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**Deliverable C - Design Project Progress Update**

Introduction to Product Development for Engineers

GNG2101

**A02-AFL1 Adapted Fitness, Leg Press**

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**List of Acronyms and Glossary**

Table 1. Acronyms

|  |  |
| --- | --- |
| **Acronym** | **Definition** |
| AFL | “Adapted Fitness Leg Press” which is the name of our product. |
| DFX | “Design for Excellence”; it is a procedure that focuses on a maximum of five to nine “vital elements” at a time to reduce costs incurred through repeated failures, make the best use of available resources, and to improve the design process overall. |
| LCA | “Life Cycle Analysis”; a methodology for assessing environmental impacts of products, processes, or services across their life cycle |
| BOM | “Bill of Materials”; extensive list of raw materials, components, and instructions required to construct, manufacture, or repair a product or service |

Table 2: Glossary.

|  |  |  |
| --- | --- | --- |
| **Term** | **Acronym** | **Definition** |
| Metric | SI | System or standard of measurement |

# **1** **Introduction**

In this deliverable, we will present a comprehensive design update for our proposed Velcro-based solution, reflecting on the valuable feedback received during our second client meeting. Our client expressed enthusiasm for the simplicity and usability of our design, highlighting its potential to enhance fitness training experiences, particularly with the leg press. Notably, the client emphasized the importance of a system that allows for easy replacement or repair, ensuring longevity and practicality in everyday settings. Building on this feedback, we have refined our concept to align more closely with the client's vision. Key modifications include the integration of a rubber pad for enhanced portability and the incorporation of a foot-securing mechanism inspired by Footwear Traction Aids, which facilitates user-friendly accessibility for clients. This document outlines our updated design, complete with detailed visual representations, subsystem linkages, and a preliminary bill of materials (BOM). Additionally, we will assess the feasibility of our updated design, addressing considerations for manufacturing and implementation, as well as identifying any skills or resources necessary for successful completion.

# **2** **Sustainability Report and DFX**

## **2.1** **Sustainability report**

Table 3: Triple Bottom Line Table with Positive and Negative Impacts.

|  |  |  |
| --- | --- | --- |
| Triple Bottom Line | Positive Impacts | Negative Impacts |
| Economic | Job creation in manufacturing, sales, distribution, and maintenance  Cost savings due to long-term durability and no need for frequent replacements.  New market opportunities | High production costs  A niche market size may lead to an increased cost per unit which could hurt the financial viability of the business. |
| Environmental | Use of long-lasting and recyclable materials (i.e., aluminum)  Reduce plastic waste by using high quality materials.  Reduce total waste by using as many reusable materials as we can. | May be made of non-renewable resources |
| Social | Promotes inclusivity and accessibility in fitness.  Improves physical health of people with limited leg mobility | If the product is too expensive or difficult to get, it could only benefit the larger, wealthier gyms. |

### 2.1.1 LCA Framework

Objective and Scope:

The objective of the LCA is to assess the environmental and social impacts of our product throughout its entire life cycle from material extraction to end-of-life disposal. The goal is to make the product as sustainable as possible by identifying areas for improvement and minimizing negative impacts. The scope of this product includes various users, specifically those with limited mobility.

Inventory Analysis: Compiling all the resources used and emissions generated throughout LCA.

Table 4: Inventory Analysis of Environmental Metrics and Impacts.

|  |  |
| --- | --- |
| Categories | Impacts |
| Materials and Manufacturing | Plastics for handles and other oddly shaped components  Metals for the frame and weight bearing parts  Rubber for grip  Water used in processing the material  Energy used in material extraction and manufacturing  CO2 from manufacturing and material processing  Waste generated during the manufacturing process such as scrap parts |
| Packaging | Energy used to package the product  Packaging materials used such as cardboard which may be wasted |
| Transport | Energy used for transportation  CO2 emissions from transport |
| Usage | Maintenace requirements utilizes materials and water to clean product |
| End Of Life | Waste generated during disposal at the end of life of the product  Potential to reuse some materials |

Impact Assessment: To evaluate the environmental and social impacts of the inputs and outputs from the inventory analysis. The impact assessment of the product reveals significant environmental challenges and social benefits throughout its life cycle.

Environmental Impact:

Global Warming: Measure of greenhouse gas emissions (CO₂) over the product's life cycle.

Resource Use: Evaluation of the depletion of natural resources (fossil fuels, minerals) and water and energy use for material extraction (ex: the plastics used are derived from petroleum which requires extraction, then refining and molding).

Waste Generation: Measurement of waste produced at each stage, especially during manufacturing and end-of-life (i.e. plastics and metals contribute to landfills if not recycled)

Social Impact:

Accessibility: Assessment of how the product improves access to fitness for individuals with disabilities.

Health Benefits: Evaluation of physical and psychological benefits from increased physical activity.

Interpretation: In this phase we will critically examine the results and draw conclusions about the sustainability of the adaptive leg press machine attachment.

Critical Examination of Results:

We analyzed the findings from the impact assessment to identify the most significant environmental and social impacts associated with the product. For example, we found that the manufacturing process generates a high level of greenhouse gas emissions, so we will prioritize strategies to reduce energy consumption or switch to renewable energy sources during production. Additionally, we assessed that the product's benefits, such as improving accessibility and promoting physical activity among individuals with disabilities, offset its environmental footprint.

Sensitivity Analysis:

We will perform sensitivity analyses to determine how changes in key parameters (such as material choices, transportation distances, or usage patterns) can impact the LCA results. For instance, if we evaluate the potential effects of using recycled materials versus new materials, we can measure the reductions in resource use and emissions. This analysis will help us identify which factors are most influential on the product’s sustainability profile, allowing us to make informed decisions on where to focus our improvement efforts.

Presentation of Results:

The results of the LCA will be summarized in a clear and accessible format. This may include visual representations such as graphs and tables to highlight key impacts, trade-offs, and benefits of the product. We will present findings that emphasize the environmental impact of our product’s manufacturing versus its potential benefits during use.

## **2.2** **Design for X**

Based on the client interview, the five most important factors in our design are adjustability, removability, ability to store, maintainability, and safety.

Table 5: Design for X Table Considering Important Features for Client.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Objectives | Metrics | Constraints | Design Criteria |
| Adjustability | Clients' feet must be able to rotate 90 degrees on the plate and translate horizontally and vertically.  Must be able to fit different shoe sizes | Cm (range for size of feet and range of motion of product) | Accommodate foot sizes (20cm to 30cm)  Height and width of leg press plate | The larger the range of accommodated foot sizes the better.  Should require minimal strength from trainer to adjust client |
| Removability | Trainer can easily remove device from clients' feet | Time | Should take under 1 min to set up client on machine | The less time for setup/removing of the device the better. |
| Ability to Store | Will be stored hanging up on the wall with a clip/clasp mechanism | m^2 and kg (size & weight of attachment) | Under 8 kg and less than 1 m^2 | Should be easy to access and not obstruct other equipment and durable enough to withstand frequent handling |
| Maintainability | Must be able to reuse over and over, good quality materials that are easy to clean | Months (frequency of maintenance checks)  Time (required for cleaning) | Must be able to last over 1yr  Cleaning should not require special chemicals | The longer the product lasts the better  Surfaces should be easy to wipe down |
| Safety | Cannot be constraining movement of client's feet in case of emergency | Load capacity (kg) | Must support a max of 100 kg | Safety features that prevent slip and can be quickly removed |

# **3** **Problem Definition, Concept Development, and Project Plan**

## **3.1** **Problem definition**

As a team, we must create a device for the trainer that allows the client to keep the weight distribution of the foot even across the plate during a leg press. The device must be removable from the machine and adjustable for various users.

Table 6: Prioritization of Client’s Statements and Needs.

|  |  |  |  |
| --- | --- | --- | --- |
| **#** | **Client Statement** | **Need** | **Importance** |
| 1 | The attachment should be able to adjust to different shoe sizes | Adjustable for different foot sizes | 5 |
| 2 | Should enable the user to move their feet both vertically and horizontally and pivot their feet in place by turning 90 degrees in either direction | Adjustable by moving feet vertically, horizontally, and rotating them | 5 |
| 3 | The trainer will place the feet on the device | Feet can be easily placed and removed from device | 4 |
| 4 | The trainer will place the device on the machine | Device can be easily placed and removed | 4 |
| 5 | The machine must have an easy, flat surface to clean | Device is easy to maintain and clean | 3 |
| 6 | All surfaces of the piece of equipment should be easily reachable | Device is easy to maintain and clean | 3 |
| 7 | Machine will hang against the wall/be clamped to the wall | Device is lightweight and small enough to store on gym wall | 2 |
| 8 | Should be good quality and last longer than 6 months | Product is durable | 3 |
| 9 | Can't be too heavy/big and cumbersome | Product is small enough to be lifted | 2 |
| 10 | When the device is locked in place/the user isn't able to move their feet around using the rails | Device prevents movement or slippage of feet | 5 |
| 11 | Nice to be professional looking, like a metallic attachment | Device matches aesthetic of existing gym equipment | 3 |
| 12 | Budget is what was given | Device costs within budget | 3 |

Table 7: Interpreted Metrics

|  |  |  |  |
| --- | --- | --- | --- |
| Metric # | Need # | Metric | Unit |
| 1 | 1 | Change in foot Size | cm |
| 2 | 2 | Displacement | cm |
| 3 | 3,4 | Degree of usability | level |
| 4 | 5,6 | Degree of maintainability | level |
| 5 | 7 | Weight of Device | kg |
| 6 | 7,9 | Size of Device | m^2 |
| 7 | 8 | Durability of Device | months |
| 8 | 10 | Degree of Slippage | level |
| 9 | 11 | Aesthetic of Device | level |
| 10 | 12 | Cost of Device | $ |

Table 8: Benchmarking.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Metric # | Need # | Metric | Unit | Resistance Bands [<https://www.youtube.com/watch?v=TYiH1rYbT0g>] | Youth Bob Skates  [<https://www.amazon.ca/Adjustable-Childrens-Reliable-Fastener-Introduce/dp/B0CNLDVM7N>] | ADL Wheelchair Leg Press  [<https://www.resolutionfitness.ca/ADL-Wheelchair-Leg-Press-p540157058>] | HUR Leg Press Rehab (5540)  [<https://www.hur.fi/en/product/5540-leg-press-5540>] |
| 1 | 1 | Change in foot size | cm | N/A | Adjustable between 20-24 cm | Adjustable up to 30 cm | Adjustable up to 35 cm |
| 2 | 2 | Displacement | cm | 5-10 cm | N/A | 20-25 cm | 20-30 cm |
| 3 | 3,4 | Degree of usability | level | Medium | Low | High | High |
| 4 | 5,6 | Degree of maintainability | level | Medium | High | High | High |
| 5 | 7 | Weight of Device | kg | 0.5 kg | 0.6 kg | 90 kg | 150 kg |
| 6 | 7,9 | Size of Device | m² | 0.01 m² | 0.05 m² | 1 m² | 1.5 m² |
| 7 | 8 | Durability of Device | months | 6-12 months | 12-24 months | 36 months | 48 months |
| 8 | 10 | Degree of Slippage | level | Medium | Low | Very low | Very low |
| 9 | 11 | Aesthetic of Device | level | Simple | Basic | Professional | Professional |
| 10 | 12 | Cost | $ | $10-20 | $30-40 | $4,500-$5,000 | $7,000-$8,000 |

Table 9: Decision Matrix.

|  |  |  |  |
| --- | --- | --- | --- |
| Metric | Unit | Marginal Value | Ideal Value |
| Change in foot Size | cm | 0-35 cm | 10-15 cm |
| Displacement | cm | 5-30 cm | 40 cm |
| Degree of usability | level | Medium | High |
| Degree of maintainability | level | Medium | High |
| Weight of Device | kg | 0.5-150 kg | 6 kg |
| Size of Device | m^2 | 0.01-1.5 m² | 0.1 m² |
| Durability of Device | months | 6-48 months | >12 months |
| Degree of Slippage | level | Low | Low |
| Aesthetic of Device | level | Medium-High | High |
| Cost | $ | $10-$8000 | $100 |

Table 10: Decision Matrix.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Selected Criteria | Importance | Cinch Straps | Velcro Mount | Sliding Rails | Magnetic Mount | Circular Rail |
| Accessibility | 4 | 3 | 5 | 4 | 5 | 4 |
| Cost | 5 | 5 | 3 | 2 | 1 | 1 |
| Appearance | 3 | 3 | 3 | 4 | 5 | 4 |
| Durability | 3 | 4 | 2 | 4 | 2 | 4 |
| Adjustability | 5 | 3 | 5 | 2 | 5 | 3 |
| Sustainability | 3 | 4 | 3 | 5 | 4 | 5 |
| **Score** | | 85 | 99 | 75 | 83 | 75 |

## **3.2** **Concept development**

To provide the client with the best possible solution to their problem, it is important to brainstorm a wide variety of potential solutions. Each team member was responsible for creating their own system to solve the problem for the client. Once each member finished brainstorming, we shared our inputs and combined subsystems to create the global solution to present to the client at the client meeting.

### 3.2.1 Velcro Solution:

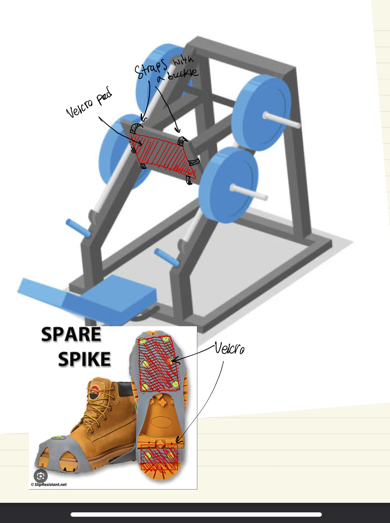


Figure 1: Sketch of the Velcro Solution.

#### Subsystem 1 (Strap-on Shoe):

To attach the clients foot to the Velcro system, the solution would incorporate an existing product that aids with the traction on ice. The metal pegs would be removed and replaced with Velcro.

Table 10: Advantages and Disadvantages of the Velcro Solution.

|  |  |
| --- | --- |
| Advantages | Disadvantages |
| 1. User friendly design that can be used without the trainer present. 2. Easy attach and detach to the machine (buckles on the straps). 3. Adjustable straps to fit various shoe sizes. 4. Adjustable angling of the feet by the trainer. 5. Easy to replace velcro if worn out or ripped. | 1. Not very secure, user could get foot stuck on Velcro pad if they lack the mobility to remove their foot. 2. Not very durable if the Velcro pad is not attached to the leg press securely. 3. Most of the product uses plastics and glues which are not environmentally friendly. 4. The velcro tape may wear out over time. 5. Not durable. |

### 3.2.2 Linear Rails Solution:

The linear rail solution consists of two overlapping perpendicular rails that have two attachment points which are able to move in the horizontal and vertical direction across the leg press plate, similar to how the rails of a 3D printer move within the printer space. The attachment points are also able to rotate around themselves by 90 degrees in each direction. On the attachment point, there will be a foot holder with two straps, one that goes around a foot’s toes and one that goes around the heel of a foot. This foot holder is extendable or compressible to fit the shoe size of various users. The rail system will be mounted to the leg press plate via hooks that go over the top of the leg press plate and a wedge at the bottom that holds the plate steady to the machine.

A drawing of a weight machine

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Figure 2: Sketch of the Linear Rails Solution.

#### Subsystem 1 (Mounting Method):

The plate of rails will be mounted to the leg press plate via hooks that go over the top of the leg press plate and a wedge at the bottom that holds the plate steady to the machine.

#### Subsystem 2 (Linear Rail System):

The linear rail system consists of two overlapping perpendicular rails that have two attachment points which are able to move in the horizontal and vertical direction across the leg press plate, similar to how the rails of a 3D printer move within the printer space.

#### Subsystem 3 (Foot Attachment):

The attachment points are also able to rotate around themselves by 90 degrees in each direction. On the attachment point, there will be a foot holder with two straps, one that goes around a foot’s toes and one that goes around the heel of a foot.

Table 11: Advantages and Disadvantages of the Linear Rails Solution.

|  |  |
| --- | --- |
| Advantages | Disadvantages |
| * Aesthetic matches gym due to metallic look. * Durable materials so long lasting. * Adjustable along plate and for different foot sizes. * Easy to clean materials. * Safe since foot will be strongly held in place and will not slip. | * Very costly. * Heavy. * Difficult to set up and remove foot and device. * Takes up a lot of space within gym. |

### 3.2.3 Circular Rails:

The circular rail design is similar to the *linear rail solution* to where it incorporates a roller guide rail and a slide block. This solution incorporates two curved linear sliding rail systems attach to the leg press plate depicted in Figure 3. The concept incorporates a system similar to the *Curved Rail Linear System (CR40 Series)* [1].

A diagram of a weight machine

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Figure 3: Sketch of the Circular Rails Solution.

The circular rails solution is divided into 3 subsystems: the clips to attach to the leg press plate, the two circular rail system, and the mechanism to secure the foot to the roller sliding block.

#### Subsystem 1 (Clip Attachment):

The clip subsystem allows both the circular rail systems to be attached to the leg press plate. The trainer can easily clip the system using a secure lock clip mechanism. It includes 4 total clips, one on the top and bottom of each rail system. The trainer can adjust the horizontal placement of the circular rail systems based from the desired location of the feet of the client.

#### Subsystem 2 (Circular Rails System):

The main component is two circular rail systems, similar to our benchmarked product, the Curved Rail Linear System (CR40 Series) shown in Figure 4.

A group of metal parts

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Figure 4: Picture of One of the Circular Rail Systems Attached to the Leg Press Plate.

The Carriage Assembly slides along the rail system to allow the client to have translational foot adjustability along the vertical axis. The client’s feet are locked in place with the system described in *Subsystem 3 (Foot-Securing Mechanism).* Once the client’s feet are secured, the carriage assembly sliders will lock in place and the client can proceed with their exercise.

To work around the inherent limited horizontal mobility of the circular rails solution, the solution will include “*modes of attachment*” for the most common foot placements on the plate based off of the client’s needs. Some examples of common foot placements are shown in Figure 5. below. The team will discuss this need with the client during the second client meeting that will cater to how we proceed with the design.



Figure 5: Image of Popular Leg Press Placements [2].

#### Subsystem 3 (Foot-Securing Mechanism):

The foot-securing mechanism will utilize features from the fifth solution in *Section 3.2.5: Adjustable Straps (Around Ankles)*. The adjustable straps mechanism will be attached to the carriage assembly in *subsystem 2 (Circular Rails System)* with each foot holder securing the clients foot with two adjustable straps.

Table 12: Advantages and Disadvantages of the Circular Rails Solution.

|  |  |
| --- | --- |
| Advantages | Disadvantages |
| 1. Easily removable from the leg press with the clip’s subsystem. 2. Stored easily by being hung on the wall with the Loop attachment on the clips. 3. High vertical adjustability. 4. Adjustable straps for multiple users with a variety of foot sizes. | 1. Low horizontal adjustability of the client’s foot as it depends on the location of the system on the leg press plate. 2. The trainer must lock the carriage assembly in place along the circular rail systems to perform the exercise. 3. Solution can be expensive proven by benchmarked products. |

### 3.2.4 Cinch Straps:

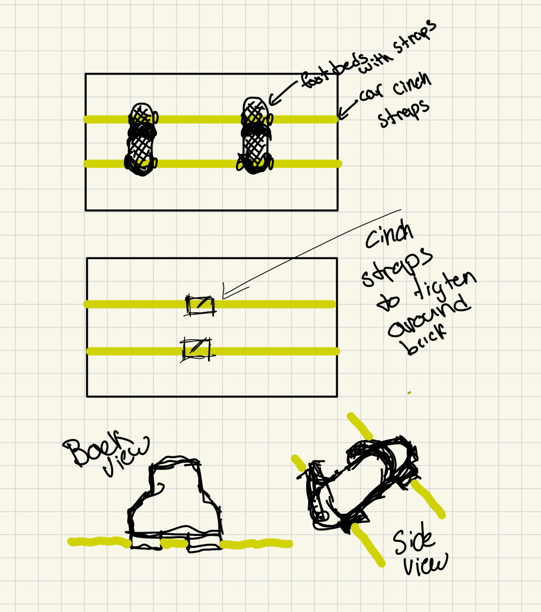


Figure 6: Sketch of the Cinch Straps Solution.

Table 13: Advantages and Disadvantages of the Cinch Straps Solution.

|  |  |
| --- | --- |
| Advantages | Disadvantages |
| 1. Easy to attach and detach from the foot of the client. 2. Easy to attach and detach from the plate of the machine. 3. Highly durable that can withstand large, applied loads. 4. Good foot security for the client. 5. Cost-efficient 6. Similar to previous solutions for adaptive gym equipment | 1. Not an aesthetically pleasing design. 2. Low horizontal adjustability |

### 3.2.5 Adjustable Ankle Straps:

The Adjustable Ankle Straps system consists of a vertical and horizontal rail system to enable the user to move their feet across the plate of the leg press machine, a footrest and 180° pivot system to allow the user to move their feet both clockwise and counterclockwise when using the leg press machine, hooks that attach the system to the leg press machine, and adjustable ankle straps to keep the user’s feet in place when using the machine.

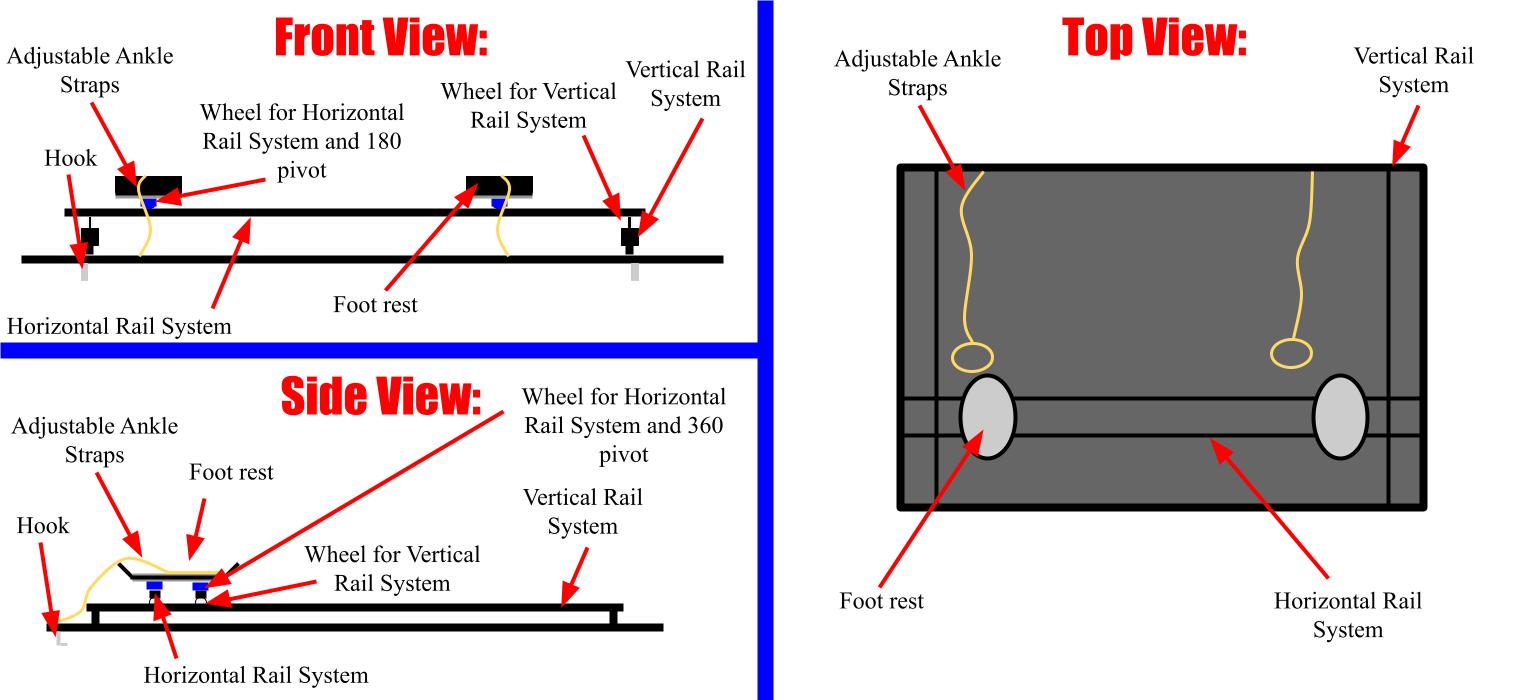


Figure 7: Sketch of the Adjustable Ankle Straps Solution.

#### Subsystem 1 (Adjustable Ankle Straps):

The adjustable ankle straps descend from the top of the apparatus and wrap around the ankles of the user; the client, or another trainer at the gym, will insert the users’ feet into the nose, and adjust the width of the nose, and the length of the rope attached to the nose, so that they do not slip downwards, off the machine. This system is particularly useful since the client will be using a horizontal leg press to train the users, meaning that the feet of the users will not dangle forward when they attempt to use the leg press machine—as would be the case with a 45 degree, or vertical, leg press machine.

#### Subsystem 2 (Footrest and 360° Pivot):

A brimmed footrest, which angles upward in both directions, will be attached to the machine with a 180° pivot. The brimming and angling of the footrest is designed to create more friction between the users’ shoes/feet and the surface of the footrest, to further prevent the users’ feet from slipping off the leg press machine. The 180° pivot will allow the user to swivel their feet around 90 degrees both in the clockwise and counterclockwise directions, so that they can adjust their foot placement to maximize comfort, and more effectively target different muscle groups; this pivot will have a locking mechanism which can be engaged once the user is comfortable with their foot placement, in order to prevent any unnecessary swiveling during exercise.

#### Subsystem 3 (Horizontal Rail System):

A horizontal rail system, comprised of two horizontal beams laid out close together, and one set of wheels attached to the bottom of the second subsystem will enable the user to independently move their feet both left and right. This subsystem will be placed on top of the fourth subsystem and will harbor the capacity to lock in place once the user is comfortable with their foot placement and is ready to begin using the leg press machine to work out.

#### Subsystem 4 (Vertical Rail System):

A vertical rail system, comprised of two vertical beams laid out on separate extremities of the apparatus, and two wheels which attach to the bottom of each horizontal beam in the third subsystem will enable the user to independently move their feet both up and down, across the plate of the leg press machine. This subsystem will be able to lock in place once the user is content with their foot placement, and it will be placed on top of a metal plate that will go on top of the plate for the leg press machine.

#### Subsystem 5 (Hooks):

The final subsystem is one set of metal hooks which will go on the back of the metal plate elucidated in the description of the fourth subsystem. Only two hooks will be used, both of which will be placed on the top of this adapted leg press attachment, since the client will need this attachment to be mounted onto a horizontal leg press, rendering the need for additional hooks redundant.

Table 14: Advantages and Disadvantages of the Adjustable Ankle Straps System.

|  |  |
| --- | --- |
| Advantages | Disadvantages |
| 1. The adjustability of the nose allows the different users with different ankle/foot sizes to use the machine. 2. The rail system for this design falls perfectly in line with the clients’ recommendations. 3. This design has an intuitive/simple to use foot binding/fastening system. 4. The foot binding/fastening system is simple and easier to build compared to other designs. 5. The hook system is simpler and easier to build compared to other designs. | 1. This design is expensive to build relative to other designs. 2. This design is very intricate which could make it difficult to build. 3. This design could potentially be hard to fix, due to niche parts needed to make it work such as the wheels and 180° pivot system. 4. This design only works properly on a horizontal leg press which could be an issue if the client ever decides/needs to replace their current horizontal leg press with a vertical leg press or 45° leg press, in the future. 5. This design renders it potentially difficult to readjust the user’s feet onto the machine since you’d have to adjust the length of the rope attached to the nose, the nose itself, and the user’s feet every time you’d want to change the user’s foot placement. |

## **3.3** **Project plan**

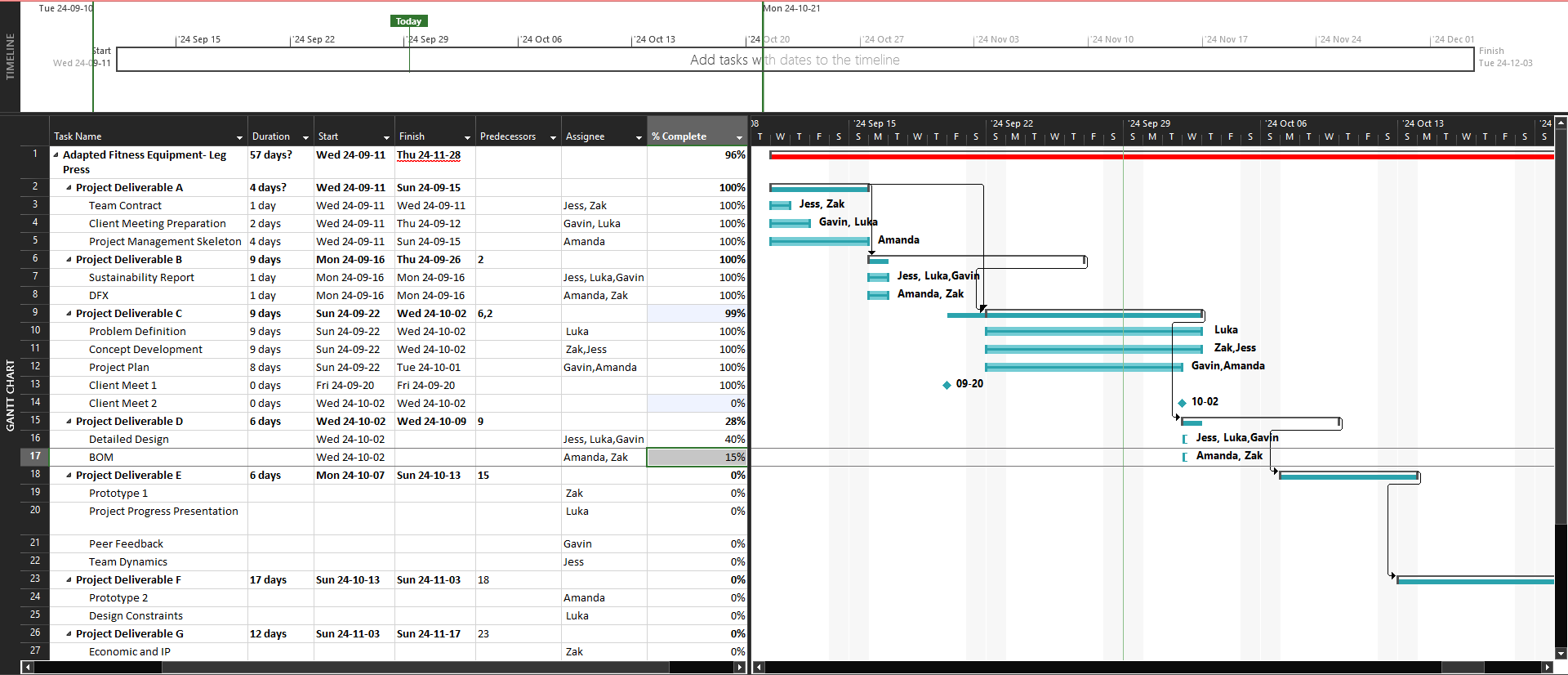


Figure 8: Updated Gantt Chart.

# 4 Detailed Design and BOM

The team decided to proceed with the Velcro design outlined in section *3.2.1 Velcro Solution,* due to the feedback received from our client during client meet 2. The client suggested some modifications to the initial design, outlined in section 4.1.2 Updated Detail Design.

## 4.1 Detailed Design

### 4.1.1 Client Feedback

Our client is enthusiastic about the Velcro idea from (insert section) we proposed during client meet 2. He enjoyed the simplicity of the design and the ease of use.

The client emphasized the idea of being able to replace or repair sections of the design himself, which the Velcro design allows for. He said many of the products students create, he is not able to use in a day-to-day setting. The Velcro idea is a product he can see himself using to benefit his clients fitness training with the leg press.

Instead of the Velcro being attached to a plate, he suggested it instead be attached to a rubber pad, to which he can roll up and store easily with the ither fitness equipment.

The Velcro design allows his clients to have free mobility of their foot placements on the leg press plate, a factor very important to our client.

The client suggested we use a device similar to Footwear Traction Aids for the foot-securing mechanism, to where his clients can easily slip on and off and store with the Velcro rubber pad.

### 4.1.2 Updated Detail Design

Our updated design is an extension of the concept outlines in section *3.2.1 Velcro Solution,* with some amenities added based off of the second client meeting and aspects of other proposed designs. Below is a figure outlining the previous design.

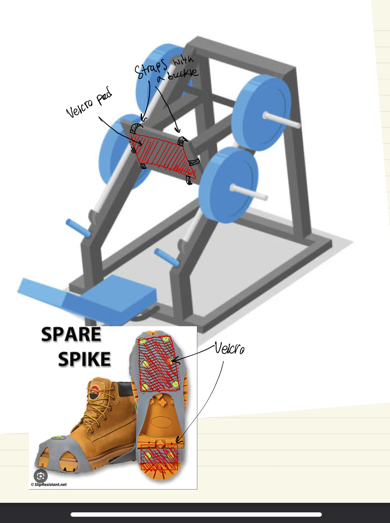


Figure 9: Sketch of the Velcro Solution.

#### Subsystem 1: Velcro and Rubber Padding

Our original idea incorporated large area of Velcro attached to a plate, which would then clip on to the front of the leg press plate. Upon discussing this idea with the client, we decided to instead attach the Velcro piece to a rubber padding, which can be rolled up and stored away easily. The rubber padding will be attached to *Subsystem 2: Straps*, to then be secured to the leg press plate.

#### Subsystem 2: Straps

This subsystem will secure Subsystem 1: Velcro and Rubber Padding onto the leg press plate. It will include two straps that clasp onto the back of the plate, ensuring it does not move during exercise. This idea extends from section *3.2.4 Cinch Straps Solution,* an idea pitched to the client. Figure 10 depicts the original idea below:

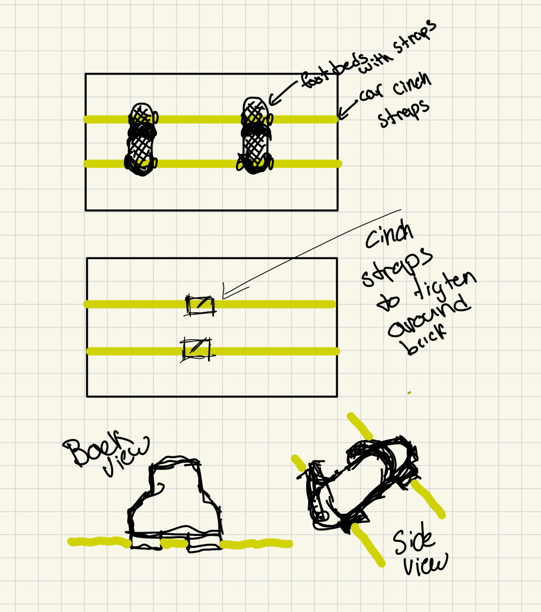


Figure 10: Sketch of the Cinch Straps Solution.

#### Subsystem 3: Foot Holder

The last subsystem involves a method to secure the users feet in place during the leg press exercise. A boot shown in figures 11, similar to what you would find on a rowing machine or ski boots, will have the other side of the Velcro fastened onto it. A “one size fits all” solution is essential, as our client is training multiple users with a variety of foot sizes. The idea originated from section 3.2.1 Velcro Solution, and was suggested by our client due to the fact it is easily replaceable.



Figure 11: Correct Placement of Foot Straps for Rowing Machine [3].

### 4.1.3 Considerations

The biggest consideration our team must meet for the client is maintainability. Our client said that many student projects are not realistically usable for the average client, as they are complex and cannot be repaired. Our team must make it a priority to incorporate aspects where our client can easily buy and replace themselves.

The Velcro itself is the system that will need to be replaced the most often, so our team decided to purchase Velcro pads from Amazon outlined in section *4.2 BOM*. The remaining subsystems, such as the rubber padding on the back, will be created around the dimensions of the easily purchasable Velcro pads.

Adjustability is an important factor in our design. In the second client meeting, we got a better idea of what kind of adjustability requirements must be met. The client emphasized the need for our solution to cater towards a wide range of people, where some place their feet in different locations depending on their needs.

### 4.1.4 Skills and Time Required

### **4.1.4.1 Available Skills:**

**Design and Prototyping:**

* Proficient in CAD software for creating detailed design models.
* Experience in rapid prototyping techniques.

**Mechanical Engineering**

* Understanding of materials and mechanical systems in fitness equipment design.
* Skills in structural analysis to ensure stability and safety.

**Project Management**

* Ability to coordinate tasks, set deadlines, and manage group activities effectively.
* Experience in resource allocation and budget management.

**Ergonomic Design**

* Skills in designing user-friendly devices.
* Knowledge in methods of conducting user satisfaction surveys to obtain feedback and improve usability.

### **4.1.4.2 Available Resources**

**Fabrication Tools:** Access to a maker space with 3D printers, laser cutters, and other fabrication equipment.

**Library/Online Resources:** Availability of technical documentation, tutorials, and design guides for reference.

**Suppliers or Local Stores:** Budget to purchase up to $100 of products to contribute to the final prototype of our device.

**Expert Guidance:** Access to teaching assistants and project managers for feedback and support.

### **4.1.4.3 Time Assessment**

**Estimated Time Required for Implementation:**

* **Design Phase:** 2 weeks
  + Finalizing designs, creating detailed documentation, and preparing for prototyping.
* **Prototyping Phase:** 3 weeks
  + Building the prototype, testing, and making necessary adjustments.
* **Testing and Refinement Phase:** 1 week
  + Conducting user tests and gathering feedback for final adjustments.

**Total Estimated Time:** 6 weeks

**Actual Time Available:**

* **Group Availability:** 3-5 hours per member per week.
* **Total Group Time (5 members):** Approximately 15-25 hours per week collectively.

**Total Time Over 6 Weeks:** 90-150 hours (combined).

### **4.1.4.4 Critical Product Assumptions**

1. Material Delivery: Assumes that all necessary materials and components can be delivered within the project timeline and budget. Delays in material delivery could impact the implementation schedule.

2. Functionality Requirements: Assumes that all critical functionalities identified during the design phase will remain consistent throughout development. Changes in requirements may result in the need for design modifications.

3. Client Approval: Assumes that the design will meet client expectations as outlined by the client. If feedback during testing indicates dissatisfaction, further iterations may be required.

## 4.2 BOM

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Item** | **Description** | **Unit of Measure** | **Quantity** | **Unit Cost** | **Extended Cost** | **Link** |
| Velcro Pads | 4x6 inch Velcro Pads for versatile applications | Unit | 12 | $2.00 | $23.98 | [Link](https://www.amazon.ca/HuaHengHT-2-36x2-36-Adhesive-Industrial-Mounting/dp/B0D6TMSTNJ?th=1) |
| Buckle Straps | Adjustable Buckle Tie Down Straps for Securing (110cm x 2.5cm) | Unit | 2 | $1.22 | $2.45 | [Link](https://www.temu.com/kuiper/dn9.html?subj=downloadable-ads-shopping&_bg_fs=1&_p_jump_id=841&_x_vst_scene=adg&goods_id=601099600838477&sku_id=17592533938799&adg_ctx=a-e7888cb4~c-19b2eebd~f-239153d6&_x_ads_sub_channel=shopping&_p_rfs=1&_x_ns_prz_type=-1&_x_ns_sku_id=17592533938799&_x_ns_gid=601099600838477&mrk_rec=1&_x_ads_channel=google&_x_gmc_account=695390730&_x_login_type=Google&_x_ads_account=6910707695&_x_ads_set=21554005098&_x_ads_id=167341245482&_x_ads_creative_id=708494331776&_x_ns_source=g&_x_ns_gclid=CjwKCAjw3624BhBAEiwAkxgTOkuVfWRbLmXtXGDk0yACp0JN_JKvfW37zfVAv6NbDOu3z2A3oQQiHRoCuFkQAvD_BwE&_x_ns_placement=&_x_ns_match_type=&_x_ns_ad_position=&_x_ns_product_id=17592533938799&_x_ns_target=&_x_ns_devicemodel=&_x_ns_wbraid=Cj8KCQjw3624BhCJARIuAOnwUb5NAyqg9wBWfsYe0B8GSSGRQ8xxWpMVKDXjWeyv0PP7wPdtJUsprxtG1xoC2Ig&_x_ns_gbraid=0AAAAAo4mICHE_sdZ-rQN5C2nMO3X_D2cU&_x_ns_targetid=pla-2323201398224&gad_source=1&gclid=CjwKCAjw3624BhBAEiwAkxgTOkuVfWRbLmXtXGDk0yACp0JN_JKvfW37zfVAv6NbDOu3z2A3oQQiHRoCuFkQAvD_BwE&is_back=1) |
| Rubber Pad | All-Purpose Ribbed Recycled Rubber (3 mm Thickness) 36-inch x Custom Length Roll | Feet | 1.5 | $7.98 | $11.97 | [Link](https://www.amazon.ca/Resistant-25-Thickness-Cushioning-Anti-Vibration/dp/B0B2QZVFL3?th=1) |
| Ski Shoes | Mini Short Ski Skates, One size fits all | Unit | 1 | $48.47 | $48.47 | [Link](https://www.temu.com/goods.html?_bg_fs=1&goods_id=601099659579121&sku_id=17592753208851&_oak_page_source=501&source_goods_id=&current_rec_strategy=&refer_page_name=goods&refer_page_id=10032_1728867071662_w8zm5svw67&refer_page_sn=10032&_x_sessn_id=9an5f7ohwu) |
| **Total product cost (without taxes or shipping)** | $86.87 | | | | |  |
| **Total product cost (including taxes and shipping)** | $98.16 | | | | |  |

## 4.3 Project Plan Update

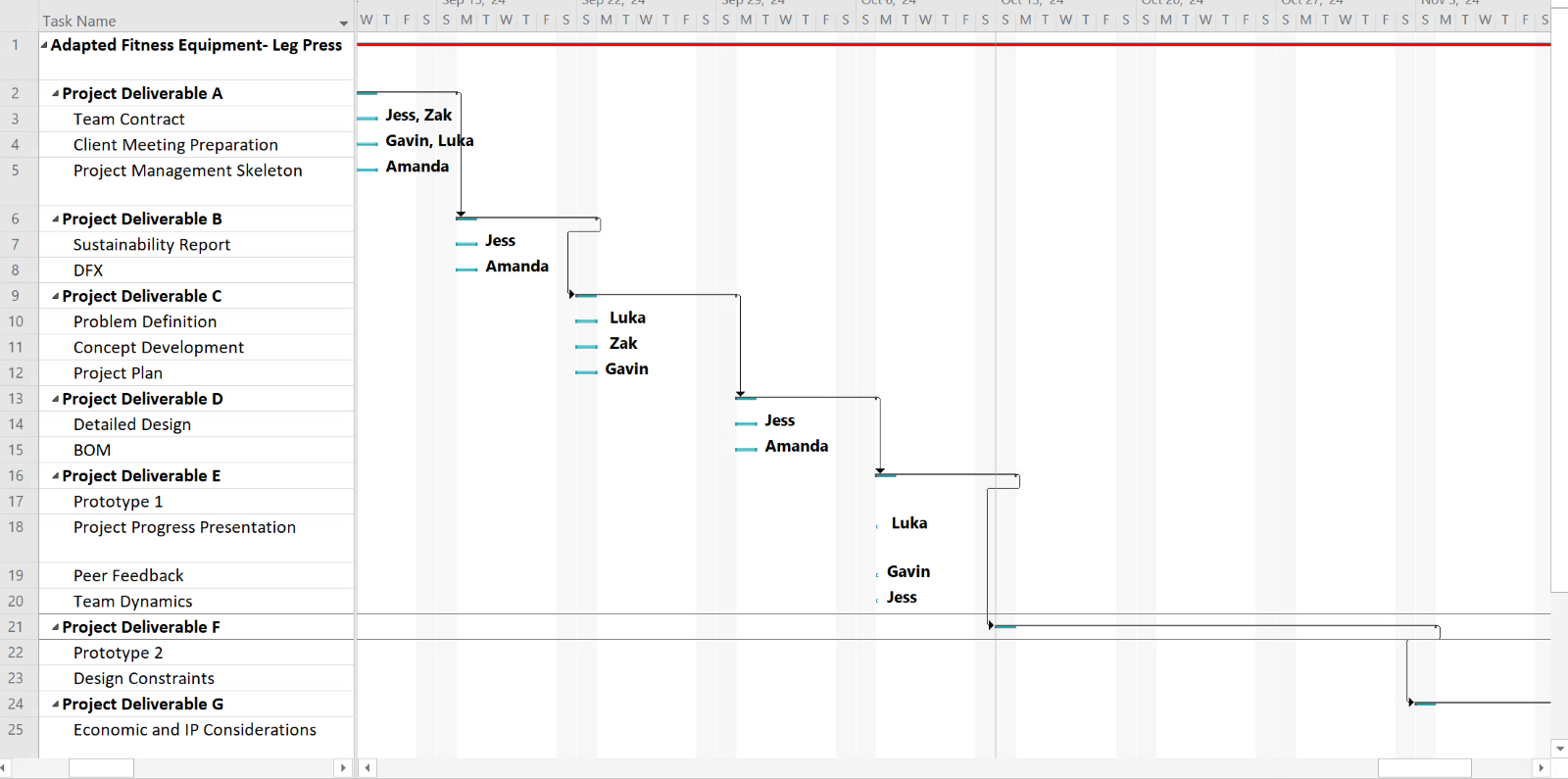
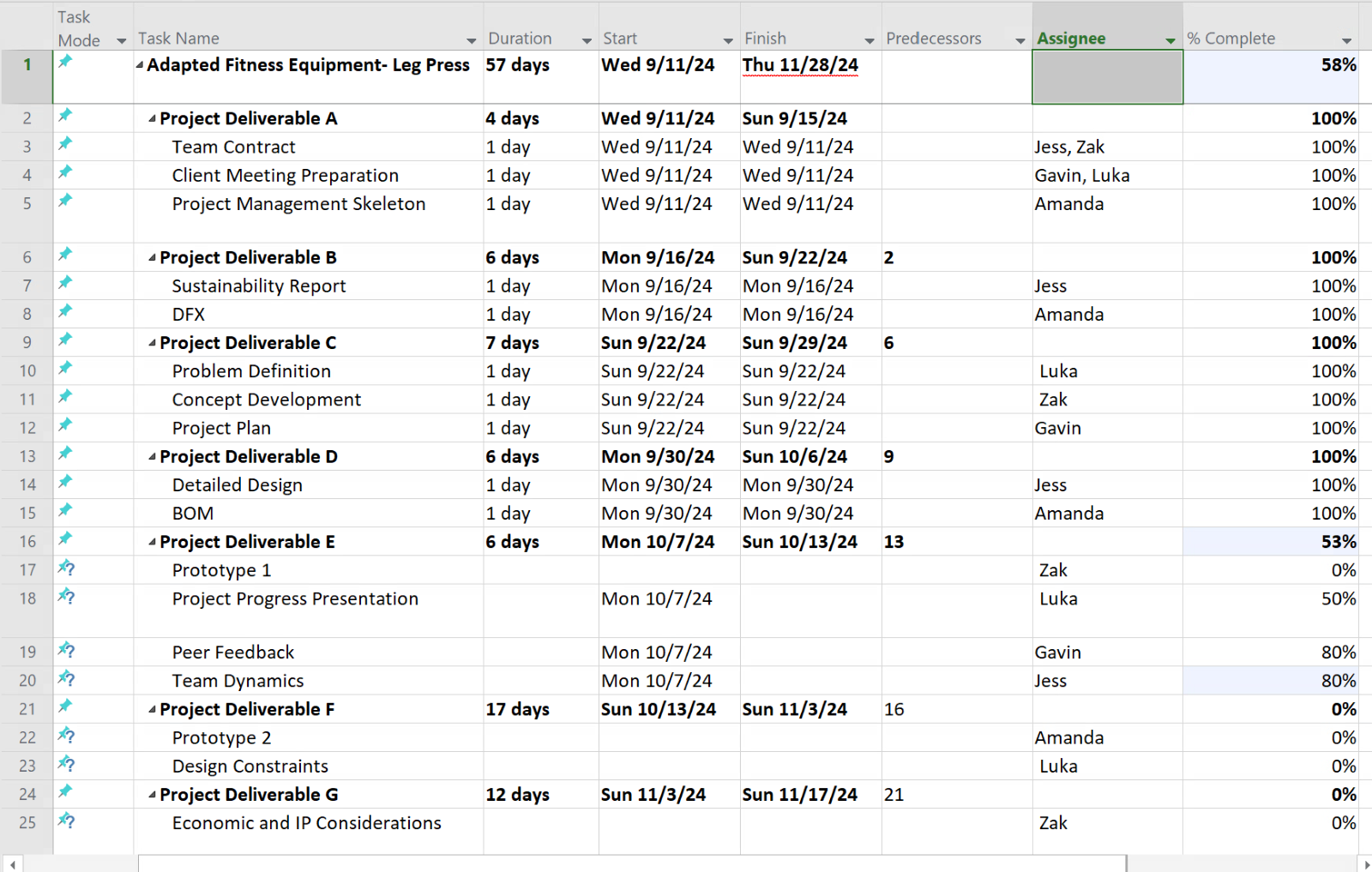


Figure 12: Updated Gantt Chart.

# **5** **Conclusion**

In conclusion, this deliverable showcases our updated design for the Velcro-based fitness solution, reflecting the insightful feedback from our client. We’ve laid out our Bill of Materials and assessed the skills and resources we have at our disposal, along with a realistic timeline for implementation. By addressing key assumptions and potential challenges, we are able to move forward in creating a prototype that not only meets our client's needs but also enhances the user experience.

# **6** **Bibliography**

|  |  |
| --- | --- |
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