NOVIA
UNIVERSITY OF APPLIED SCIENCES

Final Report

European Project Semester Spring 2024

Punching Bag Rack

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Supervisor: Josefin Stolpe

I. Abstract

For this semester and as part of our EPS program, European Project Semester, we will need to work on our project “Punching Bags Rack”. This one consists of helping a sports centre, called the OP-Arena, by offering them a solution to put a punching bags rack within their infrastructure.

This report presents the design, development, and construction of an automated rack system to support four punching bags. The main objective of the project is to create a practical and effective solution for storing punching balls out of reach when not in use, providing protection for children from nearby schools who use this gym, whilst making them easily accessible during training sessions. We had to think about a feasible design by combining the constraints linked to the layout of the room and that of the budget of 1000€ which we were given.

This project requires a lot of research and creativity, to which the four members of the group contributes. As exchange students from four different countries and different fields of study, pooling our knowledge gives us an advantage during this project. This project demonstrated the importance of careful planning, interdisciplinary collaboration, and technological innovation in achieving practical and functional solutions for athletic training needs.

II. Acknowledgement

The team would like to give a particular thank you to all the people that helped us designing and improving the rack together: Josefin Stolpe, Roger Nylund, Philip Hollins, Jukka Sumuvuori, the owner of the OP-Arena named Aki Lindroos, the Kickboxing Club, Tobias Ekfors, Panu Teräs and everyone that will use those bags.

Josefin Stolpe is our dedicated supervisor. We would like to thank you for your invaluable guidance, support, and efficient coordination throughout the project. Your expertise and insights have been instrumental in our progress.

Roger Nylund, our teambuilding teacher, and Philip Hollins, our Project Management teacher for your roles in fostering a collaborative and communicative team environment but also for your guidance in maintaining a well-organized schedule and ensuring that we stayed on track with our goals and tasks.

Thank you to Jukka Sumuvuori and Aki Lindroos, director and owner of the OP-Arena, for your unwavering commitment to the project's success and for graciously providing us with the opportunity to undertake this project.

Thank you to the Kickboxing Club for their cooperation in buying the punching bags, and enthusiasm in embracing the new rack. Tobias Ekfors and Panu Teräs helped us with their experiences in mechanical engineering and in practical building to improve our designs in terms of safety and realisability which we are extremely thankful for.

Lastly, to all the future users of the punching bags rack, your enthusiasm and commitment to training inspire us. We hope this rack serves you well in your pursuit of excellence.

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1. Team introduction

1.1 Team members

A team consists of individuals collaborating towards a shared task or a particular objective. In this context we are a group of four international students, studying in Novia, the University of Applied Sciences. Our team project is composed of Cooreman Elena, Hamza Sheriffa, Krause Magnus and Mailly Alicia.

Elena Cooreman

Figure 1 *Elena Cooreman*

I am Elena, 22 years old and originally from Antwerp, Belgium. In 2021 I started my study product development at the University of Antwerp. Currently, I am doing my third and final year of my bachelor's degree. I chose to do this exchange to widen my horizon both on an academic as on a personal basis. The EPS program is especially interesting to me because it gives me the opportunity to work in a multicultural team with people who study different majors. I get the chance to learn from them and teach what I have learned in my field of study. Furthermore, I get to make new friends here and get to discover Vaasa and Finland with them.

Sheriffa Hamza

Figure 2 *Sheriffa Hamza*

I am Sheriffa Hamza and I am from Ghana. I attended the University for Development Studies, I pursue a Bachelor of Science in Agricultural Engineering, I reside in Accra, which is the capital city of Ghana. This is my first chance to study overseas with the EPS. I selected EPS and Finland because it will allow me to further my knowledge of Finnish culture and the stunning country, while also honing my talents and skills in a variety of engineering and cross-cultural communication areas that are lacking at my home university. Above all, I wanted to live in the happiest nation possible.

Magnus Krause

Figure 3 *Magnus Krause*

My name is Magnus Krause, and I am 21 years old. I grew up in Germany and am currently studying in the sixth semester. I study mechatronics at the Kiel University of Applied Sciences in Kiel, Germany. Since I started studying, I have planned on doing an exchange semester, as I believe this will help me improve on a personal as well as on a professional basis. Especially the EPS was interesting to me as there I would get to use and therefore improve my English skills as well as my abilities to work with people of different backgrounds and experiences.

Alicia Mailly

Hello, I am Alicia, and I am 22 years old. I come from France, and I have been studying Packaging Engineering for 2 years at my home university ESIReims, University of Reims Champagne-Ardenne. The opportunity of doing the EPS program was a great chance for me. First, I had the chance to work abroad with people of different nationalities and different fields of study. It helped me to be open to new people, becoming more comfortable speaking orally and sharing my ideas. I also got the chance to discover another culture and the spirit of this magical country.

Figure 4 *Alicia Mailly*

1.2 Belbin roles

To help us carry out our project smoothly and successfully, we wanted to define the skills and abilities of each member in order to allow a more effective separation of tasks. We used several tools, and we started by taking Belbin Tests. Those tests are helpful to divide the responsibility that every member will have during the entire project. It allows us to use time at our advantage by taking the best abilities in everyone. By mixing all our results, we can see in which sector a member will feel more comfortable to work.
Dr Meredith Belbin defines a 'Team Role' as one of nine clusters of behavioural attributes identified by his research at Henley as being effective in order to facilitate team progress. Meredith Belbin's research showed that the most successful teams were made up of a diverse mix of behaviours. To build high-performing teams, we need to represent each of the nine Belbin Team Role behaviours at the appropriate times.
Figure 5 shows the nine Belbin Team Roles which are: Resource Investigator, Team Worker and Co-ordinator (the social roles); Plant, Monitor Evaluator and Specialist (the Thinking roles), and Shaper, Implementer and Completer Finisher (the Action or Task roles). (The Nine Belbin Team Roles, n.d.)

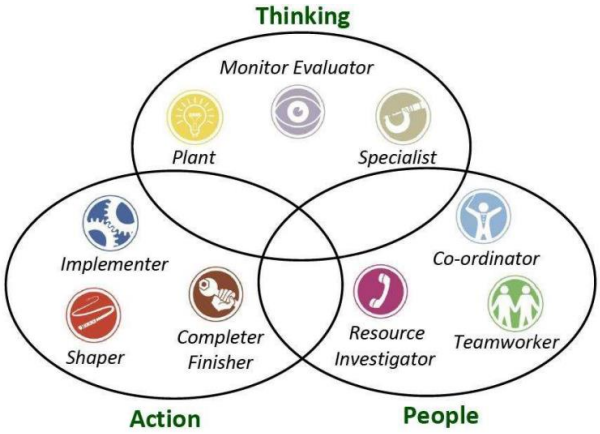


Figure 5 *Belbin Roles*

Elena Cooreman

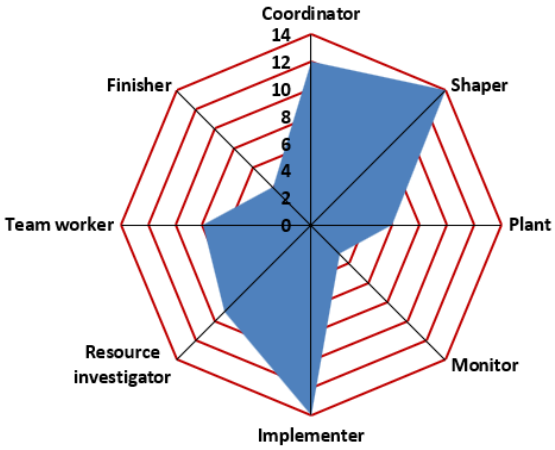


Figure 6 *Elena's Belbin Results*

I can distinguish two clear roles from the results of my Belbin test **(Figure 6)**. First, I am an implementer. I do feel like this applies well to me, since I like to be well-organised. I don't like to put the work of, so I will work very disciplined. Also, in a group project, other people are counting on me. This is an extra incentive for me to do my work in time. However, being an implementer also has its downsides. I will probably be less flexible and resistant to changes in the Schedule.

In addition, I am a shaper. I have the feeling that this applies only partly to me. I could say that I am quite extraverted, and I enjoy stimulating others. However, I am not sure that I am the right person to make sure all possibilities are considered. I tend to think inside a certain box. My weaknesses could be that I am quite argumentative, just like a shaper.

Sheriffa Hamza

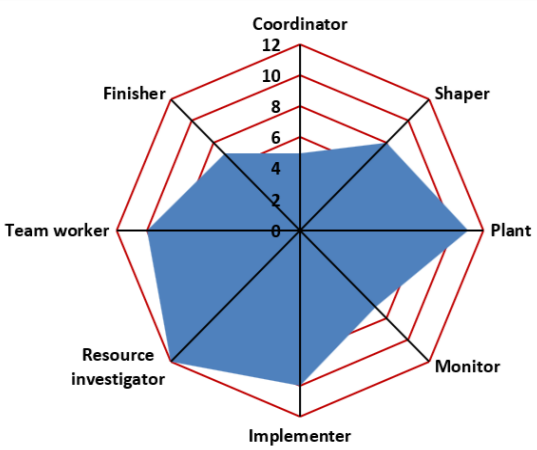


Figure 7 *Sheriffa's Belbin Results*

With the help of Belbin's questionnaire resource investigator is someone who is great at exploring opportunities and making connections. Skilled at networking and gathering information and bringing fresh ideas to the team. They are like the go-to person when it comes to finding external resources and building relationship. With my results **(Figure 7)** we can see that I am a good Resource Investigator, and I will be able to help my team in putting into conversation new ideas and I will help to develop them.

According to Belbin's questionnaire a plant is someone who is highly creative and imaginative, often the one's with innovative ideas for the team and I think if chances are given, I will be able to bring my idea and innovations to my team.

However, some ideas may seem as unconventional or unorthodox in their thinking. The plant role is crucial for bringing creativity and originality to the team's problem-solving process.

Magnus Krause

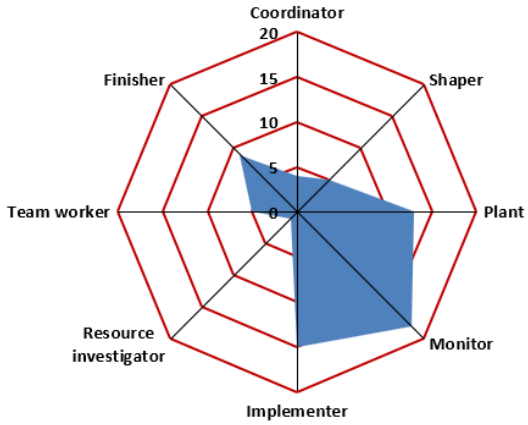


Figure 8 *Magnus's Belbin Results*

My Belbin test which is shown in **Figure 8.** indicates two different roles with the first one being clearly the main role. The first role the Belbin test assigned to me is the "Monitor Evaluator". Personally, I think that this role characterizes me quite good as I am a person who often takes some time to think about the possible solutions and their impacts. Moreover, I would I state that I often work as logical and as sober as it is possible for me. Yet I often focus more on the negative aspects of a new suggestion and hence often dismiss them.

The second most points received the role "Implementor" which is said to be reliable, efficient, practical and organizes work which must be done. I would agree to the points reliable and practical. However, I would not consider myself to organizes work for a group as I think everyone should be capable to do this on his/her own. Therefore, I only concentrate on organizing my own work.

Alicia Mailly

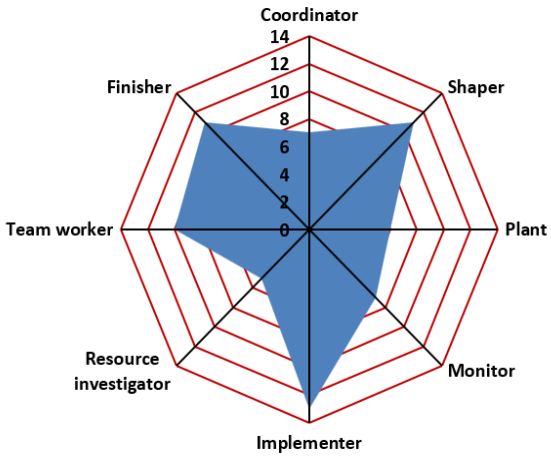


Figure 9 *Alicia's Belbin Results*

Thanks to the Belbin test that we took, we can see that I am represented as an Implementer and a Finisher **(Figure 9)**. As we can see on the **Figure 5** a Finisher is a person that is conscientious and always looking for errors we should avoid. I recognize myself in this characteristic. With this point I can also become stressed by a project if I feel that we are going the wrong way or maybe even too stressed about due dates.

That is why being linked with an Implementer or a Coordinator will help the team to be organised, have clear goals and to know how we should split the work. The Implementer is the reliable person we should trust on the dates, and to be well organised. As we seem to have two Implementers within our team it will help us to be more flexible and discuss on how to organise our work.

The group

When we put our results together as shown on **Figure 10**, we notice that for every role there is at least one person who scored a minimum of ten points in it. Therefore, we believe that every role should at least to a certain degree be filled by one of us. The role with the lowest maximum score is for us the Team worker which might result in us working not as efficient together as possible and might lead to stress or problems between team members. Nonetheless, we feel like we can form a good group despite our individual and team weaknesses and embrace our strengths to make the project work. However, as this is just a personality test, we still need to verify the test result in practice as only then we can be fully sure to be a working well together and complementing each other.

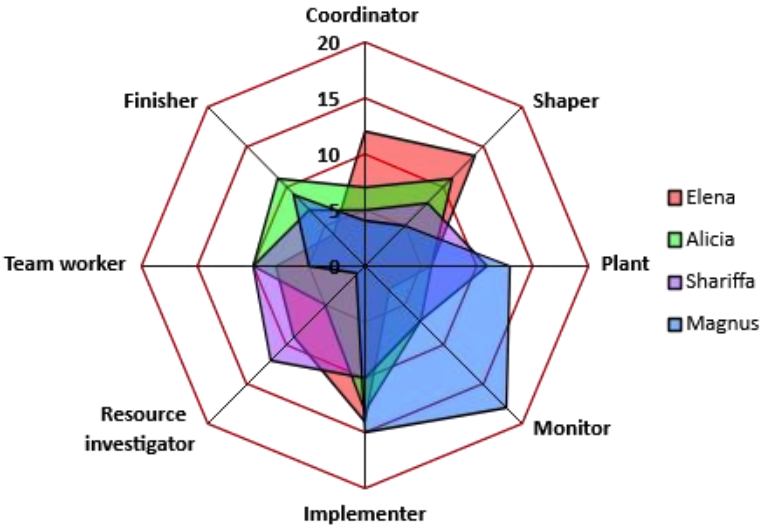


Figure 10 *Belbin Results of our group*

1.3 Leadership Test

A second way we used to gain insight into the group and how individual team members work is the leadership test.

This test is divided into five categories, each requiring a score of one to five to be given in response to five different statements. So, there are twenty-five statements in total. One stands for never and five means always. The five categories are leadership, communication, creative thinking and problem solving, dealing with uncertainty and planning.

The results are displayed in the form of a graphical radar. This cog shows both individual results and the results of the typical project manager.

Elena Cooreman

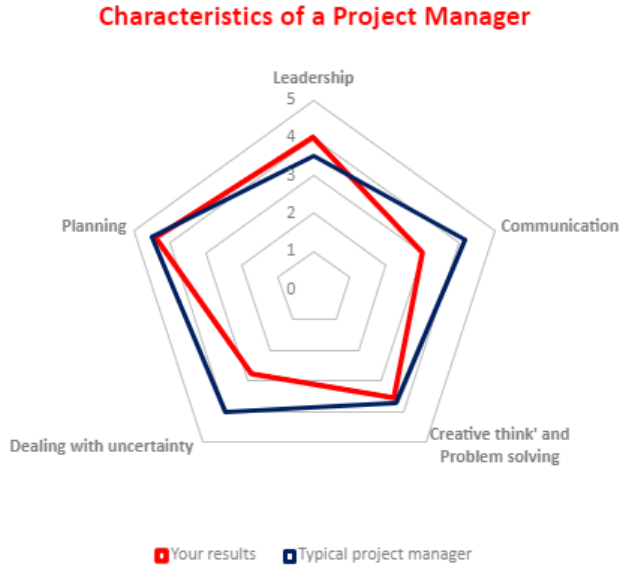


Figure 11 *Elena's Leadership Test*

In my leadership test (**Figure 11**), I scored very highly on planning. I think this is because I don't like to deliver my work late. I also don't like to do everything in the end and have some very stressful days. Therefore, I like to plan my work ahead of time and make small deadlines for myself. I also feel like this gives more structure to a teamwork because it is clearer what is expected from the individual members.

I also scored quite high on leadership. I do feel like this is correct. I always have the tendency to step up and take the lead. It can often be even quite difficult for me to step down and let someone else take charge. This is something that I have to work on.

The third thing I scored highly on is creative thinking and problem solving. This is mostly because I have learned a lot of techniques at my home institution that help me with this. I did not score so well on communication. I have to tendency to think that my idea is the best one and forget to listen to the others. I rarely give due consideration to all points of view that are expressed, and I am often not very open to feedback from others. I am however aware of these flaws, and I am trying to work on them.

Lastly, I did not score so well on dealing with uncertainty. I don't adapt very quickly to new situations and tent to forget that they can be considered as opportunities. I always need a little time to adjust.

Sheriffa Hamza

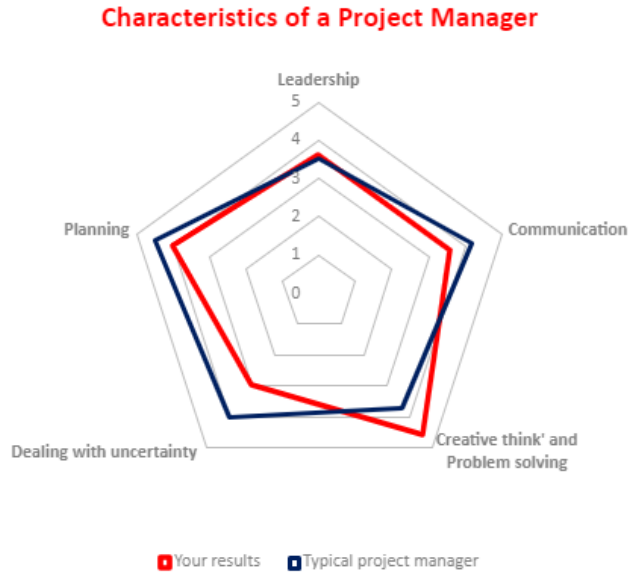


Figure 12 *Sheriffa's Leadership Test*

The leadership role theory is a popular model that identifies different roles individuals play within a team. Each role has its own strength and weakness, and a successful team should ideally have a balance on these roles. By assigning roles effectively, teams can enhance their performance and achieve better results.

According to my Leadership test results that can be seen in **Figure 12,** my strength evolves around creative thinking and problem solving, due to some past experiences. Creative thinking involves thinking outside the box and also exploring different perspective, generating new ideas whereas problem solving involves analysing the problem and identifying possible solutions and evaluating them to get the best outcome and I believe I have the best skills when it comes to creative thinking and problem solving.

According to the leadership theory, dealing with uncertainty is my weakness, I think dealing with uncertainty shouldn't be a problem to a team because each role brings a

unique perspective. By leveraging the strengths of each team member and fostering open communication, teams can better handle uncertainty and find innovative solutions.

Magnus Krause

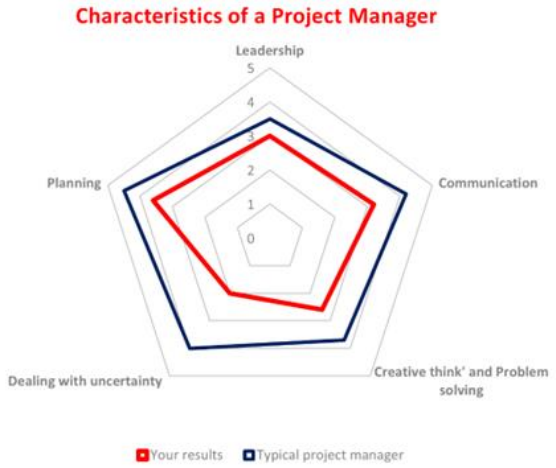


Figure 13 *Magnus's Leadership Test*

First, it is noticeable that I scored less point in every category compared to a typical project manager as it is visible in **Figure 13**. This shows that I, according to the test, am not a person suited for this position.
Nonetheless, I did score highest in planning which is understandable to me as I like to know what other people are doing and when they are expected to finish their task.
I score second highest on communication which was to a certain degree surprising to me as I am normally not that good at communicating with other people. However, here it also focussed on the ability to listen to other people's ideas and the evaluation of them suiting me well.
I scored worst in dealing with uncertainty which is be a problem of me as I always want every piece of information to evaluate the situation. New and uncertain information result in me having to think everything through again costing a lot of time.

Alicia Mailly

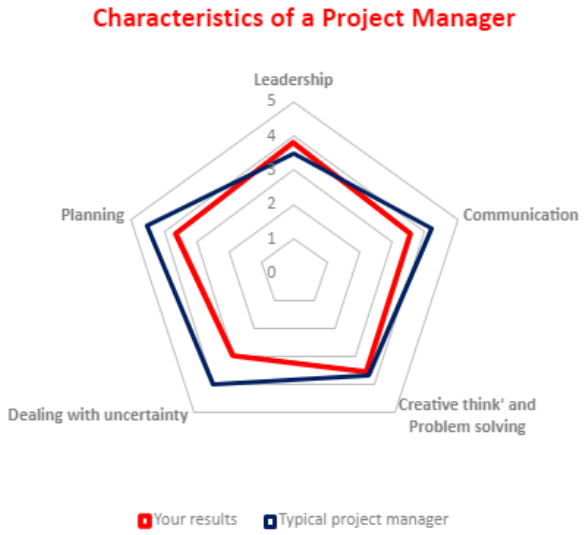


Figure 14 *Alicia's Leadership Test*

According to my leadership test results, found in **Figure 14,** and the score of a typical project manager, I am supposed to be quite good as a leader. I already experienced this position while being part of the art association back at my home school. I like to organise our project well, communicate with every member and respect the deadlines.

I also had a perfect score on the creative think and Problem solving. This is a category I can relate to. Indeed, by viewing the projects that I have been able to carry out so far, I am able to keep calm in the group in order to manage good communication and allow the group to find solutions without getting overwhelmed or too stressed by the due dates that we will have.

The group

Furthermore, we have put all our results together so that we can clearly see where we complement each other and where deficits occur. This is visible in **Figure 15**. From the results, we can conclude that there is a general deficit on 'dealing with uncertainty'. So, we should be well aware of this and try to open up to it.

Moreover, there is a small deficit on 'communication' but since this is not an extreme, we assume this will be fine if we focus on being clear so that misunderstandings and arguments can be avoided. In all other areas, the team scores well.

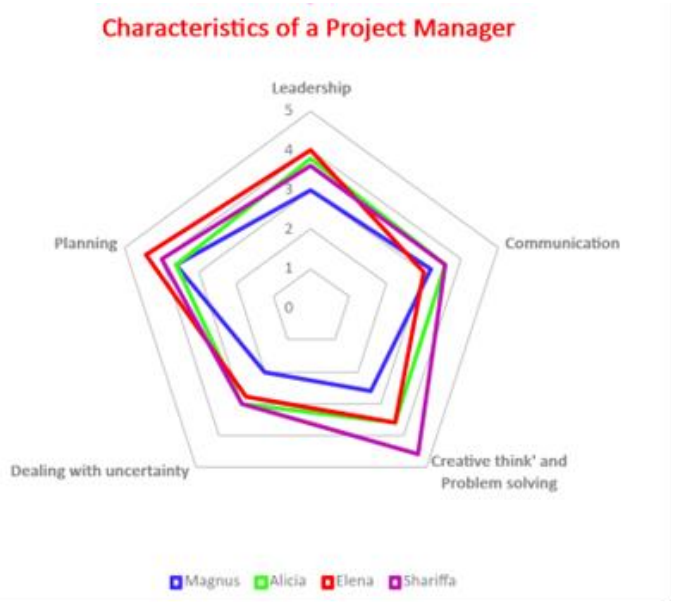


Figure 15 *Leadership Test Results of the group*

1.4 Hofstede Cultural Dimensions

Category	Explanation
Power Distance	The distribution of power
Individualism	The degree of interdependence a society maintains among its members
Masculinity	What motivates people, wanting to be the best (Masculine) or liking what you do (Feminine)
Uncertainty Avoidance	The extent to which the members of a culture feel threatened by ambiguous or unknown situations and have created beliefs and institutions that try to avoid these
Long term orientation	How the society maintains links with its past while dealing with the challenges of the present and future
Indulgence	The extent to which people try to control their desires and impulses

Figure 16 *Hofsted Categories*

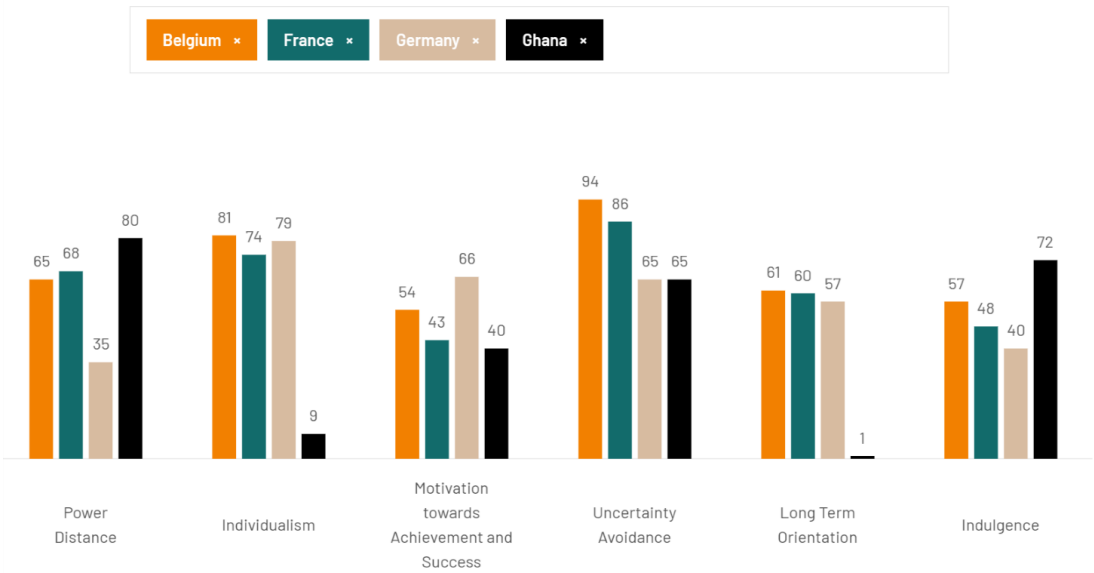


Figure 17 Hofsted Results for our four countries

The Hofstede cultural dimensions describe how different cultures deal with situations in terms of different categories. The categories are shown in **Figure 16**. Every member of our team comes from a different country. The ones compared in **Figure 17** are Belgium, France, Germany and Ghana. The most differences are noticeable in power distance, individualism and long-term orientation. In general, we can conclude that Belgium Germany and France are more alike each other than Ghana. Belgium and France are the closest together which makes sense if you look at the history of these two countries. The German people are still a bit further from them, but the European countries are close together compared to Ghana. This is not a surprise since Ghana is on another continent with a different culture and values.

Elena Cooreman

Belgium exhibits a distinctive cultural profile characterized by a high-Power Distance Index (PDI) of 65, indicating a society that accepts and expects inequalities. Hierarchy is crucial, and power is centralized, although a potential shift may occur between the Walloons and Flemish. I agree with this. Belgians are very focused on their career and want to work towards the goal of climbing higher up on the hierarchical ladder. Despite a strong individualistic orientation, scoring 81 on the Individualism index, Belgians also value hierarchy, creating a unique tension in their culture.

The Motivation towards Achievement and Success is moderately balanced at 54, reflecting a preference for consensus over confrontational negotiation styles. With an exceptionally high Uncertainty Avoidance Index (UAI) of 94, Belgians seek certainty through rules and security, which can complicate negotiations. This is something that I notice in my personal life and in this project as well. I prefer to have a clear idea of what the future holds instead.

In terms of Long-Term Orientation, Belgium scores pragmatically at 61, emphasizing adaptability and perseverance. Lastly, the country is classified as Indulgent (57), reflecting a positive attitude towards enjoying life and fulfilling desires. I believe this is true since Belgians life by the work hard – play hard lifestyle. These cultural nuances provide valuable insights for effective communication and management in the Belgian context.

Sheriffa Hamza

In general, Ghana tends to have a collectivist culture, where the emphasis is on the community and group identity rather than individual achievements. Belgium, Germany, and France, on the other hand, have more individualistic cultures, where personal goals, achievements, and self-expression are highly valued. However, it's important to note that these are generalizations, and individual beliefs and values can vary within each Sure, let me explain further. In Ghana, the culture places a strong emphasis on community and collective identity. People tend to prioritize the needs and goals of the group over individual desires. This is reflected in the value placed on extended family, communal activities, and a sense of belonging to a larger community.

In contrast, Belgium, Germany, and France have more individualistic cultures. In these countries, there is a greater emphasis on personal achievements, self-expression, and individual rights. People in these societies tend to value independence, autonomy, and pursuing personal goals and aspirations.

These cultural differences can be observed in various aspects of life, such as decision-making, social relationships, and work environments. For example, in Ghana, decisions may be made collectively, considering the opinions and needs of the community. In individualistic cultures, decisions are often made based on personal preferences and individual considerations.

Magnus Krause

Germany is characterized by a highly decentralized structure and a strong middle class, contributing to its low power distance score of 35. Co-determination rights are extensive, fostering a participative communication style. Furthermore, it is deemed a decisive society (score 66), valuing performance and self-esteem derived from work. With a score of 65 in uncertainty avoidance, Germany prefers deductive approaches and value expertise to mitigate uncertainty.

The country exhibits a pragmatic orientation (score 57), adapting traditions to changing contexts and emphasizing thriftiness and perseverance. However, it also shows restraint (score 40), with tendencies toward cynicism and pessimism. Personally, I believe that many of these characterize quite well. Especially the score for individualism and uncertainty avoidance are fitting Germany well even more with the given explanation. In my opinion, motivation towards Achievement and success is well fitting for the older generations and is changing in the younger generation towards a more work-life-balanced lifestyle.
I am also unsure about the score about the long-term orientation. This is mostly based on political decisions as these for me mostly seem to be planned till the end of their reign and rarely for me rarely planned beyond this. However, when they are planned for a longer period of time than they seem to set to a point of time where they do not have to act.

Alicia Mailly

We see that France exhibits traits of individualism winning over collectivism. It is particularly represented in large cities and professional domains where independence and autonomy are valued.

Traditionally, France has a high-power distance, with a marked respect for authorities and social hierarchies. France is quite similar to Belgium in this point. Also, France tends to have a long-term perspective in many aspects of its culture, emphasizing tradition, history, and the preservation of cultural heritage.

France has a complex relationship with uncertainty. We value planning, organization, and stability, which is reflected in several area as education or work. I really see myself in the difficulties to deal with uncertainty. My Belbin Test also revealed that about me while working on a project.

2. Project introduction

Kickboxing is a form of martial art, a dynamic and demanding sport that offers numerous advantages for gyms that choose to equip themselves with a rack featuring multiple punching bags. The aim of kickboxing is to develop physical fitness, self-defence skills and also master in martial art proficiency. It enables practitioners to develop strength, endurance, agility, and coordination, while enhancing cardiovascular health and mental well-being. The presence of a rack with multiple punching bags provides gym members with a unique opportunity to engage in varied and stimulating workout sessions, tailored to different skill levels and fitness goals. By outfitting their gym with a rack featuring multiple punching bags, owners can attract new members, retain their existing clientele, and differentiate their fitness offerings by providing a diverse and engaging training experience.

2.1 Project background

The OP-Arena is a sports facility near Vaasa and is a place for many different sports clubs as well as schools. One of these sports clubs is the kickboxing club led by Josefin Stolpe. However, to practice kickboxing to its fullest, the kickboxing team needs multiple kickboxing punching bags. As of now, the OP-Arena has not been able to provide them with these punching bags as standard mounting solutions would evoke new problems. For example, the punching bags are not able to be mounted on the walls as they are not sturdy enough to support them while in use. Furthermore, the punching bags cannot be mounted directly on the vertical steel beams supporting the walls as they would be in the way of other sports practiced inside the hall like basketball and hockey. The same problem would be created by a free-standing punching bag rack as there is no place to put them into while not in use.

Therefore, the project focuses on finding a small-budget solution to these problems and presenting it to the owners of the OP-Arena. If the presented solution is accepted by the owners, then it has to be built and installed inside the OP-Arena.

2.2 Project aim and tasks

The aim of this project is to plan, design, and build a moveable, automated, wall-mounted punching bag rack for 3-4 punching bags.

2.3 Deliverables

1. A design for the punching bag rack which fits the conditions of the OP-Arena and the kickboxing club (moveable, automated, wall-mounted, 3-4 punching bags and under 1000 €)
2. Presenting the design to the owners by a pitch including all the important information
3. Building and testing the rack
4. Installation of the rack in the OP-Arena
5. A user manual
6. A maintenance manual

2.4 Stakeholders

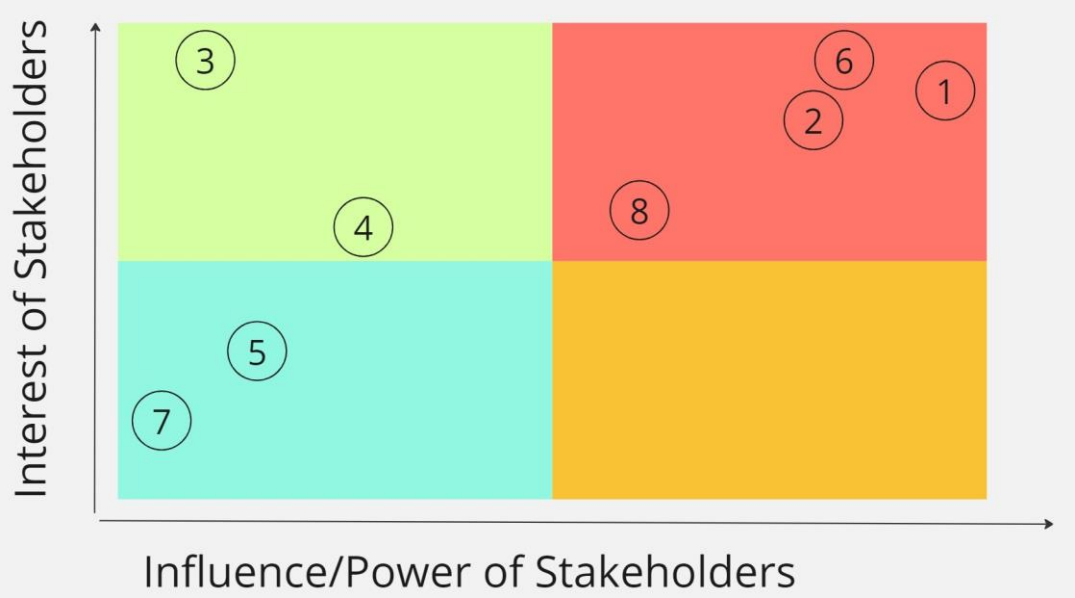


Figure 18 *Stakeholders Matrix*

There are a different persons and institutes involved in in this project which can lead to this project's success or failure. Hereby, all the following have different levels of interest in this project and different levels of power over this project which are visualized in **Figure 18**.

1. Owners of the OP-Arena
2. Josefin Stolpe
3. The kickboxing club
4. The surrounding schools that use the sports hall
5. NOVIA
6. Our project group
7. Our home universities
8. OP-Arena chef (Jukka Sumuvuori)

Here, the owners of the OP-Arena have the most power and a high interest as they are the people deciding whether the project will be financed and hence, realized. It is also their arena they want to improve through the project to get new customers.

Josefin Stolpe has a great influence on the teams as she is the team leader and spends time advising the team during problems and criticizing problems that hinder the teams' productivity. She also has a great interest in the project as she wants her team to be successful. Furthermore, as a member of the kickboxing club, she wants the kickboxing bags in the arena to improve practice.

The kickboxing club and the surrounding schools have a high interest in the project due to them being able to use the kickboxing punching bags to perform their sports, however, they do not have a high power as they only are there to check the security of the solution. The team members' home universities as well as Novia do not have a great interest as the general success of the team members is more important than the project itself. Moreover, only Novia has power over this project as it provides the tools for the project realization.

The OP-Arena chef (Jukka Sumuvuori) has a high interest as he wants to see the arena improve in different kinds of sports. However, he lacks the financial power and interest of the owners and therefore, has less interest and less influence. The team has high interest and high power over the project as they provide the possible solutions and have to pitch them. Furthermore, their grades depend on this project resulting in them wanting to achieve the best possible outcome.

2.5 Risk

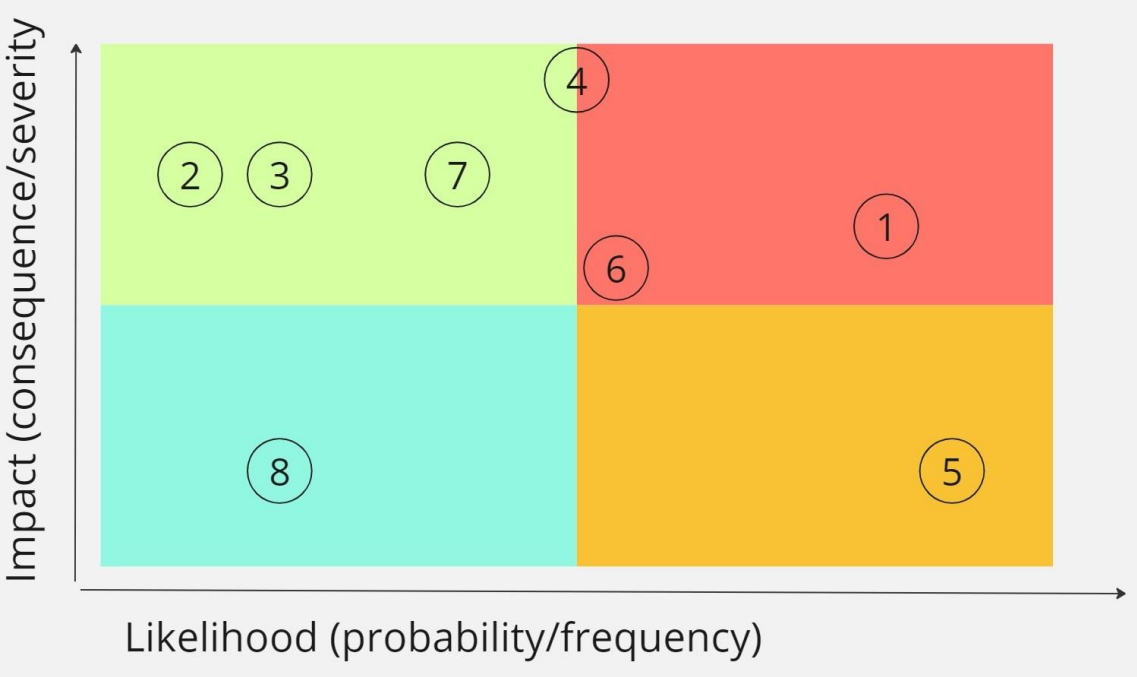


Figure 19 *Risks Matrix*

There are different risks involved in this project. Each one of them has a possibility of occurring and results in various levels of impact starting with a short delay and ending with a forced ending to the project. Their estimated position based on these two attributes can be seen in **Figure 19.**

1. Out of budget
2. Structural integrity
3. Safety for children
4. The unwillingness of the owners
5. Illnesses of team members
6. Materials not on time
7. Tasks not finished on time
8. Technical malfunctions of the automatization

The budget for this project is tight and hence there is a high probability of exceeding it. This can result in taking extra time to collect more money, a downgrade of the final

product due to fewer features, or even lead to the end of the project. If a problem with the structural integrity emerges even though everything beam has been simulated it would have an enormous impact as it would result in an unsafe rack and needs to be redesigned or new beams have to be bought. As children commonly use the arena it is important that they cannot hurt themselves with it. Therefore, in case an unthought of safety risk comes to mind that would result in redesigning the rack and losing all previous work.

The unwillingness of the owners has the highest impact because it would immediately stop the project entirely. Furthermore, it is unclear what decision the owners will take as there has been no communication between them and the team.
The possibility that a team member gets ill is very high, but that only delays the project slightly as the rest of the team will still be able to work.

On the contrary, when the materials are not on time none of the team members will be able to work resulting in a longer delay. Nevertheless, after corona, the possibility of materials being not on time has reduced and is not seen as a threat at all.
A task not finished on time could have great impacts depending on the task which is delayed. For example, if the pitch is not on time it could result in an end to the project. However, if only a small work task is not on time, it would only result in a short delay.

A malfunction of the automatization is seen as unlikely except for human errors while building or maintaining it. Nevertheless, while the rack is in use there is a possibility that people practising there might be unaware of their direct surrounding leading to unintentional kicks or movements against the automatization resulting in a destruction of it.

2.6 Work Breakdown Structure

The project is divided into three main categories which are Research, Design, and Make. Each of the three main categories has different sub-tasks. In the case of the Research, it is divided again into the groups Team and Project.

For this project, the categories Research and Design have to be completed before the Mid-term report due to them being necessary for the Pitch to the owners. This was held before the finalization of the Mid-term report.

Furthermore, the category Make is only able to start after the owners of the OP-Arena accepted the presented solution and hence, it is not certain that the project will get to this point of the project at all.

In this Work Breakdown Structure, the work tasks are already sorted by the time they have to be finished as the research is the first part to get the team working and to find out what different kinds of design would be possible for the arena before starting to find own designs. The entire Work Breakdown Structure can be found in the appendix.

2.7 Scheduling

The schedule has all the work packets of the Work Breakdown Structure. These packets are ordered similarly as they already have been ordered there. However, in the schedule, there are more tasks like the Pitch to the owner, the Mid-term report, and the Final Report, because these are also tasks that have to be done but do not fit in the Work Breakdown Structure. A Gantt chart shows the schedular helping organize the project as it shows the name of the person responsible for each task and the time one is supposed to work on it. Furthermore, it presents the start, the ending date, and the duration. It also visualizes the dates due to a chart spanning the entire time of the project, where the days for a task are marked in a specific colour. The entire schedular can be found in the appendix.

2.8 Project charter

1. General Project Information		
Project Name:	Punching Bags Rack	
Team Leaders:	Josefin Stolpe	
Sponsors:	OP Arena	
Date:	01.02.2024-20.05.2024	
2. Project Team		
Name	**Title**	**Responsabilities**
Alicia Mailly	Project Manager	In charge of planning and executing the project
Elena Cooreman	Secretary + Chief machanical officer	Taking notes of the meetings + mechanical calculations
Magnus Krause	Chief Electric Officer	Research and implement the automatisation
Sheriffa Hamza	Chief Financial Officer	Financial operations and budgeting
Novia UAS	Support Institution	Do formalities and provide access to university tools
Josefin Stolpe	Supervisor	Help with the management of the project
Philip Hollins	Writing format supervisor	Support writing, feedback and stakeholder's manager
3. Project Scope Statement		
Purpose Of The Project		
The aim of our project is to plan, design, and build a moveable automated, wall-mounted punching bag rack for 3-4 punching bags, that is gonna be installed in the OP Arena Hall.		
Objectives		
1) Research the solution that already exist and find if they could be used in this context.		
2) Design options and plans		
3) Calculate the total cost		
4) Order the materials and fabricate the rack		
5) Pilot test rack		
6) Install the construction in the sport hall		
Deliverables		
Usable finished rack for three to four punching bags		
User manual of the rack		
Maintenance manual of the rack		
Scope		
This project includes the planning and building of the punching bag rack with a defined budget of 1000 €. This budget does not include the bags themselves. The rack is only for the OP-Arena and is not supposed to be build for any other company.		

Figure 20 Our Project Charter

3. Research

3.1 Existing solutions

There are already several solutions to mount kickboxing punching bags which are used in different environments and serve various purposes. One straightforward solution is a freestanding kickboxing punching bag mounted on a pedestal like the one seen in **Figure 21**. However, this pedestal needs to be either very heavy or have another locking mechanism keeping them securely to the ground making them very hard to move around. This makes them impractical for the OP-Arena as this duty of getting them into the right place would cost large amounts of energy and time.

Figure 21 *Freestanding punching bag*

Another freestanding solution can be seen in **Figure 22**. There one kickboxing punching bag is mounted on a small movable metal rack. Even though it is lighter compared to the first option, it is still not a perfect solution as it needs more space due to the length of the bottom metal beams to not fall over while someone punches or kicks it. This space can theoretically be available in the OP-Arena, yet it would still take an enormous effort to get the punching bags to the correct part of the arena due to the weight and the unhandy design of these racks. Furthermore, these constructions do not allow the user to circle the punching bag limiting the practice someone can perform on them.

Figure 22
Freestanding punching bag rack

Wall mounting systems are common for punching bags. One of these systems is shown in **Figure 23**. However, these cannot be applied to the OP-Arena as the punching bags would hang into other sports fields when not in use as only the vertical metal beams of the hall can be used and not the walls themselves.

Figure 23 *Wall mounting system*

3.2 Location of the rack

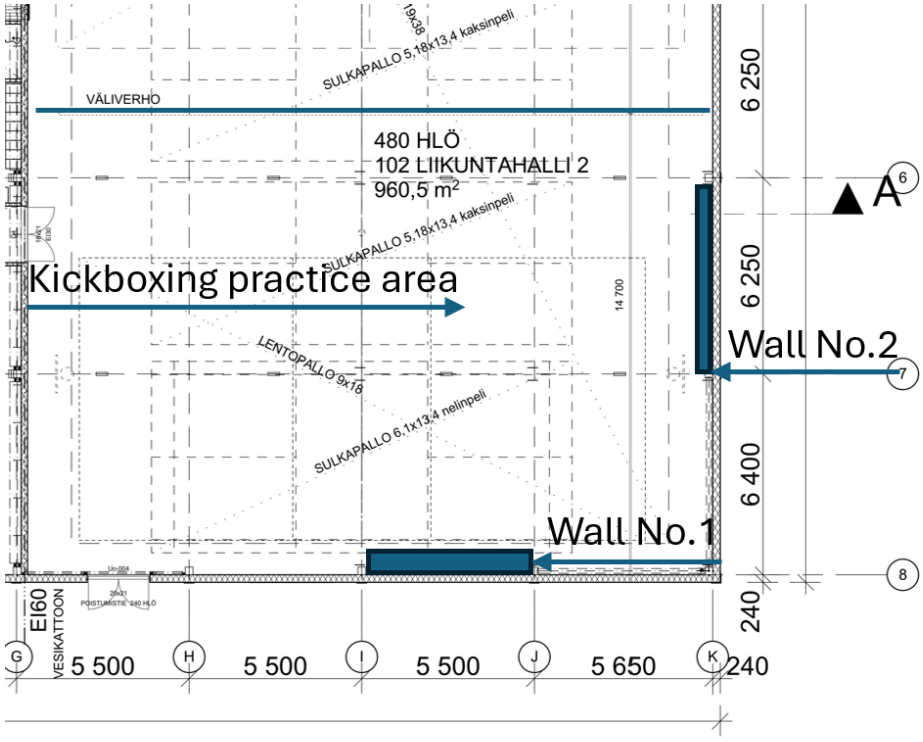


Figure 24 *Plan of the OP-Arena*

The practice of the kickboxing club always takes place in the same area of the arena.
The kickboxing club practices always in the same area of the arena. This area can be seen in **Figure 24**, takes around one-third of the entire arena and is an end part of the arena. Hence, it has three solid walls and a lowerable soft wall which can be used as a separation between the arena parts to ensure an area free of disturbances. Inside this area there are two walls on which beams the punching bag rack could be mounted. These two walls are labelled Wall No. 1 and Wall No. 2, and their location is marked in **Figure 24**. The other walls are not able to be used as they either have a door or a diagonal beam in or in front of them.

Nevertheless, both walls come with little problems of their own when trying to design and mount the rack there. On wall No. 1, for instance, there is a big banner starting at a height of 3.1 m which cannot be placed elsewhere and always has to be visible.

Furthermore, the wall is only 5.5 m small limiting the amount of punching bags that could be installed there. Moreover, the field lines for other sports are close to the wall providing the punching bag rack a narrow space while not in use. Therefore, the design has to follow a lot of rules like being very slim and small as well as not lifting the rack up when not in use. This results in a very limited possibilities and a hard to manufacture and installation of the rack.

Wall No. 2 has a lot of similar problems to wall No. 1 yet they seem less severe. For example, there is a basketball hoop mounted to one of the two beams hindering a direct up-foldable mechanism but has otherwise a lot of space above it. Additionally, the basketball field in front of it also results in a limited space as players will run near the wall. However, the space there is wider than the one on wall No. 1 giving the rack a bit more space while not in use. Similarly, does the situation there allow for a langer rack which could have an easy power excess due to a near power outlet. Hence, for wall No. 1 can more different designs be created which makes it easier to find the best fitting solution for the sports hall. In conclusion, wall No. 1 seems like the wall on which the punching bag rack should be installed on as makes the designing and constructing easier as it does not have as many and as severe limitations as wall No. 1.

3.3 Space needed around the punching bags

Some research regarding the space needed surrounding a punching bag gave the following results.

Firstly, all bags should be at least 0.5 meters from the wall when in use (Punchingbagadmin, 2020). This prevents them from swinging into the wall when someone punches them. However, for optimal use, there should be 1 to 1.5 meters around each punching bag (Imrus, 2021). This way, the user can circle the bag and use it in every direction. When two punching bags are hung side by side, at least 2 metres should be kept between them. This prevents accidents when people use them simultaneously.

3.4 Safety possibilities

There are multiple safety options and security measures which should be followed and thought of especially as the OP-Arena is also used by children starting at the age of six. Firstly, wall-mounted objects should be secured by at least two independently working safety measures against falling. For instance, this can be the connection itself holding the object up. Moreover, the connection should be at least twice as strong as it needs to be to make sure that it not only holds the weight of the object itself but also the weight of persons who might hold on to it. Likewise, another safety measure can be chains that are connected to the top of the object as well as to a nearby wall or a part of the weight can be carried by construction, which is linked to the floor, like a supporting beam.

Moreover, moving objects are supposed to be secured against unintentional movements to the outer application of forces. This can be achieved by using mechanical or electrical breaks. Another option could be supporting beams which can either be external and be put in place after opening or closing, or by putting higher forces on a vertical beam that is unable to move.

For automated objects, a key switch is a good safety mechanism as this allows only authorized personal to activate the mechanism. More importantly however, is that the key switch is installed in a line of sight to the moving object to quickly stop it in case someone walks into the area. Optimally this switch should also be placed in an extra room limiting the access even further. However, this should only be done if the line of sight is not broken.

For an even more advanced automated system, proximity sensors might be a good solution. If it detects objects or people close to the moving or about to be moving object it breaks the current transfer and hence stops the movement until nothing is near the object any longer.

Nonetheless, one of the most important safety measurements would be safety by design. This can be achieved by eliminating the more dangerous solutions from the beginning. For instance, heavy objects should be stored near the ground and next to a wall so that even if a fatal error occurred it would result in less damage and more

importantly a lower risk of injuries due to a more expected fall in less frequently visited areas.

4. Design Process

Pre-designs were created at the beginning of the design process. This way, an informed choice could be made for the most optimal solution. The most lucrative ideas went through several iterations so that they were on point. Afterwards, one design was chosen. This design was further optimised until it was perfect. When this was ready, research was done on the materials needed and where to find them. Finally, a budget was drawn up describing how much this project would cost.

4.1 Pre-designs

Seven pre-designs have been made. These are all fully finished overall designs. They include the choice of which wall will be used, the number of punching bags that can be used and a visual appendix for extra clarity in terms of communication.

Pre-design 1:

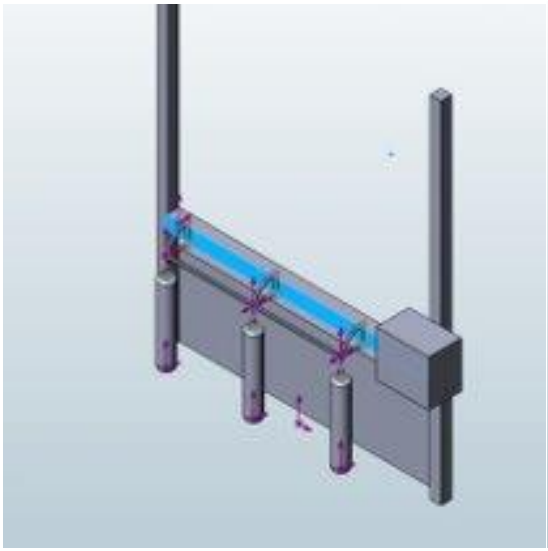


Figure 25 *Concept 1 down*

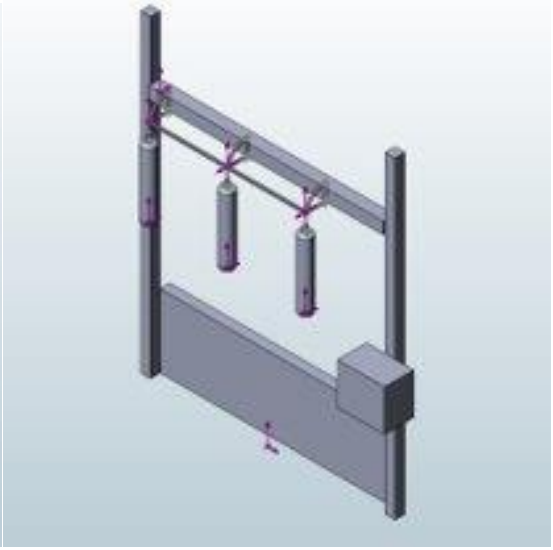


Figure 26 *Concept 1 up*

This first design would be put on wall number two. Three punching bags could be hung on the construction which can be lifted in the air using an electric engine. **Figure 25** shows what the rack would look like when in use and **Figure 26** shows what it would look like when the punching bags are not in use. The punching bags would have a fixed position that is about 0.8 meters from the wall. This prevents them from swinging into the wall when they are hit or kicked. Because of the basketball hoop, it is not possible to add a fourth punching bag and still respect the space needed between two bags. This design is in theory very safe when it is not in use because it is completely out of reach. However, in case of a malfunction, the results on the safety could be huge. This is because a big mass could fall down from a great height. If this design were chosen, several additional safeguards would have to be added.

Pre-design 2:

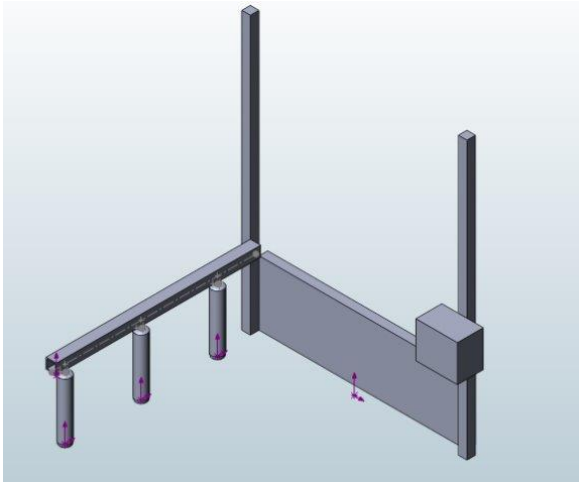


Figure 27 *Concept 2 open*

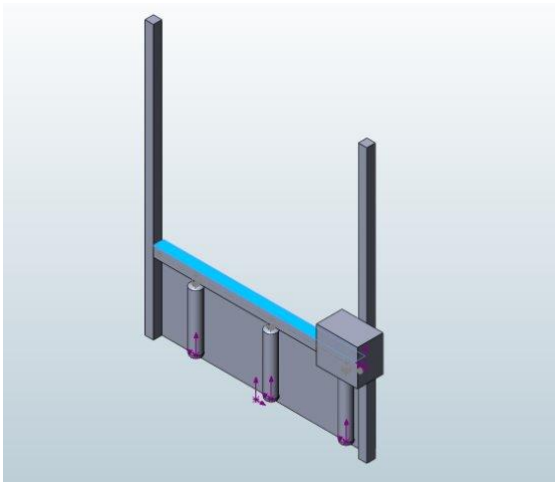


Figure 28 *Concept 2 close*

This design would also be installed on wall number two. On **Figure 27**, there is shown how the construction will look like when in use. The rack could hold up to three punching bags. There is not a lot of material used in this design which would cut some costs. As seen on **Figure 28**, the beam folds into the wall when the punching bags are not in use. This is an easy movement and therefor a save movement. A curtain could be added to prevent people touching or children climbing on the bags when they are not is use. When the rack is in use, it could start moving. Therefore, some extra beams will be needed to receive more structural integrity.

Pre-design 3:

Figure 30 *Concept 3 down*

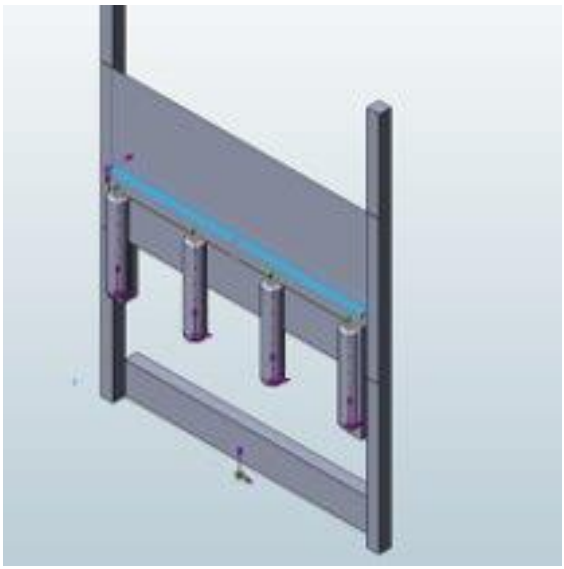


Figure 29 *Concept 3 up*

Pre-design number three would be installed on wall number one. Even though this wall gives less space, with this design it would be possible to install four punching bags as seen on **Figure 30**. By simply turning the rack upwards, the punching bags will be out of reach for anyone using the sports hall as shown on **Figure 29**. However, a big disadvantage of tis pre-design is that the construction would go in front of the existing banner that is hanging in the sports hall. It would be possible to design a mechanism that would lift the banner so that the punching bag rack would fold behind it. This could result in premature wearing out of the banner.

Pre-design 4:

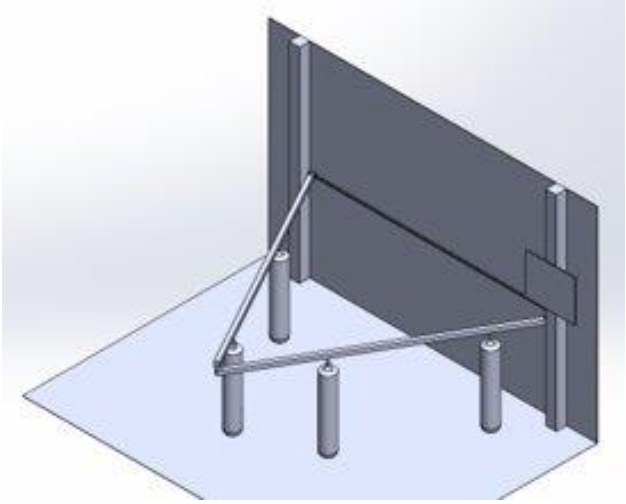


Figure 32 *Concept 4 unfolded*

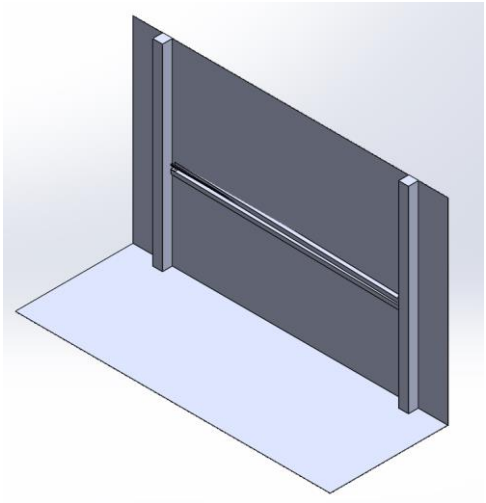


Figure 31 *Concept 4 folded*

Pre-design number four can hold up to four punching bags. It would be installed on wall number two to receive maximal space. On **Figure 32**, it shows how the rack would look when in use. Since it comes far out of the wall, all punching bags could be used optimally. To go from the closed position (**Figure 31**) to the open position, one beam would slide across a rack that is mounted on the wall. This would require a lot of strength from an electrical engine. In closed position, the rack would be completely out of the playing field, and it wouldn't bother any of the other sporters. With an added curtain, it would be completely out of reach.

Pre-design 5:

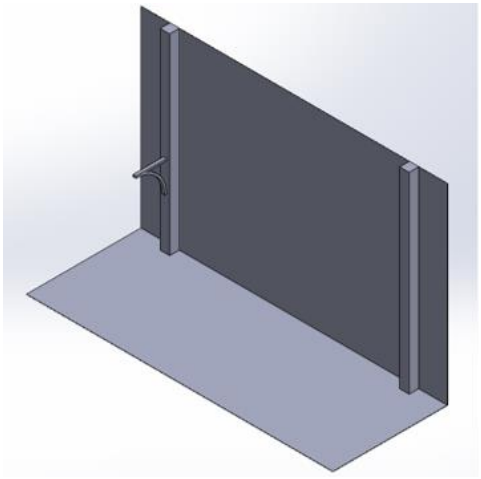


Figure 33 *Concept 5*

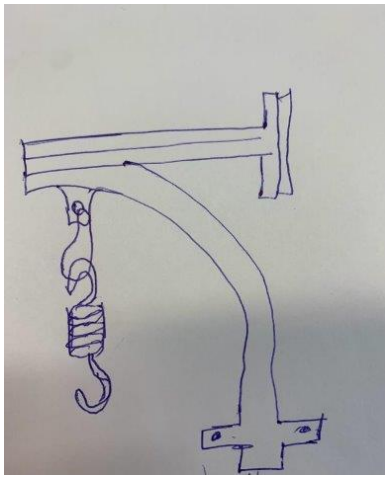


Figure 34 *Concept 5 by hand*

Pre-design 5 is very easy since it would only require the installation of an existing wall mount (**Figure 33**) as shown on **Figure 34**. This does however not meet the requirements of this project.

Pre-design 6:

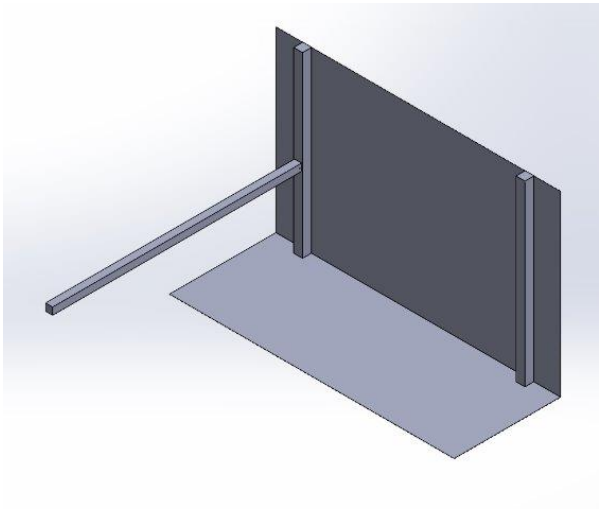


Figure 35 *Concept 6 unfolded*

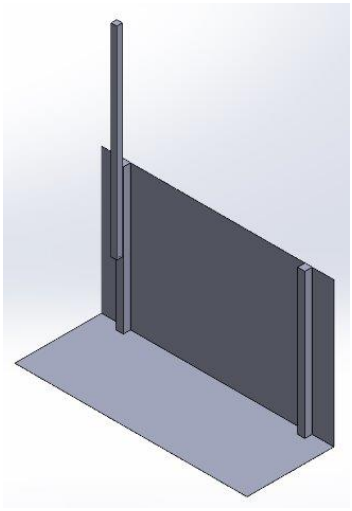


Figure 36 *Concept 6 folded*

This design would be installed on wall number two since it would go in front of the banner on wall number one. It could hold as many punching bags as wanted but the longer it gets, the harder it will be to lift up. On **Figure 35**, it is shown what it would look like when the rack is in use. **Figure 36** gives an idea of what the construction would look like when not in use. Some safety issues can be immediately noticed. In case of a malfunction, a big and heavy beam would fall into the middle of the sports hall with all its consequences. In addition, this concept also requires a lot of power to lift the rack.

Pre-design 7:

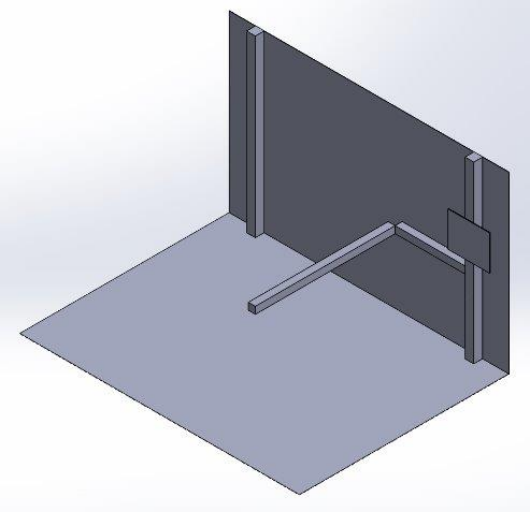


Figure 37 *Concept 7 unfolded*

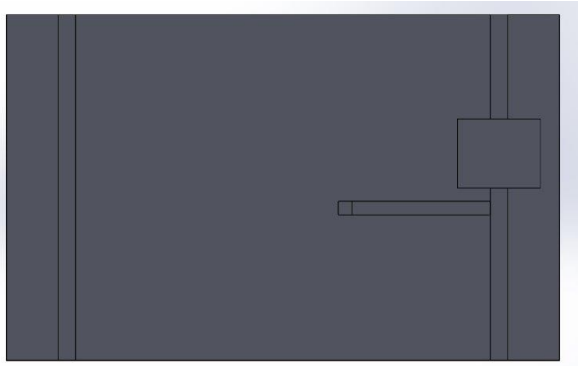


Figure 38 *Concept 7 on the side*

This design is very similar to pre-design 2. **Figure 37** shows what the punching bag rack would look like when in use. Some differences occur between this design and pre-design 2 with strength in mind. By moving the rotation point, the load might get better distributed. Also, the bags would be further away from the basketball hoop as shown on **Figure 38**. This might be an advantage. This concept would however result in less space to hang punching bags. This construction would only be able to hold two, maybe three, bags. This would not be ideal for the kickboxing club.

It was decided to continue with pre-design 4. This design had the most advantages for the user. Some optimalisation will still be necessary to lower the power that is needed to unfold the punching bag rack.

4.2 Optimalisation

To make the design more lucrative, it was decided to remove the rack on the wall and add a foldable beam. A supporting beam with a wheel was also added.

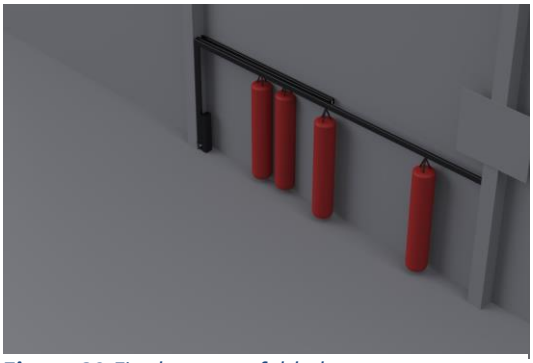


Figure 39 *Final concept folded*

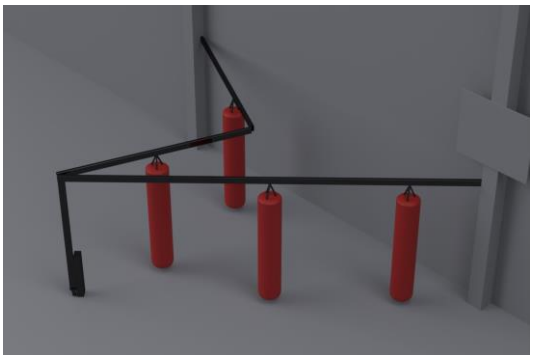


Figure 40 *Final concept moving*

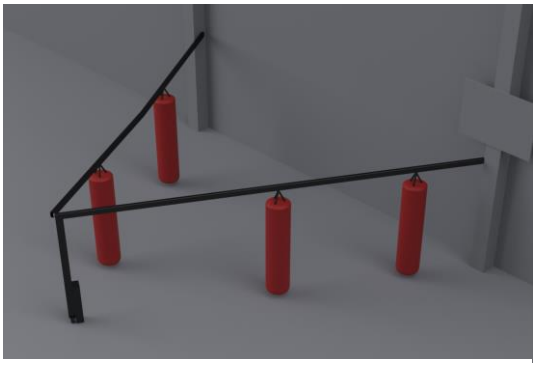


Figure 41 *Final concept unfolded*

Figure 39 to **Figure 41** are showing the different stages of opening the punching bag rack.

Figure 39 shows what the rack will look like when it is closed. All the punching bags are hanging against the wall. This results in a minimal used space since they will only come out about 50 centimetres. No sporters will be bothered by this rack when performing other sports. For safety, a curtain will be added so people cannot touch or climb on the gear.

Figure 40 shows the way the rack will open. An engine will make the wheel at the bottom of the supporting beam turn. It is also possible to open and close the construction manually by grabbing the supporting beam and rolling it out. This means that in case of a power outage, the rack could still be used as normal.

Figure 41 shows what the rack looks like when it is in use. A lock on the unfolded beam will ensure that it doesn't refold while in use. A break on the wheal will also insure that the rack will not start moving. All the punching bags have maximum space around them for optimal use.

4.3 Measurement

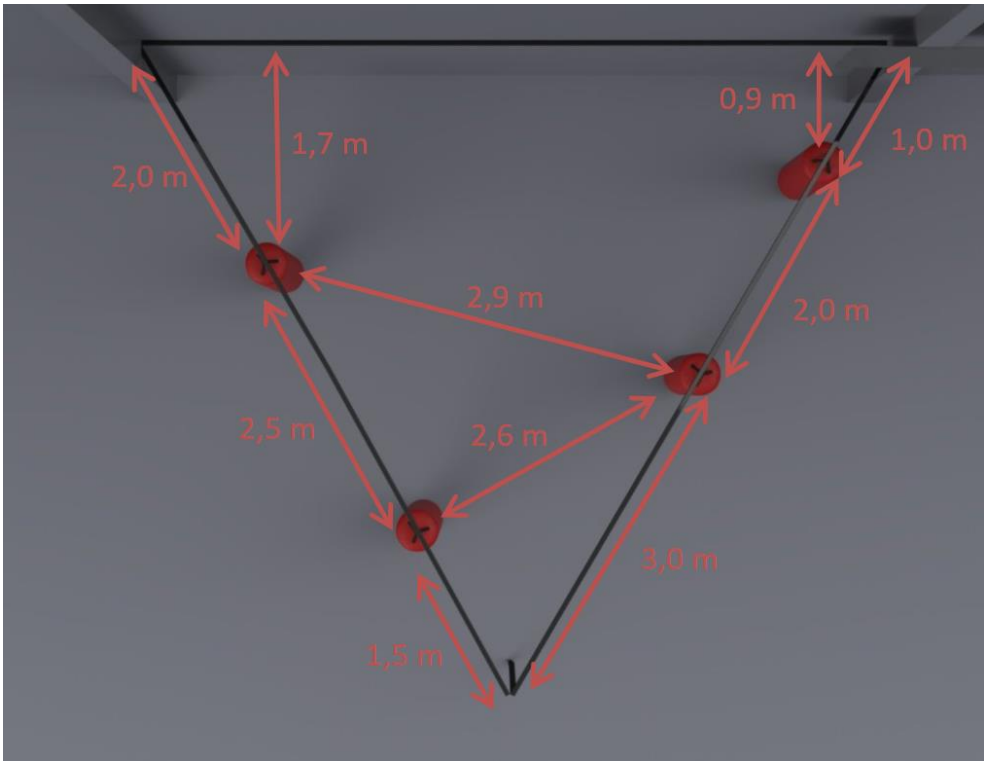


Figure 42 *Measurements within our structure*

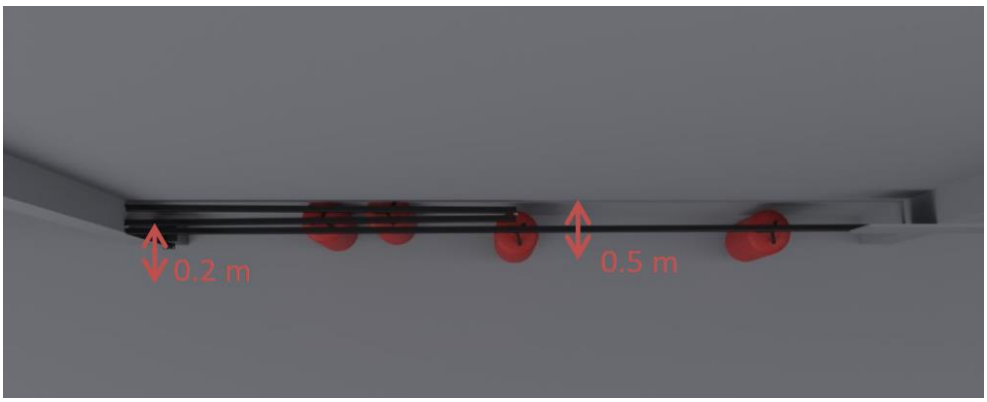


Figure 43 *Measurements within our structure once folded*

Figure 43 shows the measurements between the punching bags when in use. **Figure 42** shows how far the rack will come into the sports hall when the rack is not in use compared to the wall and compared to the supporting beams of the wall.

4.4 Materials

After the final design is optimised and finalised, is it possible to determine what materials are needed and in what quantities.

4.4.1 Beams

Most of the design consist of beams. Therefore, it makes sense to start the search for materials here. One beam of 6 meters, two beams of 3 meters and one beam of 2.1 meter are needed for the chosen design.

Two material options were found. Glued laminated timber, also called glulam or steel. Glulam turned out to be more expensive than steel. It is also more difficult to know what forces it can handle since this depends on the pieces of wood used in the glulam. Therefore, the decision was made to use steel. Steel beams come in lots of different measurement. To decide the perfect dimensions for this project, calculations were made.

First, the forces that will be put on the beams were calculated. They consist of the weight of the punching bags which is 500N per bag. Some extra force was added for safety. For this force, the choice was made to double the weight of the punching bag. This would be the same as hanging a child on it (500N).
For the longest beam of 6 meters, a load of two punching bags plus two children was added. This came out to 2000N.
For the beams of 3 meters, a load of one punching bag and one child was added. This equals 1000N.

To decide what shape and size of beam would be best to hold this load, the program RDM 7 was used. This shows how much the beams bend when put under the given load. Several profiles were tested.
From the profiles available with a length of 6 meters, the one with size 100 x 50 x 4 came out best with a maximum bend of 2.2 centimetres. However, the beam with dimension 100 x 50 x 3 would bend maximum 2.8 centimetres when the load is put on it. This

second beam is a lot cheaper than the first one. Therefore, the choice was made to work with the beam size 100 x 50 x 3.

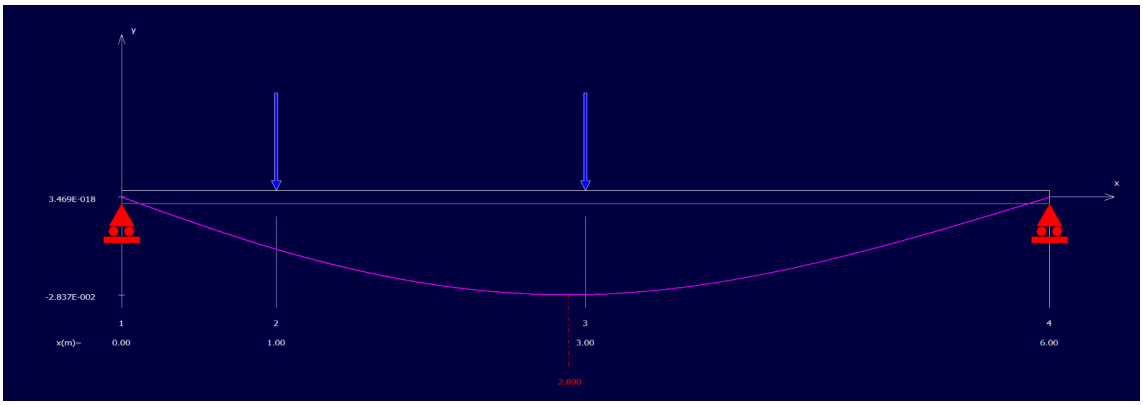


Figure 44 *Forces on the right arm of the structure*

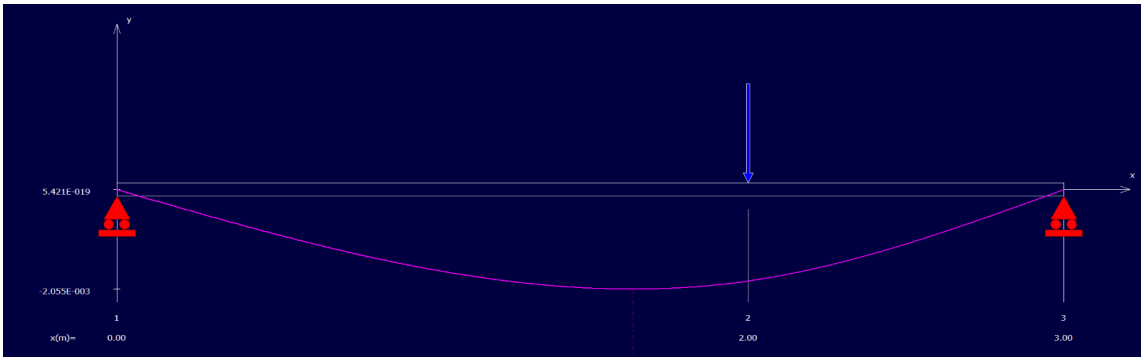


Figure 45 *Forces on the first part of the left arm of the structure*

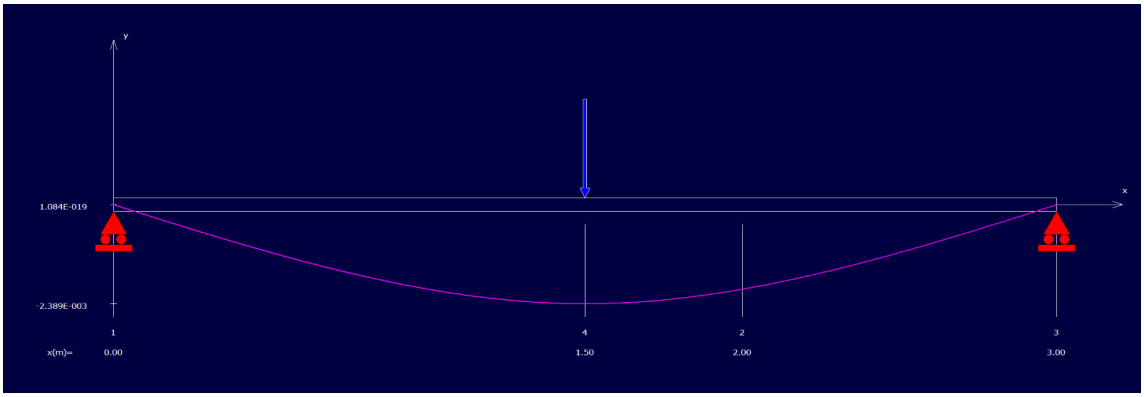


Figure 46 *Forces on the second part of the left arm of the structure*

For the chosen profile, the 6-meter beam will bend 2.837 cm under a load of 2000N (**Figure 44**). The first 3-meter beam will bend 2.055 cm under a load of 1000N (**Figure 45**) and the second 3 meter beam will bend 2.389 cm under a load of 1000N (**Figure 46**). To know whether these deflections are permissible, it is necessary to look at the yield strength. The maximum permissible yield strength for ASTM A36 steel is 250 MPa (Wikipedia contributors, 2024) as seen in the table that can be found in the appendix. As long as the yield strength is less than this, the beam will return to its original state after the given force is applied. When the yield strength becomes greater than the maximum permissible yield strength, the beam will break.

With the help of the program RDM 7, the yield strength on the used beams was calculated. **Figure 47** shows a yield strength of 89.19 MPa on the 6-meter beam. **Figure 48** shows a yield strength of 29.73 MPa on the first 3 meter and **Figure 49** shows a yield strength of 33.45 MPa on the second 3-meter beam. These are all well within the allowed value.

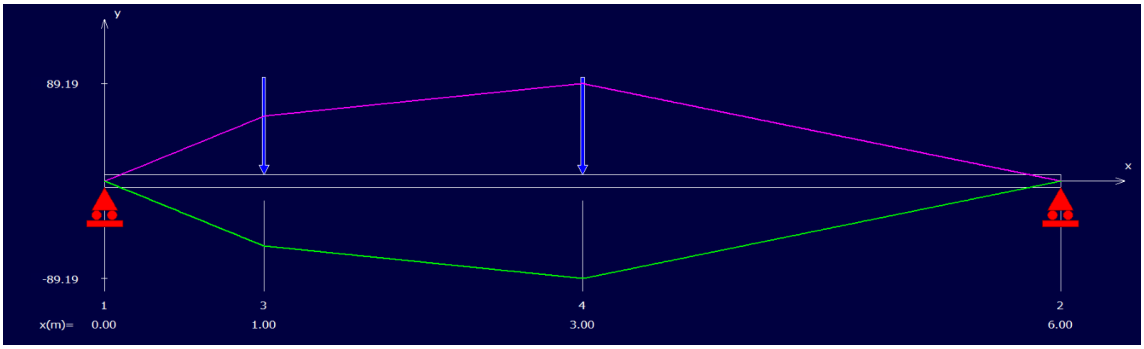


Figure 47 *Bending allowance of the right arm*

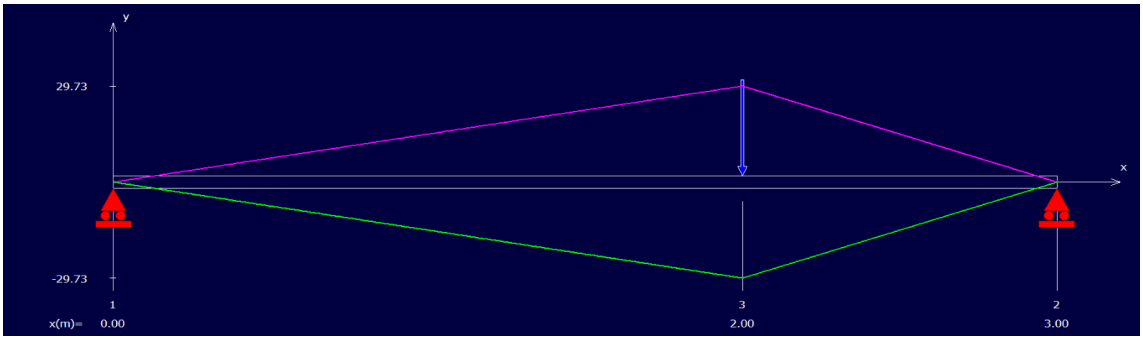


Figure 48 *Bending allowance of the first part of the left arm*

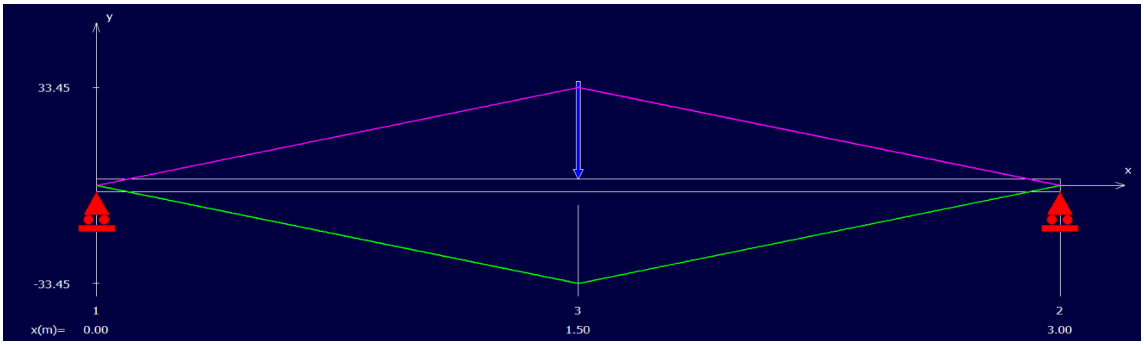


Figure 49 *Bending allowance of the second part of the left arm*

4.4.2 Motor and gearing system

The first step of the choice of a motor and a resulting gearing system is to calculate the needed torque as well as the minimal needed rotation the final gear is supposed to deliver. For the chosen design this came to a torque of 50 Nm and a final speed between 6 rpm and 16 rpm to ensure a safe but not too slow speed of the opening and closing mechanism.

After this, the size of the motor as well as the place where it will stay have to be decided. In this case, the motor could be mounted on a wall beam. There the size and mass of the motor are irrelevant as it does not need to be moved and has enough space to be mounted. However, this would also result in a long gearing system as the rotation would have to be transferred from across the six-meter beam as well as down the supporting beam. Furthermore, the gearing system will become more complex due to the motor being stationary while the gearing system moves together with the rack.

The second option would be to mount the motor on top of the six-meter beam as there is a lot of space which will not be used otherwise. Due to the large space on a horizontal top plate of the beam a large motor can still be used as the beams should be sturdy enough to support its weight and its size fully. Moreover, the gearing system will definitely be easier compared to the first option as it does not move in relation to the motor. However, while the gearing system shortens it is still quite long resulting in many moving parts that have to be covered to prevent damage and potential danger to people getting close to it. Therefore, this solution seems to be a good solution if the gearing system can be built and covered well enough to support in for a long time without harming anyone or anything.

Contrary to the second option, in the third option the motor would be mounted vertically on the supporting beam next to the wheel. One positive aspect there would be that the gearing system could be very compact with comparably few moving parts. However, this can only be achieved by a small-sized motor as it would be mounted to one side of the beam. Furthermore, less space should be used by the motor as big ones have a higher chance of accidentally being kicked and small ones can be mounted more easily on the side due to their lighter weight and the smaller mounting area of the motor as a wide mounting area could interfere with other parts of the rack.

For this rack, the motor on the supporting beam looks the most promising as it results in an easy mounting and gearing system as well as the lowest chance of damaging someone or being damaged. Despite their small size DC-motors with built-in magnet can reach quite high torque outputs and are hence the most logical option here.
Nonetheless, their weakness can be the long-term support as they often use brushes which will wear off after time. However, as this motor only needs to be used comparably few times it should still work for a long time. Even though the motor has a compared high torque output it is not nearly enough to move the entire rack. Hence the motor should come with an included gear.

For this project two types of gear motors which are often used for DC-motors seem fitting. These types are planetary gear motors and spur gear motors. Despite the fact, that companies are able to develop spur gear motors which provide high torques at a high efficiency, are they still favoured in settings were a low torque and a low speed is desired. However, their straightforward design and their low cost make them appeal (ISL Products International, 2022). Contrary to this, planetary gear motors are the most efficient in operations demanding a hight torque and a high speed due to their capability of sharing the forces across the different single gears. However, the high efficiency and endurance is sometimes overshadowed by their size as they are taller and slimer in comparison to spur gear motors resulting in them not being applicable in case of smaller spaces (ISL Products International, 2022).

For this project, a planetary gear motor is seem better fitted as it can come in a very small form factor while maintaining a high translation and efficiency. Furthermore, a planetary gear has high long-term support and should therefore not be worn out before the brushes of the motor.

The hardest problem emerged when searching for a motor with the said specification which also fit the quite small budget of 1000 € as these are mostly industrial DC motors whose prices are only revealed after a request which made it complicated to decide on a possible fitting motor. Moreover, some of the companies never responded due to there being no real company behind this task resulting in a very limited number of motors that can be used for this project. Furthermore, the prices of these motors often started around 800 €. However, there were also two motors online costing around 300€ which have all the desired properties. While this would be a good deal it is not

guaranteed to work as especially these extremely low-price motors cannot be fully trusted.

Hence, there are two options left regarding a motorized rack. First, the rack can be powered by one of the low-price motors where there is no guarantee to work as it is not able to verify beforehand. Else would be to buy a higher price motor which should be more trustworthy than the cheap one. However, this motor would exceed the budget limit enormously while the cheap motor would only be a bit over budget.

The rotation of the motor would first be converted into a rotation around an axis that is perpendicular to it with the usage of a pair of bevel gears. On the shaft of the second bevel gear would also be a chain wheel. This on the other hand is connected through a chain to a second chain wheel mounted to the axis of the wheel. The wheel then will rotate depending on the rotation of the motor. Furthermore, the wheel is also able to rotate while the motor is not in use due to not having a break inside of the motor allowing the rack to also be moved during a power outage. The entire construction of the motor and the gearing system would be covered by a plastic sheet to prevent injuries by the moving parts.

4.4.3 Wheels

In order to fortify the structure and ensure the safe utilization of punching bags, the consideration arose to incorporate a supporting beam affixed to a wheel to facilitate manual movement of the assembly. An exhaustive search for a suitable wheel ensued, encompassing an array of options available in the market. Beginning with the identification of critical criteria such as load-bearing capacity, durability, size, and compatibility with the proposed pillar design, research were conducted. The platform on which the wheel would be mounted emerged as a pivotal factor, alongside the selection of the steel pillar. Extensive research was conducted to pinpoint potential suppliers and manufacturers specializing in wheels equipped with braking mechanisms tailored to our project's needs, aiming to immobilize potential movements of the pillar induced by the swinging bags during athletic activities. Following a thorough comparison of available alternatives, a wheel with a brake was ultimately chosen, meeting our specifications and aligning with project objectives. This methodical research process empowered us to make well-informed decisions and procure the requisite components

to construct a robust and operational pillar system capable of effectively accommodating multiple punching bags.

Figure 50 *Wheel with a break*

4.4.4 Hinges

To create the rack for carrying punching bags, considerations were made regarding hinges to reinforce the pillars supporting the bags. A search for available hinge options suited to the project's requirements was undertaken. Specific criteria, including load capacity, size, and compatibility with the proposed pillar design, were established. Following a comparison of suppliers locally and online, potential hinge manufacturers were identified. After a thorough evaluation and comparison of different hinge options, hinges were selected that met the specifications and objectives, accounting for the forces acting on the rack. The chosen hinges ensure the reinforcement of the pillars, guaranteeing the stability and durability of the punching bag support system. Heavy-duty hinges were ultimately chosen, with three to be used to secure the steel beams.

Figure 51 *Heavy Duty Hinges*

4.4.5 Other

Besides the main materials, some small things will also be needed. This includes a curtain, a lock to put on the folding beam, belts to hang the punching bags on and bolts to attach the hinges to the wall and beams.

5. Realization of the real-life model

5.1 Budget

The OP-Arena was given a few options. The first one included automatization. The estimated cost of this would come to 1986€ since the automatization itself would cost around 1100€. Since the design doesn't require any heavy lifting, the second option would be to get the rack delivered without automatization. The estimated cost than came out to €886.
The customer decided to go for a not-automated version of the punching bag rack. They provided a budget of 886 euros to complete this project. The next materials, shown in figure 52, would be used with this budget in mind.

MATERIAL	QUANTITY	€/PCS	TOTAL PRICE	LINK TO SUPPLIER
Steel beam 6 meters	3	162.00	486.00	supplier
Wheel with break	1	55.18	55.18	supplier
Heavy duty hinges	4	14.74	58.96	supplier
Hooks to hang the bags	4	19.99	79.96	supplier
Lock for folded beam	1	15.99	15.99	supplier

Figure 52 *Material overview*

It was decided to cut the curtain from the design to be able to stay within the budget. The needed budget for these materials comes out to 696,09 euro. This leaves a little space for extra such as metal sheets to attach things and bolts. It also allows the building team to make mistakes and be able to rebuy certain materials if needed.

5.2 Final improvements

To ensure that the design will be strong and stiff enough while in use as well as when handled wrongly, the drawings have been sent to people having experience in building or designing mechanical constructions. While the general concept of the design has been rated very positively, there were also concerns about the safety and security of it. Specifically, the connection between the beams themselves and the wall beams was seen as a weak point in the design for different reasons.

Firstly, it has been criticized that the hinges on the wall beams would have been screwed into the wall beams itself which would reduce the maximal load the wall beams could handle. Therefore, it was advised to use a different connection style there. The easy solution here is to use a small block of steel which is welded to the wall beams. In these blocks, holes allow the hinges to be connected to them with bolts. However, with the steel blocks the hinges are further away from the wall beams reducing the length of the beams holding the punching bags.

Similarly, a named weak point is the bolt connection of the hinges as in the design the bolt only hold onto the hinge itself and one wall of the beams which has a wall strength of 3 mm before being tightened by a nut. This can lead to the bolts being able to withstand less load due to a suboptimal distribution of the forces. Hence, steel plates with holes for the bolts will be welded to the inside of the beams which gives the bolts more material to press against resulting in better force distribution. Therefore, the bolts should then withstand their nominal load and should not be a problem anymore.

For higher stability, it was advised to close the openings of the beams as this would lead to a better distribution of the forces inside the beams. This will be achieved by a lid that has the same height, width, and rounding as the beams. These will be welded once around to the end of the beam creating a solid connection between the two workpieces. Due to the length of the construction, it was suggested to add diagonal beams to it. However, the only place where it is easily manageable is between the supporting beam and the 6 m beam as they do not move relative to each other. At every other possible place, the two beams that would be connected also move relative to each other which would require a sort of hinge themselves. Therefore, only one diagonal beam will be used for the construct.

The final improvement being implemented is a locking mechanism keeping the two 3 m beams straight while in an open position. In the beginning, it was thought about using bent sheet metal which could be slid centrally over both beams. However, this method is not effective as it requires a lot of movement and needs to fit around the hinge making it less secure while in use and loose while folded in. Hence, it was decided to use a door bolt as there only the compared small bolt needs to be moved. Furthermore, it also gives a little support in the vertical direction as the bolt surround by bolt holders or the beam. The downsides to this method are that holes would need to be

drilled into the side of the beams and that the correct alignment of the two bolt holders might need to be adjusted in their positioning to create a collinearity of them as the beams might not be in a straight line when folded out.

One adjustment that received mixed responses from the different people regarded the hinges in general as they need to withstand a lot of torque due to the high masses of the beams and the punching bags as well as the forces resulting from the movement of them. Therefore, it was advised to investigate other kinematic pairs with a focus on ball joints and similar pairs which by design are not affected by torque. However, many of these also result in a vertical movement of the beams which worsens practicing kickboxing at the rack. Hence, it was decided to not use ball joints and to continue with standard hinges.

5.3 Building guide

5.3.1 Measurements and drawings

The drawings have been made with SolidWorks 2023 according to the 3d model of the punching bag rack. For each part that has to be created from a bar stock, there is one document. Furthermore, there are assembly drawings for the three beams with the bolt holders and the lid as well as for the entire rack which shows how the singular pieces are meant to be connected. Parts that will be bought and will not be edited, do not have a document of their own and are only shown in assembly drawings. Due to the design and the placement of hinges, the bolt holders and the wall connectors have two different versions of them as the place of the holes changes by a few millimetres depending on which side of the hinge they are supposed to be on. However, for both parts, the different versions have to be made in the same numbers. The exact quantity of parts that are needed for the full punching back rack is written on the assembly drawing of the punching bag rack.

It is important to mention that the measurements for the holes that have to be drilled into the beams, the bolt holders, and the wall connectors are only applicable to the here chosen components. If the hinges are changed then the place and the radiuses of the holes must be changed according to the new items. Moreover, the lock and the measurements for its holes are only a demonstration as the real chosen lock's

measurements are contradictory and physically impossible. Hence, these measurements which are available online cannot be used for the drawings and would need to be measured by hand to receive the correct measurement. Furthermore, the measurements, especially the ones for the length of the beam and the wall connectors need to be followed precisely since the simulated model was not able to fold flat against the wall in case the beams were altered by a few millimetres. All the drawings can be found under 11.6 to 11.19 in the appendix.

5.3.2 User manual

A user manual is a document that gives the user of a product specific instructions on how to use it. For this punching bag rack, one was also made. It includes a description of the rack, Step by step instructions on how to open and close the rack and a list of things that must absolutely not be done regarding safety of the user. The instructions also come with a series of images to make them clear for users of all ages. It also makes the document more attractive to look at and prevents the user from not using the manual. The full user manual can be found under 11.4 in the appendix.

5.3.3 Maintenance manual

In order to help with the future construction of the punching bag rack, a maintenance manual will be issued by our team having designed the concept of the structure. The maintenance manual is a detailed document that contains specific instructions and procedures to ensure the proper operation, proper cleaning, and durability of the infrastructure. In this case, our team developed a maintenance manual for the metal rack intended to be installed in the OP-Arena sports hall, capable of supporting four punching bags. This manual has been designed to provide a comprehensive guide to gym managers for the care and maintenance of the rack, to ensure its proper functioning and safety over the long term. By providing this maintenance manual, we ensure that the gym has the necessary resources to ensure optimal performance of the rack and provide a safe and satisfying workout experience for its users. The entire maintenance manual can be found in the appendix.

6. Risk assessment

Carrying out a new risk assessment at this stage of our project is of paramount importance, as it allows us to objectively assess the challenges and opportunities facing the project and our team. These challenges mostly arise due to a lack of shared information by the OP-Arena and communication issues when trying to receive this information. By examining the potential risks associated with continuing with the project, due to financial constraints and challenges encountered, the team can make informed decisions about the best path forward. This assessment helps identify specific risks related to continuing the project, such as the risk of compromising the quality of the final product due to budgetary constraints or insufficient resources chosen by the OP-Arena without the team's knowledge. Potential consequences can also be anticipated, such as schedule delays or budget overruns. By considering these factors in the risk assessment, the project team can determine whether it makes more sense to continue on the current path by implementing risk mitigation measures, or whether it is better to withdraw from the project to avoid harmful consequences. As you can see below in **Figure 53**, the risk register was carried out by the team, concerning the stages of the project which cast doubt on the smooth running of the project until its final construction within the OP- Arena.

There are five risks that were considered by the team. The first one is the risk of the materials not being there on time. At the time of making this risk assessment, the likelihood of this happening was already quite high since the team was already running a bit behind on schedule. This happened due to some scheduling issues with the OP-Arena as well as an usure situation about the payment and receive of the materials. If the obtaining of the materials did not happen immediately after making this risk assessment, they would not be there in time to be able to finish the building of the rack before the deadline. Therefore, the impact of this risk is also quite high.

The second risk listed is the risk of not having the right materials. Jukka Sumuvuori, the manager of the OP-Arena, wanted to look for some materials himself in order to try and lower the cost. The team send him a list of the needed materials and their specifications. Jukka found some materials but didn't let the team know which ones, which resulted in the team not having full trust in their specifications. Therefore, there is a likelihood of

this risk happening. The impact of not having the right materials would be very high since this would result in a rack that is not completely safe.

The third risk is not having the right equipment at the workshop. It was decided to use a workshop provided by the customer. The team did not know beforehand what equipment would be available. This means there is a small likelihood of not having the right equipment. The impact of this would be quite high because it would not be possible to finish the rack in time if the needed equipment is not provided.

Fourthly, there is a risk of not getting the right information on time from the OP-Arena. This includes not knowing if materials had already been ordered, when and where they would arrive etcetera. Since it had already been very hard to get a hold of the manager from the OP-Arena, the risk of this happening is quite high. Communication went very difficult up until this point and there were no signs of this getting better in the future.
Lastly, the risk of not being able to go to the OP-Arena when needed was listed. After the construction of the rack would be finished, it is crucial to go to the OP-Arena to install the rack. It was asked multiple times before when this would be possible, but no clear response was given. However, it was believed by the team that this would have been cleared up later on thus the likelihood of this happening is not listed very high.

Considering the five risks that have been listed, they each have a very high level of impact, and more than half also have a high likelihood. It was decided by the team that it was preferable to withdraw from the project with OP-Arena, in order not to be forced by time or budget to provide an unfinished product, or one that could compromise the security of future users. In order to share our design, our research and thus encourage the OP-Arena to pursue their idea of building a punching bag rack, a miniature model will then be built after scaling, as a visualization of our finished project. Both user and maintenance manuals will also be provided to the OP-Arena.

ID	Description of Risk	Impact 1-10	likelihood 1-10	Risk
1	Materials not on time	7	7	7
2	Not having the right materials	10	6	8
3	Not having the right tools in the workshop	8	4	6
4	Not getting information on time	8	9	8,5
5	Not being able to go to the OP-Arena when needed	9	3	6

Figure 53 *Risk Register of going on with the project*

7. Realisation of the miniature model

After the cancellation of the real-life model, it was decided to make a miniature model instead. This would give the opportunity to make the visualisation for external people easier. If made correctly, it could also be used to verify the different aspects of the design.

By making a miniature model, it will be easier for people to see all the different details on the design. It also can give a better idea of the dimensions and how they look next to each other.

The original purpose of the miniature model was to use it for all kinds of verification. The dimensions of the beams and the specifications of the hinges are the elements that were the most needed to verify. For the beams, it could be tested if they were strong enough to hold the weight of the punching bags and more. For the hinges, it could be tested to see it they were strong enough to withstand the forces that would be put on them. However, since the dimensions of the beams were very specific, it was not possible to find the exact scaled down version of them. Therefore, it will not be possible to judge the strength of the beams based on the miniature version. The same thing applies to the hinges. An exactly scaled down model does not exist.

Nevertheless, a few things could be learned from the miniature model. Firstly, it was noticeable that the length of the different beams needs to be measured very precise. If they are a few centimetres or even millimetres too long or too short, it will result in the rack not being able to fully close by a lot. When the real-life model will be build, this is an important thing to keep in mind. Also, it was learned that it is useful for the wheel to

be able to swivel some degrees. If the wheel is totally stuck in one direction, this might cause some difficulties. When the wheel can rotate a bit, this issue is avoided. This is also something that will need to be implemented when the real-life version is build.

7.1 Budget

After the decision of making the miniature model was final, a budget for this was made up. Figure 54 shows all the needed materials, the quantity, the price per piece and the total price per material. The total cost of making the miniature model would come out to 80,81 euros.

MATERIAL	QUANTITY	€/PCS	TOTAL PRICE
Tura tube	2	10.90	21.80
Wheel	1	4.49	4.49
Heavy duty hinges	2	3.45	6.90
Shelving white	1	13.90	13.90
Angle iron	4	0.70	2.80
Nailing plate	4	0.70	2.80
Zinc Hinges	1	8.99	8.99
Screw Hooks	5	3.70	18.5
			80.18

Figure 54 *Miniature model material overview*

7.2 Measurements

As for the construction part of the miniature model, some specific dimensions have been chosen. For the representation of the wall of the OP-Arena, a 100cm Shelving white has been used. The dimensions for the steel beams as for the space between the hooks is the same as the one for the real-life model divided by six. The complete measurements also those between the punching bags can be seen in **Figure 55** while more detailed pictures of it and their specification can be seen in **Figure 56** to **Figure 60**.

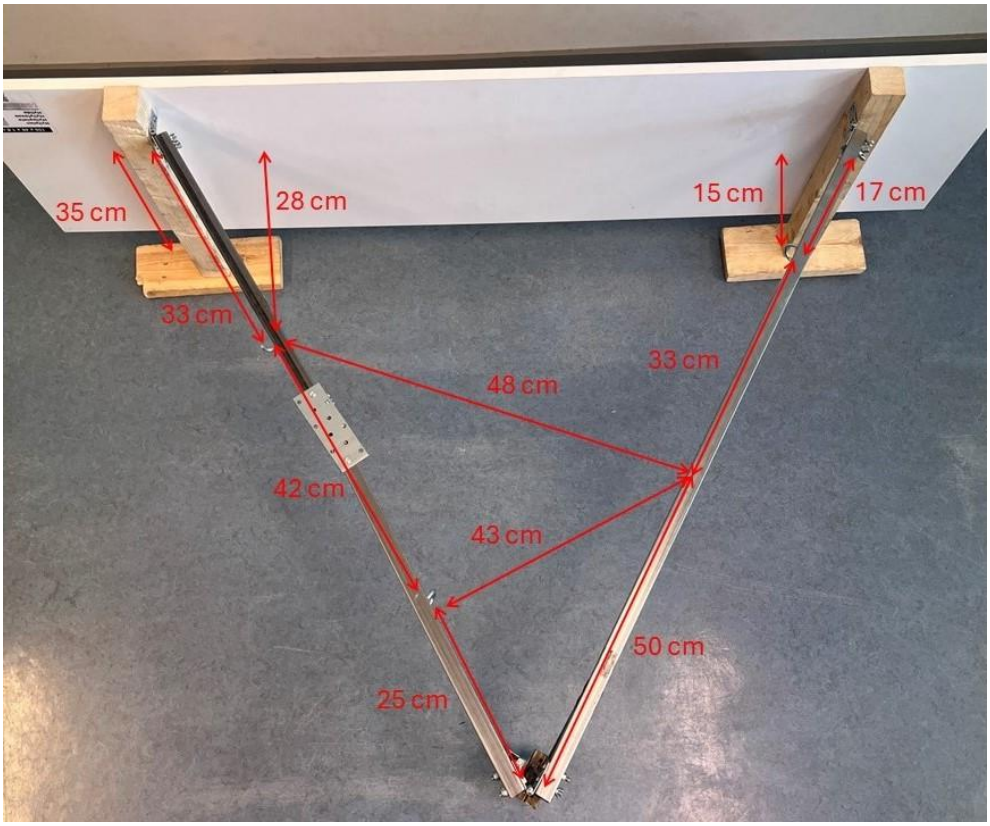


Figure 55 *Measurements of the miniature model*

Figure 57 *Miniature rack folded open*

Figure 56 *Miniature rack folded open*

Figure 58 *Miniature rack side with two beams*

Figure 59 *Miniature rack side with one beam*

Figure 60 *Miniature rack supporting and diagonal beam*

8. Results

As part of the project, several important milestones were reached and achieved significant results. First of all, a pitch to the director and main players of the OP-Arena was made, where two design options were presented to them for the metal rack: one with automation, therefore a motor, and one without. After carefully considering both proposals, they expressed satisfaction with the design and opted for the option without automation. This decision resulted in a change in the direction of the teams focus, as there was no longer a need to implement an automated lifting mechanism, so the team was able to focus on other aspects of the project. This result was essential in guiding the future steps and ensuring that the design fully met the needs and preferences of the OP-Arena.

In the second phase of the project, several difficulties were encountered due to an underestimation of the budget that was initially defined. Faced with this financial constraint, the team had to find new materials that met the quality criteria while being more economical. Despite the research and the time invested, it was unfortunately realized that these alternatives did not fully meet the needs. After careful consideration, the difficult but necessary decision was made to withdraw from the project. It was felt that it was better not to deliver a product that was unfinished or whose integrity was not to be sure of, rather than compromising the quality and safety of the equipment.

After the design nevertheless inspired the OP-Arena, which would always like to see its gymnasium equipped with punching bags, it was agreed that the structure would be built by an individual, outside the teams. The creation of a meticulous design containing all the necessary information and dimensions was therefore carried out. The OP-Arena will also have user and maintenance manuals to enable safety and sustainable use of the rack.

9. Discussion

Personally, the project went well even though we had a few harsh setbacks. For example, the search for a design which consisted of everyone presenting their own ideas and then deciding on the best one lead to a good design. This improved further when the other team members and some expert suggested some changes to make it more practical and safer. We were also able to pitch our idea successfully to the owners of the OP-Arena which took a lot of stress from us for the moment. However, for this we also made a huge mistake as we undervalued the importance of the total price and set it as low as possible and without any spare money to sell our idea to the owners. Only when our minimal price was accepted, and we wanted to start ordering the materials we realized we forgot to calculate in some costs independent from the materials which only improved due to us having overestimated the prices for the hinges by a large margin.
Nevertheless, the biggest setback was that we had to cancel the contract of the building with the OP-Arena due to a bad communication style as well as our lost trust into their managing. This together with the short time span left which was increased even further by us not knowing details about the materials which were expected to be bought or when they were supposed to be delivered left us only one choice. Yet it was still not an easy choice to make and resulted in us being unsatisfied about the project.

After this, the focus on the miniature model and the manuals for the maintenance and usage as well as the focus on possible further improvements which were all received positively by the other team members helped us getting back to work and see the project more positively again. Furthermore, we are happy to see that our design is still supposed to be installed into the OP-Arena even if we are not the people installing it.

10. Recommendations for the future

If another team would have to work on this or a similar project, it would be advisable to like the way this project started. However, it would be good to pay more attention to smaller areas of the rack which often might be seen as default. Here, there should have been a larger focus on the kinematic pairs of the beams and the wall as hinges the most well-known kinematic pairs have been taken for granted. Yet, others might have a lot better choice for this specific task but were not investigated enough. This might improve the rack but also takes a lot more research and more specific knowledge to be applied correctly.

Another part that can be focused on is the advertisement and commercialization of the rack's design as it has been seen as incredible by many independent persons despite its flaws. Hence, it could improve many other sports halls have not enough space for their own (kick-)boxing area. However, before this, the first rack should be installed and tested whether it holds up to promises in terms of safety and useability.

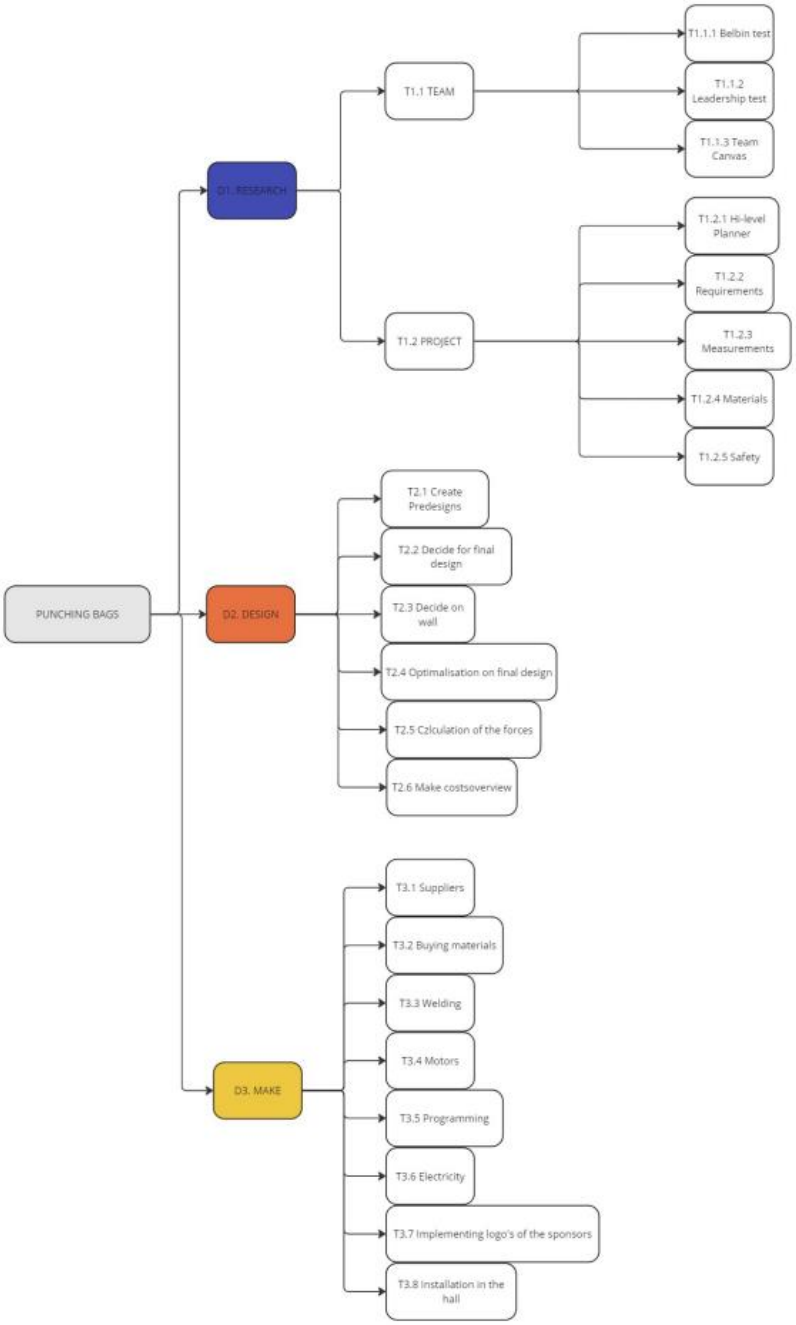
The biggest advice that can be given however is to keep a clear communication with the customer and simultaneously keep them updated about everything while demanding every important information which is needed for designing and building. Here, very important aspects are the financing, the buying, and the delivery of the materials as without these the expected schedule cannot be maintained which might lead to a cancellation of the project.

11. Conclusion

As part of the European Project semester, our team worked on the project untitled: Punching Bag Rack. The goal of this project was to imagine and design an automated or non-automated rack that could support up to three or four punching bags. This project was a real challenge for the team. Its achievement was very enriching and fruitful. First of all, each member, in their home university, studies a different field, which is why we had to pool our knowledge. Furthermore, no member of the team has any real construction skills, which was one of the group's main concerns. Thanks to the collaboration and commitment of our team, we managed to design, implement and finalize equipment that meets the specific needs of the OP-Arena sports hall. The creation of the rack has also required a lot of research and numerous changes due to the complexity of the arrangement in the sports hall of the OP-Arena. We had to respect certain conditions, such as optimizing space, so as not to interfere with the practice of other sports, or the safety aspect of the rack, due to the presence of young children within the sports area. The creation of several designs allowed each of us to bring a touch of innovation to the finality. Unfortunately, due to lack of time and a tight budget, we were unable to complete the construction within the OP-Arena. This project and its design having convinced the majority of the actors linked to its realization, the metal rack will then see the light of day thanks to an external actor who will use our designs, materials and dimensions in order to offer the OP-Arena the rack that we have developed. Through the miniature model, it is also possible to concretely observe the finished object, in order to provide a better understanding of its use. In addition, the team will provide a user manual, as well as a maintenance manual to allow the easiest and most optimal use of the rack. The latter not only adds a new dimension to the gym's training offering, but it also offers users a unique opportunity to improve their sporting practice in a secure and controlled environment. We are confident that this equipment will significantly contribute to the user experience of the OP-Arena gym and we look forward to seeing the positive results it will bring. Finally, we would like to express our gratitude to all the people who contributed to the success of this project, from the point of view of the school and the OP-Arena.

12. Appendix

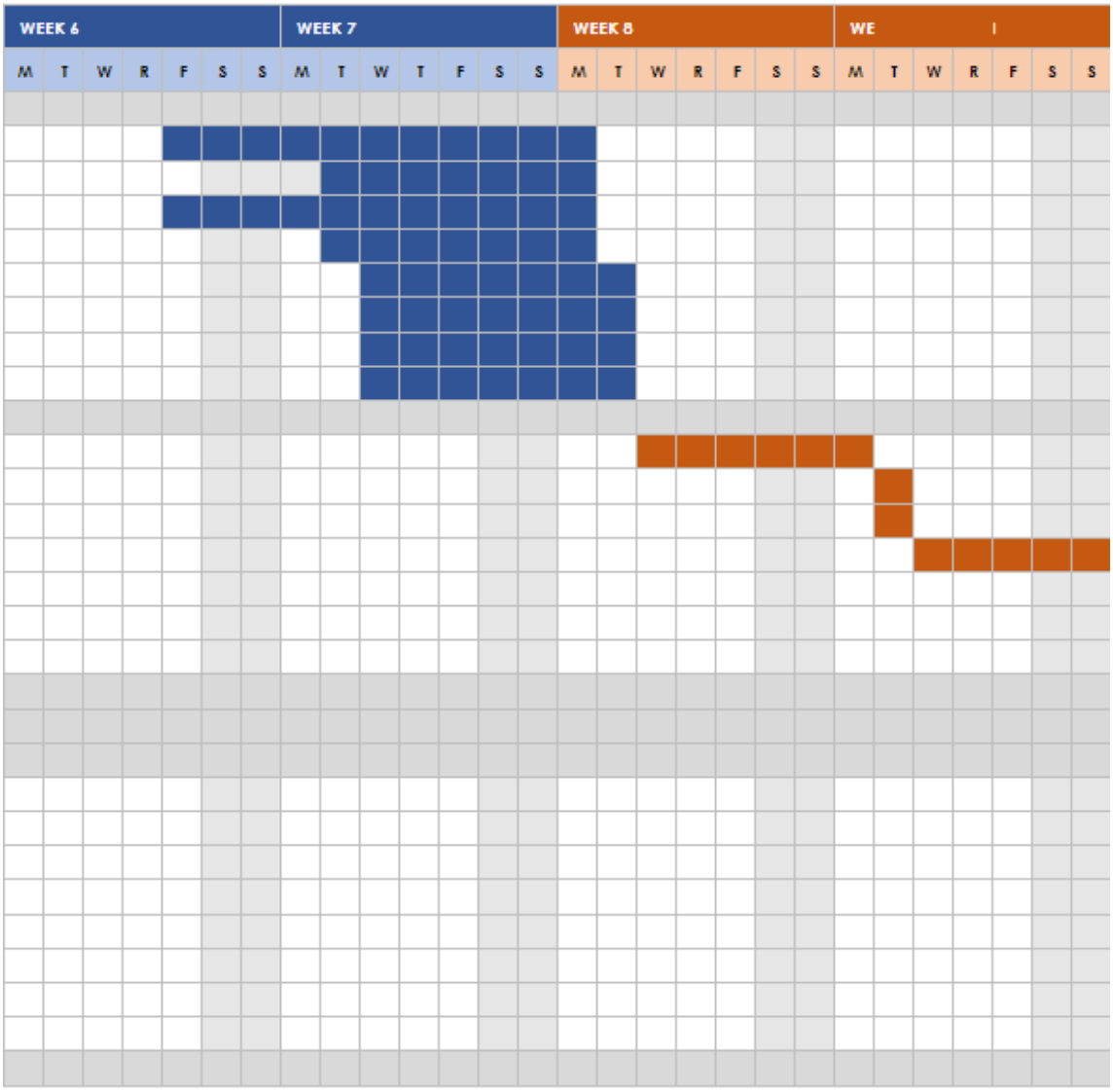
12.1 Work Breakdown Structure



12.2 Scheduler

PROJECT TITLE	Punching Bags Rack
PROJECT MANAGER	Alicia MAILLY
DATE	2024-02-22

WBS NUMBER	TASK TITLE	TASK OWNER	START DATE	DUE DATE	DURATION	% of TASK COMPLETE
D 1.	Team dynamics and Research					
T 1.1.1	Belbin Test	Everyone	09.02.2024	19.02.2024	11	100%
T 1.1.2	Leadership Test	Everyone	13.02.2024	19.02.2024	7	100%
T 1.1.3	Team Canvas	Everyone	09.02.2024	19.02.2024	11	100%
T 1.2.1	Hi-level Planner	Everyone	13.02.2024	19.02.2024	7	100%
T 1.2.2	Requirements	Elena	14.02.2024	20.02.2024	7	100%
T 1.2.3	Measurements	Alicia	14.02.2024	20.02.2024	7	100%
T 1.2.4	Materials choice	Sheriffa	14.02.2024	20.02.2024	7	100%
T 1.2.5	Safety issue	Magnus	14.02.2024	20.02.2024	7	100%
D 2.	Designing					
T 2.1	Create Predesigns	Everyone	21.02.2024	26.02.2024	6	100%
T 2.2	Decide for final design	Everyone	27.02.2024	27.02.2024	1	100%
T 2.3	Decide on the wall carrying the rack	Everyone	27.02.2024	27.02.2024	1	100%
T 2.4	Optimalisation on final design	Everyone	28.02.2024	05.03.2024	7	100%
T 2.5	Calculation of the forces	Elena - Alicia	05.03.2024	07.03.2024	3	100%
T 2.6	Make costsoverview	Sheriffa	07.03.2024	08.03.2024	2	100%
	Make the pitch	Everyone	09.03.2024	11.03.2024	3	100%
	Pitch to the owners	Everyone	13.03.2024	13.03.2024		100%
	Midterm Report	Everyone	14.03.2024	22.03.2024		100%
D 3.	Making					
T 3.1	Suppliers	Alicia - Elena	23.03.2024	26.03.2024	4	0%
T 3.2	Buying materials	Magnus - Sheriffa	26.03.2024	26.03.2024	1	0%
T 3.3	Welding and construction	Everyone	08.04.2024	20.04.2024	13	0%
T 3.4	Motors	Everyone	21.04.2024	21.04.2024	1	0%
T 3.5	Programming	Magnus	22.04.2024	26.04.2024	5	0%
T 3.6	Electricity	Magnus	27.04.2024	29.04.2024	3	0%
T 3.7	Implementing logo's of the sponsors	Everyone	29.04.2024	29.04.2024	1	0%
	Installation in the hall	Everyone	02.05.2024	04.05.2024	3	0%
	Final Report	Everyone	06.05.2024	16.05.2024		


WEEK 6
WEEK 7
WEEK 8
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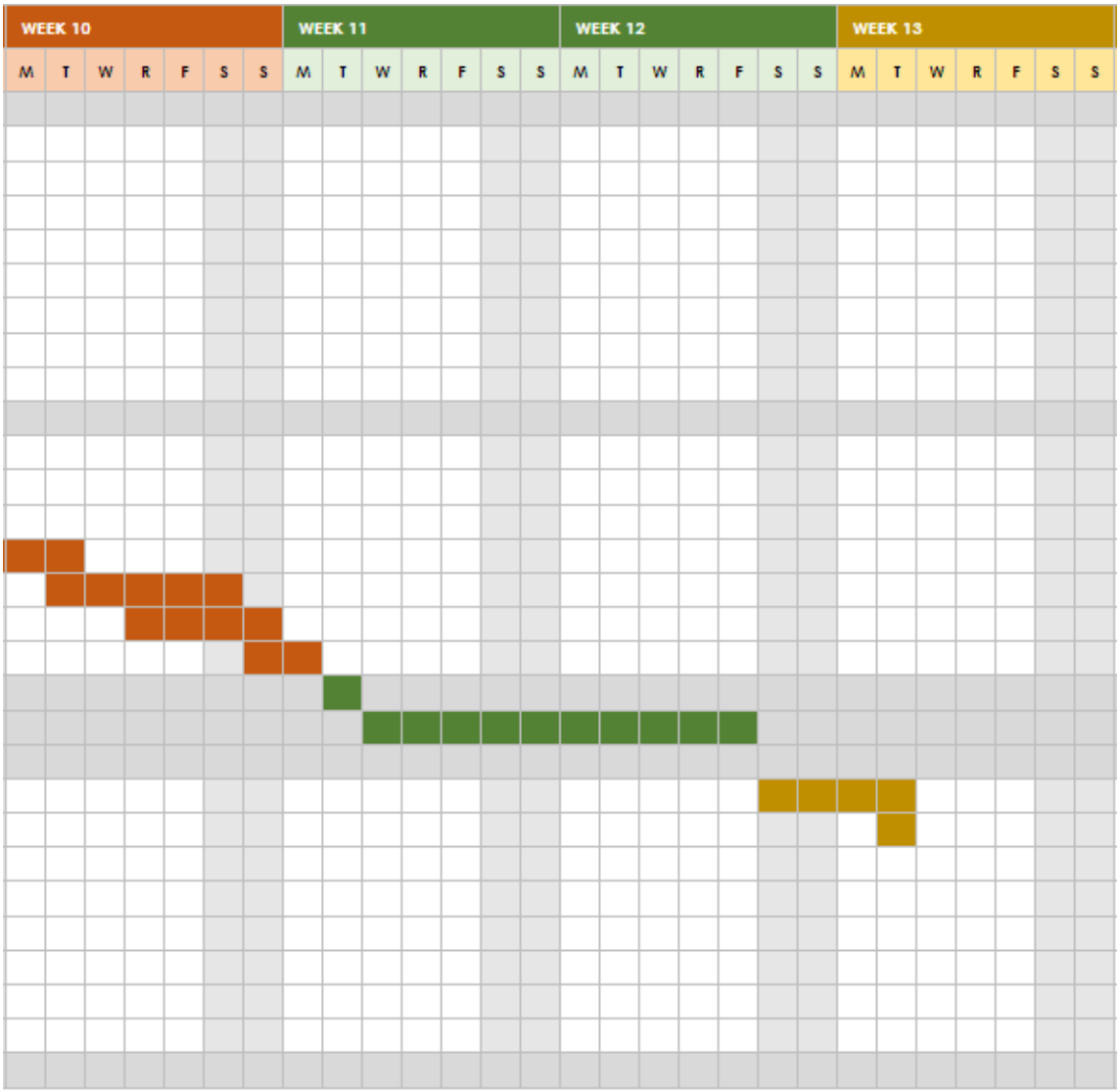
M T W R F S S M T W T F S S M T W R F S S M T W R F S S


WEEK 10
WEEK 11
WEEK 12
WEEK 13
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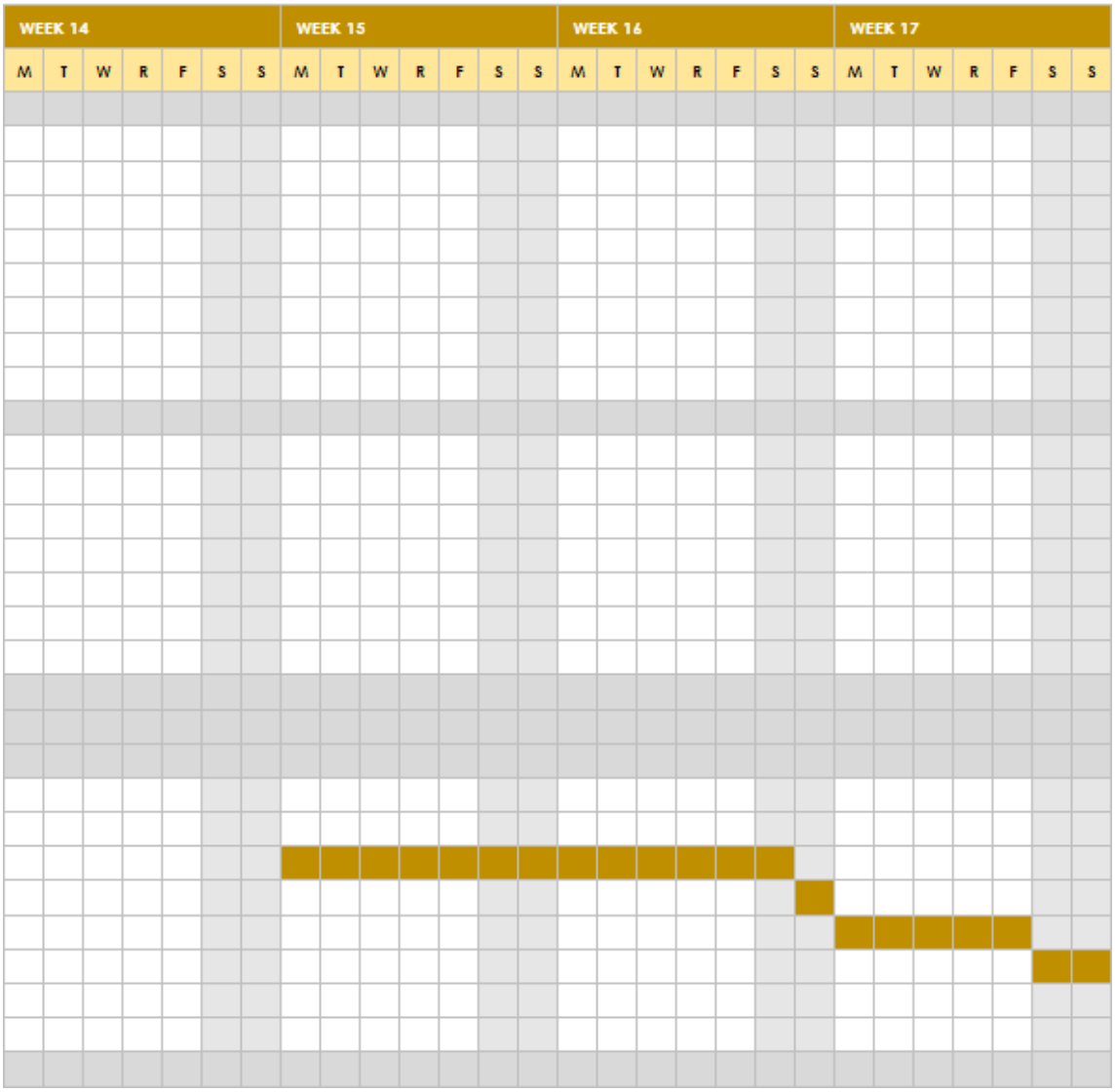
WEEK 14
WEEK 15
WEEK 16
WEEK 17
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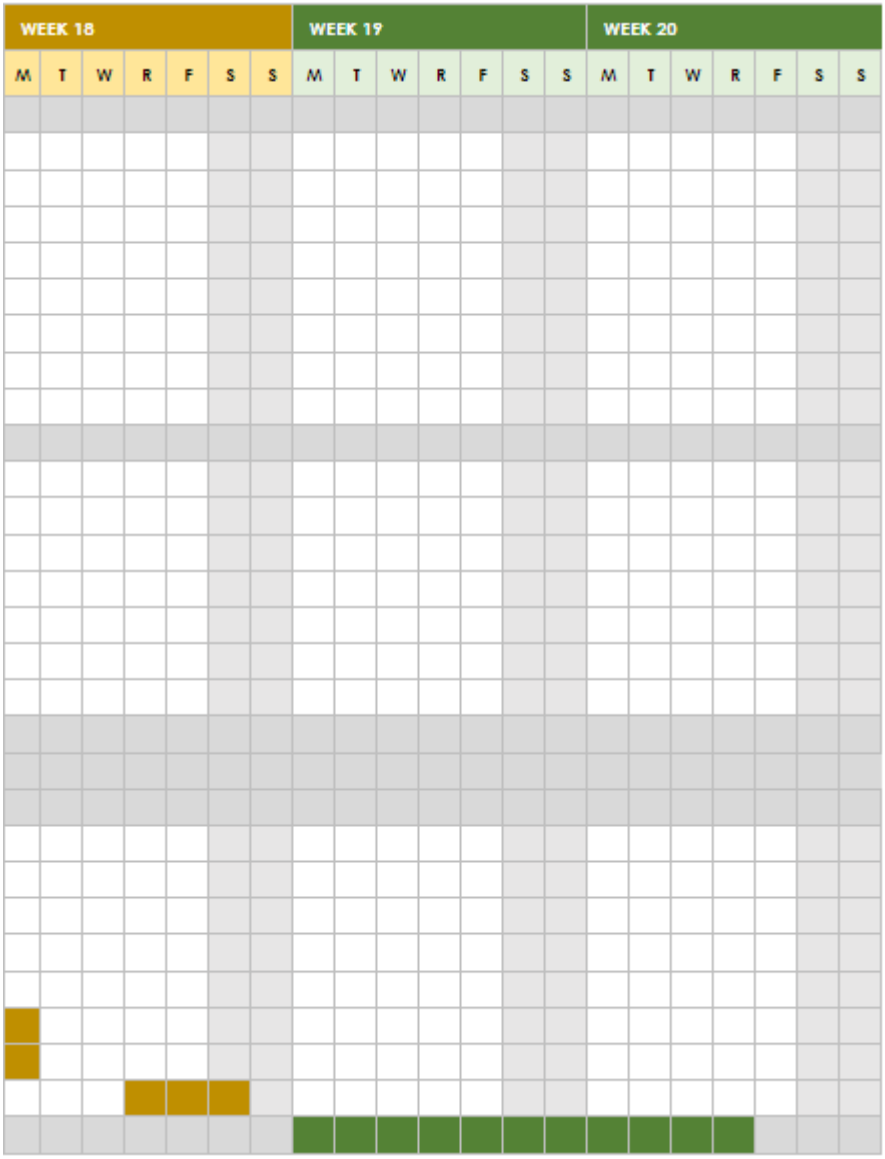
WEEK 18
WEEK 19
WEEK 20
M T W R F S S
M T W R F S S
M T W R F S S

12.3 Yield strenght

Material	Yield strength (MPa)	Ultimate strength (MPa)
Carbon fiber (CF, CFK)		5650[3]
Piano wire		1740–3300[2]
Tin (annealed)	9–14	15–200
Polypropylene	12–43	19.7–80
Nickel (annealed)	14–35	140–195
Aluminium (annealed)	15–20	40–50[8]
UHMWPE[5][6]	20	35[7]
High-density polyethylene (HDPE)	26–33	37
Copper (annealed)	33	210
Nylon, type 6/6	45	75
Copper 99.9% Cu	70	220
Iron (annealed)	80–100	350
Titanium (annealed)	100–225	240–370
Bone (limb)	104–121	130
Cupronickel 10% Ni, 1.6% Fe, 1% Mn, balance Cu	130	350
Cast iron 4.5% C, ASTM A-48[4]	172	
Tantalum (annealed)	180	200
Brass	200+ ~	550
ASTM A36 steel	250	400
Aluminium alloy 2014-T6	400	455
Steel, API 5L X65[1]	448	531
Silkworm silk	500	
Stainless steel AISI 302 – cold-rolled	520	860
Tungsten (annealed)	550	550–620
Steel, high strength alloy ASTM A514	690	760
Titanium alloy (6% Al, 4% V)	830	900
Spider silk	1150 (??)	1400
Steel, prestressing strands	1650	1860
Aramid (Kevlar or Twaron)	3620	3757
Silicon (annealed)	5000–9000	

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12.4 User Manual

User manual
European Project Semester Spring 2024

Punching Bag Rack

University: Novia University of Applied Sciences
Team Members: Elena Cooreman, Sheriffa Hamza, Magnus Krause, Alicia Mailly
Supervisor: Josefin Stolpe

Table of Contents

1 Description of the product

This rack is specifically designed for the OP Arena at Sepänkylä. When deployed, it allows 4 people to use the boxing balls.
The rack is designed to sit completely against the wall when not in use. When athletes want to use the boxing balls, the rack can be unfolded.
this document contains detailed instructions on how to use this rack.

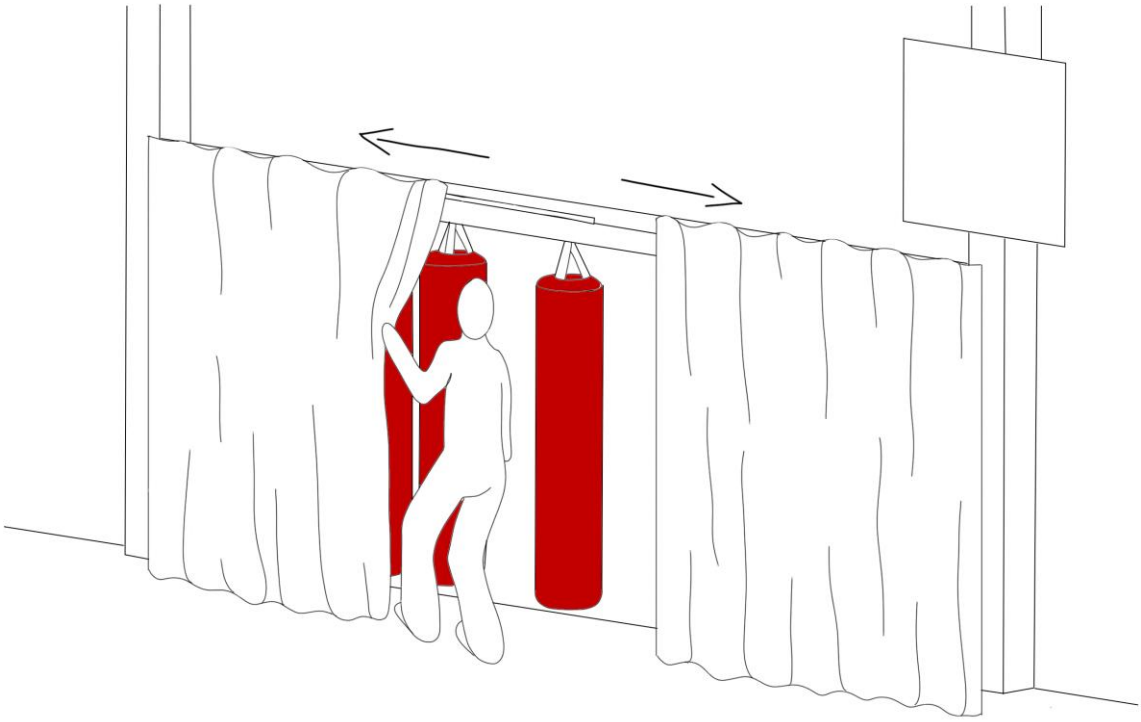
2 How to use

3.1 Opening

1. Check for open space

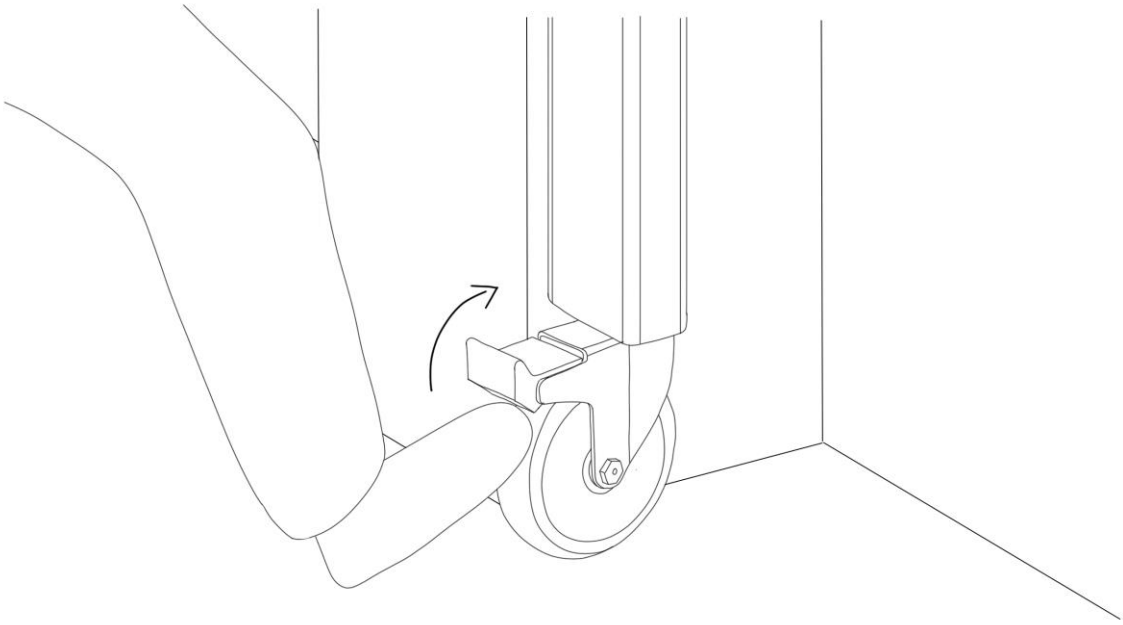
Before starting the installation of the rack, you must look around and make sure that there is no one within five meter of the rack. If no one is there, the proces of opening the rack can be started.

2. Open curtain



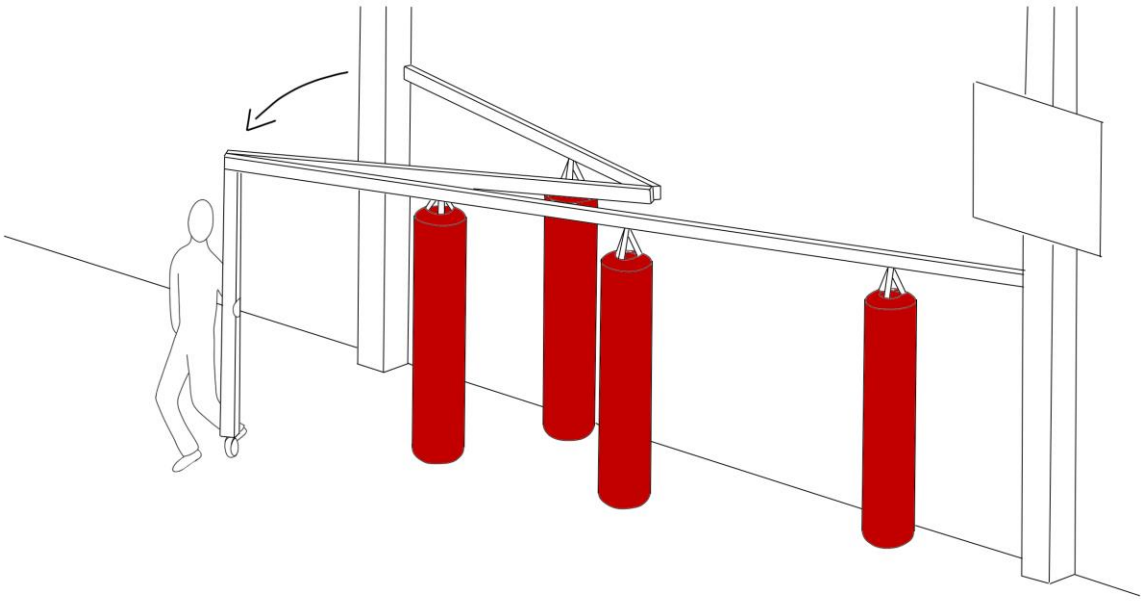
First, the curtains must be slid open. Make sure that they are completely out of the way. There must be nothing left in front of the rack.

3. Release break



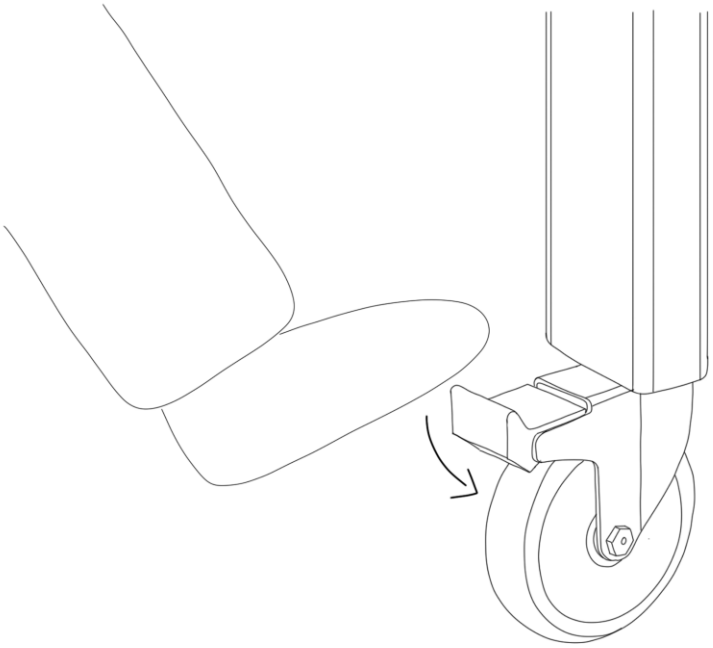
Next, the break on the wheel must be released. This is best done by using your foot. Simply push the break upwards.

4. Grab supporting beam and roll the construction open



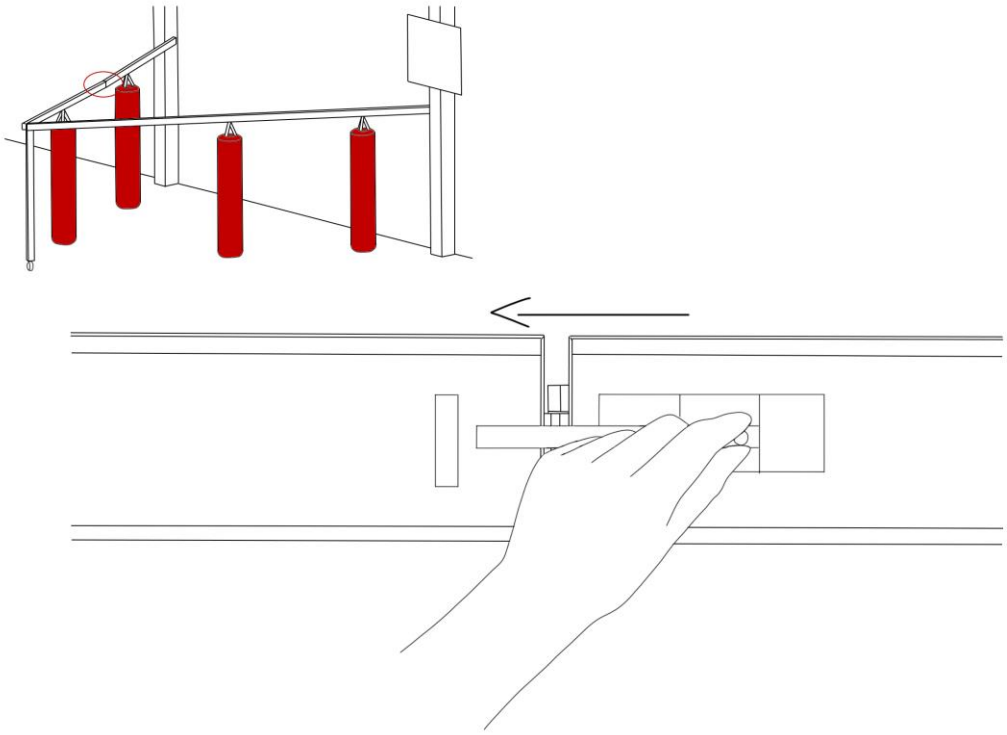
Grab the supporting beam and roll the constructing until the folded beam is completely in a straight position.

5. Put break on wheel



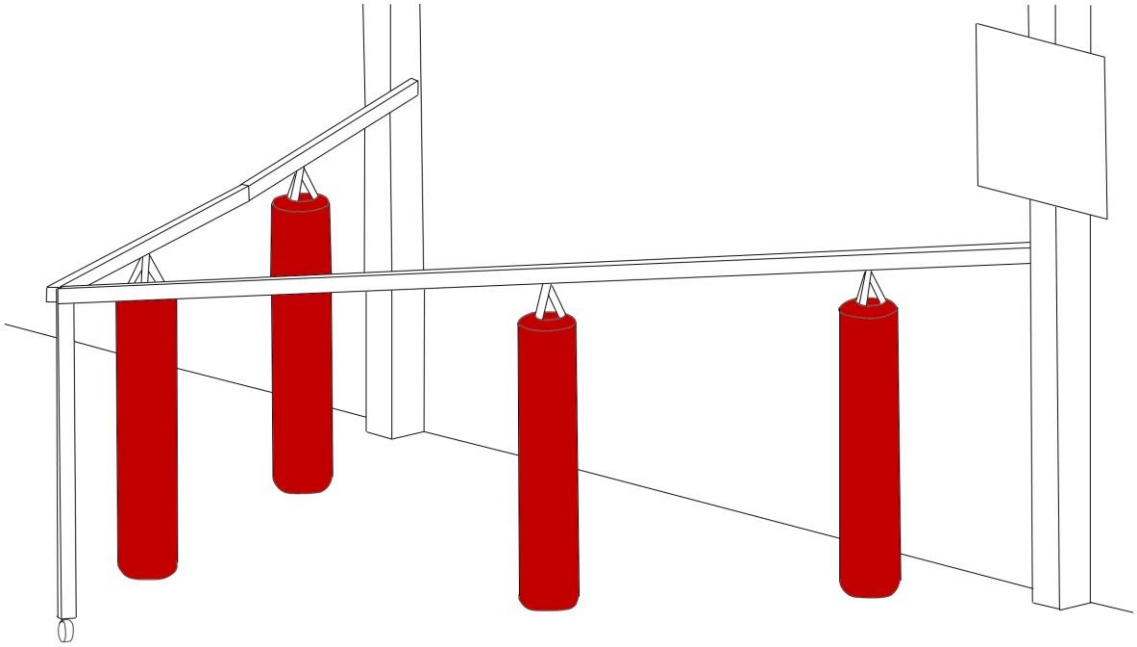
The following step is to activate the break on the wheel again. Do this by puching the break down with your foot.

6. Lock folding beam



After securing the wheel, you must lock the folding beam. DO this by sliding the lock over the fold and into the lock holder.

7. Check that everything is properly locked in position



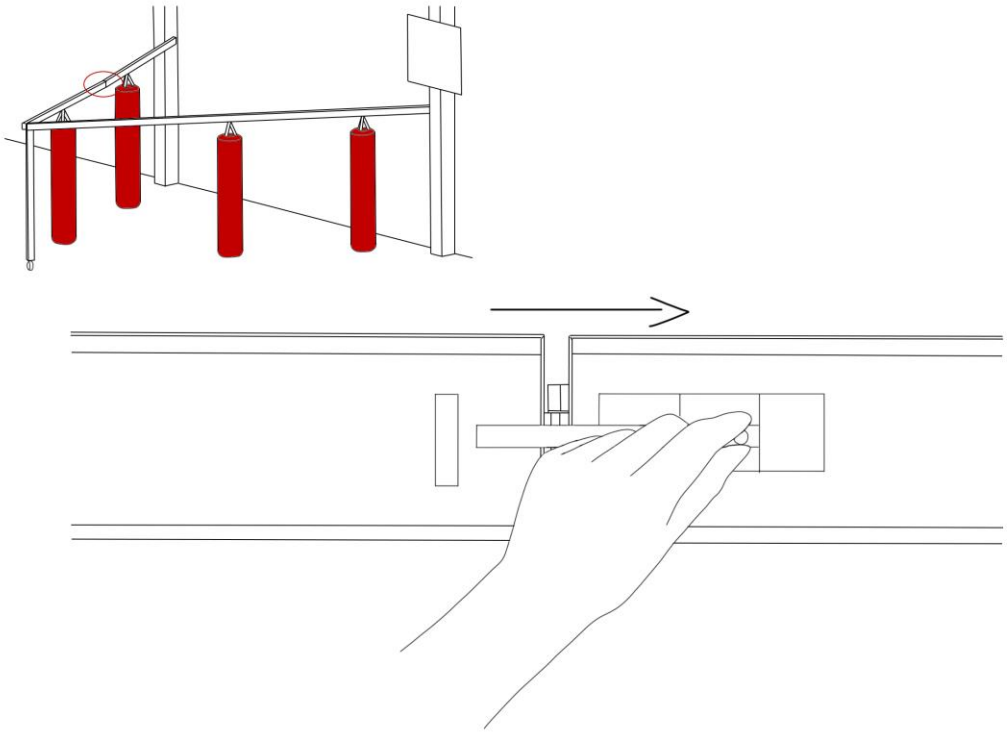
Now that the rack is completely installed, it is important to do a final check to make sure nothing is moving around. After this, the rack is ready to be used.

3.2 Closing

1. Check for open space

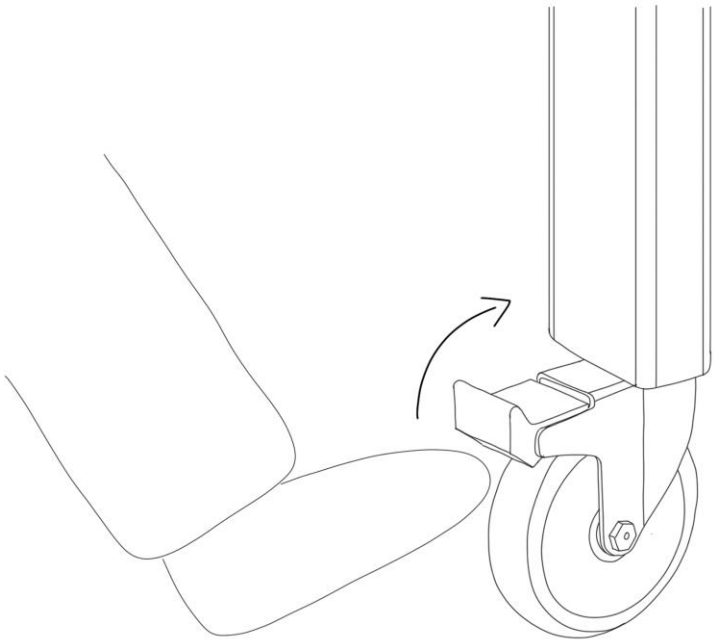
Before starting to close the rack, it is important to check that no one is within one meter of the rack.

2. Open lock on folding beam



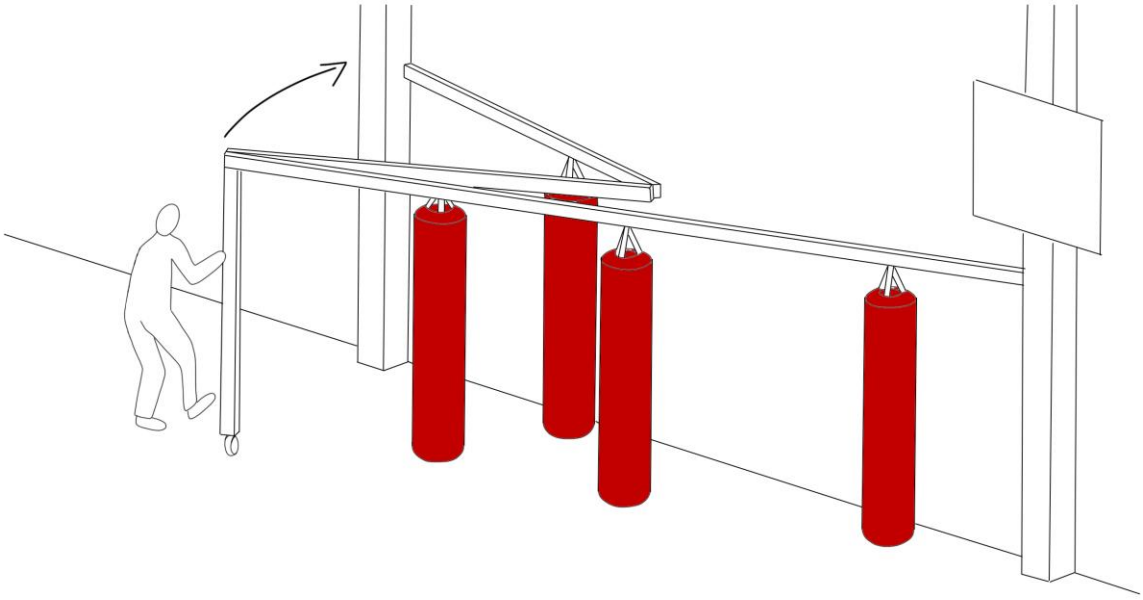
First, you must unlock the folding beam. This can be done by sliding the lock away from the fold.

3. Release break



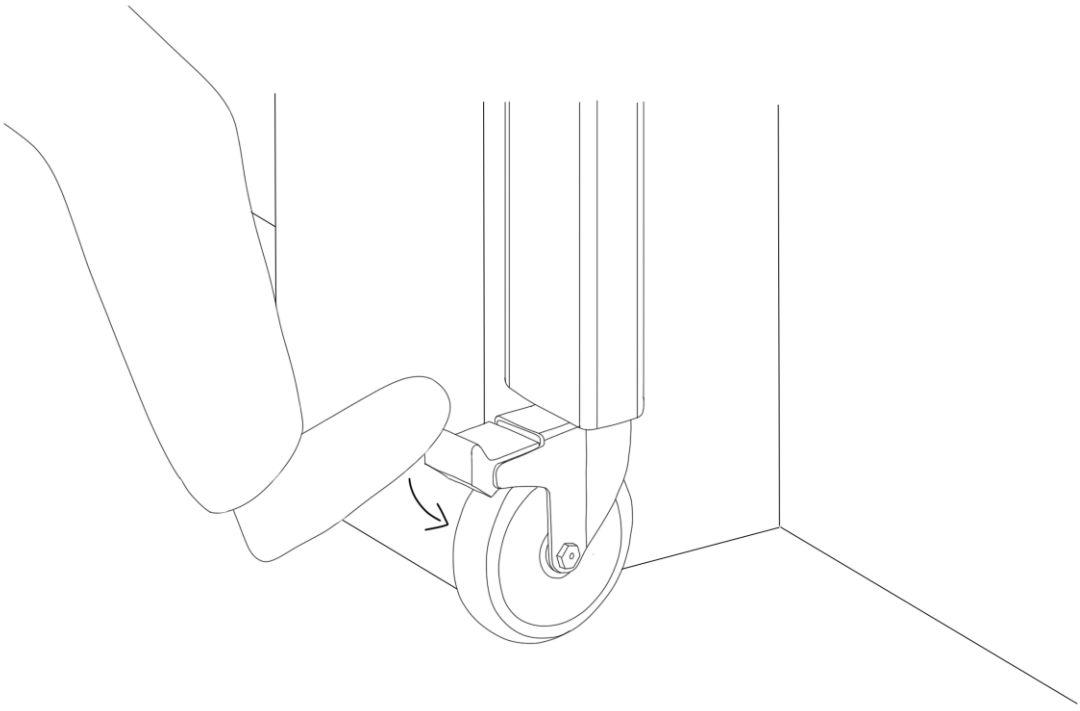
Ater this, the break on the wheel can be released by puching it upwards with your foot.

4. Grab supporting beam and close the construction



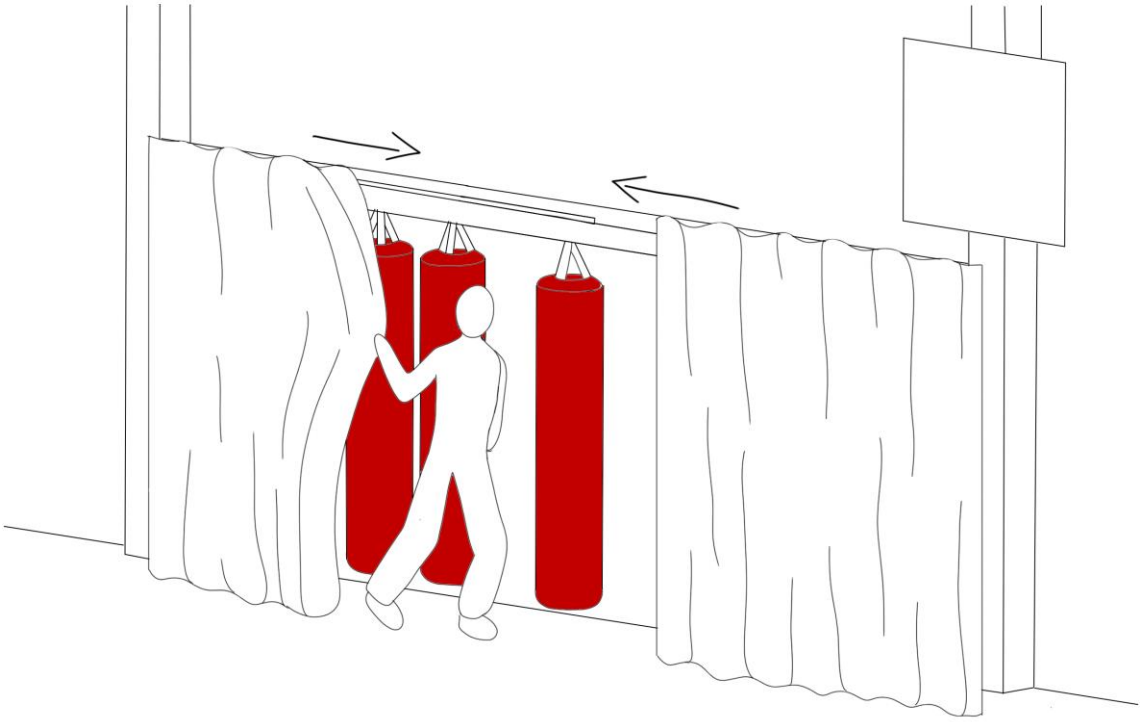
Next, you can grab the supporting beam and roll the rack until it is completely flat against the wall.

5. Put break on wheel



When the rack is back in it's original position, you must put the break back on the wheel. Do this by puching the break down with your foot.

6. Close curtain



Finaly, close the curtains so that the rack is completely covered.

3 Precautions

1. Don't hang from the beams
2. Don’t hang on the punching bags
3. Don’t touch the wheel with your hands
4. Don’t touch the hinges
5. Don’t touch the chains of the punching bags
6. Don’t go within 2 meters from the people who are using the punching bags
7. Be aware of your surroundings while using the punching bags.

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12.5 Maintenance Manual

Maintenance manual
European Project Semester Spring 2024

Punching Bag Rack

University: Novia University of Applied Sciences
Team Members: Elena Cooreman, Sheriffa Hamza, Magnus Krause, Alicia Mailly
Supervisor: Josefin Stolpe

Welcome to the maintenance manual for the metal rack designed to support four punching bags. This manual has been developed to provide you with the necessary instructions to ensure effective maintenance of your equipment. By following the recommendations and procedures outlined in this manual, you will not only ensure the durability and safety of your metal rack but also optimize its operation for peak performance. Whether you are a gym owner, facility manager, or user, this manual will guide you through the regular maintenance of your metal rack, ensuring a safe and satisfying training experience. This guide is primarily aimed at owners, concierges and technical managers who will take care of the premises, and particularly this infrastructure.

The development of this guide was prepared by four students as part of the Punching Bag Rack project, incorporated into the Erasmus Program Semester. The working group is made up of the four following people:

Elena Cooreman
Sheriffa Hamza
Magnus Krause
Alicia Mailly

The writing of this manual was also made possible by our coach and supervisor Josefin Stolpe. We also give a particular thank you to Jukka Sumuvuori and Aki Lindroos, director and owner of the OP-Arena, for your unwavering commitment to the project's success and for graciously providing us with the opportunity to undertake this project. This manual will give you all the information necessary to use our rack to its fully potential and maintain its quality throughout its lifespan.

Foreword

The creation of this maintenance manual was carried out by four exchange students from the University of Novia, University of Applied Sciences. The manual is particularly dedicated to the punching bag support that the project group designed. This semester's project as part of our EPS program, European Project Semester, consists of finding a solution to help a sports center, called the OP-Arena, by offering a solution to install a punching bag rack within of its infrastructure, while respecting. the constraints of other sports.

This project demonstrated the importance of careful planning, interdisciplinary collaboration and technological innovation to achieve practical and functional solutions for athletic training needs. Using the design and a detailed description of the rack, we explain the steps to follow in order to ensure the sustainability of the infrastructure.

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Table of Contents

1. Introduction

1.1. Presentation of the maintenance manual

This maintenance manual is designed to provide detailed instructions on the care and operation of this metal rack intended to support up to four punching balls. The metal rack has a folding and unfolding system providing a triangular shape to the structure. The latter is equipped with a supportive beam with a wheel allowing the simplicity of movement of the structure, in order to fold it against the wall, thus offering a practical solution to optimize space and avoid obstructing other sports fields. This manual is intended for operators, maintenance technicians and anyone responsible for the use and maintenance of the metal rack in the sports environment that is the OP-Arena sports center.

1.2. Purpose of the manual

The purpose of this manual is to provide users with detailed instructions for the correct installation, safe use and regular maintenance of the fold-out metal rack designed to support four punching bags. Its design allows for easy and quick installation of the rack for users. By providing clear and concise guidelines, we aim to ensure that users fully understand the procedures necessary to maximize equipment durability and performance.
This manual also aims to answer common user questions and improve their understanding of the features and functionality of the metal rack. We emphasize user safety by providing detailed instructions on usage limitations and safety precautions. By following the recommendations and procedures outlined in this manual, users will be able to install, operate and maintain the metal rack in a safe, efficient and durable manner.

1.3. Targeted users

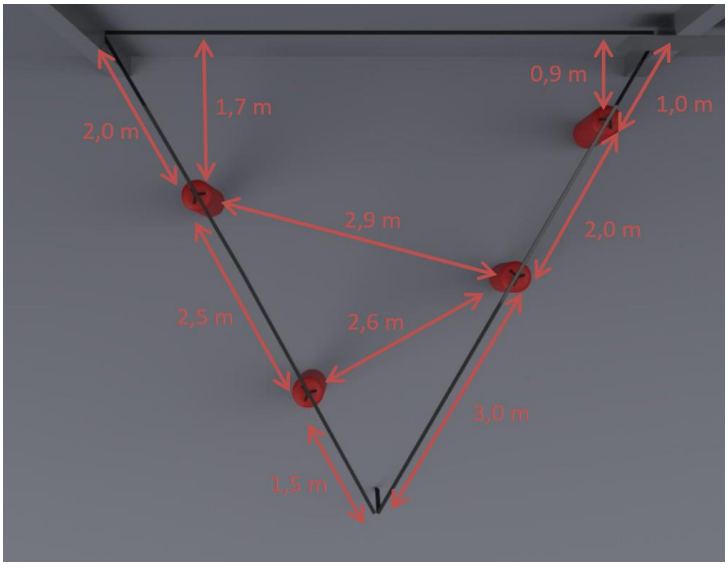
This maintenance manual is specifically designed to meet the needs of a wide range of users, including owners of sports halls, therefore OP-Arena; sports facility managers, fitness instructors, as well as individual users wishing to install and use the fold-out metal

rack to support their boxing equipment. By offering detailed and accessible instructions, this manual is suitable for all skill levels, from beginners to experienced users.
We recognize that each user may have specific needs in terms of installation, use and maintenance of the metal rack. Therefore, this manual is designed to be flexible and adaptable, to meet the unique needs of each user. Whether you are an experienced professional or new to fitness, this manual will provide you with the information you need to use the metal rack effectively and safely.
We are committed to providing ongoing support to our users, offering additional resources such as a user manual for further information as well as image aids for clarity.

2. Description of the Foldable Metal Rack

2.1. Technical specifications

First of all, we will take care to explain the technical specifications of the structure, in order to allow a complete understanding of the construction for all members who will have near or far access to this rack.
The rack has a triangular shap that can be folded back against the wall of the OP-Arena without taking to much space. The rack is made of 6 meters steel beam. With the next picture it is possible to see the dimension of the rack between the wall, and also between each punching bags.



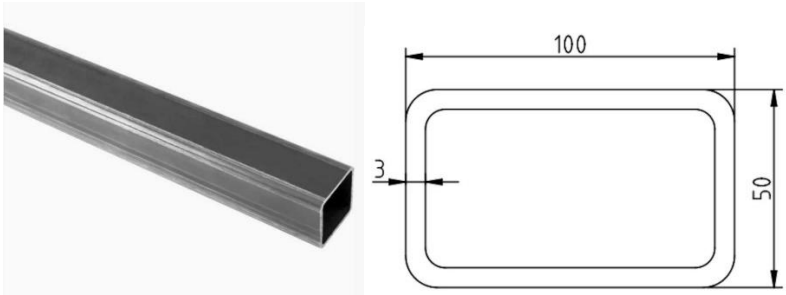
For the capacity of the rack, it has been calculated with large punching bags. They weight 50 kilograms each, which means they handle a force of 500 Newtons per bag. As for the weight of the rack we calculated so the rack could hold on to 2000 Newtons per 6-meter beam. It includes extra weight in case a child would want to play and climb on a punching bag. The maximum load capacity of the metal rack is then 4000 Newtons. It is the weight the rack can support without compromising its structure or stability.

As a folding and locking mechanisms the rack will have hinges that are used to consolidate the structure. Four are present on the structure in the most fragile places. These are the two points between the steel beam and the wall present in the sports hall, then between the wheel platform and the supportive beam; and finally, the last allows you to reinforce the left pillar which bends in order to reach the closed position. The hinges have a capacity of 300 kg.

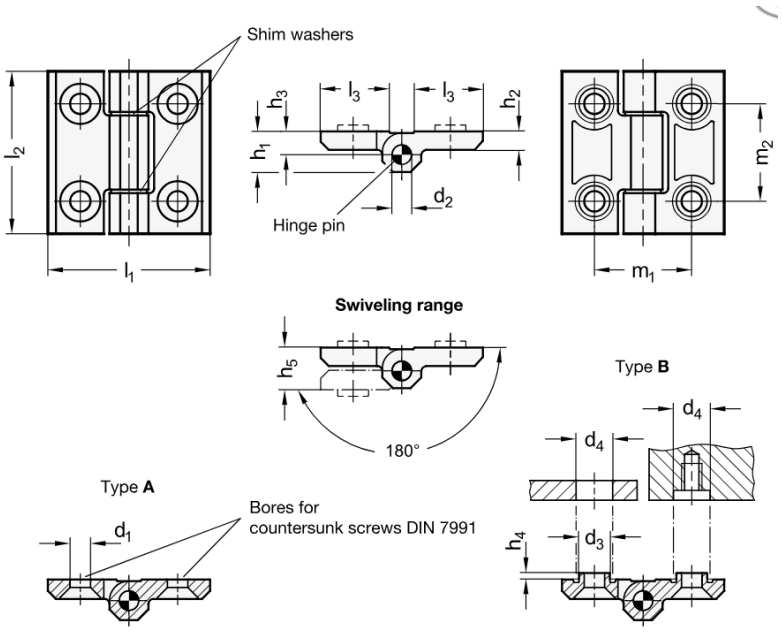
For a future investment it could also be possible to put any protective coating on the metal rack to improve its durability and corrosion resistance. This may include anti-rust coatings, epoxy paints or other surface treatments, that the OP-Arena could choose.

2.2. Rack Components

First the rack is made of steel beam. The rack will us a 6 meters long beam and a second one cut in half so the structure can be fold.

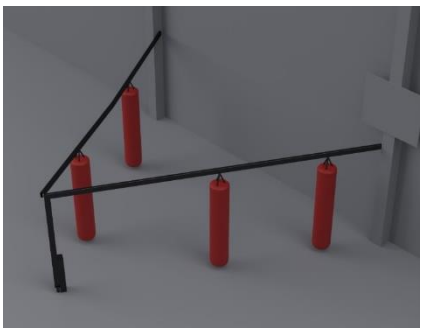
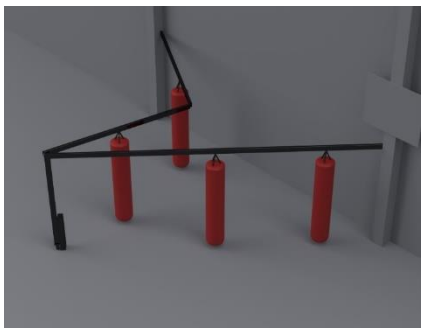
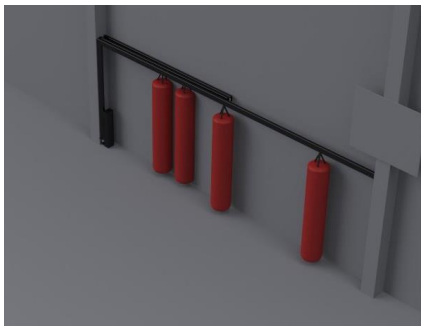


Then to stronger the construction, heavy duty hinges will be used. Four of them put on the most critical points, to attach the steel beam to the wall on the two side, then at the place where ethe left beam is going to fold, and the last one will be put to attach the 6 meters beam to the supportive beam.



Then we can note the necessary use of the wheel. This is attached to the supportive beam and first allows it to support part of the weight of the structure in order to prevent the latter from falling, but the wheel also makes it easier to store the structure thanks to the sliding of the wheel on the ground. A lock is used to secure the positioning of the structure once opened. It is positioned at the place of the fold on the left pillar. Finally we also observe the hooks on the structure which allow the punching bags to be attached to the structure. All of these elements therefore require particular attention to wear and use to ensure the durability of the structure.

2.3. System operation

With those three pictures you can observe the three-opening stage of the rack.
First it shows what the rack looks like when it is in use, so completely unfolded. A lock on the unfolded beam will ensure that it doesn't refold while in use. The break on the wheal will also ensure that the rack will not start moving.
Then the picture shows the way the rack will open. The rack can be open and close manually by grabbing the supporting beam and rolling it out.
The last picture shows what the rack will look like when it is closed. All the punching bags are hanging against the wall. This results in a minimal used space since they will only come out about 50 centimetres. No sporters will be bothered by this rack when performing other sports. For safety, a curtain will be added so people cannot touch or climb on them.

3. Safety instructions

3.1. Safe use of the rack

In order to enable safe use of the rack, it is crucial to take into account several aspects to guarantee user safety. First of all, it is essential to load the punching bags according to the manufacturer's specifications and not to exceed the maximum load capacity of the rack This is why the punching bags are attached to the rack using hooks which each support 50 kg, which is the maximum weight of the punching bag. This will ensure that the rack remains stable and secure while in use. In addition, this adequate fixing of the punching bags on the rack is necessary, to avoid any risk of falling or damage.

It is also important to ensure that the rack is correctly installed and stably attached to the floor or wall. To do this, heavy duty hinges were used located at critical points of the structure. Two hinges are present to fix the right and left steel pillars to the pillar already present in the room which supports the wall of the room. A hinge helps solidify the pillar which folds in half when stored. Finally, the last hinge allows you to fix the pillar of the supportive beam with those which support the bags. In addition, we observe the presence of a wheel in order to make the movement simpler when folding the structure. This wheel has a break in order to avoid causing movement of the structure due to the movement of the bags when the user hits it. These elements help prevent any unwanted movement during use. Additionally, it is recommended to avoid overloading the rack by hanging additional objects on it or using unauthorized installation methods, which could compromise its safety and durability.

3.2. Precautions to be taken during maintenance

It is necessary to note some precautions to take during maintenance operations on the metal rack supporting our four punching bags. First of all, it is imperative to ensure that all maintenance operations are carried out by qualified and trained personnel, who fully understand the operation of the rack and the risks associated with its components. When handling hinges, it is important to wear protective gloves to avoid potential hand injuries. Additionally, when inspecting the supportive beam and wheel, it is recommended to lock the rack in a secure position to prevent accidental movement. Be careful not to bring your hands close to the wheel, especially when it is not blocked by the brake. Finally, when working on security components such as locks, it is essential to follow the procedures recommended by the manufacturer and ensure that the rack is in the frozen position. By observing these precautions during maintenance operations, users can ensure their safety and that of others while ensuring the continued proper operation of the metal rack.

3.3. Potential risks and preventive measures

In order to provide optimal security, it is crucial to identify the potential risks associated with the use of the metal rack supporting the bags, as well as the preventive measures to take to minimize these risks. Potential risks include the risk of the rack tipping or

falling, particularly when it is in motion or when subjected to significant loads. To prevent these risks, it is essential to ensure that the track is properly secured to the floor, by the wheel, and to the walls of the gym, and that all fixings and connections are regularly inspected and maintained. Furthermore, when users use their bags, it is interesting to balance the same loads on each side, for example if bags of different sizes are used or if the number of users is less than the number of bags. . Additionally, it is important to make users aware of the risks associated with inappropriate use of the rack, such as using excessive force or engaging in unauthorized movements. It is possible to refer to the user manual in order to understand the movements that should not be carried out near this structure. By providing adequate training to rack users and posting clear instructions and warnings in the gym, the risk of an accident or injury can be significantly reduced. By implementing these preventative measures, it can be ensured that the metal rack remains a safe and secure equipment for all users.

4. Preventative Maintenance Procedures

4.1. Regular inspection of components

As part of our preventive maintenance program, it is essential to carry out a regular inspection of the metal rack components, particularly with regard to the installation of the four punching bags, and all the infrastructure that comes with it. This inspection will identify any signs of deterioration, wear or potential damage that could affect the safety and functionality of the rack. It is recommended to periodically check the condition of fixings, connections, such as locks or hinges, as well as the wheel and folding mechanism, paying particular attention to areas subject to intensive use or stress. Important, such as the weight and movement of punching bags. By carrying out these inspections regularly and thoroughly, users will be able to detect problems at an early stage and take the necessary measures to prevent breakdowns and ensure the continued good operation of the metal rack.

4.2. Lubrication of moving parts

As part of our preventive maintenance procedures, lubrication of the moving parts is crucial to ensure the smooth operation and longevity of the metal rack supporting the four punching bags. Regular lubrication of the wheels, hinges, and other moving

components is essential to reduce friction, prevent corrosion, and minimize wear and tear. It is recommended to use a suitable lubricant, as specified by the manufacturer, and apply it according to the recommended intervals. In addition, in order to fold the structure against the wall, the supportive beam as well as the wheel supports a large part of the weight of the construction and the wheel must be able to slide smoothly to allow easy use by the user. In addition, the wheel must not mark on the ground, so as not to damage the marks of the other sports fields present in the room. By keeping the moving parts properly lubricated, users can enhance the performance and efficiency of the rack, as well as prolong its service life, ultimately ensuring a safe and effective training environment for users.

4.3. Checking stability and alignment

It is essential to regularly verify the stability and alignment of the metal rack supporting the four punching bags, as a maintenance of it. This involves checking for any signs of instability, such as wobbling or shifting, as well as ensuring that the rack is properly aligned with the floor and walls of the gym. It is recommended to conduct this verification periodically, especially after heavy use or if any adjustments have been made to the rack or its surroundings. By ensuring that the rack remains stable and properly aligned, users can minimize the risk of accidents or injuries during training sessions and maintain a safe and secure environment for all users.

5. Cleaning Guide

5.1. Cleaning metal surfaces

In this section of the maintenance manual, we will cover the cleaning guide for the metal surfaces of the rack supporting the four punching bags. Regular cleaning of metal surfaces is essential to maintaining a clean and hygienic environment in the gym. To begin, it is recommended to use a soft cloth or non-abrasive sponge dampened with warm water to remove dirt, dust and sweat residue from the metal surfaces of the rack. Then, to remove stubborn stains or embedded dirt, a mild cleaner or mild detergent can be used, making sure to rinse surfaces thoroughly with clean water after cleaning. Finally, to preserve the appearance and durability of metal surfaces, it is recommended to dry them thoroughly with a clean, dry cloth after cleaning. By following these regular

cleaning steps, users can keep the rack's metal surfaces clean and looking new, ensuring a comfortable and hygienic workout environment for all users.

5.2. Maintenance of punching bags

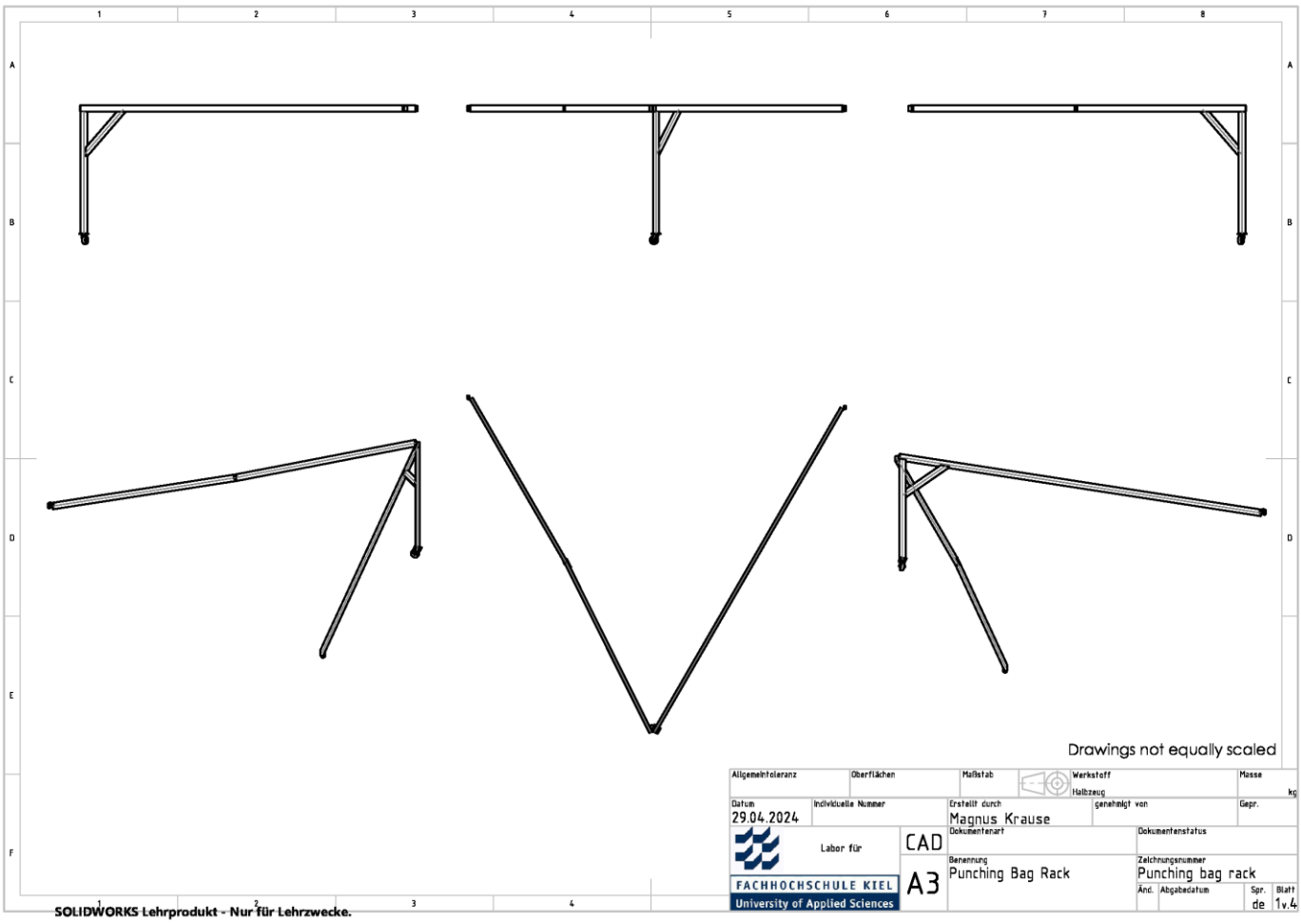
In this section of the cleaning guide, we will discuss the maintenance of punching bags hanging from the metal rack. It is important to keep these bags in good condition to ensure their durability and safety during training sessions. First of all, it is recommended to regularly inspect punching bags for any signs of damage, such as tears, loose seams or dents. In case of damage, it is essential to repair or replace damaged bags immediately to avoid any risk of accidents during use. Additionally, it is advisable to clean punching bags regularly with a damp cloth to remove accumulated dirt, dust and perspiration. It is also recommended to air the bags from time to time to avoid the accumulation of unpleasant odors. It is also necessary to regularly check the chains allowing the bags to be attached. This is the most fragile part which will first take the load due to blows in the bags. By following these maintenance tips, punching bags can remain in good condition and provide an optimal and safe training experience for gym users.

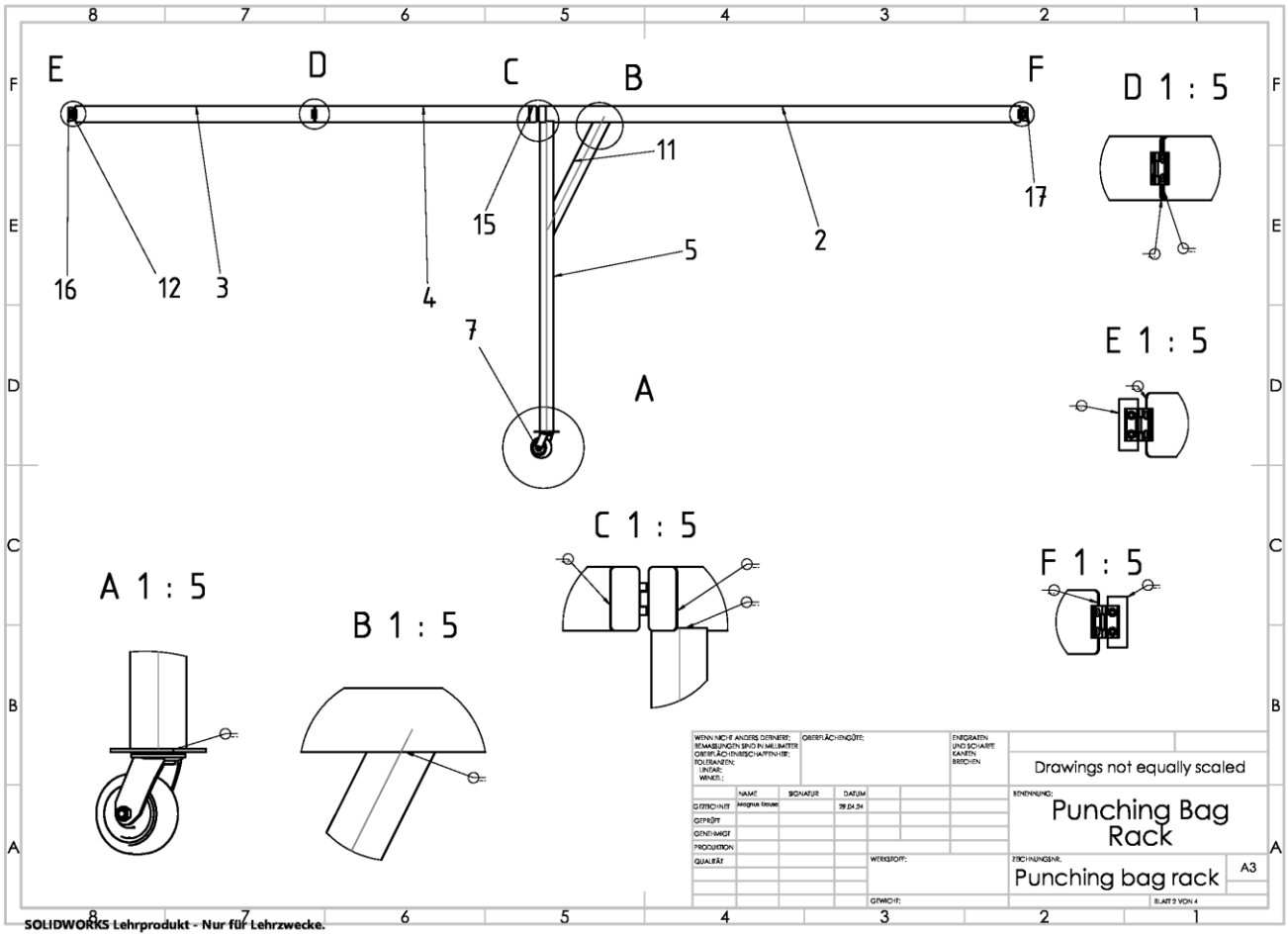
5.3. Cleaning the folding mechanism

We will discuss cleaning the metal rack folding mechanisms. It is essential to keep these mechanisms in good working order to ensure the safety and durability of the rack. First of all, it is recommended to regularly inspect the hinges, latches and wheel carrier for signs of dirt, corrosion or wear. If dirt or debris is present, it is important to clean the mechanisms thoroughly with a damp cloth to remove any buildup and ensure smooth movement. Additionally, it is advisable to periodically apply a suitable lubricant to the hinges and wheels to reduce friction and prevent premature wear. By following these cleaning and maintenance steps, the metal rack folding mechanisms can remain in excellent working order, ensuring safe and efficient use of the rack in the OP-Arena.

6. Appendices

6.1. Diagrams and illustrations

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Drawings not equally scaled
Punching Bag Rack
Punching bag rack
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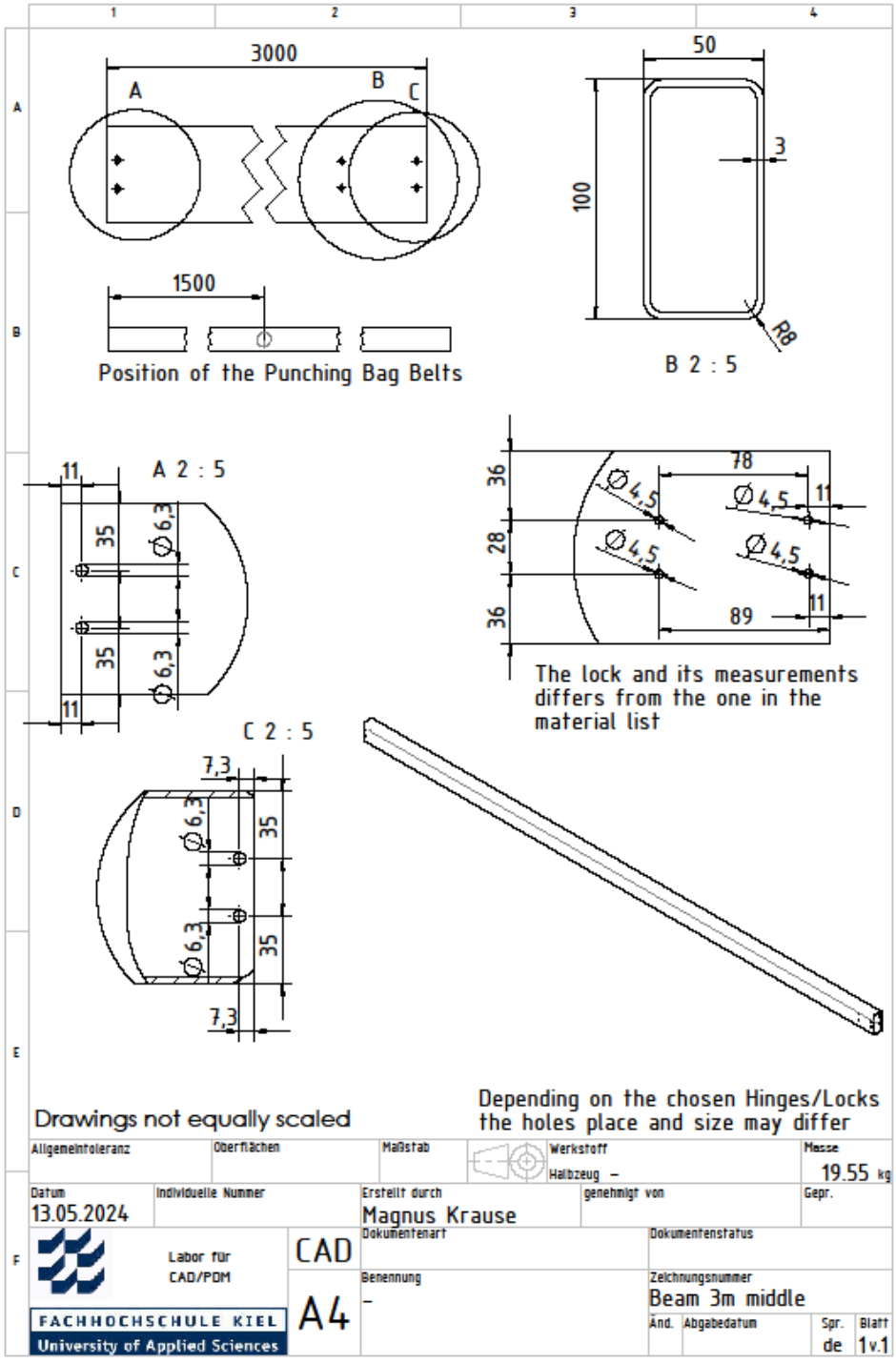
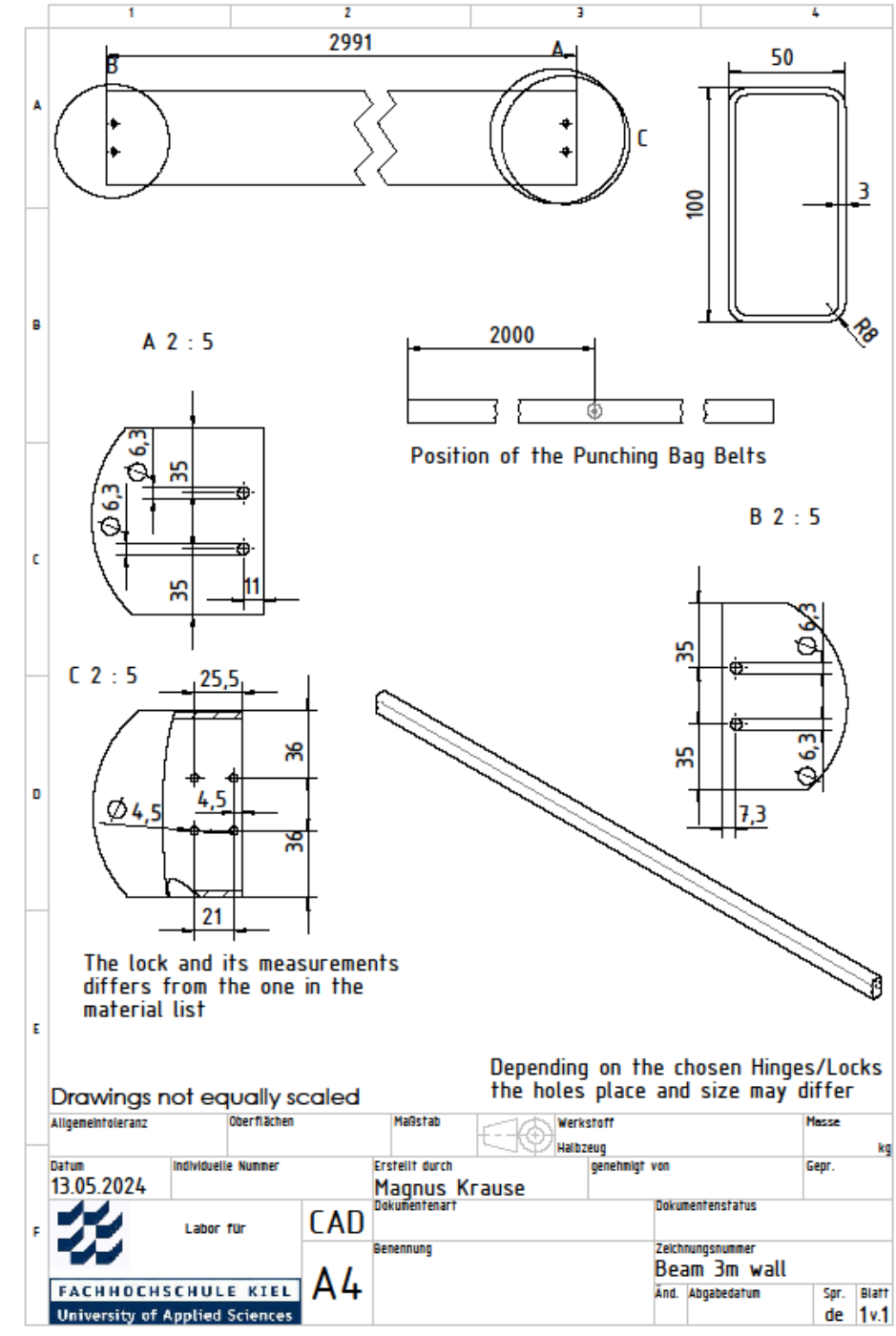
6.2. Spare parts list

MATERIAL	SPECIFICATION	QUANTITY	€/PCS	TOTAL PRICE	LINK TO SUPPLIER
Steel beam 6 meters	Capacity of 200kg	3	162.00	486.00	supplier
Wheel with break	Capacity of 90kg	1	55.18	55.18	supplier
Heavy duty hinges	Capacity of 300kg	4	14.74	58.96	supplier
Hooks to hang the bags	Hold the weight of one punching bag, 50kg	4	19.99	79.96	supplier
Lock for folded beam	Must be locked both upwards and downwards	1	15.99	15.99	supplier

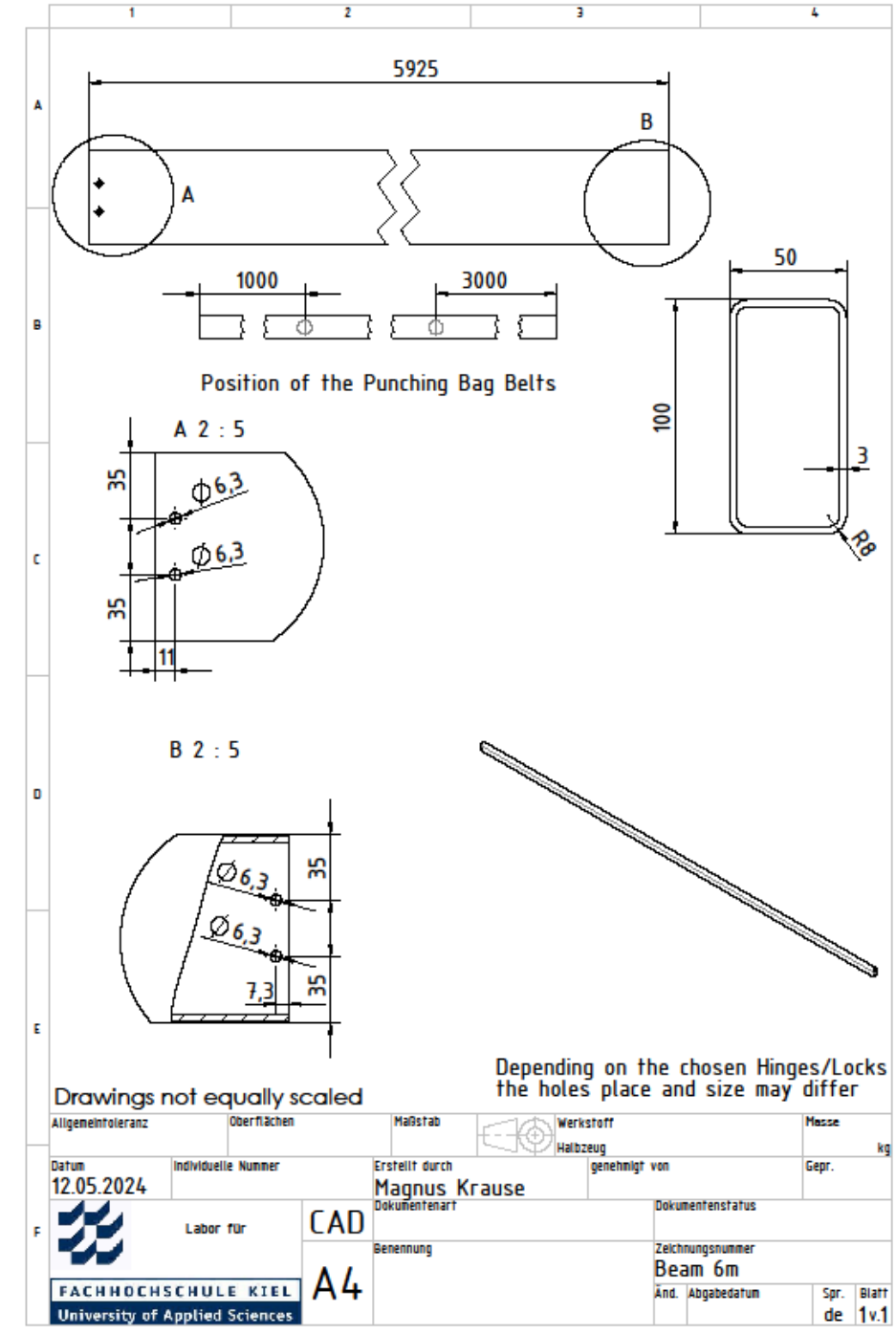
12.6 Drawing Beam 3 m middle



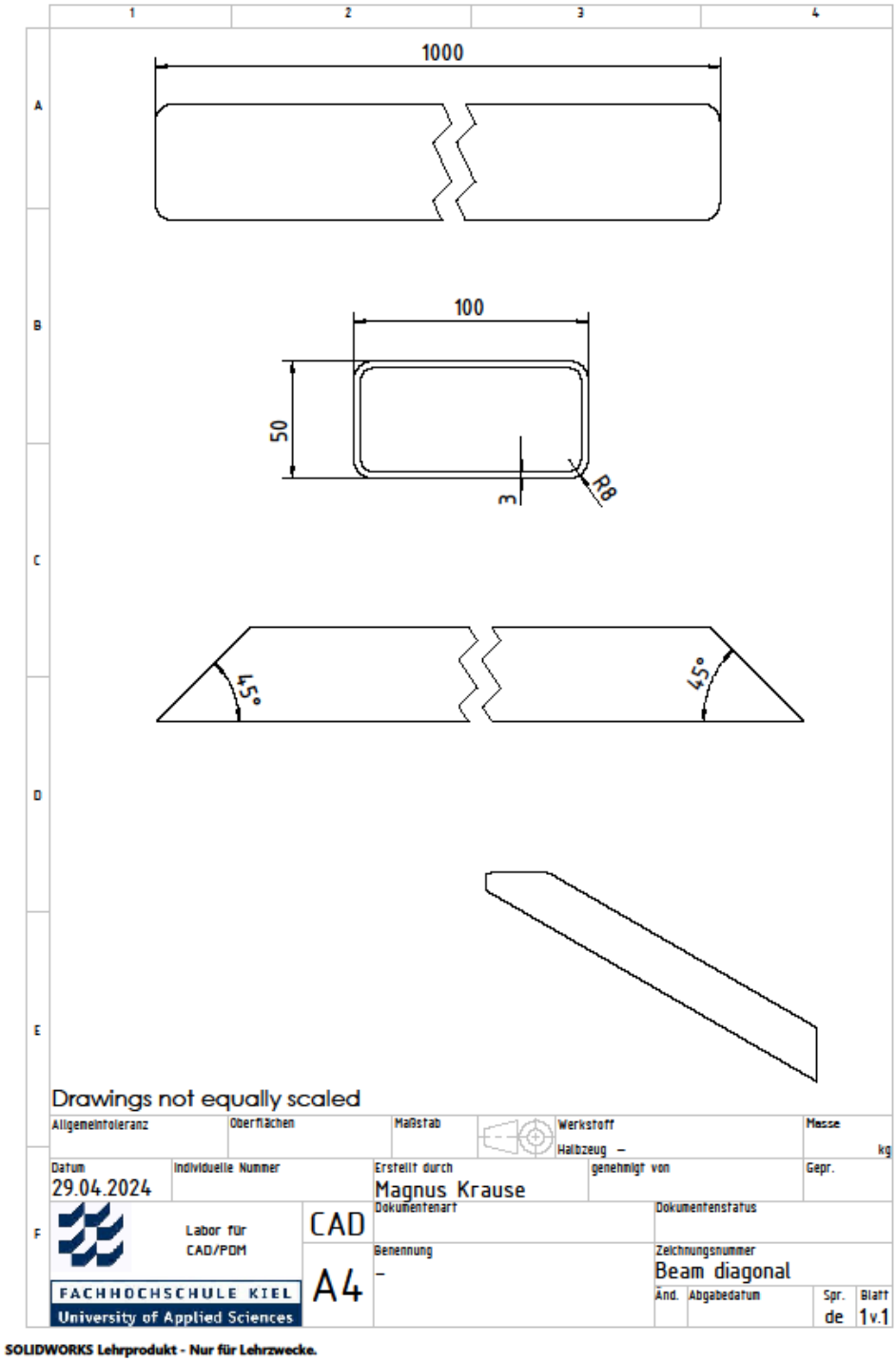
12.7 Drawing Beam 3 m wall



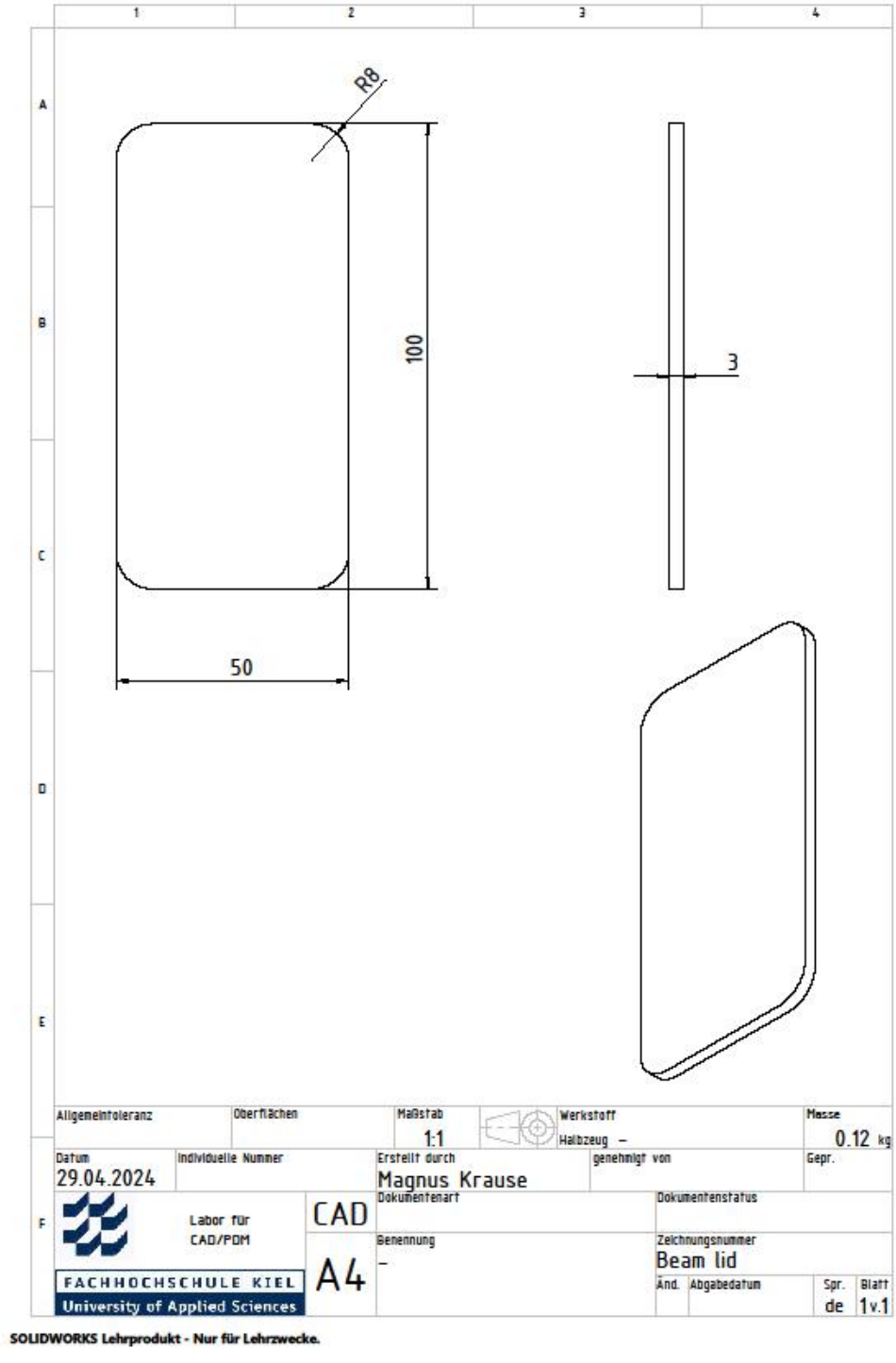
12.8 Drawing Beam 6 m



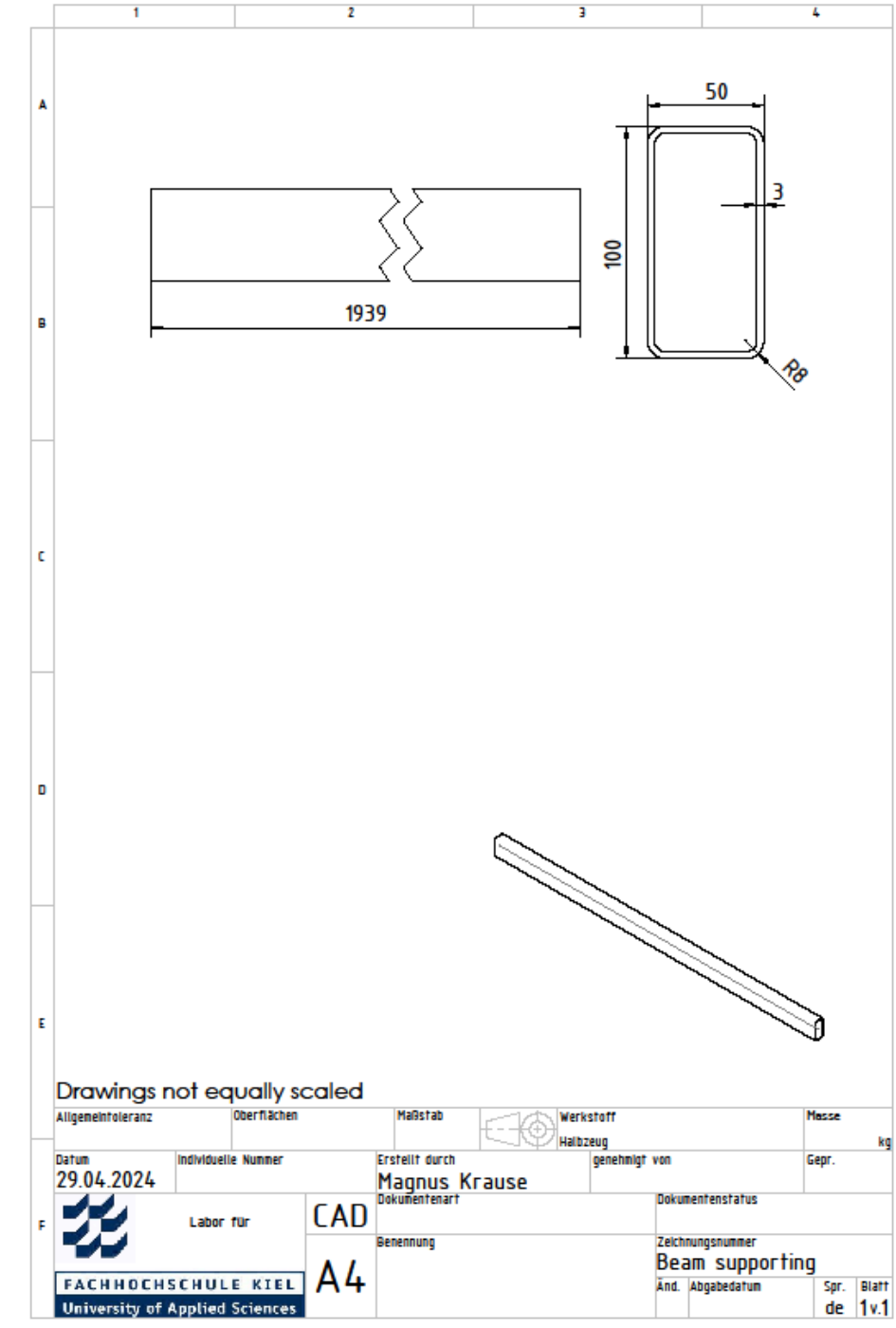
12.9 Drawing Beam diagonal



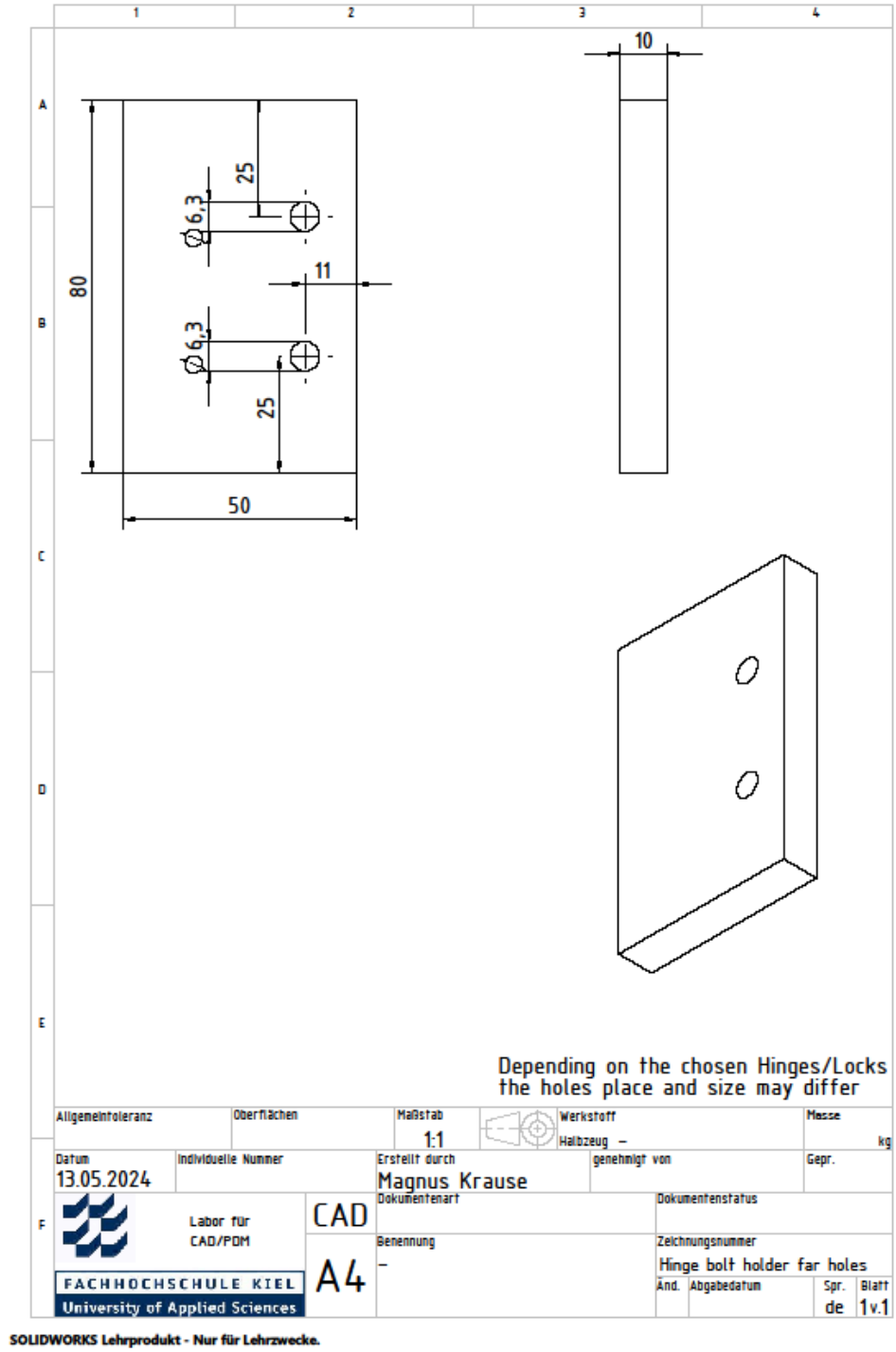
12.10 Drawing Beam lid



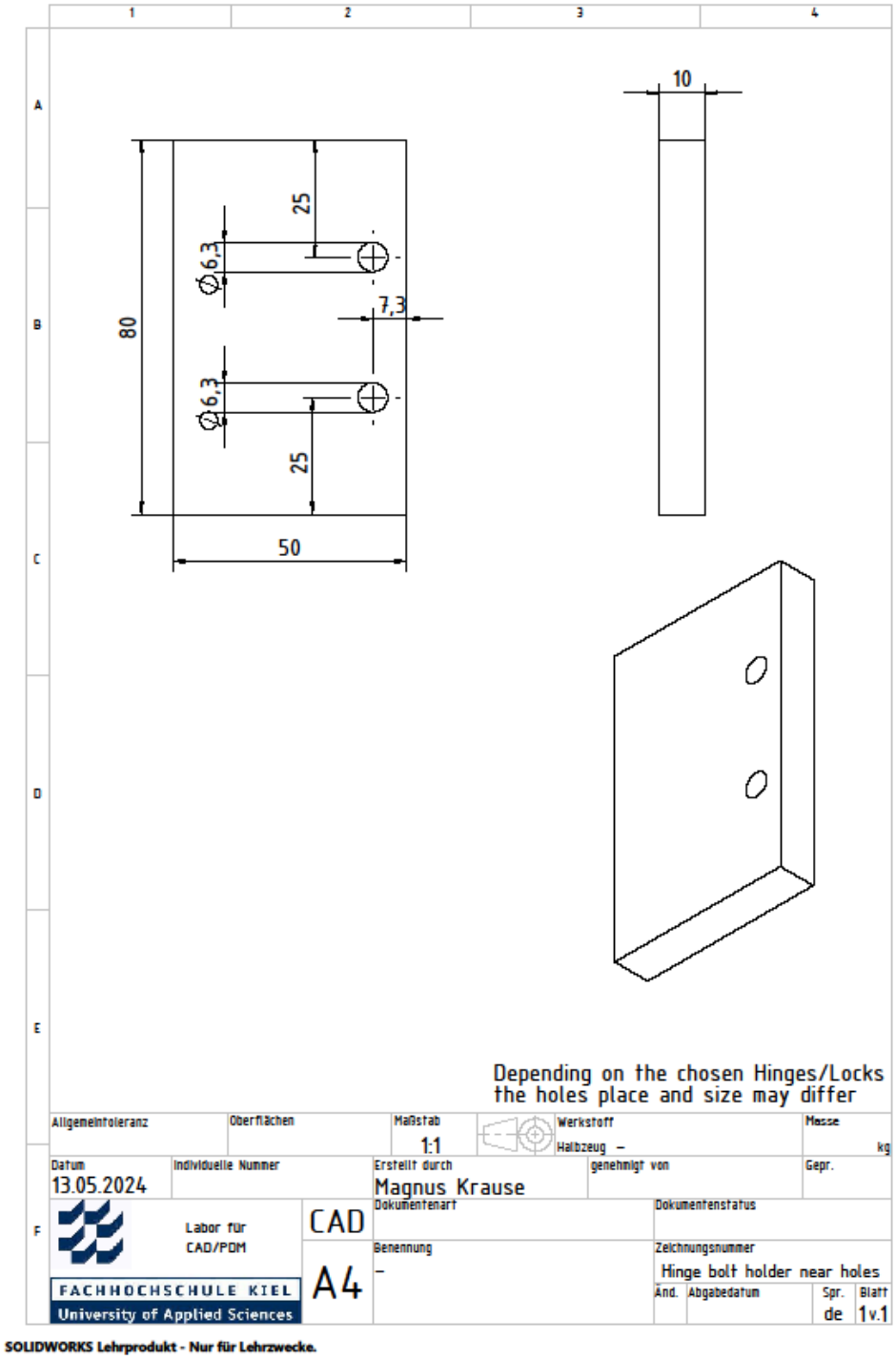
12.11 Drawing Beam supporting



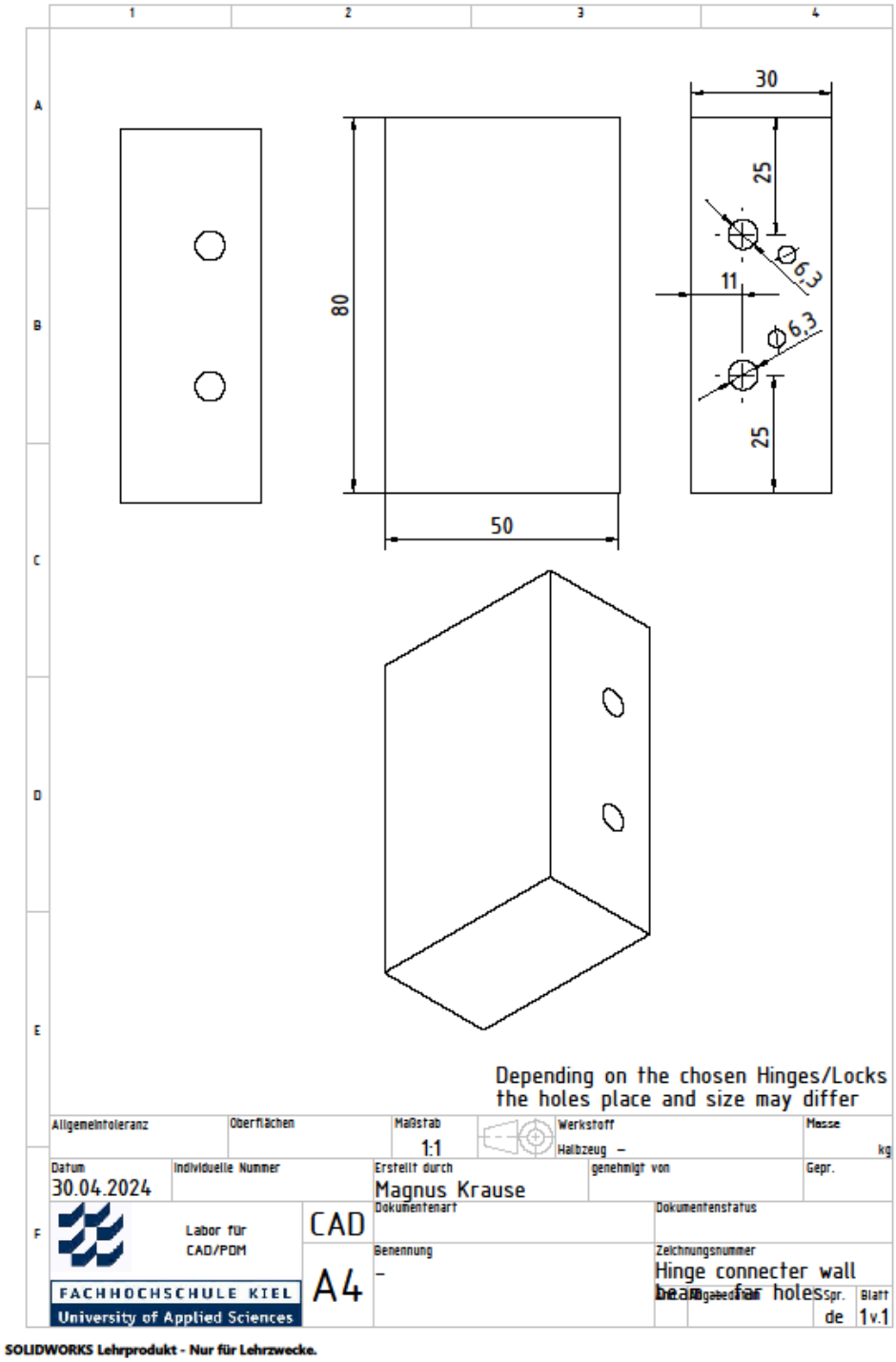
12.12 Drawing Hinge bolt holder far holes



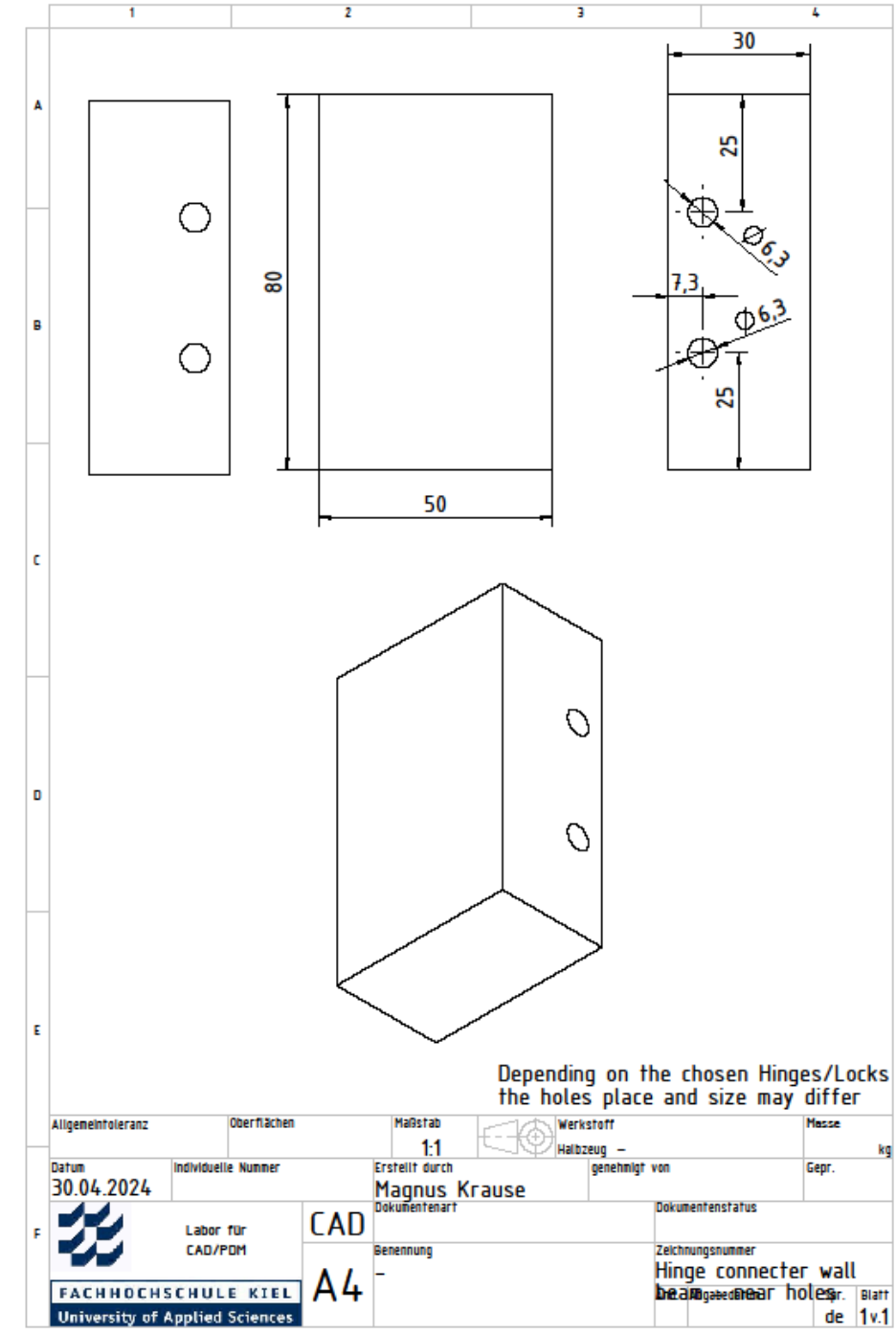
12.13 Drawing Hinge bolt holder near holes



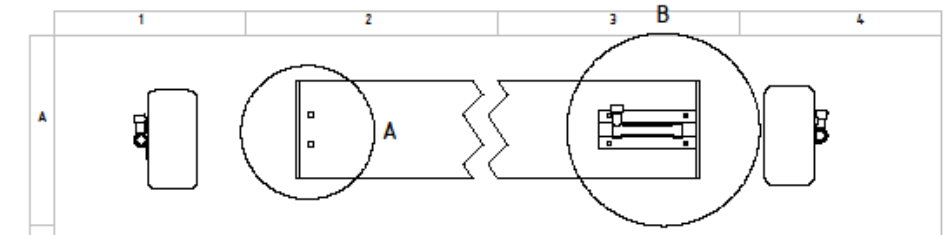
12.14 Drawing Hinge connecter wall beam - far holes



12.15 Drawing Hinge connecter wall beam – near holes



12.16 Assembly Drawing Beam 3 m middle



POS-No.	Name	Description	Quantity
1	Beam 3m middle	-	1
2	Beam lid	-	2
3	Hinge bold holder far holes	-	1
4	Hinge bold holder near holes	-	1
5	door bold bold		1
6	door bold big		1

Allgemeintoleranz	Oberflächen	Maßstab		Werkstoff / Halbzeug	Masse kg
Datum 29.04.2024	Individuelle Nummer	Erstellt durch Magnus Krause		genehmigt von	Gepr.
Labor für CAD/PDM FACHHOCHSCHULE KIEL University of Applied Sciences	CAD A4	Dokumentenart Benennung -		Dokumentenstatus Zeichnungsnummer assm Beam 3m middle	
			Änd.	Abgabedatum	Spr. de / Blatt 1v.1

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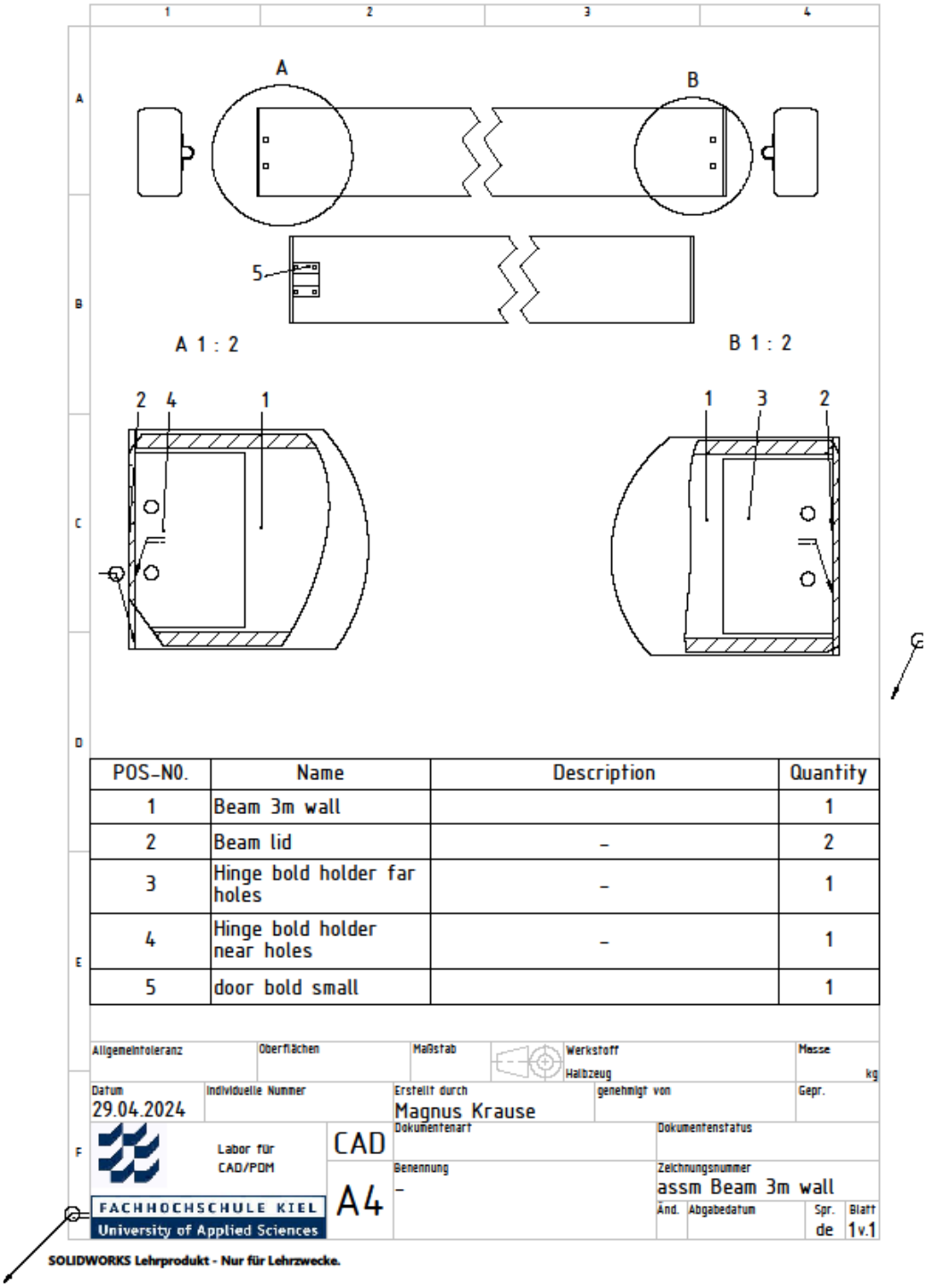
12.17 Assembly Drawing Beam 3 m wall

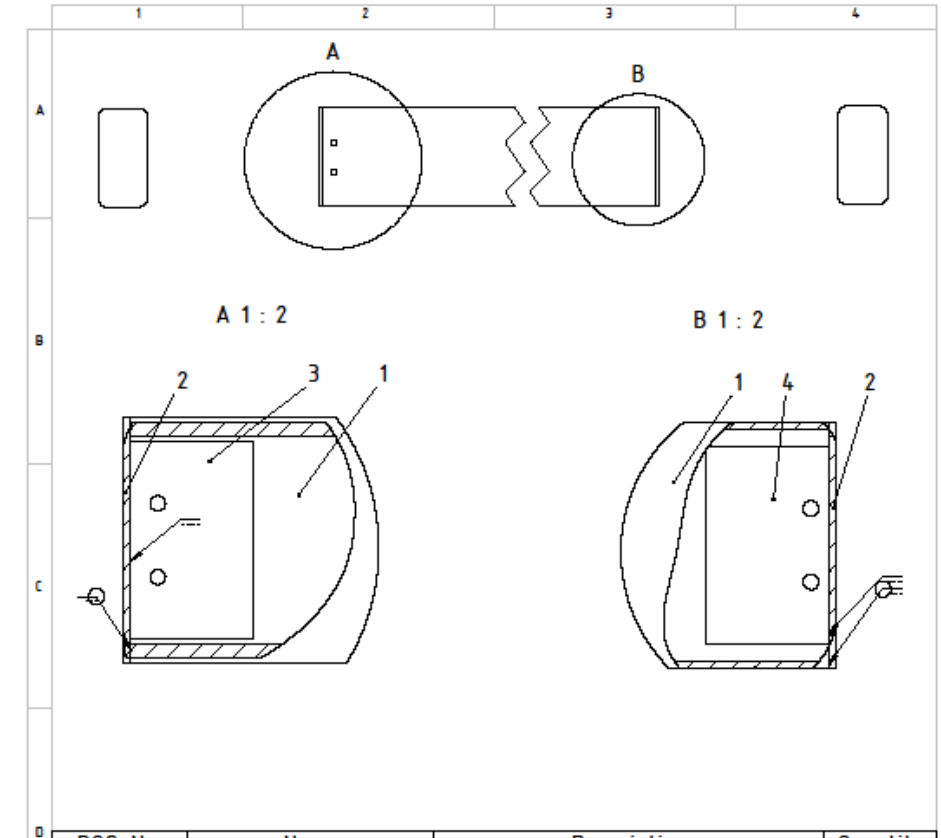


POS-NO.	Name	Description	Quantity
1	Beam 3m wall		1
2	Beam lid	-	2
3	Hinge bold holder far holes	-	1
4	Hinge bold holder near holes	-	1
5	door bold small		1

Allgemeintoleranz	Oberflächen	Maßstab		Werkstoff Halbzeug	Masse kg
Datum 29.04.2024	Individuelle Nummer	Erstellt durch Magnus Krause		genehmigt von	Gepr.
Labor für CAD/PDM FACHHOCHSCHULE KIEL University of Applied Sciences	CAD	Dokumentenart		Dokumentenstatus	
	A4	Benennung -		Zeichnungsnummer assm Beam 3m wall	
			Änd. Abgabedatum	Spr. de	Blatt 1v.1

SOLIDWORKS Lehrprodukt - Nur für Lehrzwecke.

12.18 Assembly Drawing Beam 6 m



POS-No.	Name	Description	Quantity
1	Beam 6m		1
2	Beam lid	-	2
3	Hinge bold holder far holes	-	1
4	Hinge bold holder near holes	-	1

Allgemeintoleranz | Oberflächen | Maßstab | Werkstoff: Halbzeug | Masse: kg

Datum: 29.04.2024 | Individuelle Nummer | Erstellt durch: Magnus Krause | genehmigt von | Gepr.

Labor für CAD/PDM

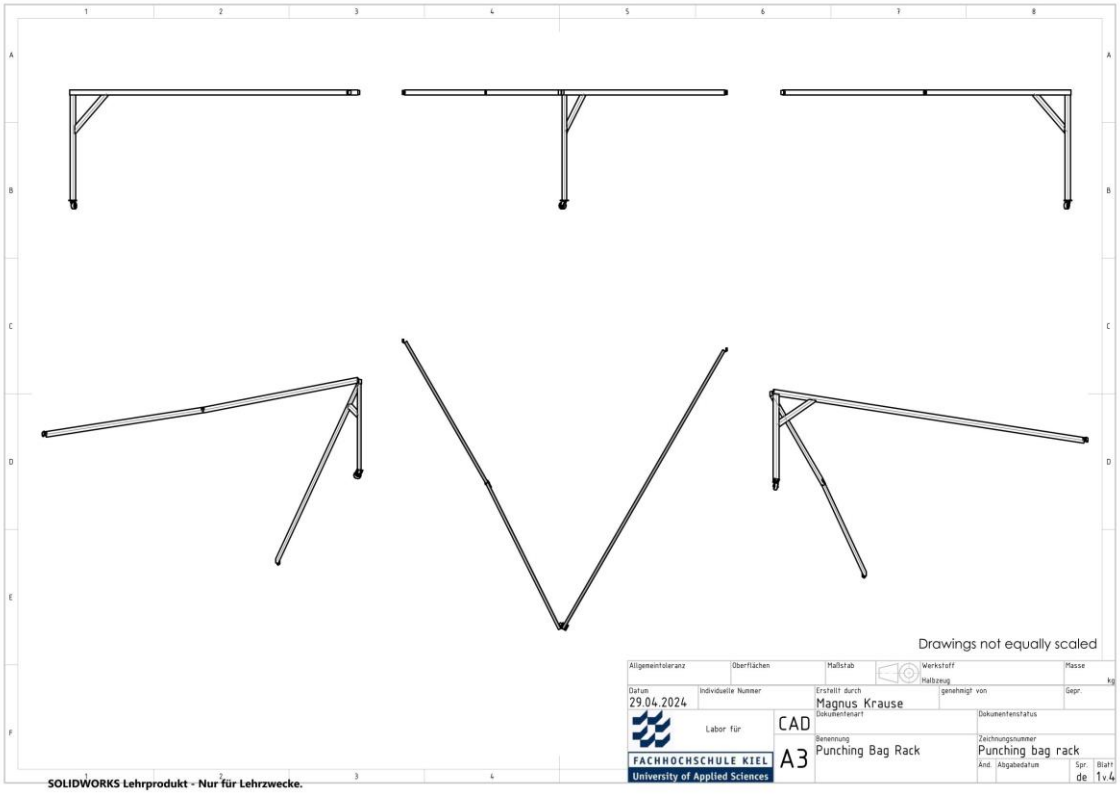
FACHHOCHSCHULE KIEL
University of Applied Sciences

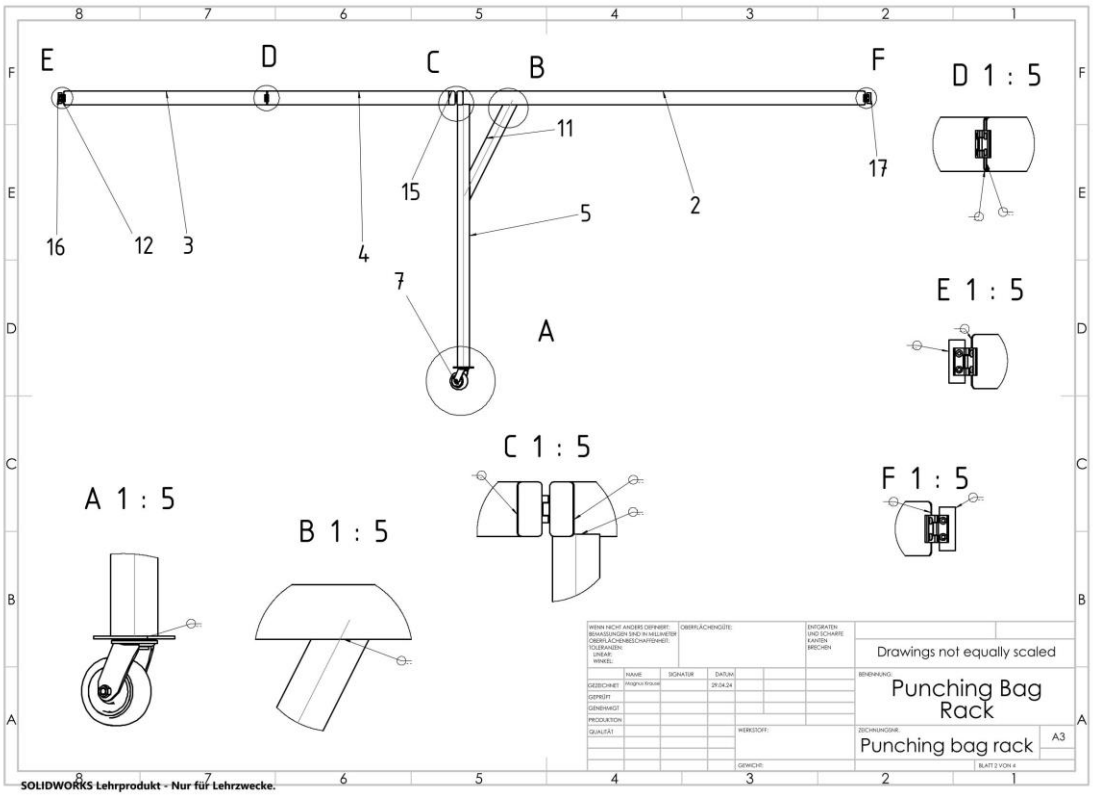
CAD | Dokumentenart | Dokumentenstatus

A4 | Benennung: - | Zeichnungsnummer: assm Beam 6m

Änd. | Abgabedatum | Spr.: de | Blatt: 1v.1

12.19 Assembly Drawing Punching Bag Rack

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Punching Bag Rack
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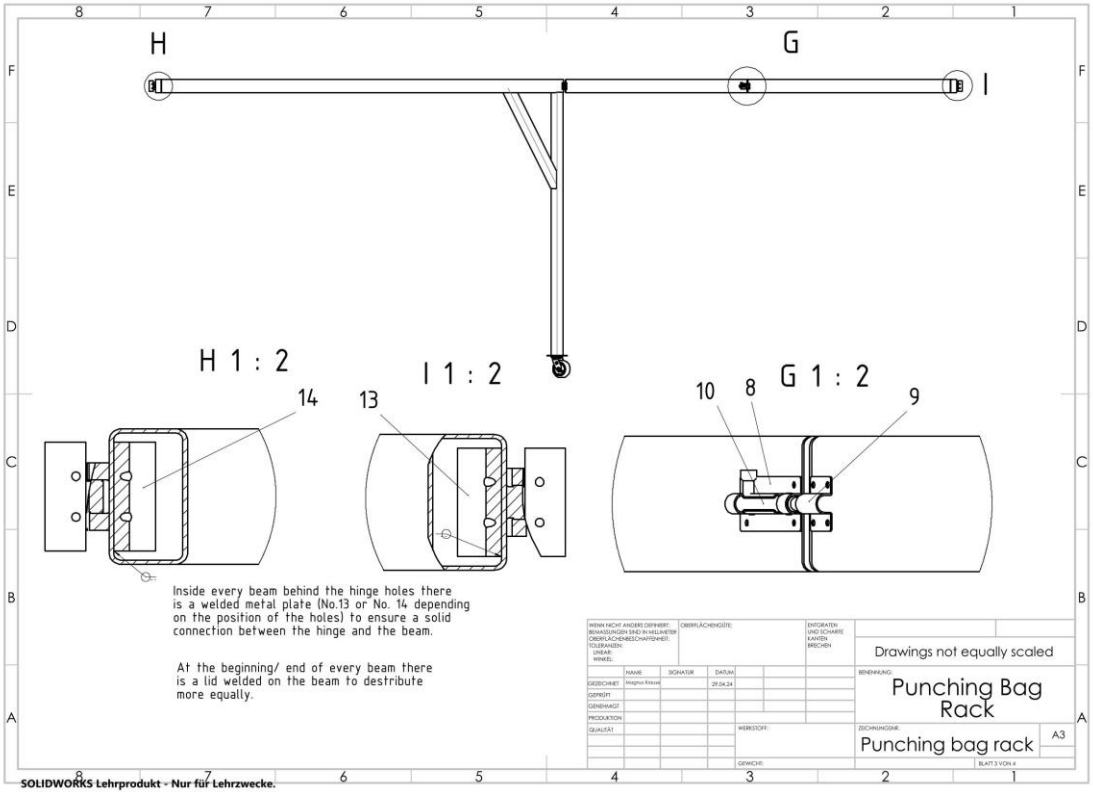
SOLIDWORKS Lehrprodukt - Nur für Lehrzwecke.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Inside every beam behind the hinge holes there is a welded metal plate (No.13 or No. 14 depending on the position of the holes) to ensure a solid connection between the hinge and the beam.
At the beginning/ end of every beam there is a lid welded on the beam to destribute more equally.
Drawings not equally scaled
Punching Bag Rack
Punching bag rack
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POS-NR.	Name	Description	Quantity
2	Beam 6m		1
3	Beam 3m wall		1
4	Beam 3m middle	-	1
5	Beam supporting		1
7	Wheel		1
8	door bold big		1
9	door bold small		1
10	door bold bold		1
11	Beam diagonal	-	1
12	Stainless Steel-Heavy duty hinge GN 237.3-NI-50-50-A-GS (0)	-	4
13	Hinge bold holder near holes	-	3
14	Hinge bold holder far holes	-	3
15	Beam lid	-	6
16	Hinge connecter wall beam - far holes	-	1
17	Hinge connecter wall beam - near holes	-	1

WENN NICHT ANDERS DEFINIERT:
BEMASSUNGEN SIND IN MILLIMETER
OBERFLÄCHENBESCHAFFENHEIT:
TOLERANZEN:
LINEAR:
WINKEL:

OBERFLÄCHENGÜTE:

ENTGRATEN UND SCHARFE KANTEN BRECHEN

Drawings not equally scaled

	NAME	SIGNATUR	DATUM
GEZEICHNET	Magnus Krause		29.04.24
GEPRÜFT			
GENEHMIGT			
PRODUKTION			
QUALITÄT			

BENENNUNG: Punching Bag Rack

WERKSTOFF:

ZEICHNUNGSNR.: Punching bag rack

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GEWICHT:

BLATT 4 VON 4

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