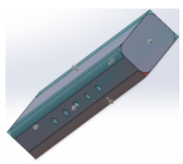
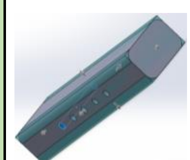
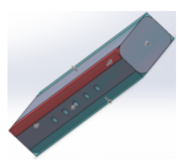
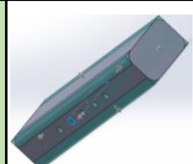
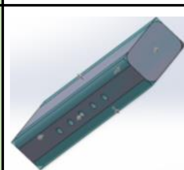
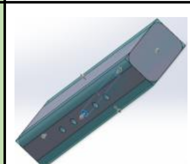
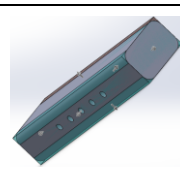
Height Regulator Manufacturing Operations			
Milling Operations		Drill Operations	
Volume 1		Drill 1	
Volume 2		Drill 2	
Volume 3		Drill 3	
Volume 4		Drill 4	
		Drill 5	

Figure 45. Machining Process – Height Regulator

11.2. Casting

The casting process consists mainly of melting the metals and then introducing them into molds with different shapes. There are also other types of casting processes, such as those of contiguous casting or pig iron, although the most commonly used is molds.

As for the mold, it can be made of different materials, although the most commonly used material is sand due to the physical properties it presents. It is essential to obtain a fluid metal that can be completely adapted to the different mold cavities. Therefore, the composition, fusion temperature and surface tension of the metal or alloy are determining factors for this type of process. The casting is used mainly for parts that have a difficult geometry and to manufacture large batches of pieces.

Therefore, depending on the characteristics that have been defined previously, the piece that best suits this type of process are the Central Axis, Common Part, Clamp_Part 3 and Stroller-Mechanism. Below are all the machining operations that would be needed to reach the final product.

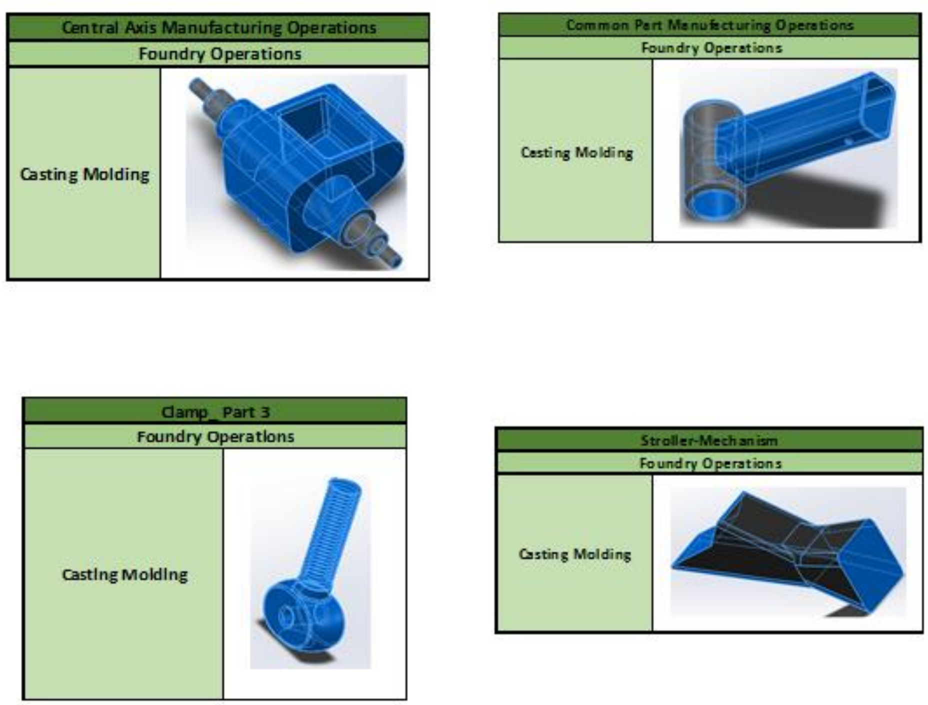


Figure 46. Casting Process – Central Axis/Common Part/Clamp_Part 3/Stroller-Mechanism

11.3. Plastic

Plastics are usually molded by a process known as injection molding. This process consists of melting the plastic material, which is then injected into the mold with the shape of the piece that we want to manufacture. During the process large resistances are used, responsible for melting the plastic material. It is a simple process, but it requires a perfect coordination of times and movements.

Therefore, depending on the characteristics that have been defined previously, the piece that best suits this type of process are the Clamp_Part 1, Clamp_Part 2 and the both Handles. Below are all the machining operations that would be needed to reach the final product.

Clamp_Part 2	
Plastic Operations	
Injection Molding	

Left/Right Handle Manufacturing Operations	
Plastic Operations	
Injection Molding	

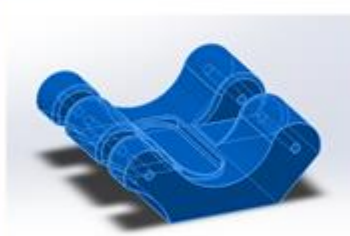
Clamp_Part 1	
Plastic Operations	
Injection Molding	

Figure 47. Plastic Process – Clamp_Part 1/Clamp_Part 2/Left/Right Handle

12. *Economic Analysis*

To carry out our economic analysis, it will be important to establish what is the relationships between each of the assemblies that integrate our mechanism. In our case, the three assemblies that we decided to create were the connector, the right-arm and the left-arm. To create a mechanism, only one set of each type of assembly is going to be needed. Within the sets it can be found:

1. Connector: The connector also will be divided into three different parts.
   - 1.1. Clamp (1): It will be formed by three different pieces.
     - 1.1.1. Clamp_Part 1 (1)
     - 1.1.2. Clamp_Part 2 (1)
     - 1.1.3. Clamp_Part 3 (2)
   - 1.2. Central Axis (1)
   - 1.3. Stroller-Mechanism (1)
2. Right-Arm: the right-arm assembly will be also divided into three different parts.
   - 2.1. Right-Handle (1)
   - 2.2. Height Regulator (1)
   - 2.3. Common Part (1)
3. Left-Arm: the left-arm assembly will be also divided into three different parts.
   - 3.1. Left-Handle (1)
   - 3.2. Height Regulator (1)
   - 3.3. Common Part (1)

The parenthesis that is found at the end of each of the pieces indicates the quantity of these pieces that are used in our mechanism. For this system, one piece will be used for each element designed, with the exception of the common parts of the mechanism and the two screws of the clamps.

Then, the next table shows how the assembly scheme of our mechanism, with all the parts and their respective quantities.

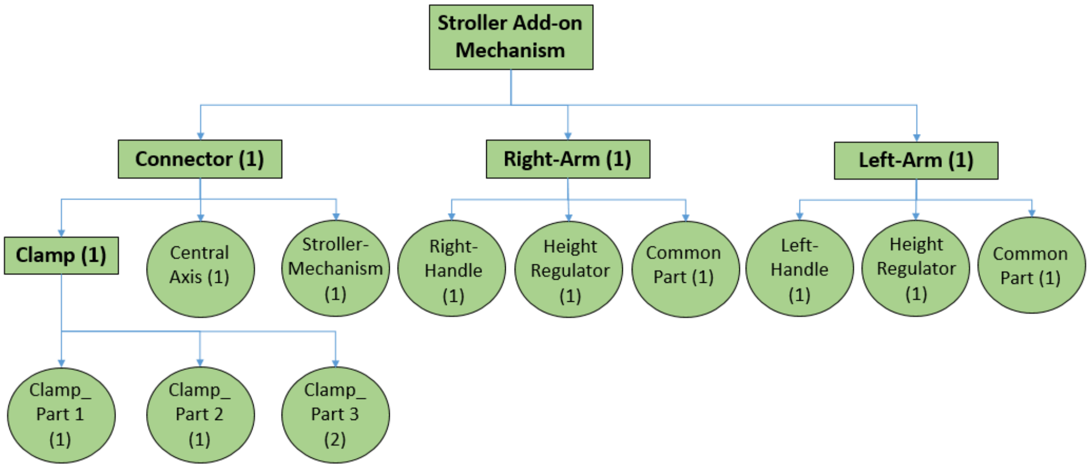


Figure 48. Mechanism´s parts distribution

Once we know which and how many pieces are going to be used in each of the assemblies, we will continue with the estimation of what would be a reasonable amount of sales for the next few years. This estimate is important to do, since the manufacturing price of many of the pieces depends mainly on the mold that is manufactured for each of the models. Therefore, the greater the number of manufactured units, the greater the amortization of our molds.

To perform this economic estimate, we are going to return to the results that were obtained in the market analysis previously carried out. Based on the size of the market, we can estimate, always assuming that our marketing campaigns work as expected, an initial sold units of 10,000 during the first year. With this data, we can calculate the total number of pieces that we will have to manufacture during the first year and based on this calculate the manufacturing costs.

Stroller Add-on Mechanism	
Name of Part	**Quantity**
Clamp_Part 1	10.000
Clamp_Part 2	10.000
Clamp_Part 3	20.000
Stroller-Mechanism	10.000
Central Axis	10.000
Common Part	20.000
Height Regulators	20.000
Right-Handle	10.000
Left-Handle	10.000

Figure 49. Total number of parts

Once we have the number of pieces to be manufactured from each of the parts of the assemblies, thanks to the help of SolidWorks tool "Costing", we will be able to make an economic analysis of each of the pieces, simply entering the manufacturing process and the material to be chosen, which have been previously defined. Through this tool, we will be able to calculate the cost associated with the material, the manufacturing process and the mold. We can even indicate the hours of workshop, in this case will be $30/hour. Another factor that is going to take into account, is the waste material. In our case, it has been decided to establish a 5% waste material, which is the value that is usually predetermined for any manufacturing. The economic analysis of each of the pieces, with each one of the manufacturing times, is presented at the end of the project in the form of appendix.

Finally, we will proceed to calculate the unit and total cost of each of the pieces. Once this study has been carried out, the manufacturing cost of the mechanism as a whole will be calculated and the viability of the project will be analyzed, concluding with a final price.

12.1. Clamp_Part 1

The first piece of the handle has been decided to make it of polycarbonate (PC). As for the manufacturing process, being a plastic, it has been decided to use injection molding of plastic. Below, a detailed view of each of the costs associated with this process is shown.

	Clamp_Part 1	
	Per Unit ($)	**Total ($)**
Total Number of Units	1	10.000,00
Part´s Weight (kg)	0,17	1.700,00
Cost/Material (1,65 USD/kg)	0,2805	2.805,00
Manufacturing Cost/Unit	2,5	25.000,00
Mold	0,5	5.000,00
Total	**3,2805**	**32.805,00**

Figure 50. Total Cost – Clamp_Part 1

12.2. Clamp_Part 2

As in the previous piece, it has been decided to use polycarbonate as a material and injection molding of plastic as a manufacturing process. Then, the breakdown of the unit and total parts prices is shown.

	Clamp_Part 2	
	Per Unit ($)	Total ($)
Total Number of Units	1	10.000,00
Part´s Weight (kg)	0,08	800,00
Cost/Material (1,65 USD/kg)	0,132	1.320,00
Manufacturing Cost/Unit	3,34	33.400,00
Mold	0,5	5.000,00
Total	**3,972**	**39.720,00**

Figure 51. Total Cost – Clamp_Part 2

12.3. Clamp_Part 3

The last piece of the clamps, as being screws, it has been decided to use casting. At the time of the material, a type of steel alloy has been chosen, which ensures the integrity of the union at all times.

	Clamp_Part 3	
	Per Unit ($)	Total ($)
Total Number of Units	1	20.000,00
Part´s Weight (kg)	0,00485	97,00
Cost/Material (3,62 USD/kg)	0,017557	351,14
Manufacturing Cost/Unit	2,5	50.000,00
Mold	0,05	1.000,00
Total	**2,567557**	**51.351,14**

Figure 52. Total Cost – Clamp_Part 3

12.4. Stroller-Mechanism

The piece that will be the union between the stroller and the mechanism was decided to be in aluminum alloy, which is the typical material presented by regular bicycles in the market. This material, as shown in the analysis of forces is able to perfectly resist the different stresses suffered in the piece. In the case of the manufacturing process, it has been decided to use a pressure mold, due to the configuration presented by the piece.

	Stroller-Mechanism	
	Per Unit ($)	Total ($)
Total Number of Units	1	10.000,00
Part´s Weight (kg)	2,2995	22.995,00
Cost/Material (1,98 USD/kg)	4,55301	45.530,10
Manufacturing Cost/Unit	2,5	25.000,00
Mold	0,1	1.000,00
Total	**7,15301**	**71.530,10**

Figure 53. Total Cost – Stroller-Mechanism

12.5. Central Axis

Like the previous part, the central axis will be made of an aluminum alloy. Although this part of the mechanism is the heaviest compared to the rest of the parts (7.11 kg including 5% of waste material), it has been decided to use a high density material, since it presents good technical specifications of design and is able to withstand the efforts of the piece. In the same way, due to the design characteristics of the piece and its structure, it has been decided to manufacture it using the previous technique, pressure mold. The following table shows the total and unit cost of the piece.

	Central Axis	
	Per Unit ($)	Total ($)
Total Number of Units	1	10.000,00
Part´s Weight (kg)	7,119	71.190,00
Cost/Material (1,98 USD/kg)	14,09562	140.956,20
Manufacturing Cost/Unit	2,5	25.000,00
Mold	0,1	1.000,00
Total	**16,69562**	**166.956,20**

Figure 54. Total Cost – Central Axis

12.6. Common Part

Due to the arrangement of the drills, it is not feasible to manufacture this piece by machining. This is due to the fact that drilling and milling operations present exorbitant prices. Therefore, like the two previous pieces, it has been decided to use the pressure mold technique. For the material, an aluminum alloy has been reused.

	Common Part	
	Per Unit ($)	Total ($)
Total Number of Units	1	20.000,00
Part´s Weight (kg)	0,588	11.760,00
Cost/Material (1,98 USD/kg)	1,16424	23.284,80
Manufacturing Cost/Unit	2,5	50.000,00
Mold	0,1	2.000,00
Total	3,76424	75.284,80

Figure 55. Total Cost – Common Part

12.7. Height Regulator

In the case that this piece was decided to be manufactured by machining, it would have four operations of milling and five operations of drilling. The other cost associated with the machining process, would be related to the configuration operations defined by SolidWorks. The price in this case, unlike the previous cases, is similar for both, the machining process and the casting process. Therefore, it has been decided to analyze both cases to get subsequent conclusions.

	Height Regulator-Casting	
	Per Unit ($)	Total ($)
Total Number of Units	1	20.000,00
Part´s Weight (kg)	0,861	17.220,00
Cost/Material (1,98 USD/kg)	1,70478	34.095,60
Manufacturing Cost/Unit	2,5	50.000,00
Mold	0,1	2.000,00
Total	4,30478	86.095,60

	Height Regulator-Machining	
	Per Unit ($)	Total ($)
Total Number of Units	1	20.000,00
Part´s Weight (kg)	0,86	17.200,00
Cost/Material (10,10 USD/kg)	8,686	173.720,00
Manufacturing Cost/Unit	6,54	130.800,00
Mold	0	0,00
Total	15,226	304.520,00

Figure 56. Total Cost – Height Regulator

As shown in the table above, the manufacturing price if it is decided to do it by machining would be three times higher than if it were decided to use casting. As for the manufacturing cost, which is what really matters for our studio, it can be observed that for small quantities of parts, the machining process is much more profitable, since the mold would constitute the majority of our cost. However, in our case, with a large number of pieces, it is much more profitable to use the casting process, since the total cost of the mold ($1,000) is amortized with the total number of pieces.

12.8. Right/Left Handle

As explained in the section on weight analysis, it was decided to choose a plastic material for both handlebars, due to the benefits that this type of materials present. Regarding the manufacturing process, it has been decided to use a hot casting mold, which is the one that best suits the plastics treatment. The results for both handlebars are shown in the following tables.

	Left-Handle	
	Per Unit ($)	Total ($)
Total Number of Units	1	10.000,00
Part´s Weight (kg)	0,8295	8.295,00
Cost/Material (2,54 USD/kg)	2,12	21.069,30
Manufacturing Cost/Unit	2,5	25.000,00
Mold	0,5	5.000,00
Total	5,12	51.069,30

	Right-Handle	
	Per Unit ($)	Total ($)
Total Number of Units	1	10.000,00
Part´s Weight (kg)	0,8295	8.295,00
Cost/Material (2,54 USD/kg)	2,12	21.069,30
Manufacturing Cost/Unit	2,5	25.000,00
Mold	0,5	5.000,00
Total	5,12	51.069,30

Figure 57. Total Cost - Handles

12.9. Total Manufacturing Cost

Once the total and unit costs of each of the pieces are calculated and the number of pieces present in each final assembly are available, it is possible to calculate the total cost associated with the manufacturing process of the mechanism. Then, it can observed in the figure below the total weight of the mechanism, such as the costs associated with the materials, manufacturing processes and molds.

	Mechanism	
	Per unit ($)	Total ($)
Total number of units	1,00	10.000
Total Weight (kg)	14,23	142.332
Cost/Material (USD/kg)	29,07	290.743
Manufacturing Cost/Unit	30,84	308.400
Molds	2,70	27.000
Total	**62,61**	**626.143**

Figure 58. Total Manufacturing Costs

As can be seen, the final price of each of the units would be $62.61, that is, in order to manufacture the estimated 10,000 units, an initial capital of $626,143 would be necessary. Once the total cost associated with the manufacturing process has been determined, it could be determined whether the project is viable or not.

12.10. *Feasibility of the project*

Then, the viability of the project will be analyzed. To do this, first we will estimate the total price at which the product would have to be sold to obtain zero profits. This point is known as break-even point and will be our reference to set an initial price for our mechanism.

To calculate this price it is necessary, in addition to taking into account the costs associated with the manufacturing, to estimate the total fixed and variable costs of our project. The variable costs will depend on the quantity of pieces that are manufactured. Therefore, within said costs are going to be found:

- Material
- Manufacturing Cost
- Molds
- Salaries
- Distribution Channels

The fixed costs, however, will remain constant, without depending on the number of pieces that are manufactured. In the case, the fixed costs will be taken into account are:

- Rent
- Utilities
- Insurance
- Office Material
- Marketing

All these values have been taken based on different estimates already made in the city of Madrid, since no physical office is available to obtain real values (SoyEntrepreneur, 2011). As for salaries, it has been thought to start with three people who have a salary between 25,000 and 40,000 dollars, depending on the position in which they are working.

Sales		10.000 *X	
Variable Cost			
	Cost/Material	290.742,84	
	Manufacturing Cost	308.400,00	
	Molds	27.000,00	
	Salaries	100.000,00	
	Distribution Channels	15.000,00	
		741.142,84	
Contribution Margin		10,000*X-	741.142,84
Fixed Cost			
	Rent	30.000,00	
	Utilities	3.000,00	
	Insurance	5.000,00	
	Office Material	15.000,00	
	Marketing	10.000,00	
		63.000,00	
Taxable Income		10,000*X-	804.142,84
Taxes @35%		3,500*X-	281.449,99
Net Income		6,500*X-	522.692,85
		X	**80,414284**

Figure 59. Break – Even Point

As can be seen, for the Net Operating Income to be equal to zero, the average selling price of each of the mechanisms must be equal to $80.41. From this price, the company would begin to generate profits.

The next step will be to analyze what the expected benefit of the company would be. This benefit will depend directly on the sale price of our product. In order to estimate what would be a reasonable price of the product, we will analyze again the price of the products of each of our competitors. In this way, we can estimate a reasonable value that can fit with what is being offered in the market and make our product competitive. Next, a table that collects the prices of each product is shown.

Name	Price ($)
Walmart´s Product	179,12
Ellipticall Stroller	1.250,00
Jogalong Stroller	1.000,00

Figure 60. Competitors´ Prices

As it was analyzed in the section of our competitors, the product that most resembles the system we are designing is the one that is commercialized in Walmart. This is because it is a system that is adaptable to all types of strollers, which was one of our main requirements. However, both the Elliptical Stroller and the Jogalong Stroller are products that at the same time incorporate the stroller system. Therefore, it can be concluded that the price of our mechanism must be similar to the one sold in the Walmart, since both are focused on the same type of needs of the clients and have similar requirements. As for benefits, both offer practically the same, although as demonstrated in our validations, our system perfectly simulated the natural movement of the human being. However, the Walmart product due to the design it presents and the study of the measurements of the strollers that have been made, it can be said that it does not simulate the movement correctly. Also as it appears in his description is a product more directed to people who are in a wheelchair and need to strengthen the back of the body.

All this coupled with some marketing strategy that can be used in these cases, such as odd pricing, is going to establish a starting price of $ 199.99. (Grasset, 2015)

Once the initial sale price has been calculated, it will be analyzed what will be the Net Operating Income that would be obtained if said price were imposed.

Sales	$1.999.900
Variable Cost	
Cost/Material	290.742,84
Manufacturing Cost	308.400,00
Molds	27.000,00
Salaries	100.000,00
Distribution Channels	15.000,00
	$741.142,84
Contribution Margin	1.258.757,16
Fixed Cost	
Rent	30.000,00
Utilities	3.000,00
Insurance	5.000,00
Office Material	15.000,00
Marketing	10.000,00
	$63.000,00
Taxable Income	$1.195.757,16
Taxes @35%	$418.515,01
Net Income	**$777.242,15**

Figure 61. Total Net Operating Income (NOI)

At the time of analyzing the year-to-year growth that the number of sales of our product will experience, it could be assumed proportional to the estimate of the number of runners that had been calculated until the year 2030. For this, the values of the forecast will be taken, which are the average values between upper and lower confidence bounds. Therefore, the number of sales of our product in the coming years will be as follows.

	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Number of Runners (millions)	65,05	67,75	70,05	72,35	74,65	76,96	79,26	81,56	83,87	86,17	88,47	90,77	93,08	95,38
Increase in %	-	4,14%	3,40%	3,29%	3,18%	3,08%	2,99%	2,91%	2,82%	2,75%	2,67%	2,60%	2,54%	2,47%
Number of units	**10.000**	**10.414**	**10.768**	**11.122**	**11.476**	**11.830**	**12.184**	**12.538**	**12.892**	**13.246**	**13.600**	**13.954**	**14.308**	**14.662**
Increase in %	-	4,14%	3,40%	3,29%	3,18%	3,08%	2,99%	2,91%	2,82%	2,75%	2,67%	2,60%	2,54%	2,47%

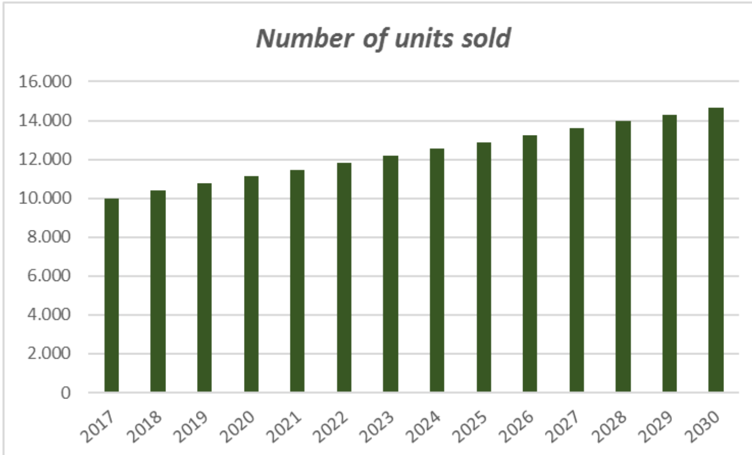


Figure 62. Forecast of number of units sold

Once we have the estimated units that will be sold worldwide in the following years and assuming that the sale price of the units will be maintained, it is easy to calculate what the total sales will be in the coming years.

Regarding the variable costs, it has been decided to make the following assumptions:

- ***Cost/Material***: directly depends on the units manufactured, so as estimated the unit price will be $29.07/unit.
- ***Manufacturing Cost***: like the Cost/Material, it will depend on the manufactured units. In the case of manufacturing cost, this price will continue to be $30.84/unit.
- ***Molds:*** the last variable cost that depends totally on the units manufactured is the cost of the molds, since the more units the lower the price of the manufactured cost will be. In this case, it will keep constant at 2.7$/unit, to facilitate calculations.
- ***Salaries:*** it has been decided to increase the salary gradually depending on the number of sales of the company. In the same way, depending on the needs of the sales, we will try to adapt the workers template with the incorporation of new workers.
- ***Distribution Channels:*** by increasing the number of sales of the product, the expenditure on distribution logistics will increase considerably. Therefore,

these expenses will gradually increase, obtaining certain discounts as the number of orders increases.

For the fixed costs, it has been decided to increase 10% each year the share of utilities, office material and marketing. The marketing part has been estimated that will increase that percentage, due to the type of product that is being offered. This type of product has to be in constant exposure, sponsoring in most events. However, the cost of renting the office and insurance of the company, it has been decided to keep constant.

Once all the estimates have been collected and each of the project numbers are analyzed, it is time to start calculating the benefit that the product could generate in the coming years. The particular data of each of the calculations can be found as appendix at the end of the project.

Then, the following table shows the final numbers that would be obtained as benefits for our project. These benefits would begin in the year 2018 and would be estimated until the year 2030.

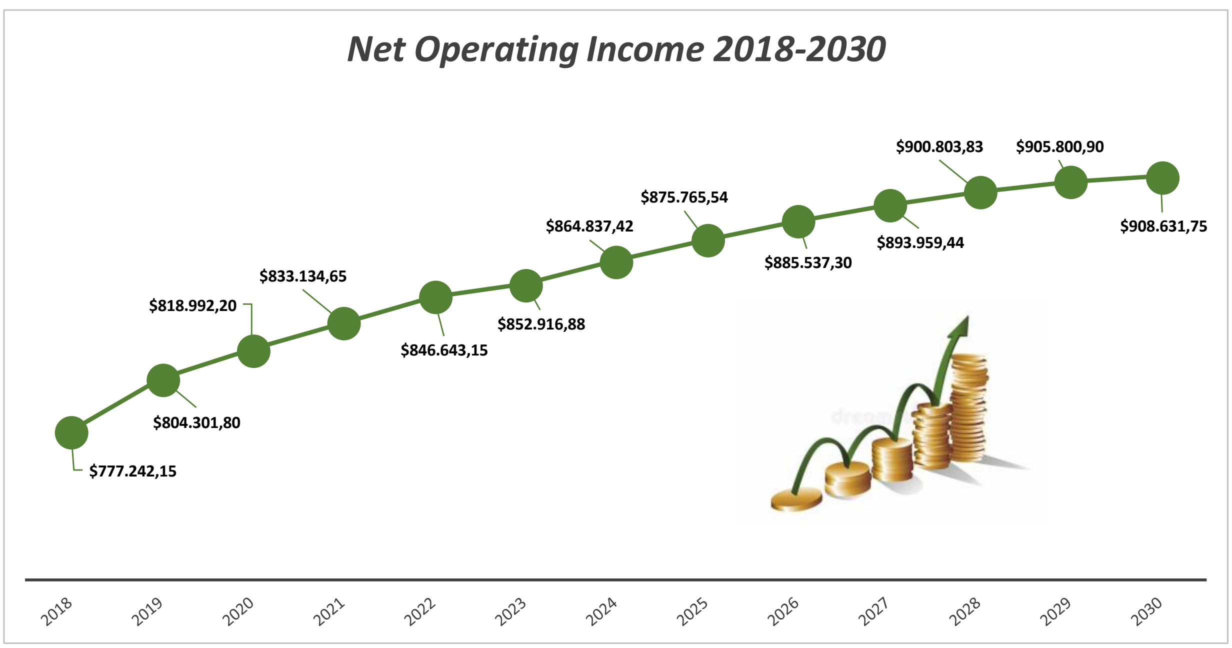


Figure 63. Net Operating Income 2018-2030

As can be observed in the previous graph, the economic growth in terms of benefits, presents a greater slope during the first years, that is, there is a greater increase year by year. This is what usually happens in new products, since they have different stages clearly defined. These stages are usually classified as: introduction, growth, maturity and decline. (Heizer, 2007). Comparing these stages with the benefits that will be obtained with the product, it can be said that by the end of the 2030s it will be partially at the time of maturity.

The next step will be to calculate what would be the initial investment to obtain a Net Present Value of the project equal to zero. This value will mark the barrier when the investment begins to recover and the project begins to give benefits. To calculate this value, it is necessary to suppose a type of interest for the project that is adapted to what exists in the actual market. Normally, a reasonable annual interest rate for this type of project is usually around 10%. (Investopedia, s.f.). Therefore, the first step is to calculate the present value of each of the cash flows. For this, the following formula will be used. (Jan, s.f.)

$$NPV = \frac{R}{(1+i)^n} - Initial\ Investment \tag{17}$$

The present values of each of the cash flows and their total sum can be shown in the following table.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13
Present Value of Cash Flows	706.583,78	664.712,23	615.320,96	569.042,17	525.698,79	481.449,34	443.798,34	408.551,09	375.554,26	344.660,06	315.726,25	288.616,08	263.198,25
Total PV of Cash Inflows	6.002.911,60												

Figure 64. Initial Investment to get NPV equal to zero

Therefore, for the Net Present Value to be equal to zero, the initial investment would have to be around six million dollars. From this value, an attempt could be made to estimate a reasonable value that fits the needs of the project and that maintains the net present value always greater than zero.

With the idea of recovering the investment around two years from the initial investment, it has been decided that a reasonable amount for this type of projects would be around one and a half million dollars. With this data we can calculate what would be the profits of our project, if things happened as expected. Below is the value of the Net Present

Value for an initial investment of $ 1,500,000. All the calculations that are behind this final number are found as annexed tables in the final part of the project.

Net Present Value	**$4.502.911,60**

Figure 65. Net Present Value

Once we have the present value of the benefits, it is interesting to know when the initial investment would be recovered, that is, when we would start having benefits. Previously, it was decided to choose an initial investment of $1,500,000 with the objective of recovering said investment around the first two years of the project. There is a financial tool known as payback period, which calculates the exact date of recovery. Below is what would be the year and the month of recovery.

Payback Period	**1,898615234**

Figure 66. Payback Period (years)

As can be seen in the previous figure, the recovery will occur between the first and the second year. As for the months, it can be said that it will take place around the month of September. Therefore, it can be said that a year and nine months after the initial investment, the company will begin to receive benefits from sales.

13. Conclusion

The project that I have carried out directly with Dr. Huayamave has helped me to realize and identify all the steps that must be followed and consider when developing a new product. The creation of a new product is a huge risk for the development companies, since there are many factors that must be taken into account when studying the viability of the product. Therefore, although it may be thought that it can be a product that revolutionizes the market, there may be many details that can lead it to failure.

It is also important to highlight the amount of information that can be obtained through the internet or with a simple interview. This information is one of the most important resources that a company can have. It is incredible the amount of things that can be discovered simply by entering the internet and analyzing our competitors, for example.

In the initial part of the document we talked and tried to analyze what were the main objectives of this project, to create a mechanism that fulfilled its function, while ensuring the correct position of the human body. As it has been seen in the design specifications, this process of adapting the needs of the clients has not been easy, having to get to simulate three practically different scenarios. All these designs involve many hours of work, translated into a large initial capital investment for any company. Therefore, the conclusion I get from the design specifications, is that it is often complicated to put on the screen what the developers have in their heads, having to make numerous sketches and diagrams. Finally it can be said that it is always much better to carry out different analyzes of different designs to reduce the risk of failure of our product.

Going out to the street to exercise is one of the daily routines for many people in today's societies. Therefore, we consider that this can be a market in which our product could fit perfectly and would have a great acceptance.

14. References

(n.d.). Retrieved from AulaFacil: http://www.aulafacil.com/articulos/sabias/t2649/el-origen-del-cochecito-para-bebes

Abbott, E. (2018, January 7). *Business2community*. Retrieved from https://www.business2community.com/entertainment/shark-tank-elliptical-stroller-fails-get-deal-01986763

Allain, R. (2012, August 31). *Wired*. Retrieved from Maximum Acceleration in the 100 M Dash: https://www.wired.com/2012/08/maximum-acceleration-in-the-100-m-dash/

Belén. (2015, February 4). *Accesorios para GoPro*. Retrieved from https://www.tutiendastore.es/blog/accesorios-para-gopro/

Bike-Advisor. (2012, September 18). *Aluminum Frames: 6061 vs 7005. Which is the best?* Retrieved from https://www.google.es/search?ei=j68WW4KvEoGUUfGEr7gG&q=6061-t6+bicycle&oq=6061-T6+bic&gs_l=psy-ab.3.0.0i22i30k1l3.4970.13366.0.15203.10.6.4.0.0.0.368.751.5j3-1.6.0....0...1c.1.64.psy-ab..0.10.769...0i20i263k1j0i203k1j0i22i10i30k1.0.UkGFefo5V3M

Formación, S. (2015, February 19). *Las fuerzas de rozamiento*. Retrieved from http://www.sophiaformacion.com/las-fuerzas-del-rozamiento/

Grasset, G. (2015, July). *Odd Pricing*. Retrieved from LOKAD: https://www.lokad.com/odd-pricing-definition

Grewolls, D. G. (2014). *Sensitivity Analysis of Evacuation Simulations.*

Grumeber. (n.d.). *¿Cómo funciona el proceso de mecanizado*. Retrieved from http://www.grumeber.com/proceso-mecanizado/

Heizer, J. (2007). *Dirección de la producción y de operaciones. Decisiones estratégicas.*

Investopedia. (n.d.). *Effective Annual Interest Rate*. Retrieved from https://www.investopedia.com/terms/e/effectiveinterest.asp

Jan, I. (n.d.). *Net Present Value (NPV)*. Retrieved from Accounting Explained: https://accountingexplained.com/managerial/capital-budgeting/npv

Jogalong. (n.d.). Retrieved from https://jogalong.com/

Kan, W. (2017, March 23). *Running USA*. Retrieved from https://www.runningusa.org/2017-us-road-race-trends

LBDC. (2015, November 26). Retrieved from Sport: https://www.sport.es/labolsadelcorredor/correr-con-carritos-de-bebe-la-nueva-moda-runner/

Panea, A. (2015). *Women'sHealth*. Retrieved from http://www.womenshealth.es/bugaboo/articulo/pisada-postura-brazos-como-correr-con-un-carrito

Prim, A. (n.d.). *Innokabi*. Retrieved from https://innokabi.com/canvas-de-modelo-de-negocio/

sc. (n.d.). Retrieved from Dinámica de la partícula y de los sistemas de partículas: http://www.sc.ehu.es/sbweb/fisica3/dinamica/rozamiento/rozamiento.html

SoyEntrepreneur. (2011, September 1). *¿Cúanto cuesta montar una oficina base?* Retrieved from Entrepreneur: https://www.entrepreneur.com/article/264598

Spurrier, J. (2018, March 23). *BabyGearLab*. Retrieved from The Race for the Best Jogging Stroller of 2018: https://www.babygearlab.com/topics/getting-around/best-jogging-stroller?specs=y&n=0&sort_field=score#compare

Statista. (2016). Retrieved from https://www.statista.com/statistics/195908/number-of-births-in-the-united-states-since-1990/

Statista. (2017). Retrieved from https://www.statista.com/statistics/227423/number-of-joggers-and-runners-usa/

Ulrich, K. T. (n.d.). Diseno y desarrollo de productos. Mexico.

Walmart. (n.d.). Retrieved from https://www.walmart.com/ip/Love-Handles-RX-10-0705-Portable-Upper-Body-Exerciser-to-use-with-Chair-or-Wheelchair/15555451?wmlspartner=wlpa&selectedSellerId=0&adid=22222222227009567946&wl0=&wl1=g&wl2=c&wl3=52285417935&wl4=pla-61907952186&wl5=9011504&wl6=&w

APPENDIX A – FORECAST ANALYSIS

Year	Number of births (millions	Forecast(Number of births (millions)	Lower Confidence Bound(Number of births (millions)	Upper Confidence Bound(Number of births (millions)
2000	4.06			
2001	4.03			
2002	4.02			
2003	4.09			
2004	4.11			
2005	4.14			
2006	4.27			
2007	4.32			
2008	4.25			
2009	4.13			
2010	4			
2011	3.95			
2012	3.95			
2013	3.93			
2014	3.99			
2015	3.98			
2016	3.95	3.95	3.95	3.95
2017		3.937987879	3.81	4.07
2018		3.925935918	3.73	4.12
2019		3.913883957	3.67	4.16
2020		3.901831997	3.60	4.20
2021		3.889780036	3.54	4.24
2022		3.877728076	3.48	4.28
2023		3.865676115	3.41	4.32
2024		3.853624154	3.35	4.36
2025		3.841572194	3.29	4.40
2026		3.829520233	3.22	4.44
2027		3.817468273	3.16	4.48
2028		3.805416312	3.09	4.52
2029		3.793364352	3.03	4.56
2030		3.781312391	2.96	4.60

Year	nber of people who went running or jogging (mi	recast(Number of people who went running or jogging (milli	nfidence Bound(Number of people who went running or joggin	fidence Bound(Number of people who went running or joggi
2008	45.67			
2009	47.3			
2010	51.02			
2011	54.18			
2012	57.21			
2013	61.87			
2014	65.48			
2015	60.84			
2016	64.17			
2017	65.05	65.05	65.05	65.05
2018		67.74575349	62.96	72.53
2019		70.04850511	64.06	76.03
2020		72.35125673	65.37	79.33
2021		74.65400835	66.80	82.51
2022		76.95675996	68.31	85.60
2023		79.25951158	69.89	88.63
2024		81.5622632	71.52	91.61
2025		83.86501482	73.19	94.54
2026		86.16776644	74.89	97.45
2027		88.47051805	76.62	100.32
2028		90.77326967	78.38	103.17
2029		93.07602129	80.16	105.99
2030		95.37877291	81.96	108.80

APPENDIX B – FINANCE ANALYSIS

Income Statement

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Number of Units Sold	10.000	10.414	10.768	11.122	11.476	11.830	12.184	12.538	12.892	13.246	13.600	13.954	14.308
Price ($)	199,99	199,99	199,99	199,99	199,99	199,99	199,99	199,99	199,99	199,99	199,99	199,99	199,99
Sales	**$1.999.900,00**	**$2.082.778,36**	**$2.153.574,26**	**$2.224.370,15**	**$2.295.166,05**	**$2.365.961,94**	**$2.436.757,84**	**$2.507.553,73**	**$2.578.349,63**	**$2.649.145,52**	**$2.719.941,42**	**$2.790.737,31**	**$2.861.533,20**
Variable Cost													
Cost/Material	290.742,84	302.791,59	313.083,80	323.376,02	333.668,23	343.960,45	354.252,66	364.544,87	374.837,09	385.129,30	395.421,52	405.713,73	416.005,95
Manufacturing Cost	308.400,00	321.180,48	332.097,76	343.015,03	353.932,30	364.849,57	375.766,85	386.684,12	397.601,39	408.518,67	419.435,94	430.353,21	441.270,48
Molds	27.000,00	28.118,91	29.074,71	30.030,50	30.986,29	31.942,08	32.897,88	33.853,67	34.809,46	35.765,25	36.721,05	37.676,84	38.632,63
Salaries	100.000,00	110.000,00	130.000,00	150.000,00	170.000,00	200.000,00	220.000,00	240.000,00	260.000,00	280.000,00	300.000,00	320.000,00	340.000,00
Distribution Channels	15.000,00	16.500,00	18.150,00	19.965,00	21.961,50	24.157,65	26.573,42	29.230,76	32.153,83	35.369,22	38.906,14	42.796,75	47.076,43
TOTAL	**$741.142,84**	**$778.590,98**	**$822.406,26**	**$866.386,54**	**$910.548,32**	**$964.909,75**	**$1.009.490,80**	**$1.054.313,42**	**$1.099.401,77**	**$1.144.782,44**	**$1.190.484,64**	**$1.236.540,53**	**$1.282.985,48**
Contribution Margin	**$1.258.757,16**	**$1.304.187,38**	**$1.331.167,99**	**$1.357.983,61**	**$1.384.617,72**	**$1.401.052,19**	**$1.427.267,04**	**$1.453.240,31**	**$1.478.947,85**	**$1.504.363,08**	**$1.529.456,78**	**$1.554.196,78**	**$1.578.547,72**
Fixed Cost													
Rent	30.000,00	30.000,00	30.000,00	30.000,00	30.000,00	30.000,00	30.000,00	30.000,00	30.000,00	30.000,00	30.000,00	30.000,00	30.000,00
Utilities	3.000,00	3.300,00	3.630,00	3.993,00	4.392,30	4.831,53	5.314,68	5.846,15	6.430,77	7.073,84	7.781,23	8.559,35	9.415,29
Insurance	5.000,00	5.000,00	5.000,00	5.000,00	5.000,00	5.000,00	5.000,00	5.000,00	5.000,00	5.000,00	5.000,00	5.000,00	5.000,00
Office Material	15.000,00	16.500,00	18.150,00	19.965,00	21.961,50	24.157,65	26.573,42	29.230,76	32.153,83	35.369,22	38.906,14	42.796,75	47.076,43
Marketing	10.000,00	12.000,00	14.400,00	17.280,00	20.736,00	24.883,20	29.859,84	35.831,81	42.998,17	51.597,80	61.917,36	74.300,84	89.161,00
TOTAL	**$63.000,00**	**$66.800,00**	**$71.180,00**	**$76.238,00**	**$82.089,80**	**$88.872,38**	**$96.747,94**	**$105.908,72**	**$116.582,77**	**$129.040,86**	**$143.604,73**	**$160.656,94**	**$180.652,72**
Taxable Income	**$1.195.757,16**	**$1.237.387,38**	**$1.259.987,99**	**$1.281.745,61**	**$1.302.527,92**	**$1.312.179,81**	**$1.330.519,10**	**$1.347.331,60**	**$1.362.365,08**	**$1.375.322,22**	**$1.385.852,05**	**$1.393.539,84**	**$1.397.895,00**
Taxes @35%	**$418.515,01**	**$433.085,58**	**$440.995,80**	**$448.610,96**	**$455.884,77**	**$459.262,93**	**$465.681,69**	**$471.566,06**	**$476.827,78**	**$481.362,78**	**$485.048,22**	**$487.738,94**	**$489.263,25**
Net Income	**$777.242,15**	**$804.301,80**	**$818.992,20**	**$833.134,65**	**$846.643,15**	**$852.916,88**	**$864.837,42**	**$875.765,54**	**$885.537,30**	**$893.959,44**	**$900.803,83**	**$905.800,90**	**$908.631,75**

Net Present Value

Year	1	2	3	4	5	6	7	8	9	10	11	12	13
Net Operating Income	777.242,15	804.301,80	818.992,20	833.134,65	846.643,15	852.916,88	864.837,42	875.765,54	885.537,30	893.959,44	900.803,83	905.800,90	908.631,75
x Present Value Factor (10%)	0,91	0,83	0,75	0,68	0,62	0,56	0,51	0,47	0,42	0,39	0,35	0,32	0,29
Present Value of Cash Flows	706.583,78	664.712,23	615.320,96	569.042,17	525.698,79	481.449,34	443.798,34	408.551,09	375.554,26	344.660,06	315.726,25	288.616,08	263.198,25
Total PV of Cash Inflows	6.002.911,60												
Initial Investment	X												
Net Present Value	0,00												

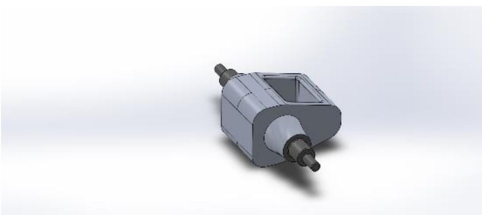
Year	1	2	3	4	5	6	7	8	9	10	11	12	13
Net Operating Income	777.242,15	804.301,80	818.992,20	833.134,65	846.643,15	852.916,88	864.837,42	875.765,54	885.537,30	893.959,44	900.803,83	905.800,90	908.631,75
x Present Value Factor (10%)	0,91	0,83	0,75	0,68	0,62	0,56	0,51	0,47	0,42	0,39	0,35	0,32	0,29
Present Value of Cash Flows	706.583,78	664.712,23	615.320,96	569.042,17	525.698,79	481.449,34	443.798,34	408.551,09	375.554,26	344.660,06	315.726,25	288.616,08	263.198,25
Total PV of Cash Inflows	6.002.911,60												
Initial Investment	1.500.000,00												
Net Present Value	**4.502.911,60**												

Payback Period (years)

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Cash Flow	-1.500.000,00	777.242,15	804.301,80	818.992,20	833.134,65	846.643,15	852.916,88	864.837,42	875.765,54	885.537,30	893.959,44	900.803,83	905.800,90	908.631,75
Cumulative Cash Flow	-1.500.000,00	-722.757,85	81.543,95	900.536,14	1.733.670,79	2.580.313,94	3.433.230,82	4.298.068,23	5.173.833,77	6.059.371,07	6.953.330,52	7.854.134,35	8.759.935,25	9.668.567,00
Payback Period	**1,898615234**													

APPENDIX C – COST ANAYLISIS & MANUFACTURING PROCESSES

Informe de SOLIDWORKS Costing



Nombre del modelo: CentralAxis

Fecha y hora del informe:	12/06/2018 9:42:47

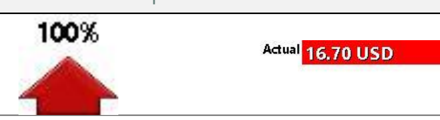
Método de fabricación: Fundición

Material:	Aleación 7079
Peso del material:	6.78 kg
Tipo de molde:	Molde a presión
Duración:	15.0 s
Coste/peso del material:	1.98 USD/kg
Tarifa de taller:	30.00 USD

Cantidad para producir

N.º total de piezas:	10000
Número de cavidades:	10000

Coste estimado por pieza: 16.70 USD

Plantilla utilizada:	machiningtemplate_default(metric).sldctm
Modo de Costing utilizado:	Reconocimiento de proceso de fabricación
Comparación:	

Desglose de costes

Material:	14.10 USD	84%
Fabricación:	2.50 USD	15%
Marca:	0.00 USD	0%
Molde:	0.10 USD	1%

Tiempo estimado por pieza:	**00:05:00**
Configuraciones:	00:05:00
Operaciones:	00:00:00

Informe de costes

Nombre del modelo:	CentralAxis	Material:	Aleación 7079	Coste del material:	14.10 USD	Coste total/pieza:	**16.70 USD**
				Coste de fabricación:	2.50 USD	Tiempo total/pieza:	**00:05:00**
				Marca:	0.00 USD		

Desglose de los costes de fabricación

Configuraciones de operación	Tiempo (hh:mm:ss)	Coste (USD / Pieza)
Operación de configuración 1	00:00:00	0.00
Total	**00:00:00**	**0.00**

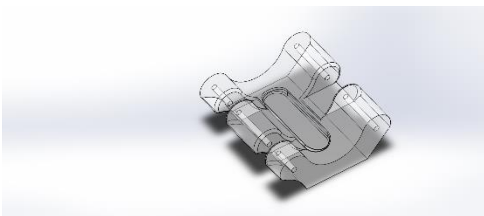
Configuraciones de carga y descarga	Tiempo (hh:mm:ss)	Coste (USD / Pieza)
Operación de configuración 1	00:05:00	2.50
Total	**00:05:00**	**2.50**

Operación de molde	Tiempo (hh:mm:ss)	Coste de fabricación (USD / Pieza)	Coste de molde (USD / Pieza)
Moldeo por fundición	00:00:00	0.00	0.10

Operaciones de configuración

1. Operación de configuración 1
   a. Moldeo por fundición

Informe de SOLIDWORKS Costing



Nombre del modelo: Clamp_Part1

Fecha y hora del informe:	11/06/2018 17:00:40

Método de fabricación: Plásticos

Material:	ABS PC
Peso del material:	0.17 kg
Tipo de molde:	Molde de colada caliente
Espesor máximo de pared:	5.00 mm
Coste/peso del material:	1.65 USD/kg
Tarifa de taller:	30.00 USD

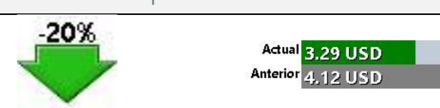
Cantidad para producir

N.º total de piezas:	10000
Número de cavidades:	10000

Coste estimado por pieza: 3.29 USD

Plantilla utilizada:	machiningtemplate_default(metric).sldctm
Modo de Costing utilizado:	Reconocimiento de proceso de fabricación

Comparación:



Desglose de costes

Material:	0.29 USD	9%
Fabricación:	2.50 USD	76%
Marca:	0.00 USD	0%
Molde:	0.50 USD	15%

Tiempo estimado por pieza:	00:05:00
Configuraciones:	00:05:00
Operaciones:	00:00:00

Informe de costes

Nombre del modelo:	Clamp_Part1	Material:	ABS PC	Coste del material:	0.29 USD	Coste total/pieza:	3.29 USD
				Coste de fabricación:	2.50 USD	Tiempo total/pieza:	00:05:00
				Marca:	0.00 USD		

Desglose de los costes de fabricación

Configuraciones de operación	Tiempo (hh:mm:ss)	Coste (USD / Pieza)
Operación de configuración 2	00:00:00	0.00
Total	**00:00:00**	**0.00**

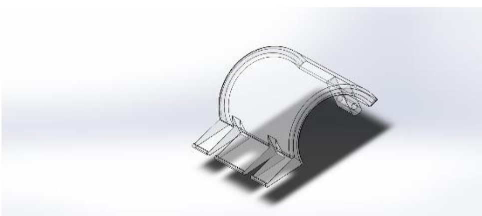
Configuraciones de carga y descarga	Tiempo (hh:mm:ss)	Coste (USD / Pieza)
Operación de configuración 2	00:05:00	2.50
Total	**00:05:00**	**2.50**

Operación de molde	Tiempo (hh:mm:ss)	Coste de fabricación (USD / Pieza)	Coste de molde (USD / Pieza)
Moldeo por inyección de plástico	00:00:00	0.00	0.50

Operaciones de configuración

1. Operación de configuración 2
   a. Moldeo por inyección de plástico

Informe de SOLIDWORKS Costing



Nombre del modelo: Clamp_Part2

Fecha y hora del informe:	11/06/2018 18:05:39

Método de fabricación: Plásticos

Material:	ABS PC
Peso del material:	0.08 kg
Tipo de molde:	Molde de colada caliente
Espesor máximo de pared:	5.00 mm
Coste/peso del material:	1.65 USD/kg
Tarifa de taller:	N/A

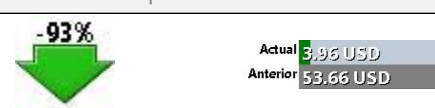
Cantidad para producir

N.º total de piezas:	10000
Número de cavidades:	10000

Coste estimado por pieza: 3.96 USD

Plantilla utilizada:	machiningtemplate_default(metric).sldctm
Modo de Costing utilizado:	Reconocimiento de proceso de fabricación

Comparación:



Desglose de costes

Material:	0.13 USD	3%
Fabricación:	3.34 USD	84%
Marca:	0.00 USD	0%
Molde:	0.50 USD	13%

Tiempo estimado por pieza:	00:05:00
Configuraciones:	00:05:00
Operaciones:	00:00:00

Informe de costes

Nombre del modelo:	Clamp_Part2	Material:	ABS PC	Coste del material:	0.13 USD	Coste total/pieza:	3.96 USD
				Coste de fabricación:	3.34 USD	Tiempo total/pieza:	00:05:00
				Marca:	0.00 USD		

Desglose de los costes de fabricación

Configuraciones de operación	Tiempo (hh:mm:ss)	Coste (USD / Pieza)
Operación de configuración 2	00:00:00	0.00
Total	**00:00:00**	**0.00**

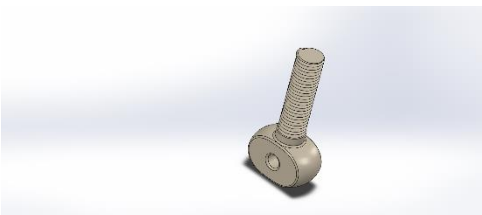
Configuraciones de carga y descarga	Tiempo (hh:mm:ss)	Coste (USD / Pieza)
Operación de configuración 2	00:05:00	3.33
Total	**00:05:00**	**3.33**

Operación de molde	Tiempo (hh:mm:ss)	Coste de fabricación (USD / Pieza)	Coste de molde (USD / Pieza)
Moldeo por inyección de plástico	00:00:00	0.00	0.50

Operaciones de configuración

1. Operación de configuración 2
   a. Moldeo por inyección de plástico

Informe de SOLIDWORKS Costing



Nombre del modelo: Clamp_Part3

Fecha y hora del informe:	11/06/2018 18:46:34

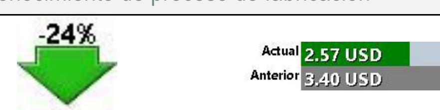
Método de fabricación: Fundición

Material:	Aleación de magnesio
Peso del material:	0.00 kg
Tipo de molde:	Molde a presión
Duración:	15.0 s
Coste/peso del material:	3.62 USD/kg
Tarifa de taller:	30.00 USD

Cantidad para producir

N.º total de piezas:	20000
Número de cavidades:	20000

Coste estimado por pieza: 2.57 USD

Plantilla utilizada:	machiningtemplate_default(metric).sldctm
Modo de Costing utilizado:	Reconocimiento de proceso de fabricación
Comparación:	

Desglose de costes

Material:	0.02 USD	1%
Fabricación:	2.50 USD	97%
Marca:	0.00 USD	0%
Molde:	0.05 USD	2%

Tiempo estimado por pieza:	00:05:00
Configuraciones:	00:05:00
Operaciones:	00:00:00

Informe de costes

Nombre del modelo:	Clamp_Part3	Material:	Aleación de magnesio	Coste del material:	0.02 USD	Coste total/pieza:	2.57 USD
				Coste de fabricación:	2.50 USD	Tiempo total/pieza:	00:05:00
				Marca:	0.00 USD		

Desglose de los costes de fabricación

Configuraciones de operación	Tiempo (hh:mm:ss)	Coste (USD / Pieza)
Operación de configuración 2	00:00:00	0.00
Total	**00:00:00**	**0.00**

Configuraciones de carga y descarga	Tiempo (hh:mm:ss)	Coste (USD / Pieza)
Operación de configuración 2	00:05:00	2.50
Total	**00:05:00**	**2.50**

Operación de molde	Tiempo (hh:mm:ss)	Coste de fabricación (USD / Pieza)	Coste de molde (USD / Pieza)
Moldeo por fundición	00:00:00	0.00	0.05

Operaciones de configuración

1. Operación de configuración 2
   a. Moldeo por fundición

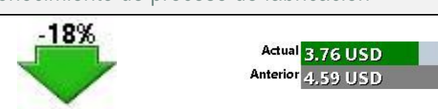
Informe de SOLIDWORKS Costing

Nombre del modelo:	CommonPart
Fecha y hora del informe:	12/06/2018 10:08:28

Método de fabricación:	Fundición
Material:	Aleación 7079
Peso del material:	0.56 kg
Tipo de molde:	Molde a presión
Duración:	15.0 s
Coste/peso del material:	1.98 USD/kg
Tarifa de taller:	30.00 USD

Cantidad para producir

N.º total de piezas:	10000
Número de cavidades:	10000

Coste estimado por pieza:	3.76 USD
Plantilla utilizada:	machiningtemplate_default(metric).sldctm
Modo de Costing utilizado:	Reconocimiento de proceso de fabricación
Comparación:	

Desglose de costes

Material:	1.16 USD	31%
Fabricación:	2.50 USD	67%
Marca:	0.00 USD	0%
Molde:	0.10 USD	3%

Tiempo estimado por pieza:	00:05:00
Configuraciones:	00:05:00
Operaciones:	00:00:00

Informe de costes

Nombre del modelo:	CommonPart	Material:	Aleación 7079	Coste del material:	1.16 USD	Coste total/pieza:	3.76 USD
				Coste de fabricación:	2.50 USD	Tiempo total/pieza:	00:05:00
				Marca:	0.00 USD		

Desglose de los costes de fabricación

Configuraciones de operación	Tiempo (hh:mm:ss)	Coste (USD / Pieza)
Operación de configuración 2	00:00:00	0.00
Total	**00:00:00**	**0.00**

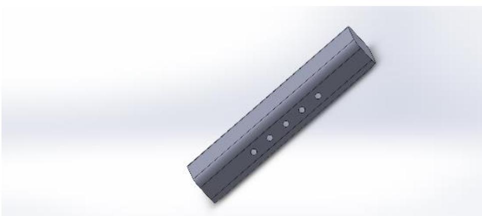
Configuraciones de carga y descarga	Tiempo (hh:mm:ss)	Coste (USD / Pieza)
Operación de configuración 2	00:05:00	2.50
Total	**00:05:00**	**2.50**

Operación de molde	Tiempo (hh:mm:ss)	Coste de fabricación (USD / Pieza)	Coste de molde (USD / Pieza)
Moldeo por fundición	00:00:00	0.00	0.10

Operaciones de configuración

1. Operación de configuración 2
   a. Moldeo por fundición

Informe de SOLIDWORKS Costing



Nombre del modelo:	HeightRegulator
Fecha y hora del informe:	12/06/2018 10:20:21
Método de fabricación:	Fundición
Material:	Aleación 7079
Peso del material:	0.82 kg
Tipo de molde:	Molde a presión
Duración:	15.0 s
Coste/peso del material:	1.98 USD/kg
Tarifa de taller:	30.00 USD

Cantidad para producir

N.º total de piezas:	10000
Número de cavidades:	10000

Coste estimado por pieza:	**4.30 USD**
Plantilla utilizada:	machiningtemplate_default(metric).sldctm
Modo de Costing utilizado:	Reconocimiento de proceso de fabricación
Comparación:	-16% Actual 4.30 USD Anterior 5.13 USD

Desglose de costes

Material:	1.69 USD	39%
Fabricación:	2.50 USD	58%
Marca:	0.00 USD	0%
Molde:	0.10 USD	2%

Tiempo estimado por pieza:	00:05:00
Configuraciones:	00:05:00
Operaciones:	00:00:00

Informe de costes

Nombre del modelo:	HeightRegulator	Material:	Aleación 7079	Coste del material:	1.69 USD	Coste total/pieza:	**4.30 USD**
				Coste de fabricación:	2.50 USD	Tiempo total/pieza:	**00:05:00**
				Marca:	0.00 USD		

Desglose de los costes de fabricación

Configuraciones de operación	Tiempo (hh:mm:ss)	Coste (USD / Pieza)
Operación de configuración 1	00:00:00	0.00
Total	**00:00:00**	**0.00**

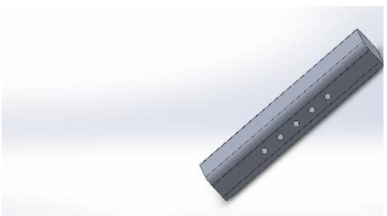
Configuraciones de carga y descarga	Tiempo (hh:mm:ss)	Coste (USD / Pieza)
Operación de configuración 1	00:05:00	2.50
Total	**00:05:00**	**2.50**

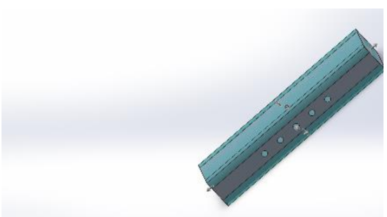
Operación de molde	Tiempo (hh:mm:ss)	Coste de fabricación (USD / Pieza)	Coste de molde (USD / Pieza)
Moldeo por fundición	00:00:00	0.00	0.10

Operaciones de configuración

1. Operación de configuración 1
   a. Moldeo por fundición

Informe de SOLIDWORKS Costing





Nombre del modelo: HeightRegulator

Fecha y hora del informe:	12/06/2018 10:44:03

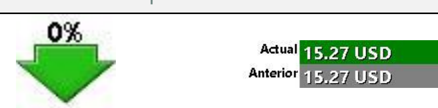
Método de fabricación: Mecanizado

Material:	Aleación 6061
Peso del material:	0.86 kg
Tipo de material	Bloque
Tamaño de bloque:	200.00x32.00x50.00 mm
Coste/peso del material:	10.10 USD/kg
Tarifa de taller:	30.00 USD

Cantidad para producir

N.º total de piezas:	10000
Tamaño del lote:	10000

Coste estimado por pieza: 15.27 USD

Plantilla utilizada:	machiningtemplate_default(metric).sldctm
Modo de Costing utilizado:	Reconocimiento de proceso de fabricación
Comparación:	

Desglose de costes

Material:	8.73 USD	57%
Fabricación:	6.54 USD	43%
Marca:	0.00 USD	0%
Molde:	0.00 USD	0%

Tiempo estimado por pieza:	**00:13:05**
Configuraciones:	00:10:00
Operaciones:	00:03:04

Configuraciones de operación	Tiempo (hh:mm:ss)	Coste (USD / Pieza)
Operación de configuración 1	00:00:00	0.00
Operación de configuración 2	00:00:00	0.00
Total	**00:00:00**	**0.01**

Configuraciones de carga y descarga	Tiempo (hh:mm:ss)	Coste (USD / Pieza)
Operación de configuración 1	00:05:00	2.50
Operación de configuración 2	00:05:00	2.50
Total	**00:10:00**	**5.00**

Operación	Acabado superficial	Volumen eliminado (mm^3)	Tiempo (hh:mm:ss)	Coste (USD / Pieza)	Mecanizado	Coste por volumen (USD/mm^3)
Volumen 1	Desbaste	2746.90	00:00:05	0.05	Fresa plana	N/A
Volumen 2	Desbaste	2746.90	00:00:05	0.05	Fresa plana	N/A
Volumen 3	Desbaste	2746.90	00:00:05	0.05	Fresa plana	N/A
Volumen 4	Desbaste	2746.90	00:00:05	0.05	Fresa plana	N/A
Total		**10987.62**	**00:00:23**	**0.19**		

Operación de taladro	Acabado superficial	Volumen eliminado (mm^3)	Tiempo (hh:mm:ss)	Coste (USD / Pieza)	Mecanizado	Coste por volumen (USD/mm^3)
Taladro 1	Taladrado	1413.72	00:00:32	0.27	Broca de acero rápido	N/A
Taladro 2	Taladrado	1413.72	00:00:32	0.27	Broca de acero rápido	N/A
Taladro 3	Taladrado	1413.72	00:00:32	0.27	Broca de acero rápido	N/A

Taladro 4	Taladrado	1413.72	00:00:32	0.27	Broca de acero rápido	N/A
Taladro 5	Taladrado	1413.72	00:00:32	0.27	Broca de acero rápido	N/A
Total		**7068.58**	**00:02:41**	**1.35**		

Operaciones sin coste
Redondeo 1
Redondeo 2
Redondeo 3
Redondeo 4

Operaciones de configuración

1. Operación de configuración 1
    a. Taladro 1
    b. Taladro 3
    c. Taladro 4
    d. Taladro 2
    e. Taladro 5
2. Operación de configuración 2
    a. Volumen 2
    b. Volumen 4
    c. Volumen 3
    d. Volumen 1

Informe de SOLIDWORKS Costing

Nombre del modelo: LeftHandle

Fecha y hora del informe:	12/06/2018 11:04:33

Método de fabricación: Plásticos

Material:	ABS
Peso del material:	0.79 kg
Tipo de molde:	Molde de colada caliente
Espesor máximo de pared:	5.00 mm
Coste/peso del material:	2.54 USD/kg
Tarifa de taller:	30.00 USD

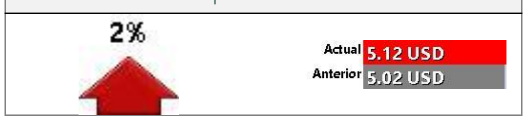
Cantidad para producir

N.º total de piezas:	10000
Número de cavidades:	10000

Coste estimado por pieza: **5.12 USD**

Plantilla utilizada:	machiningtemplate_default(metric).sldctm
Modo de Costing utilizado:	Reconocimiento de proceso de fabricación

Comparación:



Desglose de costes

Material:	2.12 USD	41%
Fabricación:	2.50 USD	49%
Marca:	0.00 USD	0%
Molde:	0.50 USD	10%

Tiempo estimado por pieza:	**00:05:00**
Configuraciones:	00:05:00
Operaciones:	00:00:00

Informe de costes

Nombre del modelo:	LeftHandle	Material:	ABS	Coste del material:	2.12 USD	Coste total/pieza:	**5.12 USD**
				Coste de fabricación:	2.50 USD	Tiempo total/pieza:	**00:05:00**
				Marca:	0.00 USD		

Desglose de los costes de fabricación

Configuraciones de operación	Tiempo (hh:mm:ss)	Coste (USD / Pieza)
Operación de configuración 1	00:00:00	0.00
Total	**00:00:00**	**0.00**

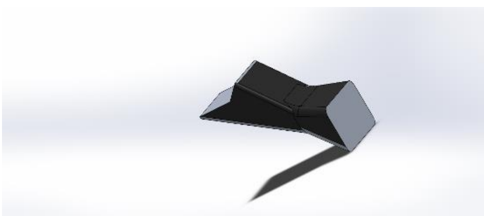
Configuraciones de carga y descarga	Tiempo (hh:mm:ss)	Coste (USD / Pieza)
Operación de configuración 1	00:05:00	2.50
Total	**00:05:00**	**2.50**

Operación de molde	Tiempo (hh:mm:ss)	Coste de fabricación (USD / Pieza)	Coste de molde (USD / Pieza)
Moldeo por inyección de plástico	00:00:00	0.00	0.50

Operaciones de configuración

1. Operación de configuración 1
   a. Moldeo por inyección de plástico

Informe de SOLIDWORKS Costing



Nombre del modelo:	Stroller-Mechanism
Fecha y hora del informe:	11/06/2018 19:02:18
Método de fabricación:	Fundición
Material:	Aleación 7079
Peso del material:	2.19 kg
Tipo de molde:	Molde a presión
Duración:	15.0 s
Coste/peso del material:	1.98 USD/kg
Tarifa de taller:	30.00 USD

Cantidad para producir

N.º total de piezas:	10000
Número de cavidades:	10000

Coste estimado por pieza:	**7.16 USD**
Plantilla utilizada:	machiningtemplate_default(metric).sldctm
Modo de Costing utilizado:	Reconocimiento de proceso de fabricación
Comparación:	-0% Actual 7.16 USD Anterior 7.17 USD

Desglose de costes

Material:	4.56 USD	64%
Fabricación:	2.50 USD	35%
Marca:	0.00 USD	0%
Molde:	0.10 USD	1%

Tiempo estimado por pieza:	00:05:00
Configuraciones:	00:05:00
Operaciones:	00:00:00

Informe de costes

Nombre del modelo:	Stroller-Mechanism	Material:	Aleación 7079	Coste del material:	4.56 USD	Coste total/pieza:	7.16 USD
				Coste de fabricación:	2.50 USD	Tiempo total/pieza:	00:05:00
				Marca:	0.00 USD		

Desglose de los costes de fabricación

Configuraciones de operación	Tiempo (hh:mm:ss)	Coste (USD / Pieza)
Operación de configuración 2	00:00:00	0.00
Total	**00:00:00**	**0.00**

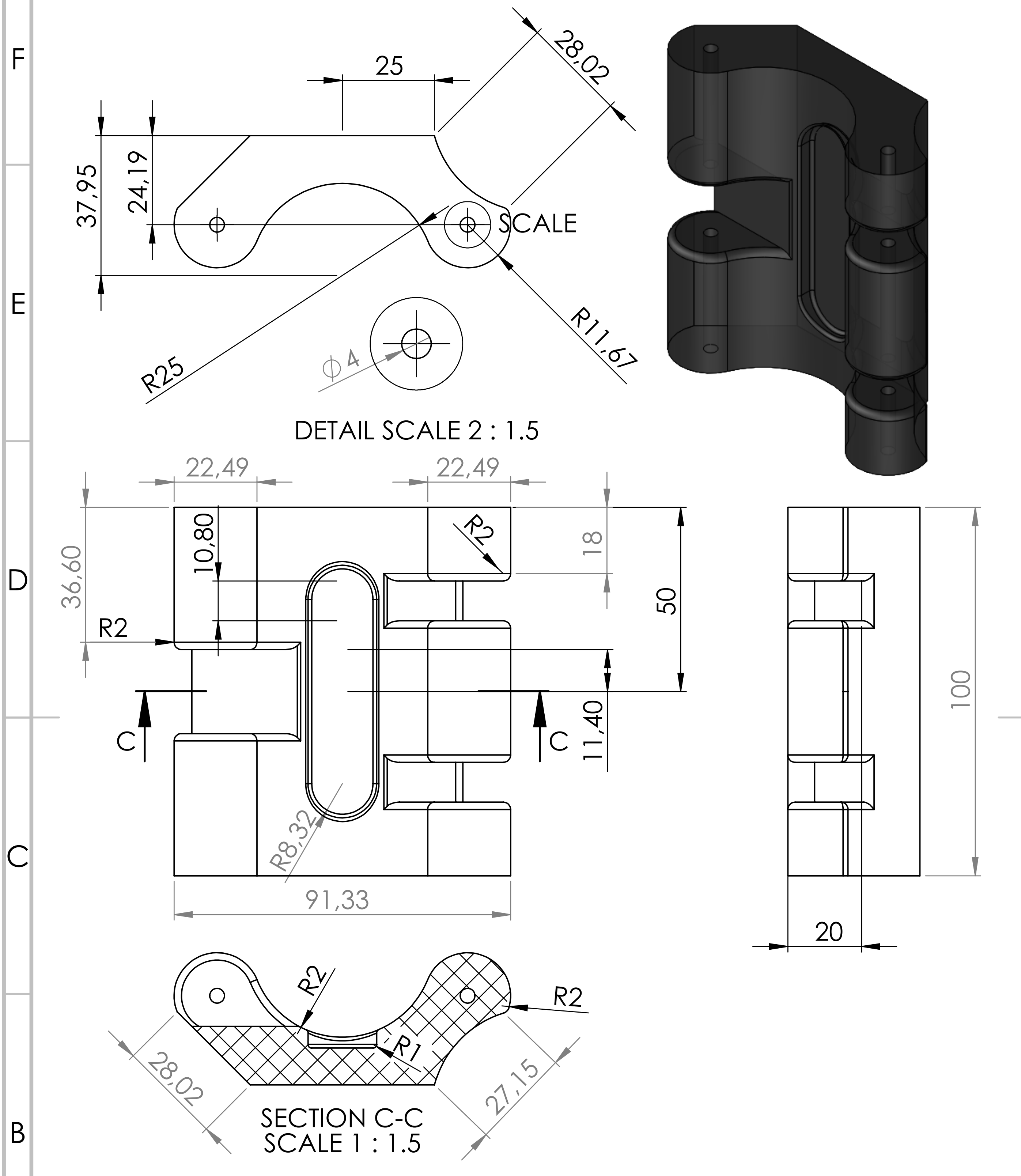
Configuraciones de carga y descarga	Tiempo (hh:mm:ss)	Coste (USD / Pieza)
Operación de configuración 2	00:05:00	2.50
Total	**00:05:00**	**2.50**

Operación de molde	Tiempo (hh:mm:ss)	Coste de fabricación (USD / Pieza)	Coste de molde (USD / Pieza)
Moldeo por fundición	00:00:00	0.00	0.10

Operaciones de configuración

1. Operación de configuración 2
    a. Moldeo por fundición

APPENDIX D – DRAWINGS



DETAIL SCALE 2 : 1.5

SECTION C-C
SCALE 1 : 1.5

DIMENSIONS IN MM
ANGLES IN DEGREES

FINISHED:
Alfonso Delgado Navarro

Embry-Riddle Aeronautical University

	NAME	SIGNATURE	DATE
DRAW.	Alfonso Delgado Navarro		05/02/2018
VERIF.	Víctor Huayamave		05/02/2018
APPRO.	Jean-Michel Dhainaut		05/02/2018

Clamp_Part 1

MATERIAL:
PC HIGH VISCOSITY

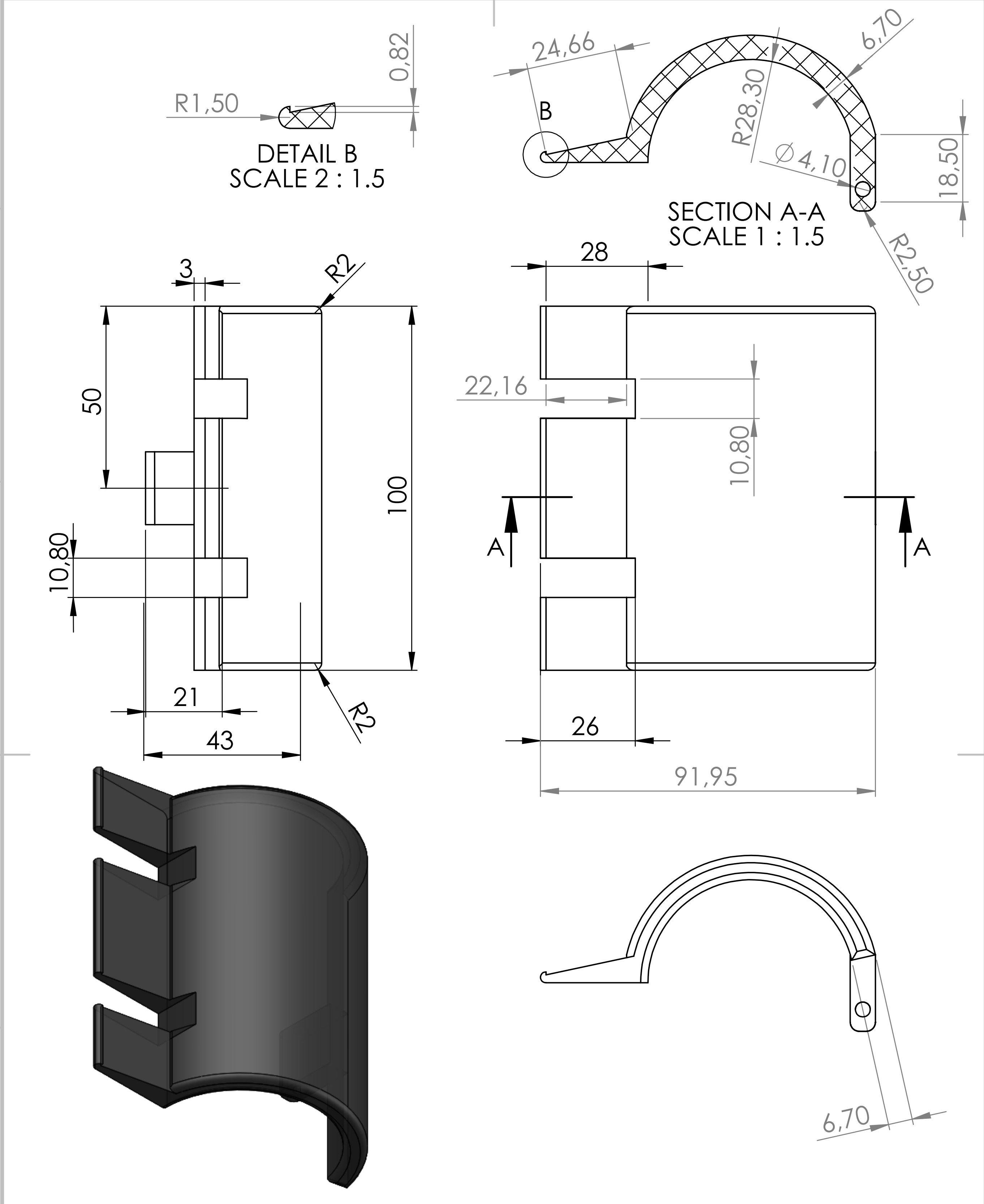
WEIGHT: 184.679 g

N.º OF DRAWING
Drawing 1

A4

SCALE:1:2

PAGE 1 OF 1



DIMENSIONS IN MM
ANGLES IN DEGREES

FINISHED:
Alfonso Delgado Navarro

Embry-Riddle Aeronautical University

	NAME	SIGNATURE	DATE
DRAW.	Alfonso Delgado Navarro		05/02/2018
VERIF.	Víctor Huayamave		05/02/2018
APPRO.	Jean-Michel Dhainaut		05/02/2018

Clamp_Part 2

MATERIAL:
PC HIGH VISCOSITY

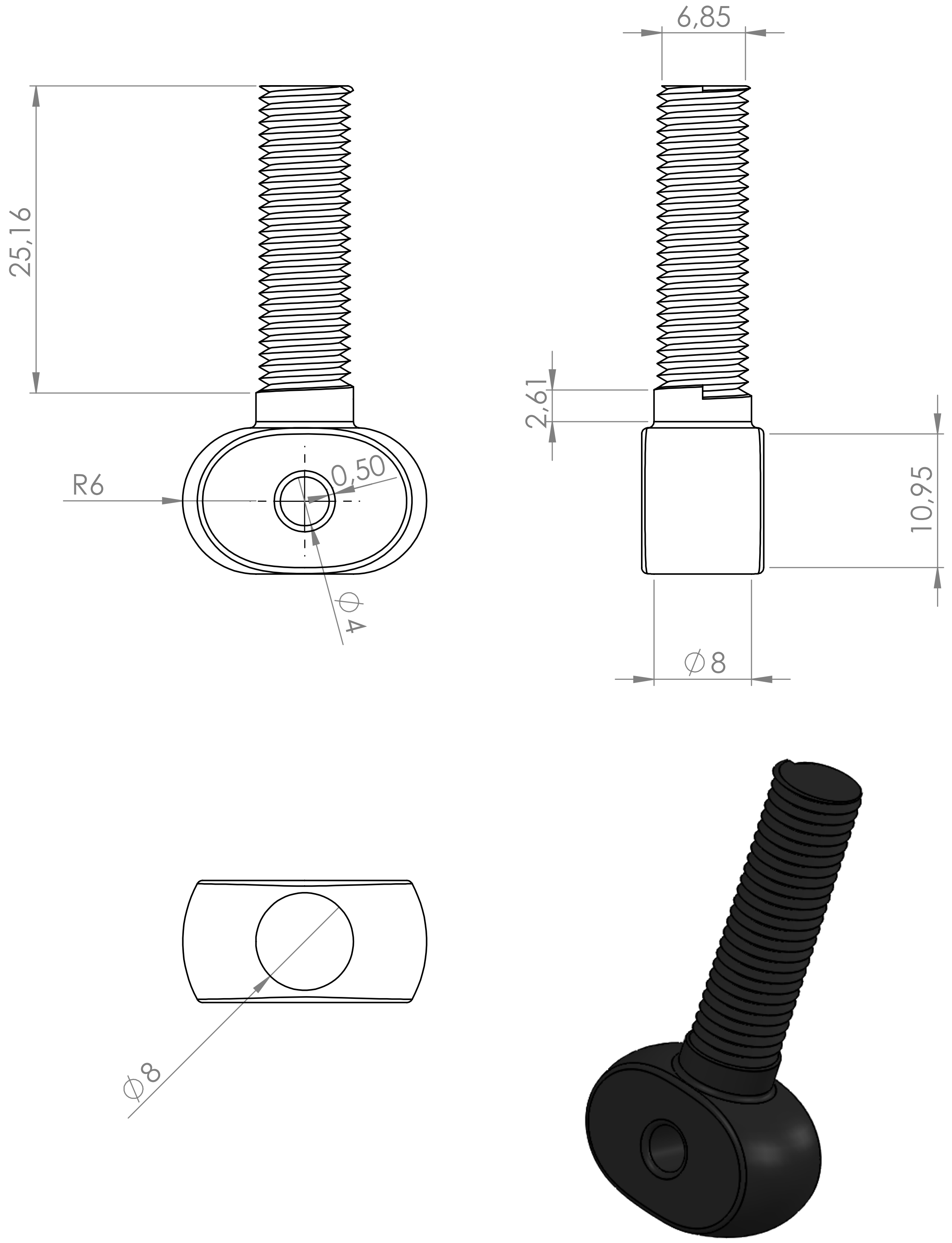
WEIGHT: 84.74 g

N.º OF DRAWING
Drawing 2

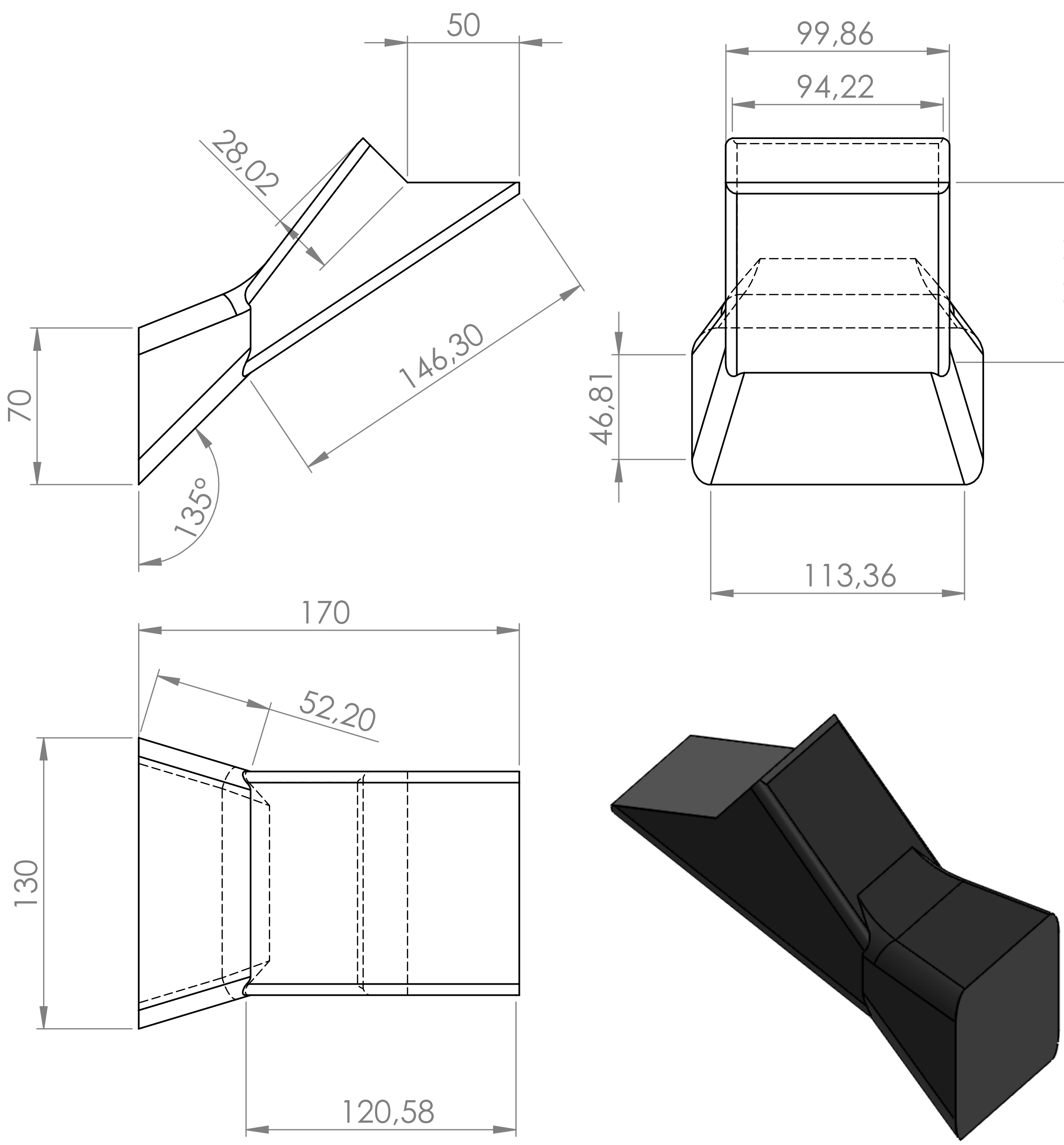
A4

SCALE:1:2

PAGE 1 OF 1



DIMENSIONS IN MM ANGLES IN DEGREES	FINISHED: Alfonso Delgado Navarro			Embry-Riddle Aeronautical University
	NAME	SIGNATURE	DATE	Clamp_Part 3
DRAW.	Alfonso Delgado Navarro		05/02/2018	
VERIF.	Víctor Huayamave		05/02/2018	
APPRO.	Jean-Michel Dhainaut		05/02/2018	
		MATERIAL: AISI 316L Acero Inoxidable		N.º OF DRAWING Drawing 3 — A4
		WEIGHT: 22.89 g		SCALE:2:1 — PAGE 1 OF 1



DIMENSIONS IN MM
ANGLES IN DEGREES

FINISHED:
Alfonso Delgado Navarro

Embry-Riddle Aeronautical University

	NAME	SIGNATURE	DATE
DRAW.	Alfonso Delgado Navarro		05/02/2018
VERIF.	Víctor Huayamave		05/02/2018
APPRO.	Jean-Michel Dhainaut		05/02/2018

Stroller-Mechanism

MATERIAL:
Aluminum 6061 T-6

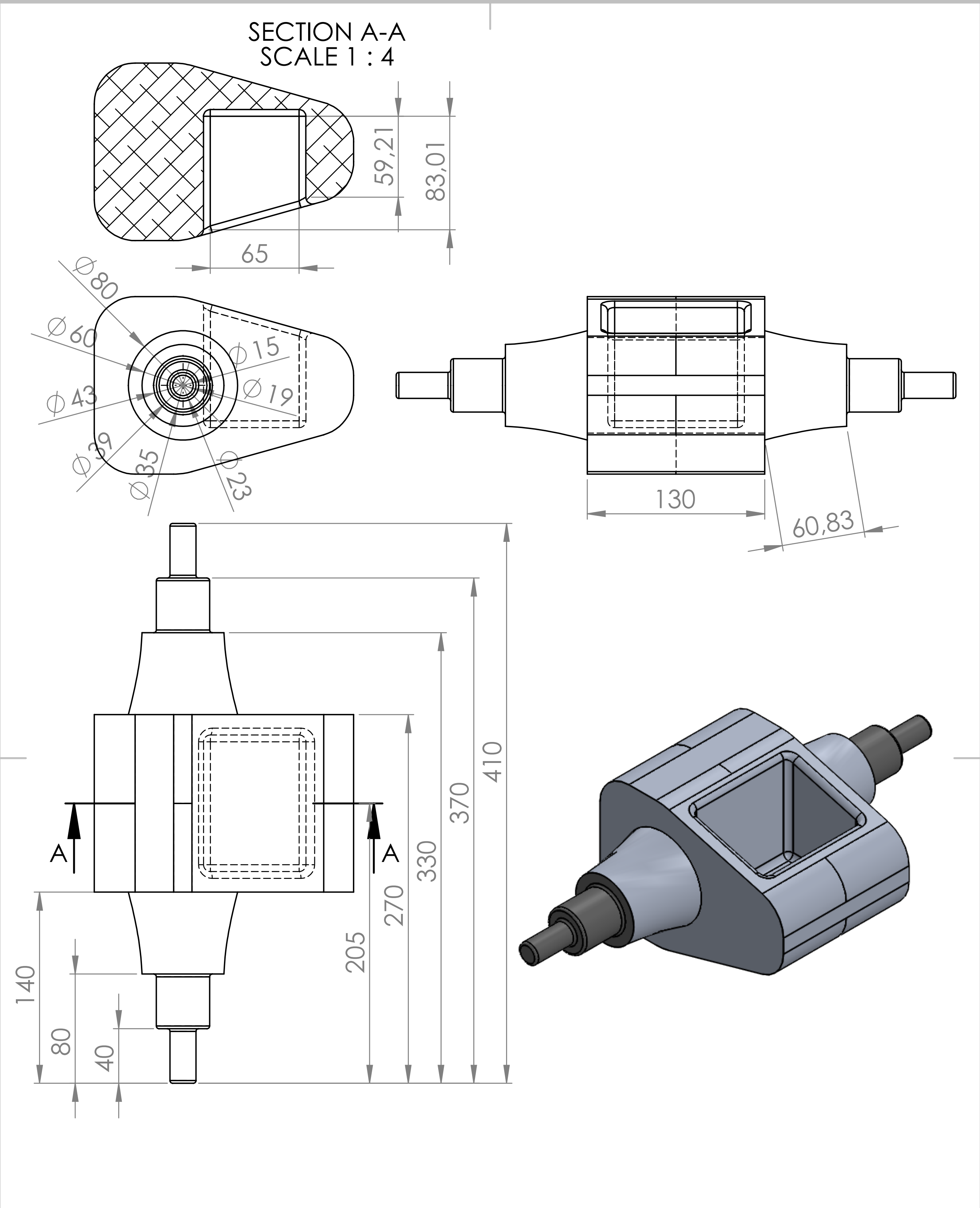
WEIGHT: 2139.39g

N.º OF DRAWING
Drawing 4

A4

SCALE:1:3

PAGE 1 OF 1



DIMENSIONS IN MM
ANGLES IN DEGREES

FINISHED:
Alfonso Delgado Navarro

Embry-Riddle Aeronautical University

	NAME	SIGNATURE	DATE
DRAW.	Alfonso Delgado Navarro		05/02/2018
VERIF.	Víctor Huayamave		05/02/2018
APPRO.	Jean-Michel Dhainaut		05/02/2018

Central Axis

MATERIAL:
Aliminum 6061-T6

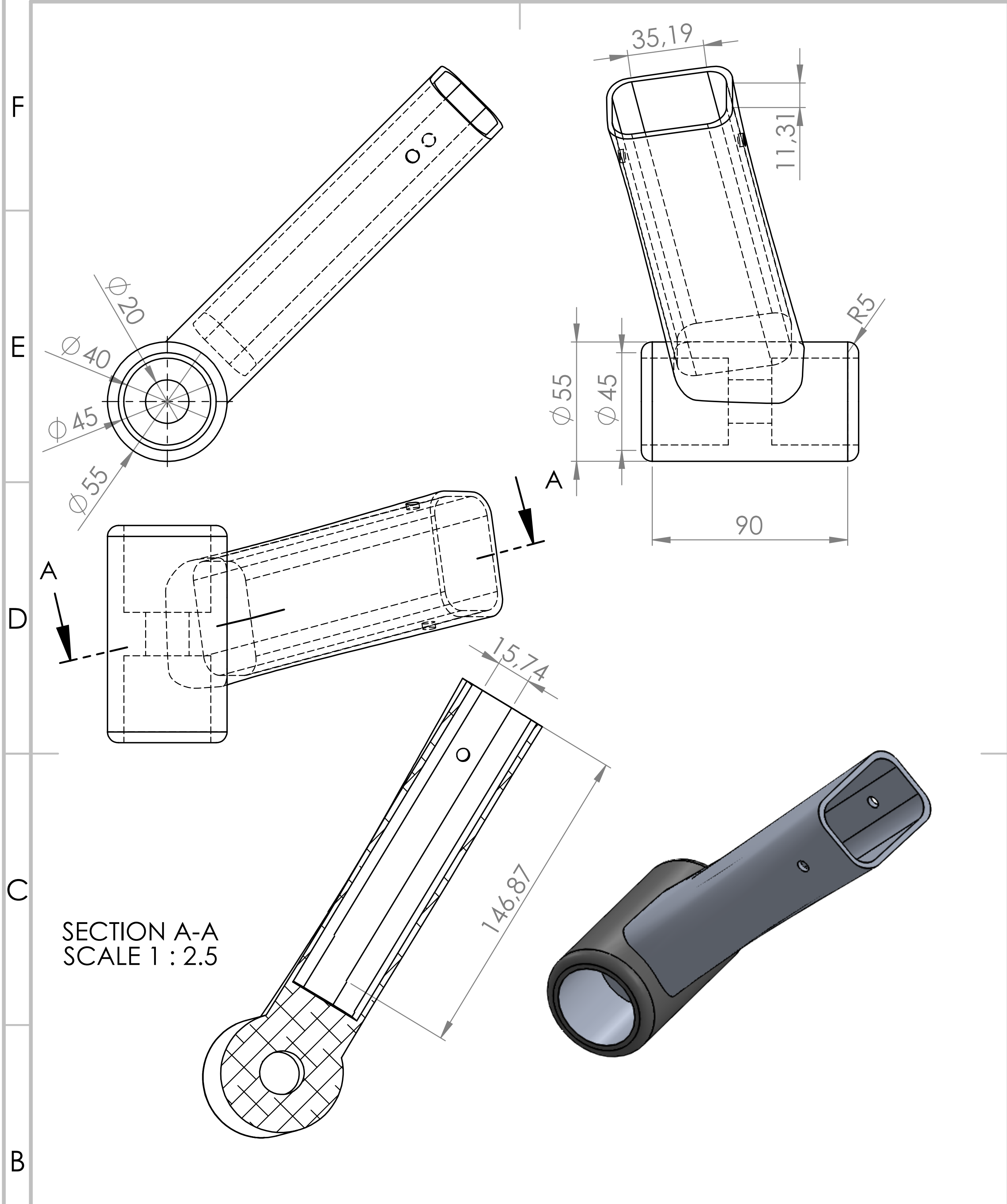
WEIGHT: 6781.82 g

N.º OF DRAWING
Drawing 5

A4

SCALE:1:10

PAGE 1 OF 1



DIMENSIONS IN MM
ANGLES IN DEGREES

FINISHED: Alfonso Delgado Navarro

Embry-Riddle Aeronautical University

	NAME	SIGNATURE	DATE
DRAW.	Alfonso Delgado Navarro		05/02/2018
VERIF.	Víctor Huayamave		05/02/2018
APPRO.	Jean-Michel Dhainaut		05/02/2018

Common Part

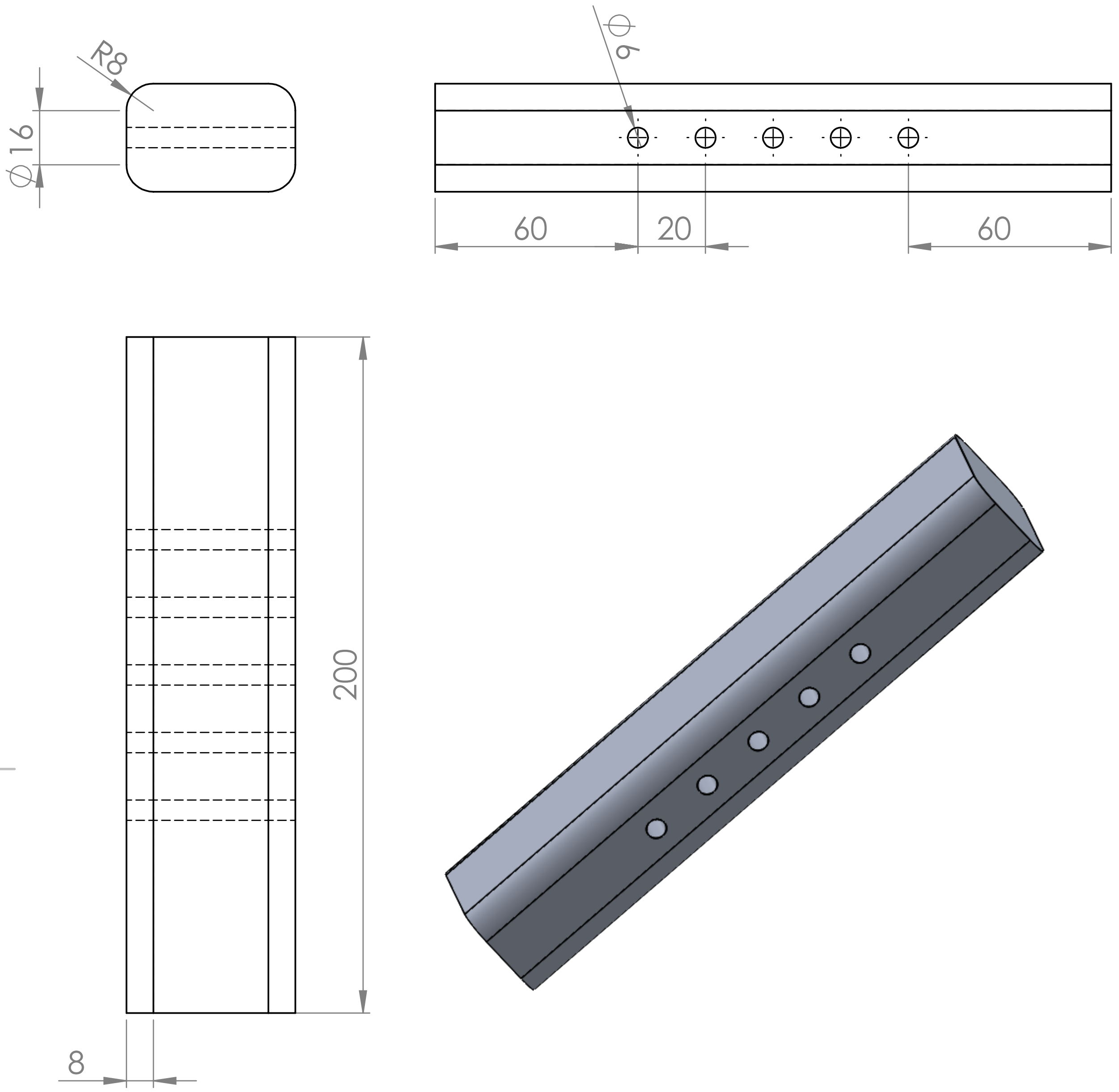
MATERIAL: Aluminum 6061 T-6

WEIGHT: 556,87 g

N.º OF DRAWING: Drawing 6

A4

SCALE:1:2.5



DIMENSIONS IN MM
ANGLES IN DEGREES

FINISHED: Alfonso Delgado Navarro

Embry-Riddle Aeronautical University

	NAME	SIGNATURE	DATE
DRAW.	Alfonso Delgado Navarro		05/02/2018
VERIF.	Víctor Huayamave		05/02/2018
APPRO.	Jean-Michel Dhainaut		05/02/2018

Height Regulator

MATERIAL: Aluminum 6061-T6

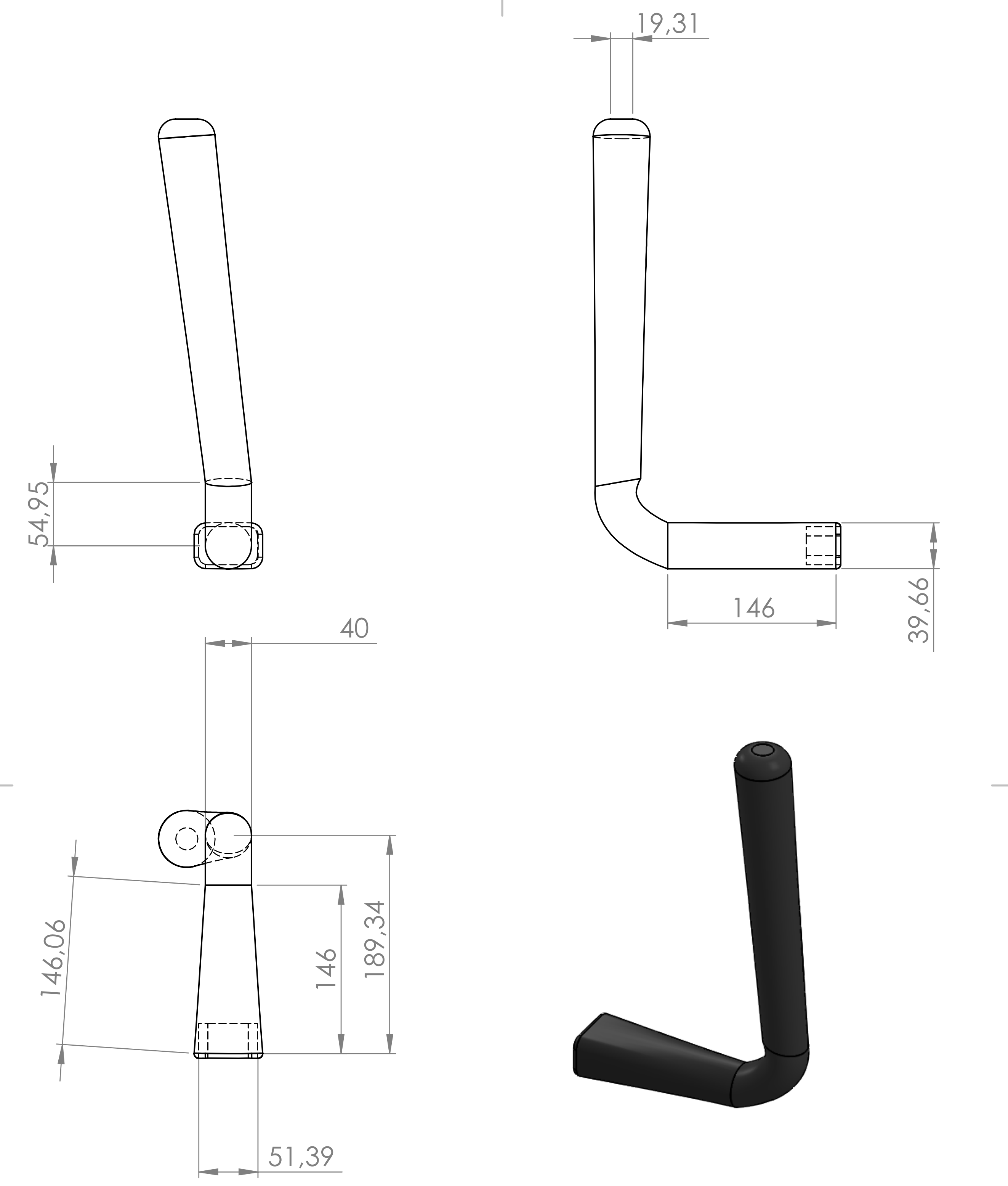
N.º OF DRAWING: Drawing 7

A4

WEIGHT: 815.25 g

SCALE:1:2

PAGE 1 OF 1



DIMENSIONS IN MM
ANGLES IN DEGREES

FINISHED: Alfonso Delgado Navarro

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	NAME	SIGNATURE	DATE
DRAW.	Alfonso Delgado Navarro		05/02/2018
VERIF.	Víctor Huayamave		05/02/2018
APPRO.	Jean-Michel Dhainaut		05/02/2018

Left-Handle

MATERIAL: BUTYL

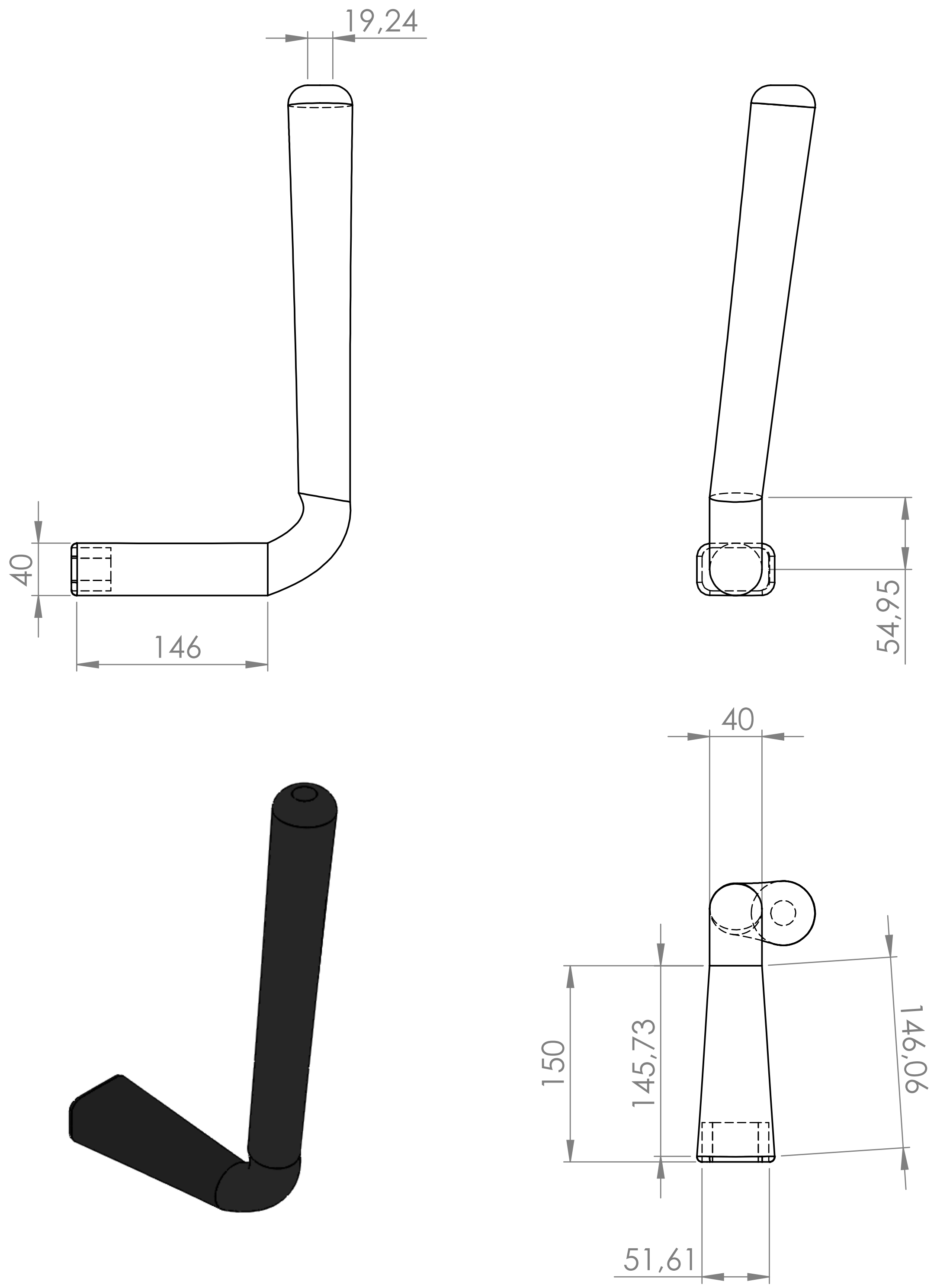
WEIGHT: 903.02 g

N.º OF DRAWING: Drawing 8

A4

SCALE:1:5

PAGE 1 OF 1



DIMENSIONS IN MM
ANGLES IN DEGREES

FINISHED:
Alfonso Delgado Navarro

Embry-Riddle Aeronautical University

	NAME	SIGNATURE	DATE
DRAW.	Alfonso Delgado Navarro		05/02/2018
VERIF.	Víctor Huayamave		05/02/2018
APPRO.	Jean-Michel Dhainaut		05/02/2018

Right-Handle

MATERIAL:
BUTYL

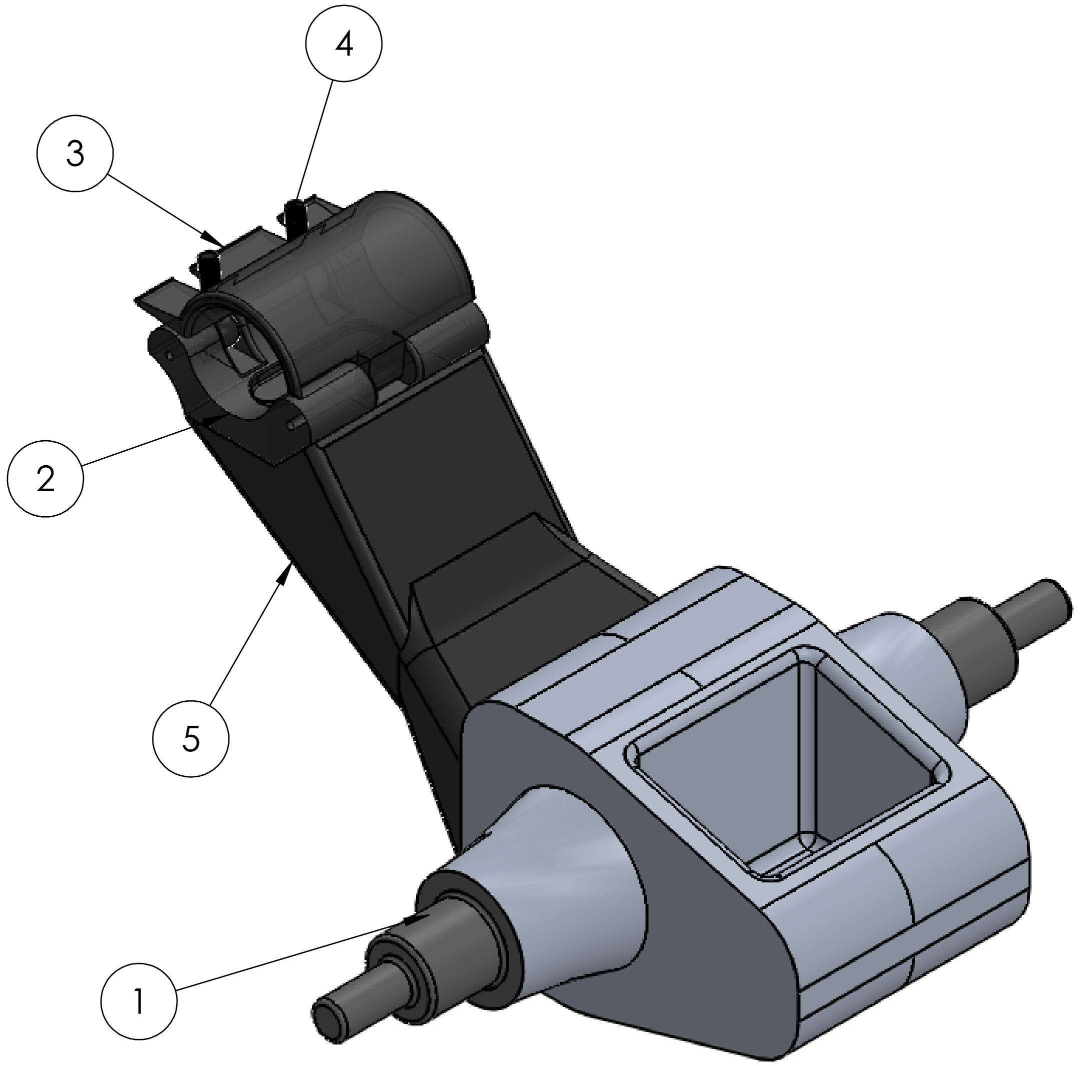
WEIGHT: 903.02 g

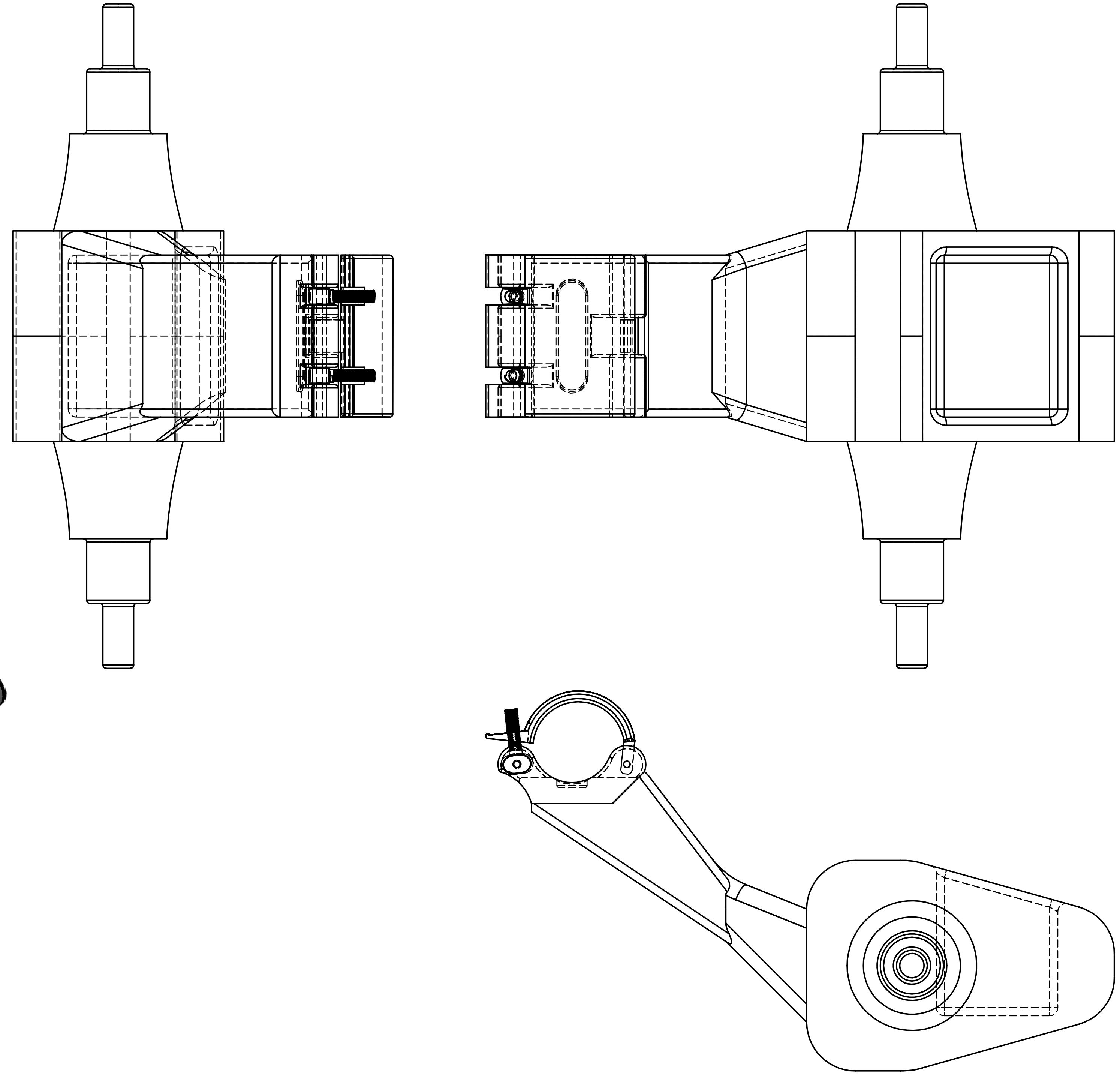
N.º OF DRAWING
Drawing 9

A4

SCALE:1:5

PAGE 1 OF 1





N.º OF ELEMENT	N.º OF PART	DESCRIPTION	QUANTITY
1	CentralAxis	Central part of the mechanism	1
2	Clamp_Part1	Base part of the clamp	1
3	Clamp_Part2	Top of the clamp	1
4	Clamp_Part3	Union Screws	2
5	Stroller-Mechanism	Connector part (stroller-mechanism)	1

DIMENSIONS IN MM
ANGLES IN DEGREES

FINISHED:
Alfonso Delgado Navarro

Embry-Riddle Aeronautical University

	NAME	SIGNATURE	DATE
DRAW.	Alfonso Delgado Navarro		05/02/2018
VERIF.	Víctor Huayamave		05/02/2018
APRO.	Jean-Michel Dhainaut		05/02/2018

Connector

MATERIAL:

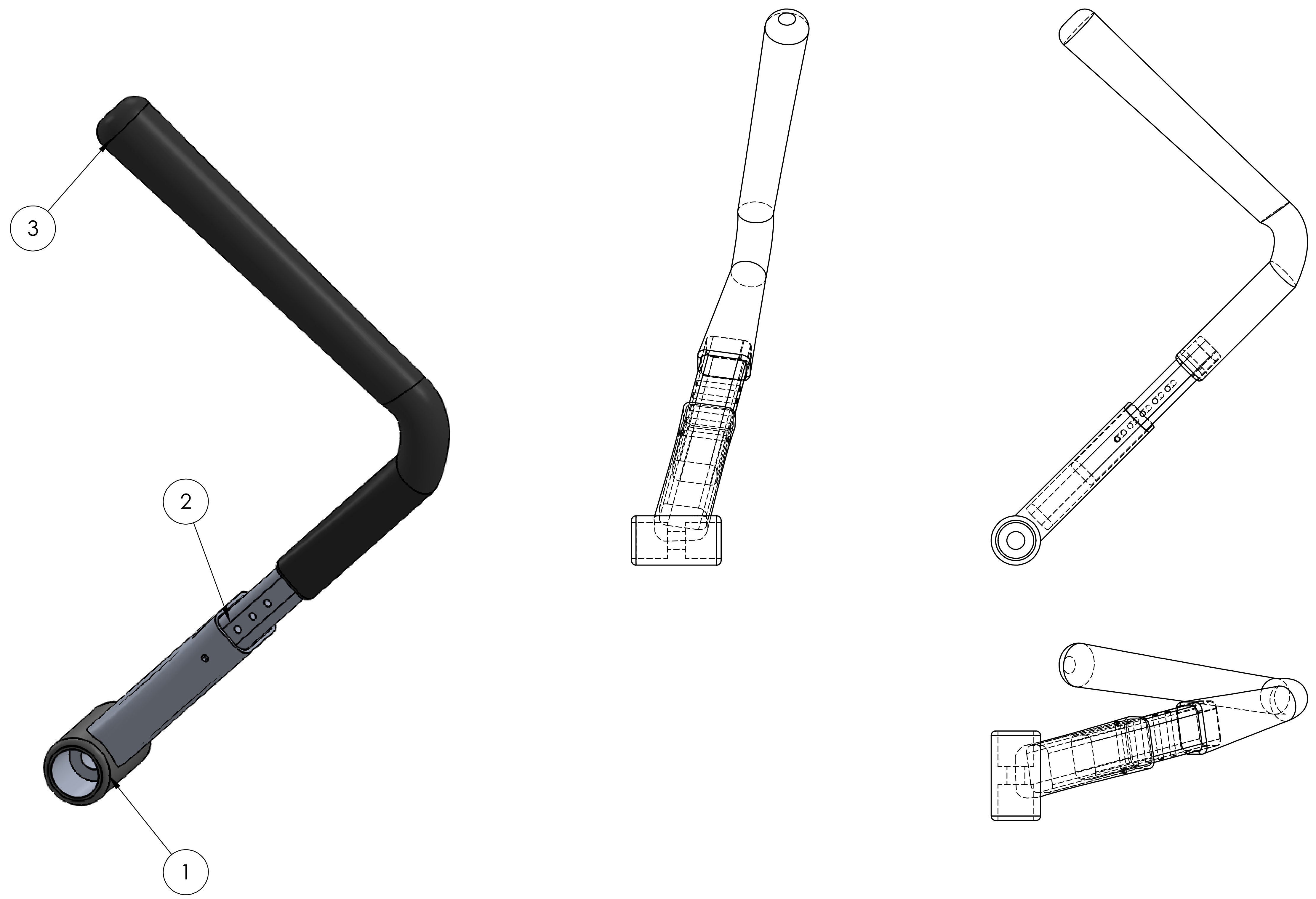
WEIGHT:

N.º OF DRAWING
Drawing 10

A3

SCALE:1:3.5

PAGE 1 OF 1



N.º OF ELEMENT	N.º OF PART	DESCRIPTION	QUANTITY
1	CommonPart	Base of the handles	1
2	HeightRegulator	Regulator of users´height	1
3	LeftHandle	Ergonomic Left-Handle	1

DIMENSIONS IN MM
ANGLES IN DEGREES

FINISHED: Alfonso Delgado Navarro

Embry-Riddle Aeronautical University

	NAME	SIGNATURE	DATE
DRAW.	Alfonso Delgado Navarro		05/02/2018
VERIF.	Víctor Huayamave		05/02/2018
APRO.	Jean-Michel Dhainaut		05/02/2018

LeftArm

MATERIAL:

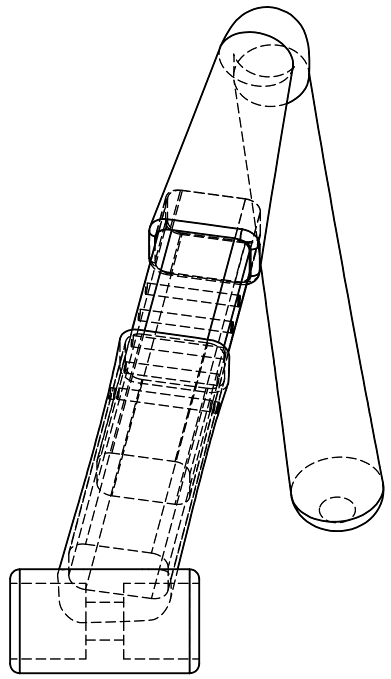
N.º OF DRAWING: Drawing 11

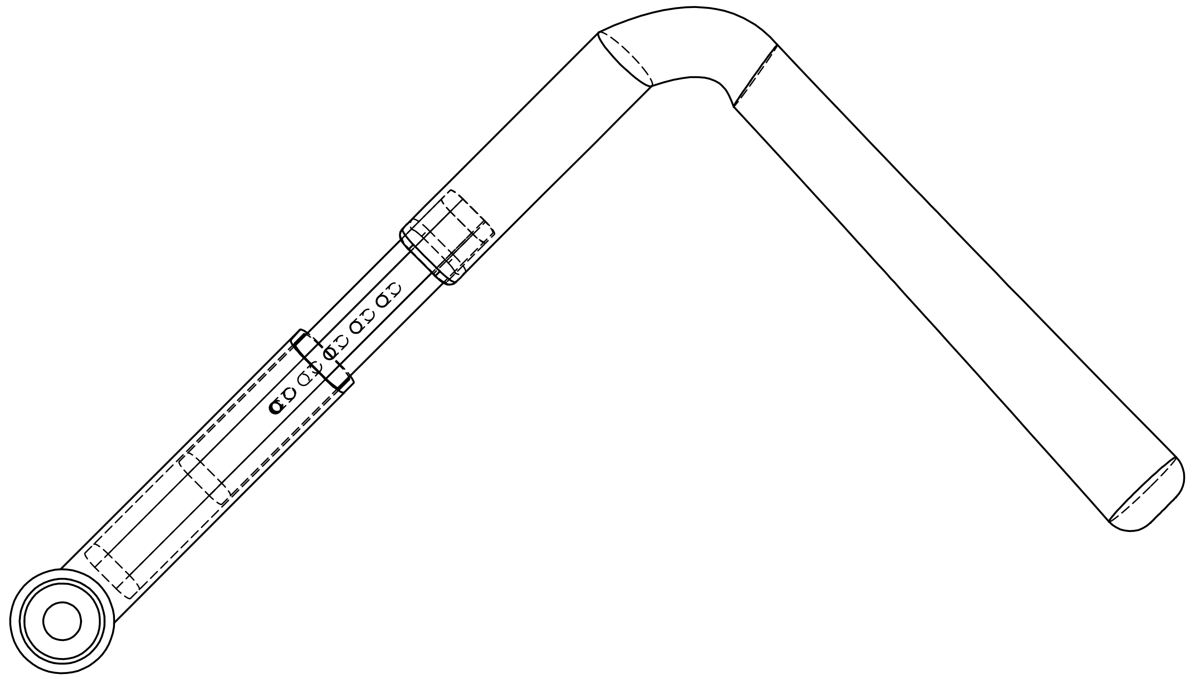
A3

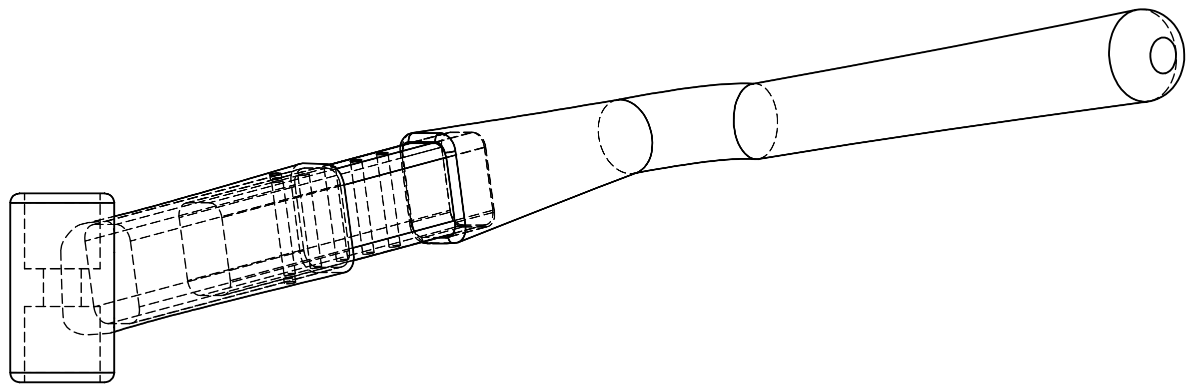
WEIGHT:

SCALE:1:5

PAGE 1 OF 1







N.º OF ELEMENT	N.º OF PART	DESCRIPTION	QUANTITY
1	CommonPart	Base of the handles	1
2	HeightRegulator	Regulator of users´height	1
3	RightHandle	Ergonomic Right-Handle	1

DIMENSIONS IN MM
ANGLES IN DEGREES

FINISHED:

Alfonso Delgado Navarro

Embry-Riddle Aeronautical University

	NAME	SIGNATURE	DATE
DRAW.	Alfonso Delgado Navarro		05/02/2018
VERIF.	Víctor Huayamave		05/02/2018
APRO.	Jean-Michel Dhainaut		05/02/2018

RightArm

MATERIAL:

WEIGHT:

N.º OF DRAWING

Drawing 12

A3

SCALE:1:3.5

PAGE 1 OF 1