GNG2101

**Design Project Progress Update**

**Bathroom Assist (g\_2)**

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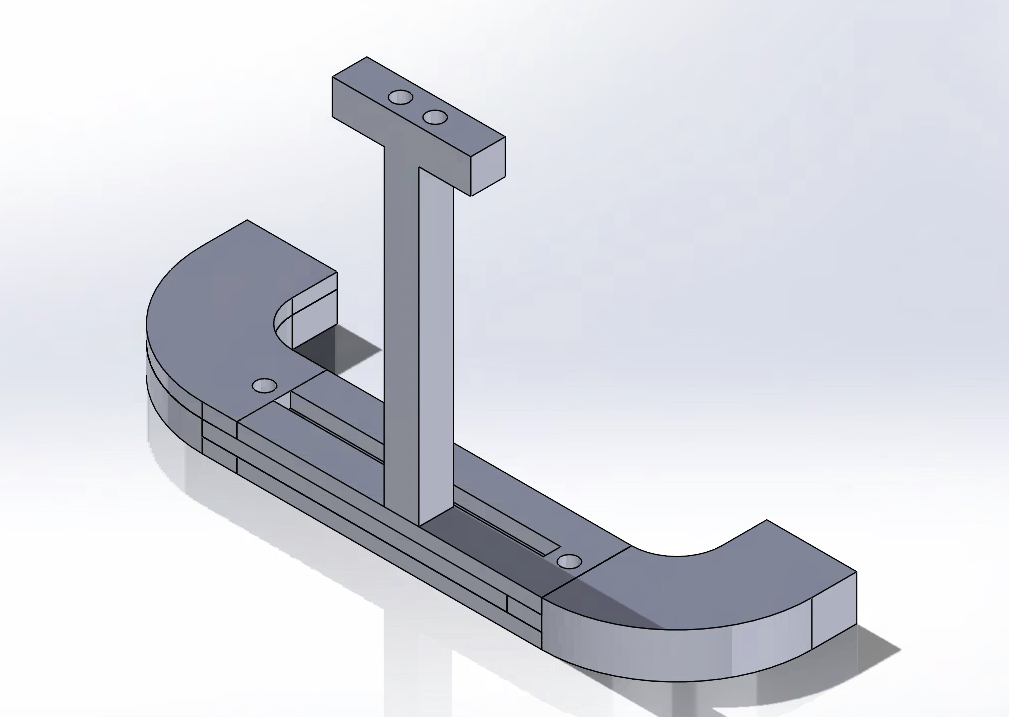


Figure 1: Prototype I

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**List of Acronyms and Glossary**

**Table 1. Acronyms**

| **Acronym** | **Definition** |
| --- | --- |
| ABS | Acrylonitrile Butadiene Styrene |
| PLA | Polylactic acid |
|  |  |
|  |  |
|  |  |

**Table 2. Glossary**

| **Term** | **Acronym** | **Definition** |
| --- | --- | --- |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

# Introduction

The activities regarding Prototype I are outlined in Section 2, including whether our critical assumption from our global design concept was validated and if the product design can sufficiently move forward to Prototype II.

Sections 5-7 are currently unfinished.

# Prototype 1, Project Progress Presentation, Peer Feedback and Team Dynamics

## Prototype 1

**Choose one (or more) critical assumption(s) you defined in Project Deliverable D, or other problematic or unknown elements of your design and outline tests you must carry out in order to validate the assumption. Explain which of your DFX factors from Project Deliverable B this test(s) relates to.**

For our product design, the primary unknown element is the cumulative weight of all subcomponents when put together. This unknown is particularly important because it is the biggest consideration in regards to the client being able to use the product, as they are unable to hold heavy products for any more than a short (5-10 seconds) period of time. As a result, the primary assumption that we will use prototype I to validate is that the weight of the product is at least in the range between our specified target specification and marginal specification (130-250).

The testing will be carried out through the use of CAD by measuring our prototype volume and then applying the proposed materials (as defined in our BOM) onto the manifold and then calculating the cumulative weight of the product. If the product weight is higher than our acceptable values, then the product materials will be swapped with materials proposed in our client meeting and design review sessions, and then retested to see if they fall into the appropriate range.

This test relates to the Design For the Portability factor, which is stated as:

**“**

**Portability**

* 1. This product's use case is that it allows people with certain debilitating conditions to become far more independent. As a result, the product must be made with specific weight and dimensional considerations in mind.
  2. This would be measured by checking to see that the product is sufficiently foldable/collapsible such that it can fit into an average-sized backpack/briefcase.
  3. To achieve this design specification, the product ought to weigh less than 3 Kgs and be less than 18(h)/12(w)/6(d) in volume.
  4. A product that has less weight and a smaller dimensional volume is better.

**”**

As a result, the test will confirm whether we have met the design specifications outlined in the section above.

**Create your first prototype(s) and document it using as many sketches/diagrams/pictures as required and explain the purpose and function of your prototype(s).**

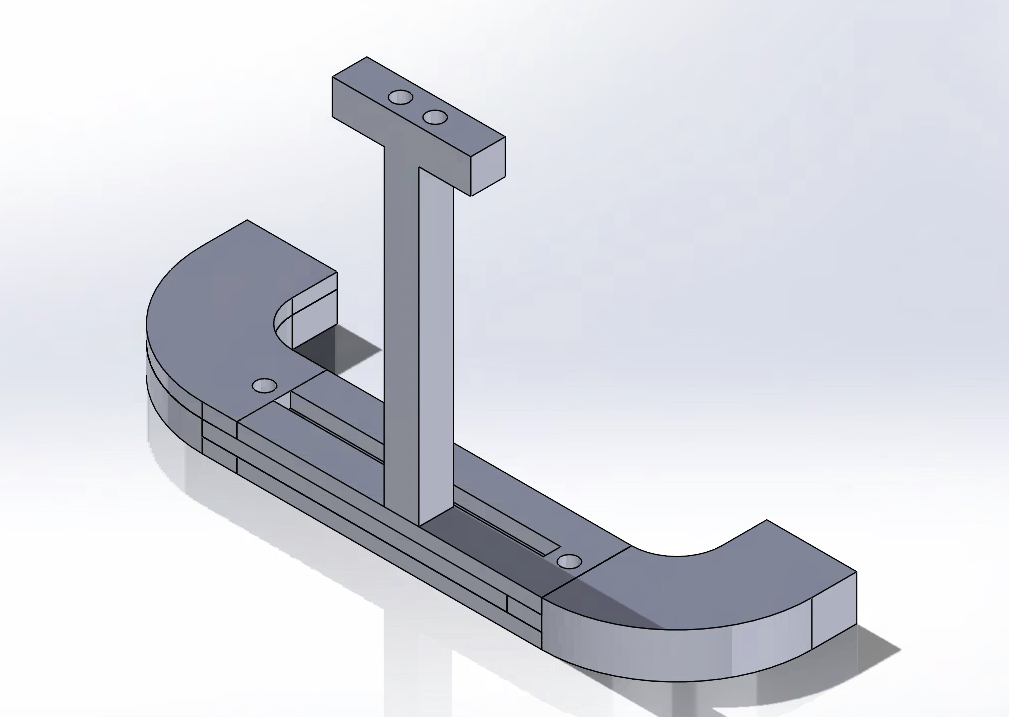


Figure 1: Prototype I

The function of Prototype I is to have a design such that various materials can be applied and tested for their contributions to the weight of the product, such that the initial critical assumption of our design is validated, being that the product is light enough for the client to use on a daily basis.

**Carry out prototype testing, analyze and evaluate performance compared to the target specifications developed in Project Deliverable C and document all your testing results. Your target specifications can evolve from PD C. Present your testing in an organized, tabular format that shows expected versus actual values.**

|  | Units | Expected Value (target) | Expected Value (marginal) | Actual Value |
| --- | --- | --- | --- | --- |
| Weight (ABS) | g | 1000 | 1500 | 1916.82 |
| Weight (PLA) | g | 1200 | 1800 | 1942.5 |

As can be seen from the above table, the actual weight values measured from the prototype I are larger than the expected values, mostly due to the linear actuator in the design, which has a standalone weight of 1.14kg. The other parts of the design themselves combined are far lower than the expected weight values and are lightweight enough to be comfortably used by the client.

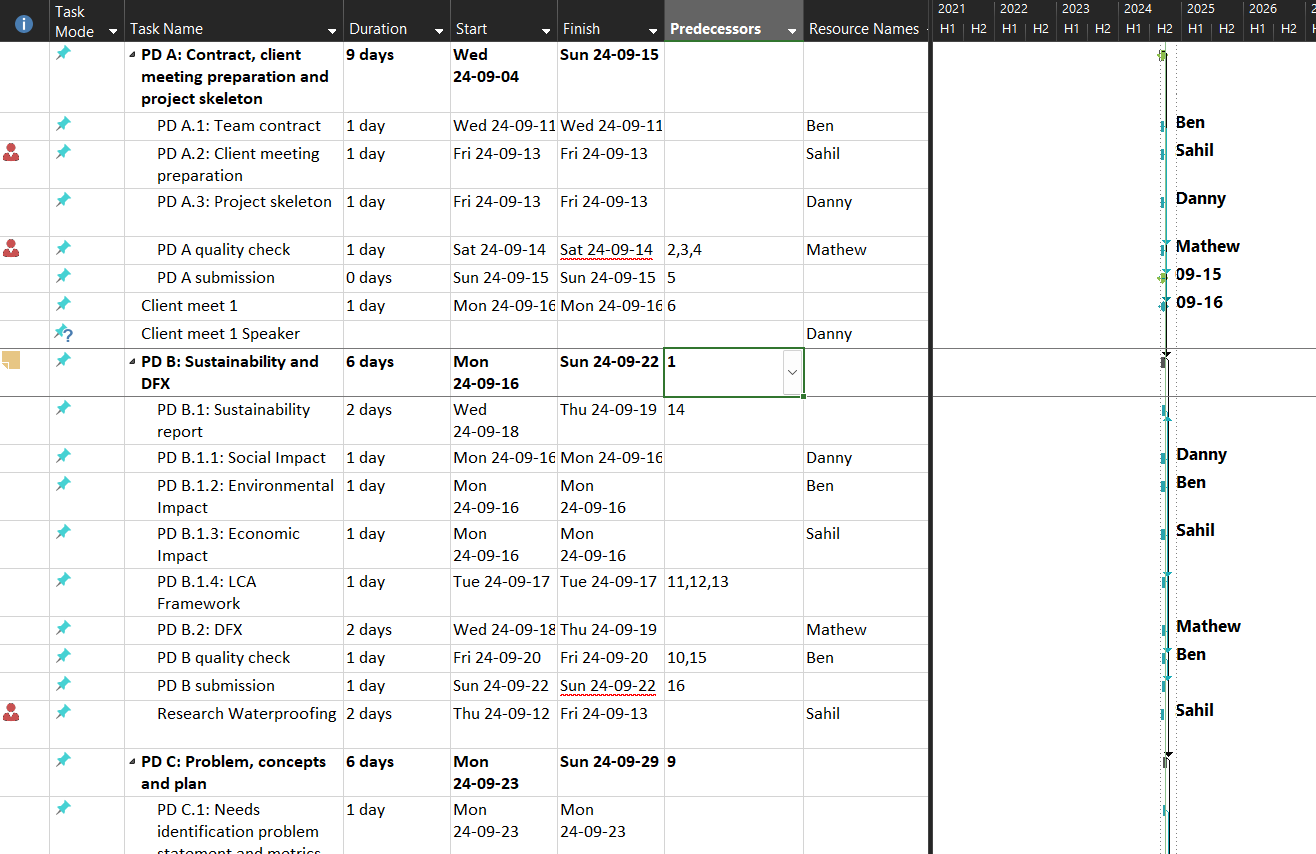
As a result, changes will have to be made specifically regarding the linear actuator such that the overall weight of the design is closer to our expected values and within a comfortable range such that the client can effectively utilize the product.

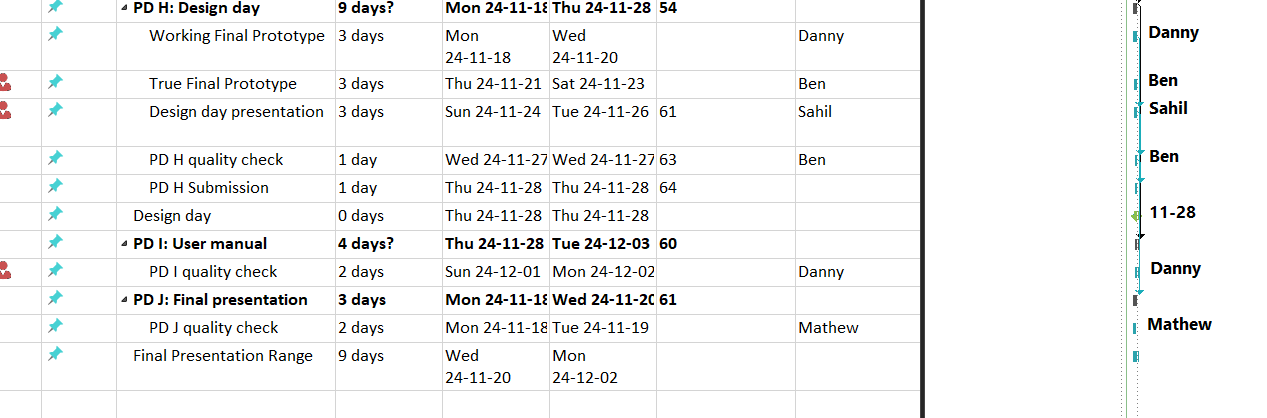
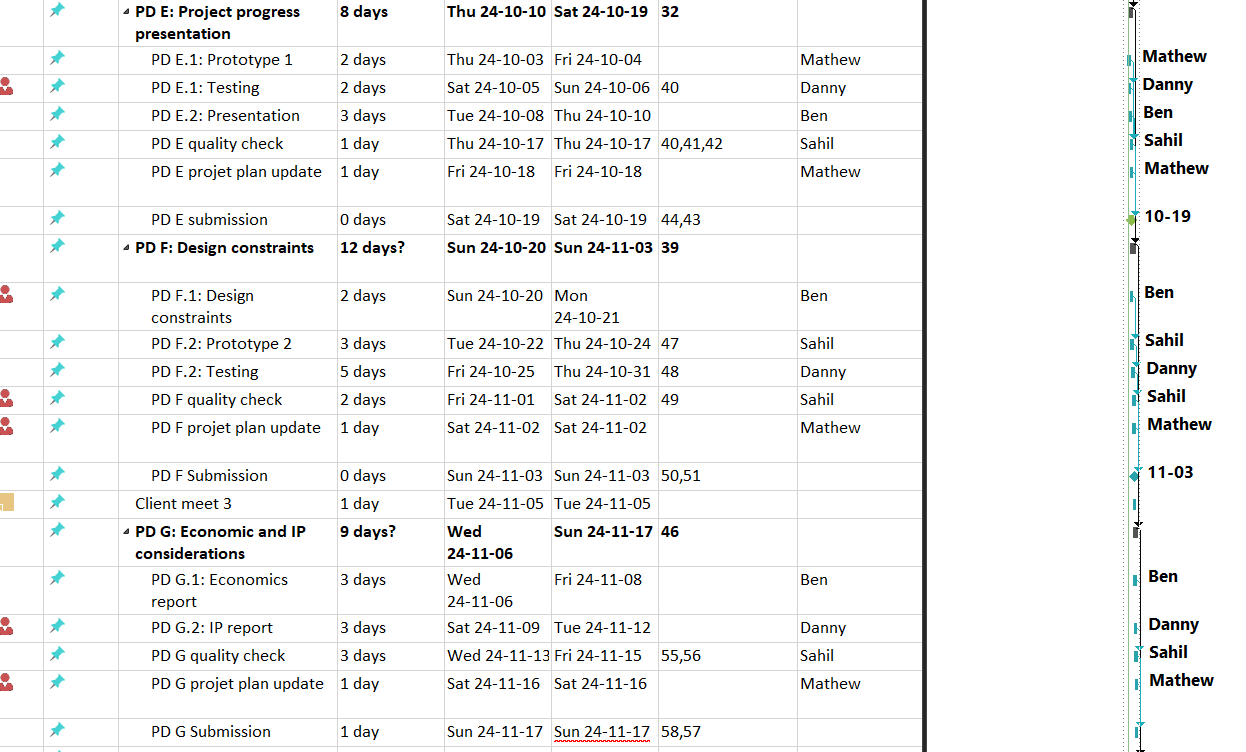
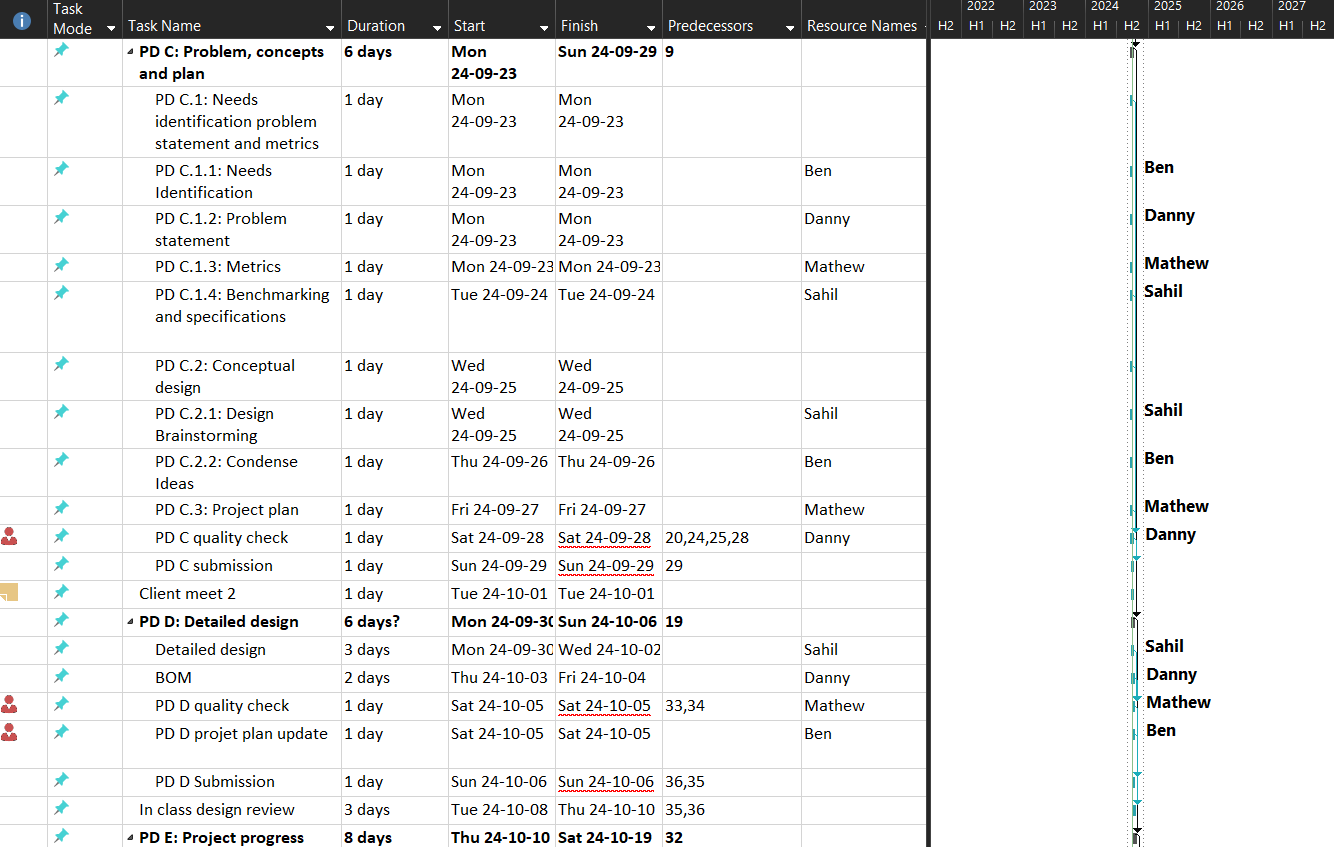
## Project Progress Presentation

[Project progress presentation](https://docs.google.com/presentation/d/1n00tyXVnm3MK0bRzwtTBubwbJI56MZClgSu4Tmsd4CY/edit?usp=sharing)

<https://docs.google.com/presentation/d/1n00tyXVnm3MK0bRzwtTBubwbJI56MZClgSu4Tmsd4CY/edit>

## Project plan update





# Design Constraints and Prototype 2

## Design constraints

**Identify your two most important non-functional design constraints (DFX factors) that play an important role in the development of your prototypes. Justify your reasoning**

1. **Design for maintainability**

Because this product is intended to stay with the client for a long time, it would be useful if the materials of which the design is made were durable, long-lasting, and not prone to rips or tears as they accumulate daily use.

**For each design constraint, explain in detail what changes would need to be made to your design to satisfy the constraint (if any) or what already exists in the design to respect the constraint.**

This DFX constraint is being fulfilled by examining the properties of materials used and observing how daily usage affects both its structural integrity and that of the systems (eg. if a clamp weakens over time, the system altogether begins to break down in capable usage).

1. **Design for adaptability**

As was stated for Design for maintainability, because the product is meant to be used over a long time horizon, having it so that the product can be user-modified such that it contorts to differing user preferences would greatly benefit the product overall.

**For each design constraint, explain in detail what changes would need to be made to your design to satisfy the constraint (if any) or what already exists in the design to respect the constraint.**

This DFX constraint is being fulfilled by having the straps that are fed through the device be both long enough to accommodate the client as they grow and having a mechanism that can hold excess strap material while the client is still growing.

**Provide proof (e.g. analysis, simple calculations and/or simulations, research) to demonstrate the effectiveness of your design in satisfying the constraints. Justify the process and methods you used.**

**Design for maintainability:**

Below is a table of the BOM for our current prototype, and their respective lifespans within products.

| ITEM | Description | Material | Size | Qty | Seller/  Process | Price |
| --- | --- | --- | --- | --- | --- | --- |
| 1 | Fabric Strap | Polypropylene webbing | 1.5”x10yard | 1 | [link](https://www.amazon.ca/Strapworks-WSR-PRO-LWP-112-10Y-BLK-Lightweight-Polypropylene-Webbing/dp/B01KTVAYBE/ref=sr_1_8?dib=eyJ2IjoiMSJ9.-Q6G3XqttHhtXhehwaug3NU7UZy7MfshtIBtynFDEUnYR8TnNdQKsw1K2Mm_HFn3RM4mi08KMB4kOtHreIWILoXzsEZa8paTjgYu0HSW3Rrfuj0jznvjU-GsJVft4d4Bxq3Boduvz-cIF7ontzif0Bxvb6FMnK10zCLy8YP_i2I3gU2n66LqSs7mlajkBjVG_jLglWL-78QmNyPAj6RVq1sdqj7z_EKPJIeBTPgQMDBfoa0vvWRaYmulf662bxn8qb7_gq97jICKXm-q3c5RSAWu6Bv8rLyVGNsqrHfOfCY.iEnj6aOCOihBfGGpkwy7qMbvryYegbI9YJGAXosoyl8&dib_tag=se&hvadid=667095757576&hvdev=c&hvlocphy=9000671&hvnetw=g&hvqmt=e&hvrand=15897828673203563692&hvtargid=kwd-300489834688&hydadcr=20601_13479321&keywords=polypropylene%2Bwebbing&qid=1730400531&sr=8-8&th=1&psc=1) | $12.61 |
| 2 | Foam padding | Neoprene foam | ¼ Thick x 17” x 80” | 1 | [link](https://www.amazon.ca/Homend-Neoprene-Adhesive-multiple-dimensions/dp/B0811V5MHK?dib=eyJ2IjoiMSJ9.AYwh-XvxfRPUE70KT8f_VGhse9Gq5cXNzP6IFioWSkhKUsrfgVZJwcgq_7CM6Cl8XOrJMEPQSOGQCkAd9BxBPsnsq0ilqOryAIZOVzdMbw9aJKOgcL0Tw5GZL-aGo_lwgrUmBpqZEtuuC1l5uaOGZtwNOZ-6jB1FPPK-XFI161jd8O4K-a6WlSSEskno3_sFI8lR2PTiB28XnQil3sUlZwT867sPFX8CsdbsE9eLTlPZoDMmleBc7pXRaEr6KKRK47ex8htpaN_qlfEAyTUiuD4p-nLYF_aBBe4e54ktKy4.uuf9SNUVTji1_w4NAVTosDicjpp3iV1m254pBY9FBXg&dib_tag=se&keywords=closed%2Bcell%2BPolyethylene%2BFoam&qid=1730402116&sr=8-38&th=1) | $23.50 |
| 3 | Padding cover | Canvas tarp | 4ft x 5ft | 1 | [link](https://www.amazon.ca/Avalon-Home-Canvas-Premium-Quality/dp/B08WKHQMXH/ref=sr_1_10?dib=eyJ2IjoiMSJ9.E0Y7bndb5hlyM4_2m2iWnK3vkzfnawLev20Pj_qzlnPhMfVo7Rt_L3K0lPz6tyE7j3JxHHxMl7Kw5ZFvDZb_jn_nDwM6gUrk2abtIfzyZl9yNt8pZebTY1l7Jb6HLkvaPpkNh-VunXd5FzuYvL3dBZNwICMZRPKVedg24ZmPia6GdyAoU6c3Unzqaq9lW3pkuptaGhf_dVx7jNBUHsEE0LMg5NIlMIr2diHIyyR1i6aAbeA8s6EBSo_mjPnWAgxqCrPY4P5dlXHBbsDSPUiEEsKIIi7TXVJYwSMRiAsa0NM.m127l774VWTYpVQ_ph39m_kyZfAW7ibKbXyTKNHHe9g&dib_tag=se&keywords=canvas%2Bfabric&qid=1730431762&sr=8-10&th=1) | $16.99 |
| 4 | Fixed Loop Snap | Zinc-plated metal | 1 ½ inch | 4 | [link](https://www.canadiantire.ca/en/pdp/ben-mor-fixed-square-eye-champion-snap-zinc-plated-assorted-sizes-0618803p.0618803.html?ds_rl=1283573&ds_rl=1283573&gclid=Cj0KCQjw1Yy5BhD-ARIsAI0RbXbpK2G7vOS_naNmJjKr9AaTBEFsVdwc0NCaj6vqJJGcUs_6ltQCLUEaAlp9EALw_wcB&gclsrc=aw.ds&colorCode=PRODUCT_LENGTH_CD_3_4) | $11.56 |
| 5 | Belt | NA | NA | 1 | NA | Preowned |
| 6 | Pants | NA | NA | 1 | NA | Preowned |

Polypropylene products typically have useable lifespans of ~20 years, which is particularly long because the material will be covered and have little UV exposure. (Mannheim, V., & Simenfalvi, Z., 2020, August 24)

Neoprene padding has a lifespan of 5-10 years, especially shortened by exposure to moisture. In the typical use case for this product, the assumption is that there is moisture exposure and a shorter lifespan. (Interstate Specialty Products, 2024, September 30)

Canvas tarp typically has a lifespan of 5 years, with little externalities because the material is made specifically to be used outside and exposed to the natural environment. (Tarp Supply Inc, n.d.)

Zinc plating stays rust-free for 70-150 years without significant exposure to moisture. (American Galvanizers Association, n.d)

**Design for adaptability:**

Because the purchased straps are absorbently long (10 yards=360”), they will be cut down to ~6.5ft (to accommodate the maximum length for an average person). As a result, the rolling mechanism which will keep excess length needs to be able to hold at least 7ft (such that it can be pulled out easily).

According to these requirements, we can calculate the dimensions of the required mechanism:

fabric thickness: 0.04”

fabric length: 84”

n = fabric length/2πr, n=layers of fabric, r=initial inner radius

suppose r=0.5, n = 0.04/2pi\*0.5 = ~40 layers.

Rfinal=r + n \* Fabric thickness = 2.1”.

Width = 1.5”

**Update your detailed design accordingly.**

****

**Note: for prototype II, we are making a physical prototype which is far simpler.**

## Prototype 2

**Summarize any new client feedback that you have received or any new testing results and clearly state what needs to be changed or improved in your design. Update your detailed design accordingly**

Following the presentation of our testing results of the prototype I, we realized a couple of important things.

Firstly, we got feedback that the weight of our design may have been satisfactory for the client to utilize, whereas our results concluded that our product may need to be lighter. Because there has been a significant change between prototype I and prototype II, we have taken this feedback and implemented it by allowing more weight onto the center parts of the belt.

Secondly, there was skepticism regarding the use of a piston that pushes down a belt to sufficiently allow for the pants to be pushed and pulled. Specifically, the friction that is incurred by the action might be uncomfortable enough that the product becomes unusable. As a result, the piston has been removed from the design in favor of a pull-and-push system with clamps attached to the belt, which resolves the friction that is created.

**Define the most critical product assumptions that you have not yet tested. Explain which of your DFX factors from Project Deliverable B this assumption(s) relates to**

The most critical assumption that has been tested is whether the force required to pull down the straps such that the product can operate correctly is sufficiently within the range of what the client can reasonably manage to achieve. Another assumption is that the straps that attach to the belt are sufficient to hold the weight of the pants to which the belt is attached.

These assumptions relate specifically to:

**Design for Reliability:**

The assumptions relate to reliability as a product that can sufficiently hold the weight of pants while not requiring force greater than that which the client can provide means the product is sufficiently reliable for use daily.

**Document your latest prototype(s) using as many sketches/diagrams/pictures as required and explain the purpose and function of your prototype(s).**

**Carry out prototype testing, analyze and evaluate performance compared to the updated target specifications first developed in Project Deliverable C and document all your testing results and prototype specifications. Present your testing in an organized, tabular format that shows expected versus actual results (i.e. compare your measured prototype specifications to your target specifications by including both in a similar table to the one your developed for Project Deliverable C).**

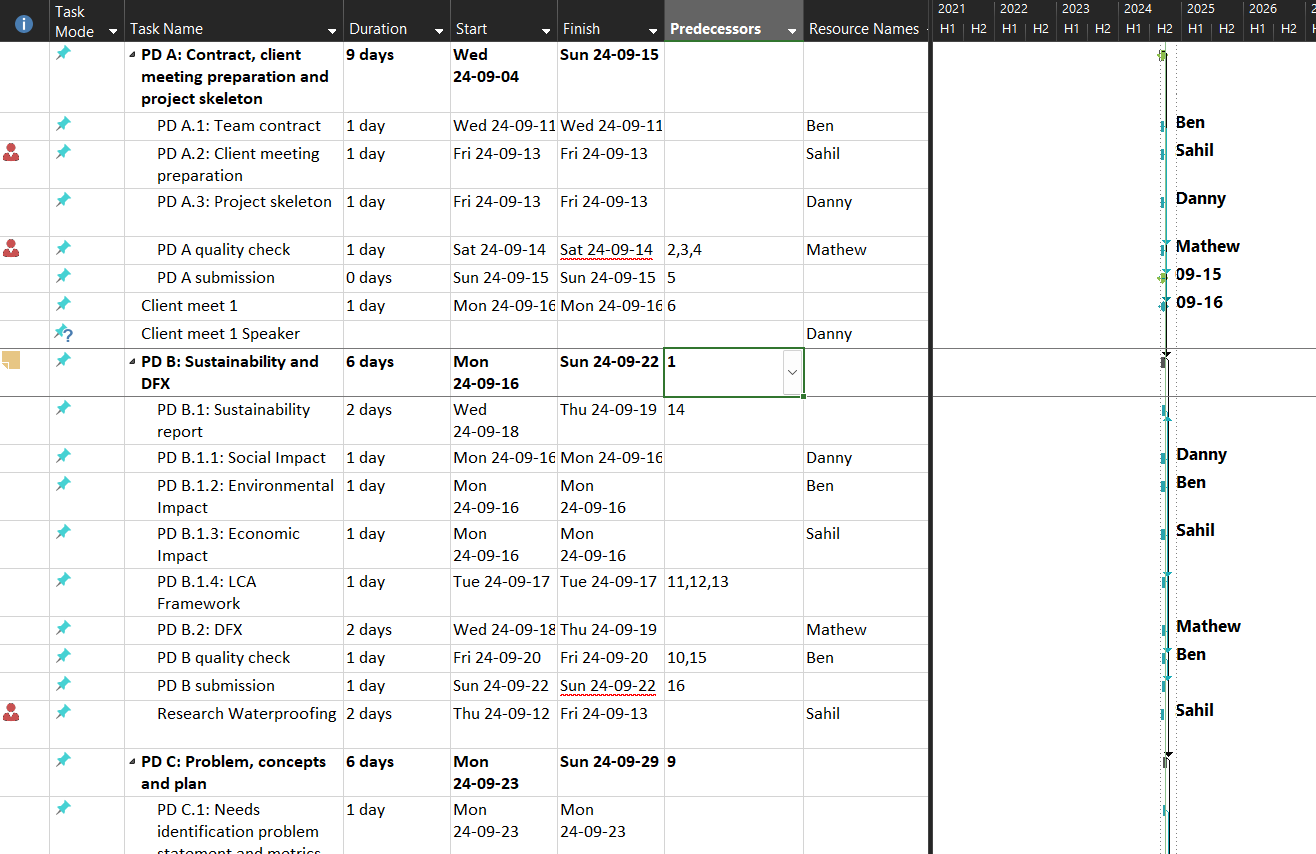
| Description | Unit | Marginal | Target | Actual |
| --- | --- | --- | --- | --- |
| Weight | g | 250 | 130 | 221 |
| Force Req. | N | 2.450 | 1.275 | 2.168 |

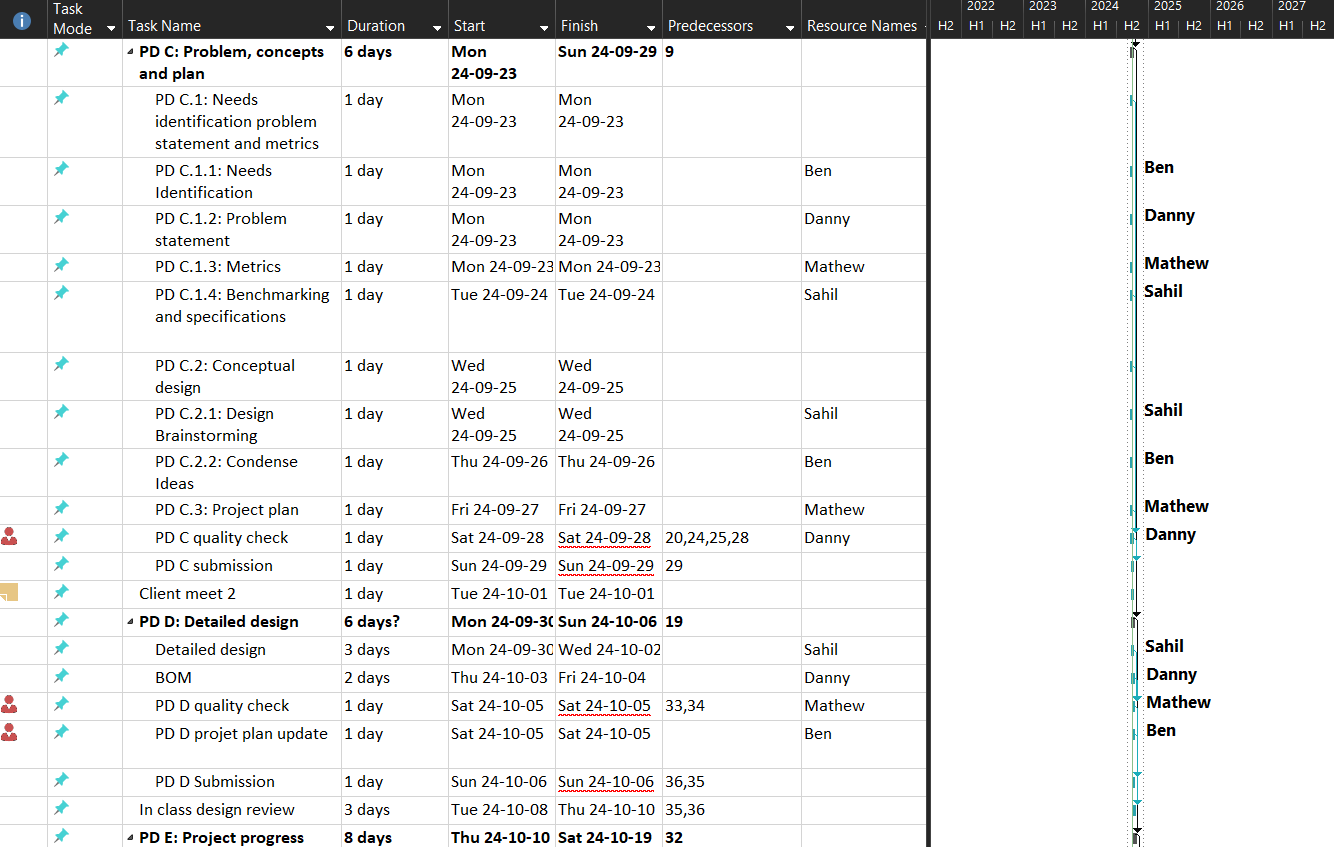
As can be seen, the new prototype vastly improves on weight and therefore force, mostly due to the removal of the piston which previously had taken up 2/3rd of the weight of the product.

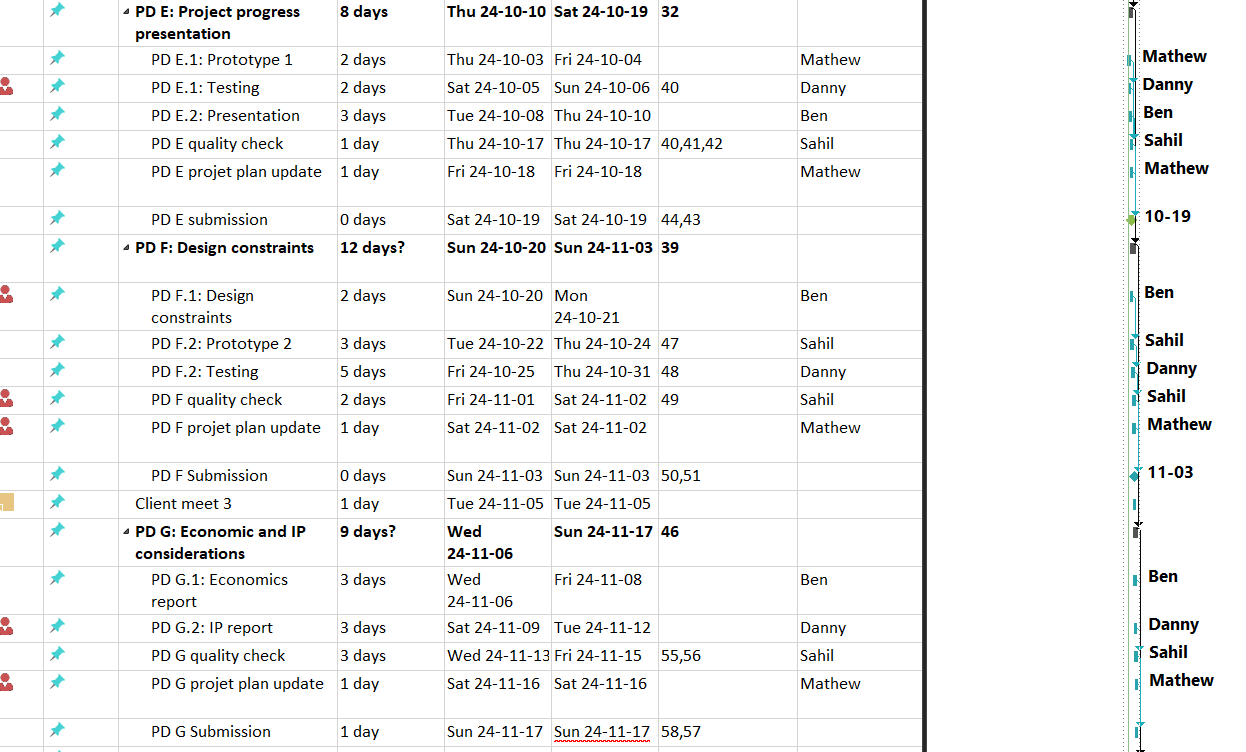
**Outline what your team intends to present to your client(s) and what information you would like to gather at your next client meeting.**

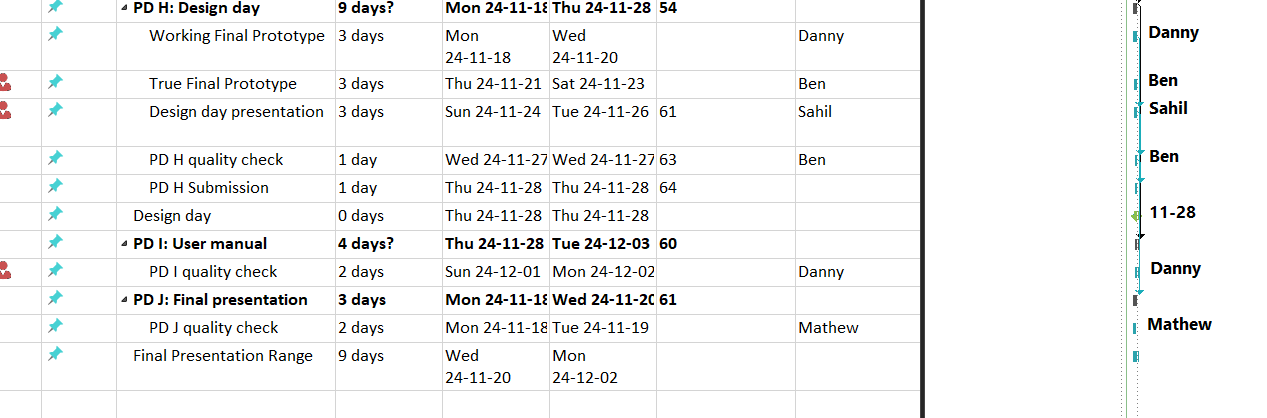
For our next client meeting, we plan to showcase our physical prototype II to the client and see what their general thoughts are on the mechanism. We also hope to see whether or not the client has enough applied force to pull up the pants on their own, or if we would need to add some assistive mechanism. Finally, we hope to gather some crucial measurements so that the final prototype is made correctly for the client.

## Project plan update









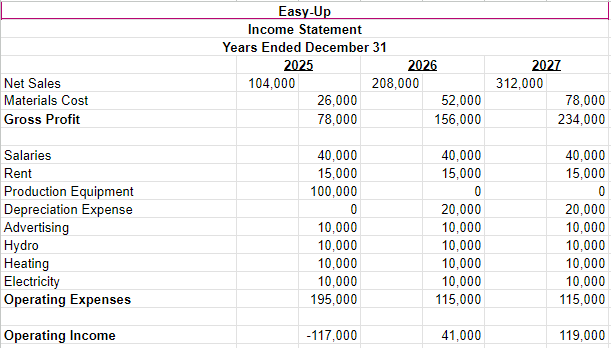
# Economic and IP Considerations

## Economics report

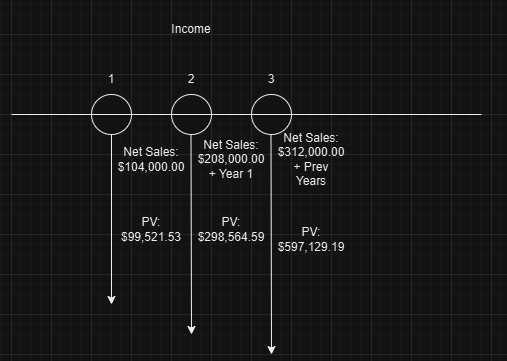
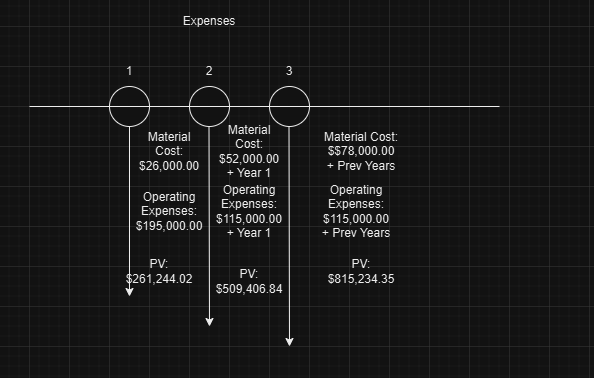
**Include a list of variable/fixed, direct/indirect, and material/labour/overhead costs associated with your business, based on the manufacturing and sale of your product. Make sure that you distinguish between price and cost and realize that prototyping and higher-volume manufacturing costs will probably be different.**

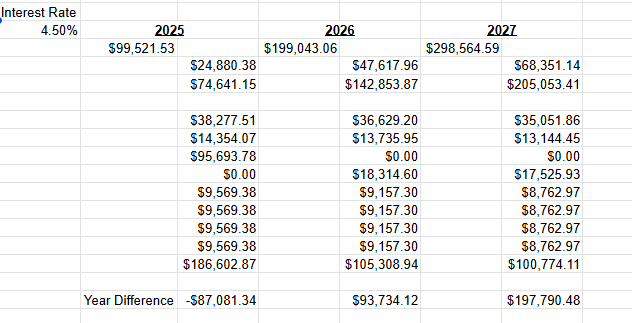
| Name | Variable/fixed | direct/indirect | material/labour/overhead |
| --- | --- | --- | --- |
| fabric Straps | variable | direct | material |
| Foam padding | variable | direct | material |
| Padding cover | variable | direct | material |
| Backpack clips | variable | direct | material |
| Salaries | variable | direct | labour |
| Electricity | variable | indirect | overhead |
| Rent | fixed | indirect | overhead |
| Production Equipment | fixed | direct | overhead |
| Hydro | fixed | indirect | overhead |
| Heating | fixed | indirect | overhead |
| Advertising | fixed | direct | overhead |

**Develop a 3-year income statement, which includes sales revenue and costs of units sold for each year, gross profit, operating expenses and operating income (no need to include interest and taxes).**

****

**Using a NPV analysis, determine the break-even point (i.e. number of units that must be sold for your business to become profitable). Draw two cash flow diagrams of the expenses and incomes for the next three years. Calculate the NPV value of each expense/income and determine the differences and then the break-event point.**

****

****

Converting all the numbers to present value, looking at the net present value per year the break-even point is somewhere around the end of the 2nd year, as you lose money in the first year.

**Describe and justify all assumptions that you have made in developing your economics report. The assumptions must be factual based on a preliminary market research that you conduct in order to determine the amount of demand in your target market, the expected % of the market that you would own, and the unit price of your product based on a sound pricing strategy.**

* Materials cost per unit = $26

An approximate unit cost of 26$ was assumed since the cost of materials purchased for our final prototype to date is around 75$. Given that only around a 3rd of the materials were used and the backpack clips are slightly more expensive than the metal clips used in prototype 2, $26 is a logical cost for the final prototype.

* Small user base means low sales

Due to this product's nature as an accessibility device it can be assumed that the majority of the product's users will be clients with disabilities and mobility issues, meaning the user base is relatively small. In considering this assumption, another assumption can be made that the amount of units sold will be low as well, our assumption was that sales would not exceed the single digit thousands.

* Selling price of $104 is reasonable for a specialized accessibility product

When researching the price of similar accessibility products, it was noticed that the prices tend to vary wildly depending on the manufacturer however it seemed that products that were being significantly oversold were still able to succeed. A combination of low sales and high cost of similar accessibility products led us to deciding on a unit price of $104 which is 4 x “unit cost”. Based on the aforementioned research it was assumed that this price was reasonable for a specialized accessibility product

* Depreciation rate of 20% (Class 8 according to [This Page](https://www.canada.ca/en/revenue-agency/services/tax/businesses/topics/sole-proprietorships-partnerships/report-business-income-expenses/claiming-capital-cost-allowance/classes-depreciable-property.html#class3))

Research was done regarding the average depreciation rate of industrial production equipment where it was found that said equipment has a depreciation rate of 20% per year. This value makes sense when considering that the production equipment for our product is mainly sewing machines which wear quickly with use, especially when sewing tough materials like canvas and polypropylene. Therefore an assumption was made that the depreciation rate of our production equipment is 20%.

* Expected to own 40-50% of the market due to lack of other market solutions

When researching other market solutions there was a distinct lack of products that solved the issue that we aim to assist with, and many of the market solutions had a tendency of being multipurpose tools that just happened to aid with the problem. This is why the assumption was made that our product would allow us to own a large portion of the market since we have designed a product that solves our specific problem efficiently and simplistically.

## Intellectual property report

**Explore intellectual property databases (i.e. patents, industrial designs, integrated circuit topographies, trademarks, copyrights, creative commons, or open source software) to identify at least two intellectual properties related to your product or business:**

Within our product, we have a number of designs that have been patented previously. Specifically, our design includes detachable straps, backpack clips, and woven polypropylene backpack strap material.

For the detachable straps, US Patent: 121,992 was filed on Dec. 19, 1871 regarding an innovation regarding straps hooking onto other straps with hooks and punctured holes. This patent, although expired, is an important part of our product, and thus will need to be considered.

For the backpack clips, worldwide USD680901S1 patent was filed regarding the intertwining of two pieces of the strap with metal clips. As this patent was filed in 2012 in the United States, it is still valid and would need to be licensed to be sold in the United States.

Finally, the method of polypropylene being woven was patented in 1983, and is used in backpack straps. As the product utilizes this method, this patent would have to be considered when developing the product.

The links to the patents are below:

detachable straps: [**https://www.datamp.org/patents/displayPatent.php?pn=121992&id=57608**](https://www.datamp.org/patents/displayPatent.php?pn=121992&id=57608)

backpack clips: [**https://patents.google.com/patent/USD680901S1/en**](https://patents.google.com/patent/USD680901S1/en)

woven polypropylene: [**https://patents.google.com/patent/US4503007A/en**](https://patents.google.com/patent/US4503007A/en)

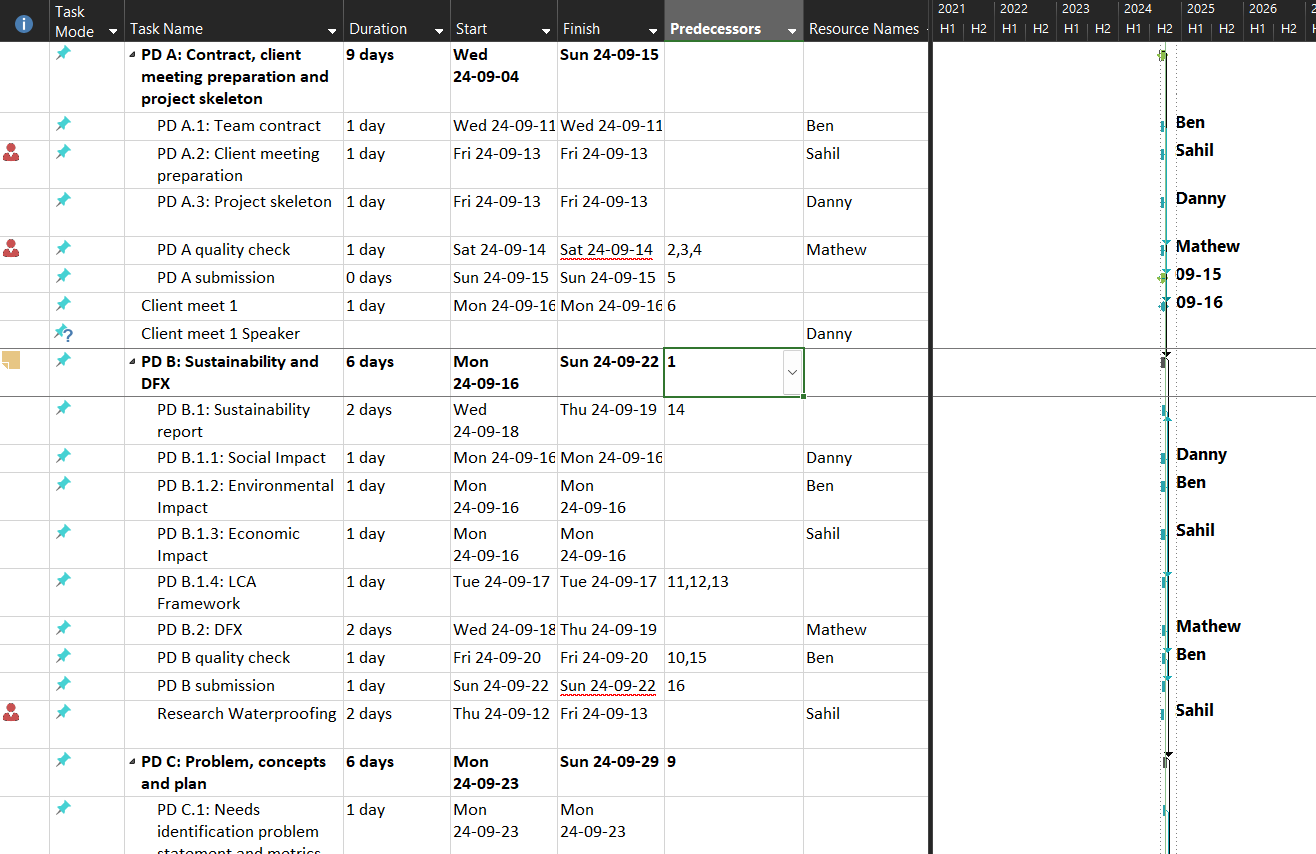
**Explain the importance of these intellectual properties and the legal constraints they place on developing your product or business**

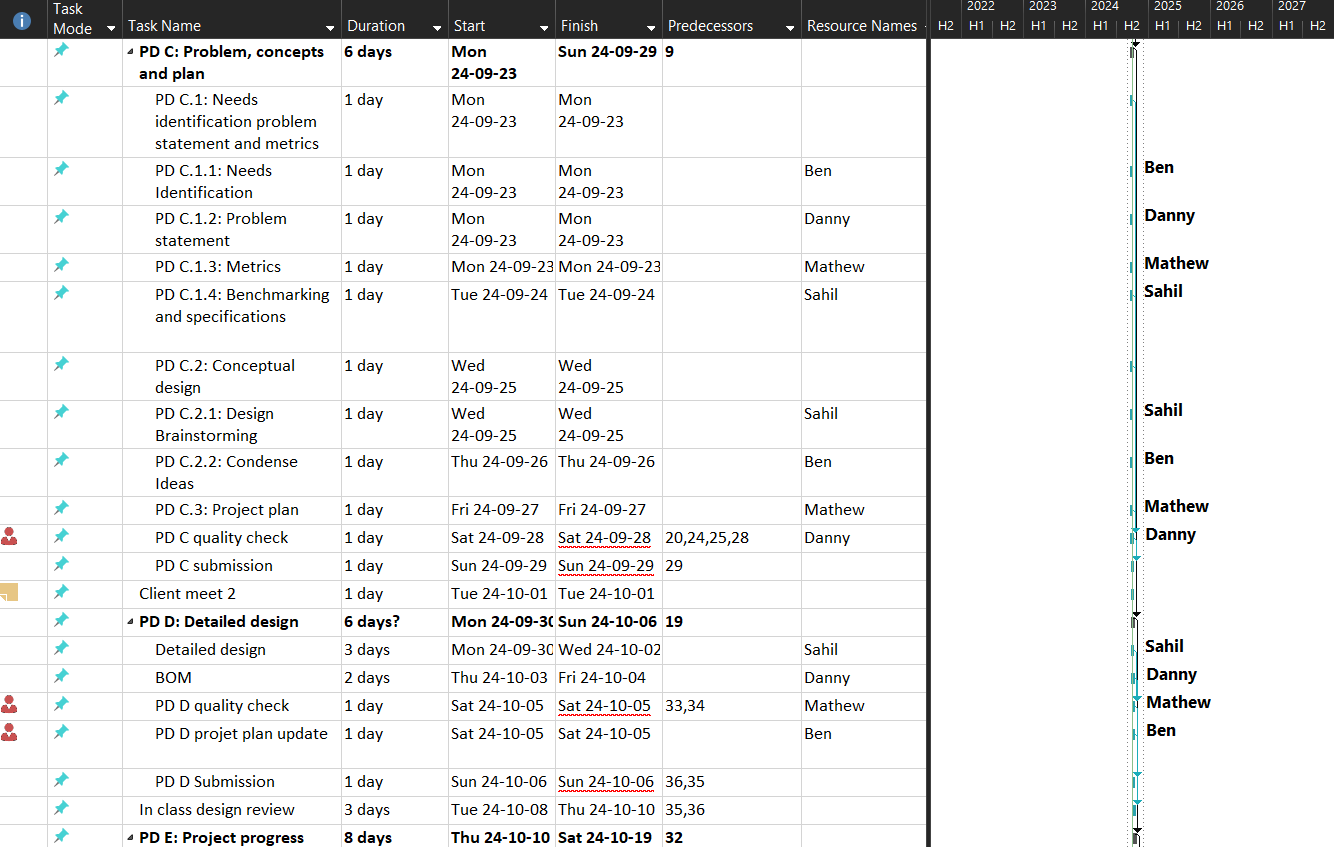
Detachable Straps (Patent US121992): A detachable strap system that is simple to attach and remove is described in this patent. Its capacity to offer flexibility and adaptability—enabling the device to be tailored for various users or situations—makes it relevant to the product. The straps' ability to be detached guarantees that parts can be changed or repositioned with little difficulty, improving the device's upkeep and usability. Given that the patent is more than a century old, it has expired and is already in the public domain, enabling unrestricted adoption into future designs.

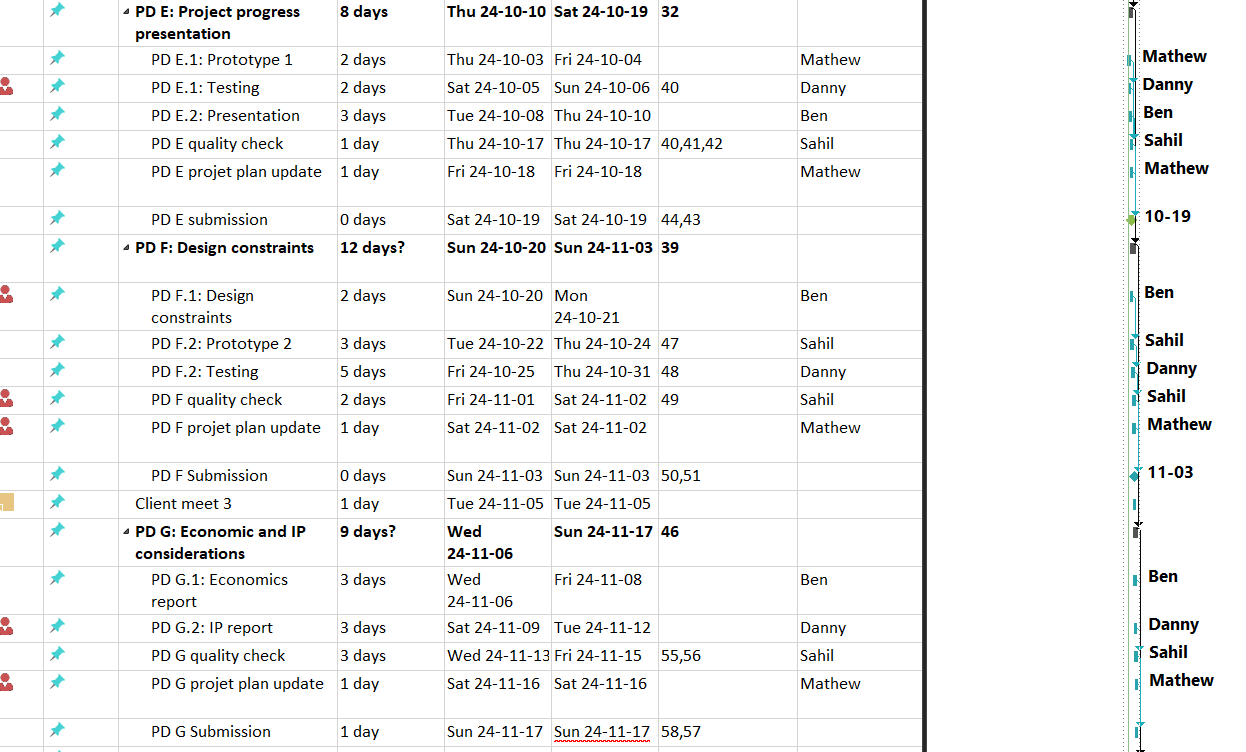
Backpack Clips (Patent USD680901S1): This patent describes a particular decorative style for clips that are frequently found in backpacks and related items. In order to keep the device stable while in operation, these clips are essential for fastening straps or other accessories. The patented feature concentrates on the design's appearance, which could need to be altered if it is still protected, even though it is useful in its intended usage. It will be necessary to either license or use other designs that do not violate this patent in order to use similar clips.

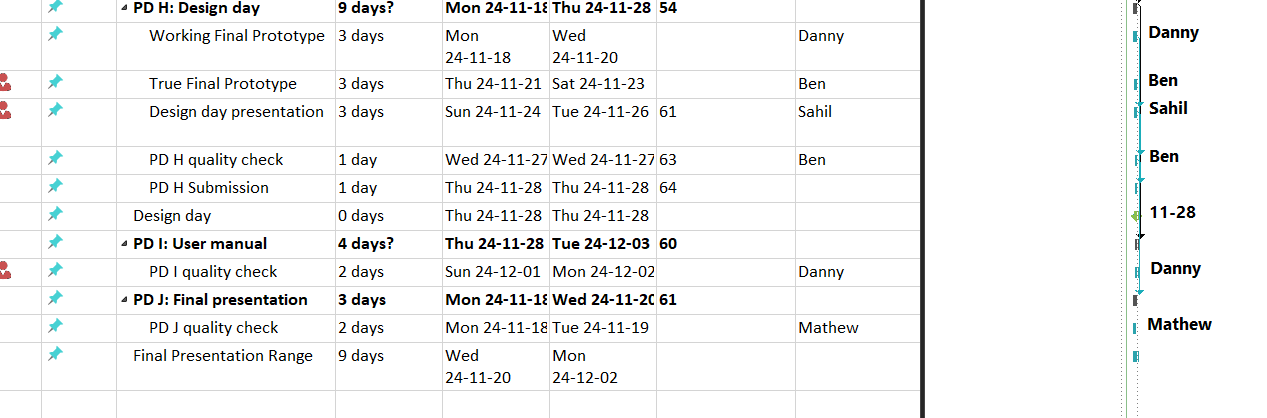
Adjustable Mechanisms for Clothing (Patent US4503007A): A mechanical device that helps with clothing alterations, including tugging or fastening garments, is presented in this patent. Its tenets are highly compatible with the product's functional objectives, providing motivation for developing an intuitive and efficient solution. Direct copying of its design parts would require a licensing arrangement, though, if the patent is still in effect. The gadget may innovate to produce a distinct implementation while incorporating similar features to prevent infringement.

## Project plan update









# Design Day Pitch and Final Prototype Evaluation

Can be found in separate presentation

# Video and User Manual

## Video pitch

<https://youtu.be/45eEfWdD3ig?si=A8vHIO4dkzYj5N9k>

## User manual

Can be found in separate document

# Conclusions

Summarize your lessons learned and your work related to your project. Discuss any outstanding issues or implications for the project.

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