GNG2101

Design Project Progress Update

Adaptive Ride Co. A02-WSA1

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Table 1. Acronyms

Acronym	Definition
DFX	Design for X
lb	Pounds (Unit of measurement)
BOM	Bill of Materials

Table 2. Glossary

Term	Acronym	Definition
Metrics	N/A	Measurable features of the system's performance, cost, time for implementation and safety etc.
Benchmarking	N/A	Process of measuring a product, service, or process against a competitor, industry standard, or someone who's considered "best in class."

1 Introduction

For GNG2101A, our group will create a universal wheelchair to stroller attachment device that is fully usable and accessible by the wheelchair user. Throughout deliverable A to D, we looked over our problem statement, our sustainability report, which covers how we plan on minimizing environmental impacts, and maximizing accessibility. We then talk about some vital DFX elements to our project, and the things we plan to do to incorporate them effectively. We then discus our problem definition, concept development, and project plan in deliverable C. Then in deliverable D we discussed our detailed design and BOM. Throughout this document we will cover deliverables E to I. In deliverable E, we discussed our first prototype, project progress presentation, peer feedback, and team dynamics. We explained our first prototype and described the type of tests we used and included our project progress presentation.

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

2.1 Prototype 1

2.1.1

A critical assumption we have made from deliverable D was that we were going to try to 3D print as many parts as possible to save money. We will make sure to test the strength and functionality

of the 3D printed parts. For the strength test we will add force to the part, and make sure it stays fully intact, we will make sure we test with double the force the part must withstand to ensure full strength. To test functionality, we will test the product with multiple different users and make sure all parts function correctly. Testing for strength relates to DFX 'design for strength', and testing for functionality relates to DFX 'design for usability' and 'design for durability'.

2

Figure 1: 3D-Print Prototype

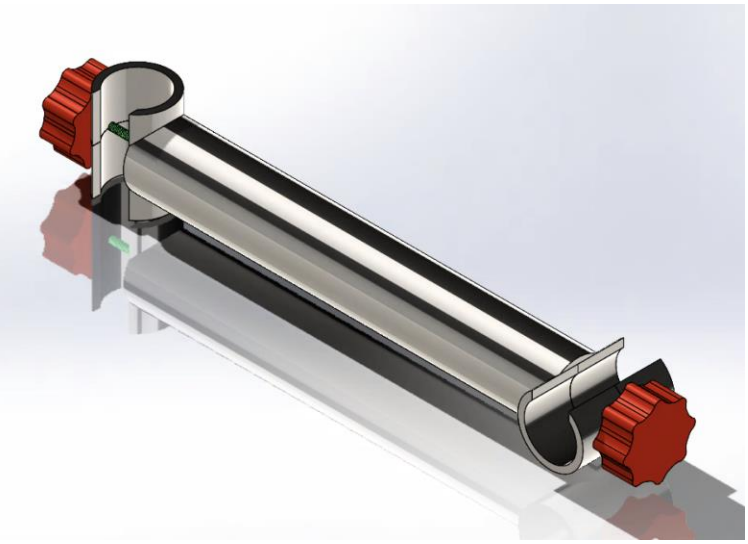


Figure 2: CAD Model

Our first prototype we made was scaled down in order to test the first version of our clamp. With this prototype we noticed that a single screw securing the bar to the wheelchair and stroller would not be strong enough for our use. This is why we are opting to make a new clamping system for our product. This prototype was also used to test the strength and maneuverability of the final product. We discovered that while having two simple bars is very maneuverable, the strength is lacking for our ideal design. This is why we have decided to make a frame with supports instead of just two individual bars.

2.1.2

We completed some tests for our first prototype and some results were the same as expected, some of our tests failed. However, this was not too surprising considering this is out first prototype which was simply 3d printed opposed to our finial which will be made out of steel.

Table 3: Testing

The test	Expected results	Actual Results
Clamp strength	Should be able to clamp and stay secured	Did screw in but was still able to spin and slide on bar
Clamp screw security	The plastic thread will fail	Plastic thread did fail
Torsion strength	Will not crack	Did not crack
Crossbar strength	Some damage will appear	Small cracks formed
Compression strength	Should not be crushed	Did not get crushed

2.2 Project Progress Presentation

Lab6 Presentation PD-E (sharepoint.com)

2.3 Project plan update

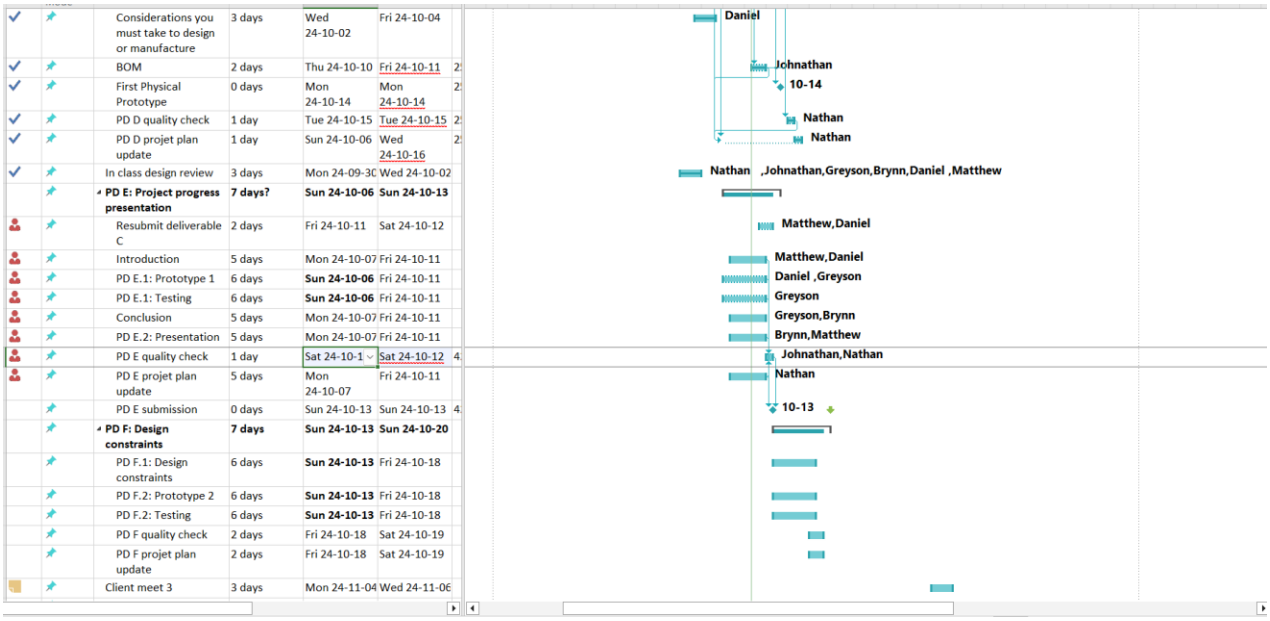


Figure 3: Project plan

2.4 Conclusion:

We have made substantial progress throughout these deliverables making 3D-printed prototypes and generating many ideas for clamping. With our tests we revealed satisfactory maneuverability but insufficient strength due to the material of our prototype. This led to redesigning the clamping system and considering a frame with supports. Testing highlighted the need for a more secure clamping mechanism and stronger materials. We are refining our design based on feedback, focusing on enhancing durability and usability to meet target specifications and ensure accessibility for wheelchair users.

3 Design Constraints and Prototype 2

3.1 Design constraints

3.1.1 Non-Functional Design Constraints

Our two most important non-functional design constraints that play a significant role in the development of our prototypes are design for safety and design for usability. Design for safety is so important as our product involves small children and babies. We need to make sure that it does not affect or interfere with the wheelchair or the stroller. Design for usability is another particularly crucial factor as we need the user to be able to fully attach and detach the attachment by themselves.

3.1.2 Design to Satisfy

One change in our design that would help satisfy design for safety would be to add a rubber lining on the clamps. This would ensure that the attachment would stay secure while in use, which is a huge safety factor. To line the clamps with rubber we would use a rubber lining dip to coat the clamps, this would ensure that the whole clamp will have a rubber coating and good grip on the wheelchair and stroller.

3.1.3 Analysis/Simple calculations

Our next step for our prototype is to add rubber lining on the clamps. We have done a bit of research on materials used for strollers and wheelchairs. It was found that most wheelchairs and strollers frames are made from aluminum or steel (1). Our clamps are made from aluminum. We then did more research to find the coefficients of friction with and without rubber lining on both steel and aluminum. (bellow). We know that a higher coefficient of friction means more grip between materials. Therefore, by adding a rubber lining to the clamps we will increase the grip.

Table 4: Analysis

Clamp Material	Wheelchair/Stroller Material	Coefficient of Friction [2]
Aluminum	Aluminum	0.7
Aluminum	Steel	0.7
Rubber	Aluminum	0.8
Rubber	Steel	0.8

3.2 Prototype 2

There has been no new client feedback received since our latest prototype. The new testing we have conducted was for the clamps. We have tested the grip of the clamps without a rubber dip lining, we have concluded that the rubber dip lining will be needed. When we tested the clamps, we added force, and they twisted and slipped on the metal bar. We need to make sure there is zero slippage and by adding the rubber dip we predict this will eliminate that. Further testing will be done once the rubber dip lining is added.

3.2.1 Critical Product Assumptions

The most critical product assumptions we have not yet tested are design for usability. We have not used a wheelchair and stroller to fully test the usability of our product. We plan to test this eventually when we can get access to a stroller and wheelchair. For now, we will test usability in other ways like usability of clamps.

3.2.2 Prototypes

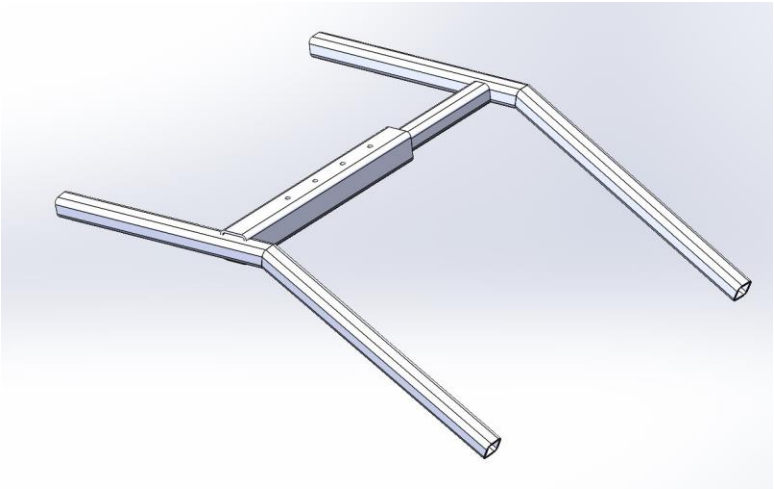


Figure 4: CAD Model of Prototype 3

This is our CAD model of our next prototype. Where we have introduced the idea of the H-bar which is telescopic to accommodate for different widths of strollers/wheelchairs. We have yet to add the clamps, but we are using the same clamps in prototype 2 since they proved to be very secure. We implemented an angle of 30 degrees to reduce length of the bars. We have yet to test this prototype however, our next steps are to create this prototype in a physical model to test the security of the H-bar and compare it to the tested results of the X-bar.

3.2.3 Latest Prototype

Figure 5: Prototype 2

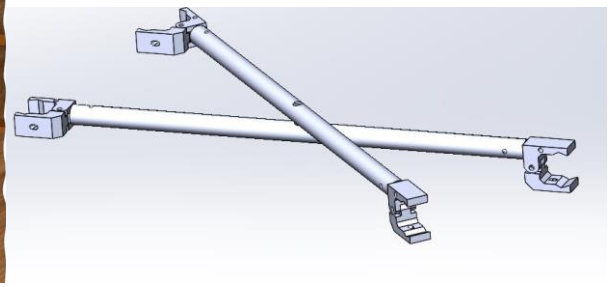


Figure 6: CAD Model of Prototype 2

Our latest physical prototype is made from wood and now has two bars in a cross to help with stability and strength. It has an adjustable width as it can swivel on the center pin. It also includes clamps that have a V shape on the inside to maximise grip. The clamps have quick release pins for users with less mobility, and a long handle to tighten the clamps. The clamps on each end are oriented perpendicular to each other so they can attach properly to the wheelchair and stroller.

3.2.4 Prototype Testing & Evaluation

3.2.4.1 Weight Test

Table 5: Weight Test

Target Weight	Actual Weight
Under 20lbs	7lbs

Target Weight was good but for the final prototype we will have to test again.

3.2.4.1 Grip Test

Table 6: Grip Test

Target Clamp Grip	Actual Clamp Grip
No rotation with 20lbs of force applied	Rotated with 20 lbs force applied

We will be adding a rubber lining to the clamps and retest again in the future.

3.2.4.1 Clamp Usability Test

Table 7: Clamp Usability Test

Target Usability	Person (Numbered)	Actual Usability (Yes or No could they use clamp)
All should be able to function clamp without assistance	1	YES
	2	YES
	3	YES
	4	YES
	5	YES
	6	YES

Everyone we have tested the clamps on could properly use them without assistance.

3.2.5 Client Meet Plans

For Client Meeting 3, we plan to present our initial prototype 1 and our prototype 2. Along with the testing results from both prototypes. We will discuss the findings from our testing and the changes implemented from prototype 1 to 2 and from 2 to 3. Also, we will talk about our updated materials for the final design. We would like feedback on the structure of prototype 2 and 3, where we have switched from horizontal bars to and X-bar and then a H-bar. We would also like to introduce our new clamping system that we redesigned based off the previous feedback received as well as our previous designs and testing. We believe these new structures and clamping system will be highly effective. We hope that the client agrees. If they have reservations, we will incorporate their input into our next iteration before moving on to our final design.

Link to Slide show: [Client meet 3.pptx]

3.3 Project plan update

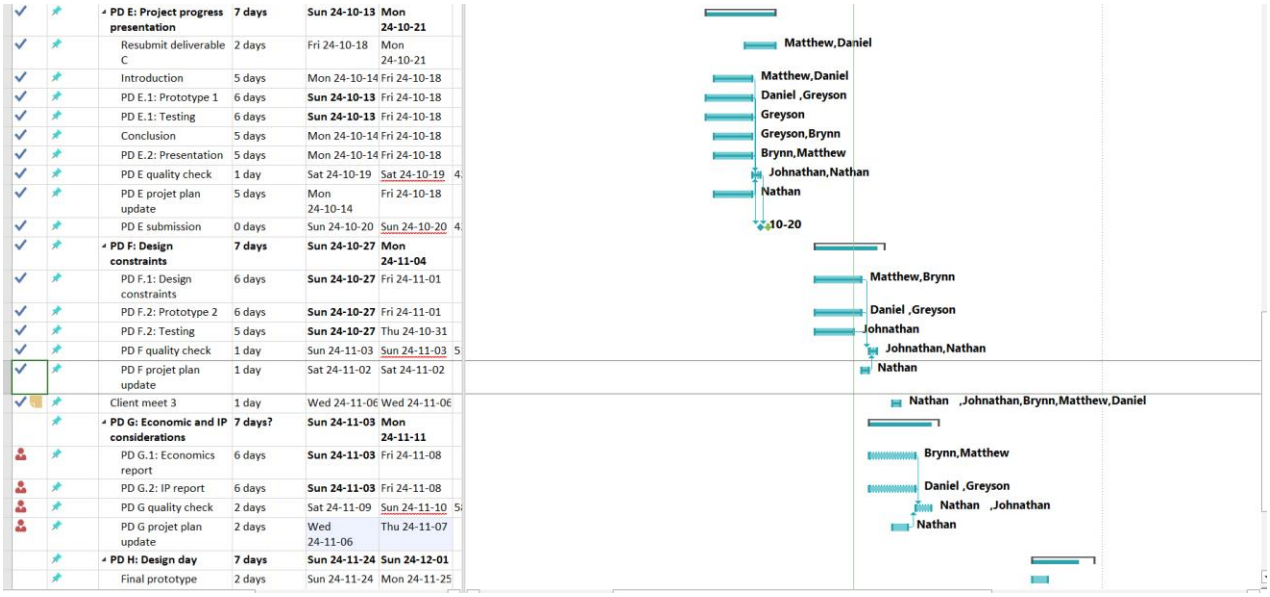


Figure 7: Updated Project Plan

4 Economic and IP Considerations

4.1 Economics report

	Material	Labor	Overhead Cost
Direct	- Steel Rods - Clamps - Bolts/Nuts/Washer	- Salaries	- Production of Materials
Indirect			- Marketing - Rent - Electricity - Overhead
Fixed			- Production of Materials - Marketing - Rent - Electricity
Variable	- Steel Rods - Clamps - Bolts/Nuts/Washer	- Salaries	- Overhead

4.2

Year 1	Year 2	Year 3
Sales: 50 Unit price: 200$ Gross Profit: 200$ x 50 = 10000$ Cost of units sold: 100$ x 50 = 5000$ Operating expenses: Rent – 1200$ Overhead – 800$ Wages – 1000$ Total – 3000$ Operating income: 10000$- 3000$ = 7000$	Sales: 500 Unit price: 250$ Gross Profit: 250$ x 500 = 125000$ Cost of units sold: 100$ x 500 = 50000$ Operating expenses: Mortgage – 40000$ Overhead – 8000$ Wages – 10000$ Total – 58000$ Operating income: 125000$- 58000$ = 67000$	Sales: 3000 Unit price: 300$ Gross Profit: 300$ x 3000 = 900000$ Cost of units sold: 100$ x 3000 = 300000$ Operating expenses: Mortgage – 40000$ Overhead – 12000$ Wages – 200000$ Total – 252000$ Operating income: 900000$- 252000$ = 648000$

Net Revenue: 7000$- 5000$ = 2000$	Net Revenue: 67000$- 50000$ = 17000$	Net Revenue: 648000$- 300000$ = 348000$

4.3

Financial Overview

The business has shown steady financial growth:

-Year 1: Revenue was $10,000, with total costs of $8,000. This resulted in a net cash flow of $2,000.

-Year 2: Revenue jumped to $125,000, with costs of $108,000, leaving a net cash flow of $17,000.

-Year 3: Revenue surged to $900,000, while costs totaled $552,000, generating a substantial net cash flow of $348,000.
-Year 1: Sold 20 more units than needed.
-Year 2: Sold 113 more units than needed.
-Year 3: Sold 1,740 more units than needed.

Assuming a discount rate of 10% (standard business assumption): $NPV = CF_1/(1+r)^1 + CF_2/(1+r)^2 + CF_3/(1+r)^3$

Where: CF = Cash Flow r = discount rate (10% = 0.10)

$NPV = 2,000/(1.1)^1 + 17,000/(1.1)^2 + 348,000/(1.1)^3 = 1,818.18 + 14,049.59 + 261,818.18 =$ $277,685.95

-Break-even Analysis

Fixed Costs per year: Year 1: $3,000 Year 2: $58,000 Year 3: $252,000

-Variable Cost per unit: $100 (consistent across years) Selling price evolution: Year 1: $200 Year 2: $250 Year 3: $300

-Break-even Point Calculation

Break-even quantity = Fixed Costs / (Price - Variable Cost)

Year 1: 3,000 / (200 - 100) = 30 units Year 2: 58,000 / (250 - 100) = 387 units Year 3: 252,000 / (300 - 100) = 1,260 units

Therefore, the breakeven point for year 1 is 30 units, year 2 is 387 units, year 3 is 1260 units. Based off the positive NPV of $277,685.95 indicates that we are profitable over the three-year period, with break-even points achieved in each year.

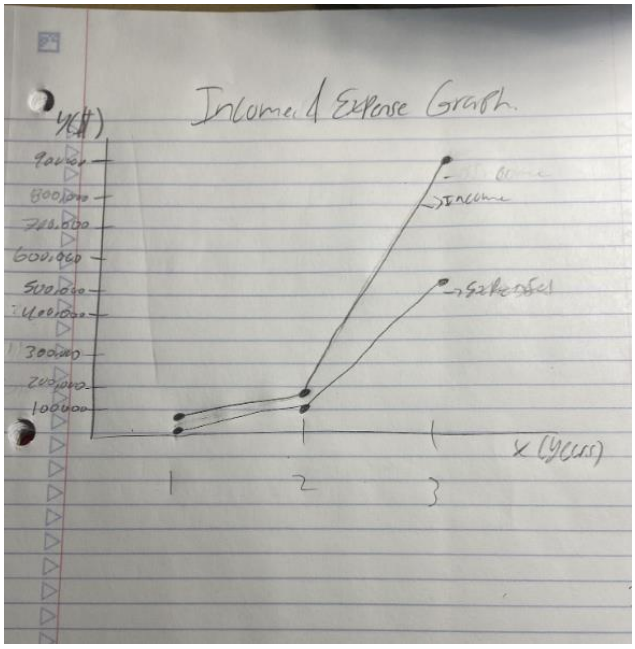


Figure 8: Cash Flow Income vs. Expense Graph

4.4

The assumptions we made were sales, unit price, gross profit, cost of units sold, operating expenses, rent, overhead, wages, and operating income. We made these assumptions by looking at economic reports from small businesses in Canada. We used this information to make our assumptions.

https://ised-isde.canada.ca/site/sme-research-statistics/en/key-small-business-statistics/key-small-business-statistics-2023

Key Small Business Statistics 2023

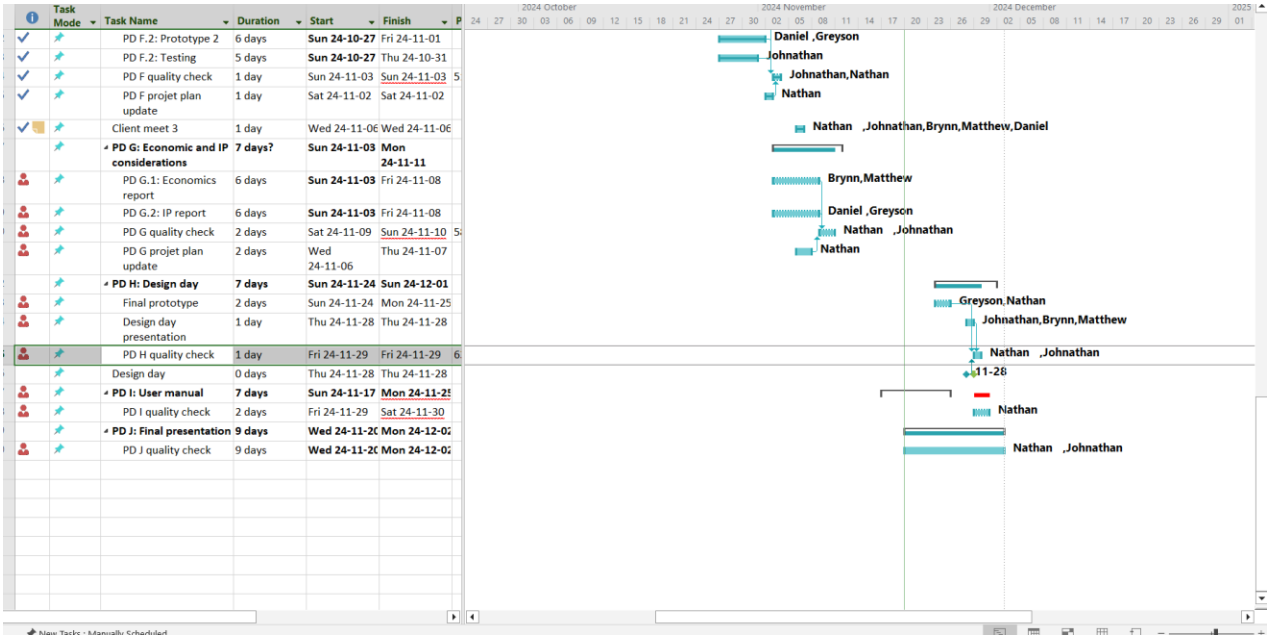
4.5 Intellectual property report

Two intellectual properties related to our product are these patents; one is an attachment for strollers (https://patents.google.com/patent/RU2788593C2/en?q=(wheelchair+stroller)&oq=wheelchair+stroller) and the other is a way to attach wheelchairs with other machines (https://patents.google.com/patent/US20230109303A1/en?q=(wheelchair+stroller)&oq=wheelchair+stroller). These both relate to our products as patents give the owner the right to use, manufacture, and sell and these designs are similar to our product.

The importance of these intellectual properties and the legal constraints they place on developing our product is the claims that they have published for their design. Our design may have to consider either improving on the patents, cite them and their patent citations, or risk legal action. Legally, the intellectual properties could cause problems for our product if it is too similar to the patents. The publisher of the patents could sue us as the patents are there to protect their innovations while also allowing other people such as our company to design and develop other products.

These also might impact our design process as we might want to create our own patents for our designs to create our own intellectual property. These could impact our costs for the application process and create more legal constraints that may have to be revisited late on in the company's tenure (such as the time and geographical location limitations).

4.6 Project plan update



Task Mode	Task Name	Duration	Start	Finish
	PD F.2: Prototype 2	6 days	**Sun 24-10-27**	Fri 24-11-01
	PD F.2: Testing	5 days	**Sun 24-10-27**	Thu 24-10-31
	PD F quality check	1 day	Sun 24-11-03	Sun 24-11-03
	PD F projet plan update	1 day	Sat 24-11-02	Sat 24-11-02
	Client meet 3	1 day	Wed 24-11-06	Wed 24-11-06
	PD G: Economic and IP considerations	**7 days?**	**Sun 24-11-03**	**Mon 24-11-11**
	PD G.1: Economics report	6 days	**Sun 24-11-03**	Fri 24-11-08
	PD G.2: IP report	6 days	**Sun 24-11-03**	Fri 24-11-08
	PD G quality check	2 days	Sat 24-11-09	Sun 24-11-10
	PD G projet plan update	2 days	Wed 24-11-06	Thu 24-11-07
	PD H: Design day	**7 days**	**Sun 24-11-24**	**Sun 24-12-01**
	Final prototype	2 days	Sun 24-11-24	Mon 24-11-25
	Design day presentation	1 day	Thu 24-11-28	Thu 24-11-28
	PD H quality check	1 day	Fri 24-11-29	Fri 24-11-29
	Design day	0 days	Thu 24-11-28	Thu 24-11-28
	PD I: User manual	**7 days**	**Sun 24-11-17**	**Mon 24-11-25**
	PD I quality check	2 days	Fri 24-11-29	Sat 24-11-30
	PD J: Final presentation	**9 days**	**Wed 24-11-20**	**Mon 24-12-02**
	PD J quality check	9 days	**Wed 24-11-20**	**Mon 24-12-02**

5 Design Day Pitch and Final Prototype Evaluation

5.1 Adaptive Ride CO.'s goal is to create a universal wheelchair to stroller attachment device that is fully usable and accessible to the wheelchair user. This problem is important as it will help the parent build connections with the child and make the parent more independent.

3 Minute Pitch.pptx

Figure 9: Final Design Detached

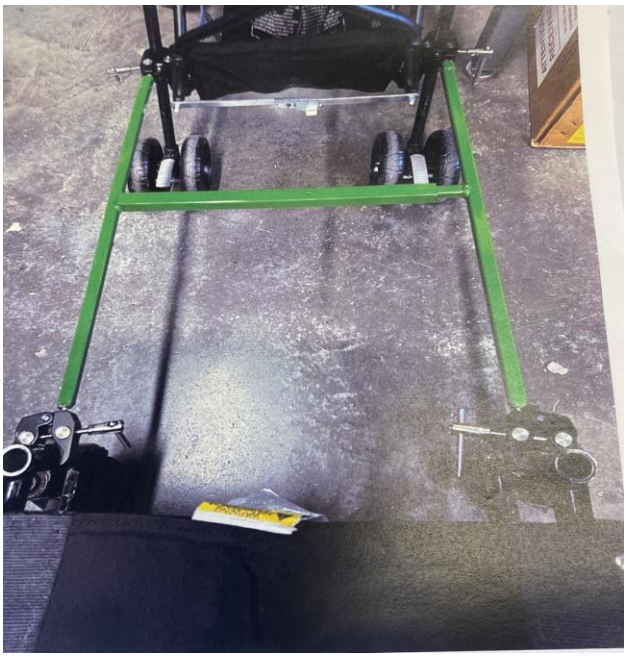


Figure 10: Final Design Attached

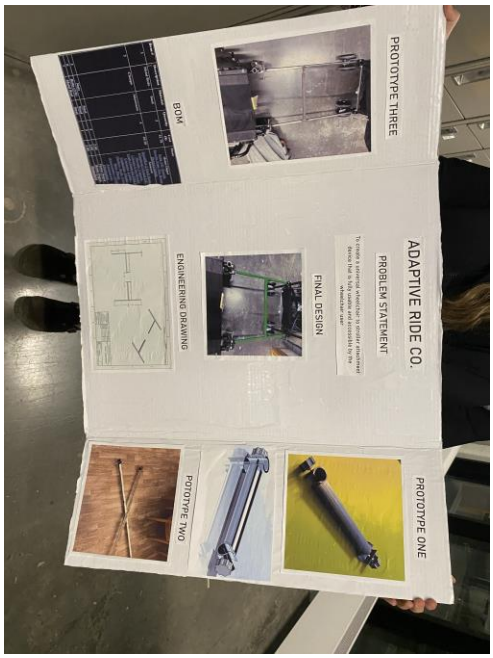


Figure 11: Design Day Board

6 Video and User Manual

6.1 Video pitch

6.2 User manual

PDI-User & Product Manual.docx

7 Conclusions

Through our group project, we discovered how important good communication and teamwork are. By dividing tasks and setting clear expectations early, we avoided confusion and made sure everyone stayed accountable. Bringing together our different perspectives sparked creativity, but it also meant learning to compromise and work through disagreements. Regular check-ins kept us organized and on track, even when things got challenging. Most of all, we realized that mutual respect and supporting each other made a huge difference in how well we worked as a team. As well as getting started on prototyping as soon as possible. We have created an amazing product that is cost effective and reliable, which ticks all our DFX boxes. Our client and the judges were very happy with the outcome of our design.

8 Bibliography

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