GNG2101

Design Project Progress Update

Team A04-HCH1

Submitted by:

Abdurahman Omar, 300188545

Jordon Li, 300298991

Matthew Robinson, 300300363

Demetrius Hummel, 300377680

Jonathan Tang, 300359949

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University of Ottawa

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List of Acronyms and Glossary

Table 1. Acronyms

|  |  |
| --- | --- |
| **Acronym** | **Definition** |
| DFX | Design For Excellence |
| GHG | Green House Gas |
| HCH | High Cup Holder |
| LCA | Life Cycle Assessment |
| DFS | A DFX focusing on simplicity |
| DFQ | A DFX focusing on quality |
| DFAes | A DFX focusing on aesthetics |
| DFAdj | A DFX focusing on adjustability |
| DFU | A DFX focusing on usability |

Table 2. Glossary

|  |  |  |
| --- | --- | --- |
| **Term** | **Acronym** | **Definition** |
| Design for X | DFX | Design for excellence. The X can refer to several different things a product can be designed for, such as manufacturing, sustainability, cost, reliability, etc. |

# Introduction

This project for GNG2101 involves our group to design a cup holder tailored for the specific needs of our client. Our client is afflicted with cerebral palsy, poor eyesight and uses a wheelchair as well. After an interview with our client, we have received multiple design criteria's we must abide by.

# Sustainability Report and DFX

## Sustainability report

|  |  |  |
| --- | --- | --- |
| Triple Bottom Line | Positive Impact | Negative Impact |
| Economic | Reusable, so does not require frequent purchases of product | Requires cost of creating quality cup holders specifically for wheelchairs |
| Affordable (<$1000) | Making something affordable decreases profit margins |
| Reusable, so doesn’t require large amounts of production | Wheelchair cup holders is a small and niche market |
| Environmental | Durable, replaced less meaning less manufactured products necessary | Requires higher quality materials which requires more energy and resources at a base level |
| Reusable, so it causes less pollution and waste | Limited availability of recycled and green materials and means of processing those materials into something of use to us |
| Sustainable manufacturing during production can minimize carbon footprint | Creating a few for one or a couple clients, per unit, is not environmentally viable due to economies of scale |
| Social | Inclusive for people with disabilities who require wheelchairs | Will likely not be able to be used or convenient to those without a wheelchair |
| Independence for client when managing drinks | Designing specifically for one client may limit broader appeals |
| Sturdy design reduces chance of spillage while in public | Each type of wheelchair may need it’s own design, increasing labor of employees |

**LCA Framework**

[Comparison Product](https://www.amazon.ca/Stroller-Universal-Pushchair-Wheelchair-Motorcycle/dp/B07CZ81K72/ref=sr_1_6?crid=2Z9DX6ZHCM9T6&dib=eyJ2IjoiMSJ9.TzZ7DD-NDFxAYgFWCWfZujX60KpI-9DBG8aTxhfXL3gPMrwzd9nRTx98kBUprE_9g04IEYyLADlJxEQJvCY9LQwS-E-lCk5y9ZYUbdSQpuWM5M2gnGp3PGlM2wWhQsXHFJtNnUWCyafbnjag49B8f5DABIATGk0EXI7NuAVhFjLXLrix0D19jVcYigP7qYiF8Hnk2Hg-_O8C4c1dh2JlNDBIUfMm1b4wwHVmFlLTIc1XHnml13SH85kZjXw5ZESYp6dwhxacobFr3aBlGN1p6uthqquxidAY1q2fekidyfM.6A-8PnN-nqxWuqQCMmnYFPPJ8IbZuDyUSg0nTzOujyg&dib_tag=se&keywords=wheelchair+cup+high+holder&qid=1727051284&sprefix=wheelchair+cup+high+holder%2Caps%2C130&sr=8-6)

**Objective and Scope**

* The objective of this LCA is to analyze the environmental impacts associated with the entire creation, life cycle, and disposal of our cup holder. Using an existing product linked above, we can see the typical environmental impacts of creating a wheelchair cup holder. By observing this, we can make design adjustments to make our cup holder more environmentally sustainable.

**Inventory Analysis**

* Examine the raw material needed and carbon emissions produced during the lifetime of this cupholder
  + Raw materials gathered in the product (Plastic and aluminum totalling 100g)
  + Manufacturing processes
  + Transportation and logistics
  + Durability: Expected lifetime, cleaning, maintenance, replacement parts
  + End-of-life: Can it be recycled, disposed of in an environmentally friendly manner

**Impact Assessment**

* Assess environmental harm from manufacturing and disposal processes
* Compare GHG emissions during production and transportation, special considerations with MakerSpace 3D printer, materials obtained through purchasing or recycling
* Analyze quantity of non-renewable/non-recyclable resources used in the design and compare it to our future design
* Look at potential total waste at the end of the product lifetime

**Interpretation**

* After a complete analysis of environmental impact and identification significant environmental impact factors, opportunities for improvement can and will be created
* Create alternate solutions, manufacturing processes, and modify product if needed if environmental impact relative to control product is outside of acceptable rage

## Design for X

1. Design for Simplicity (DFS)

1. As easy/intuitive to use as possible
2. Time taken to get drink/time taken to get cup out of cup holder and able for use (seconds) especially upon first use
3. Must be connected to a frame, must be balanced out with usability/adjustability
4. The less time, the better

2. Design for Quality (DFQ)

1. Improved durability
2. Stress tests: (How many impacts of the same force can the cup holder withstand), tensile tests
3. Material cost must remain low-profile and not obstruct any tasks
4. Can withstand outdoor use and able to remain functional after potential impacts or forms of tension

3. Design for Aesthetics (DFAes)

1. Sleek design
2. Color, have the ability for a wide color range
3. Minimalistic appearance
4. Custom edits, as in name engravings or other personal badging

4. Design for Adjustability (AFAdj)

1. Can be moved closer and further from reach.
2. Number of practical ways the cup holder can be adjusted, adjustment angle in degrees
3. Placement ensuring all adjustable modes will not interfere with mobility and other user needs.
4. The wider the adjustment settings, the better

5. Design for Usability (DFU)

1. Applicable to a wide range of different cups (in case of cup replacement) and environmental factors such as temperature (in case of use with hot beverages)
2. Can measure radius of maximum size or depending on the material, there can be minimum and maximum temperature (degrees Celsius) recommendations
3. Ensuring the cup stays in place with minimal wobble, safety concerns, heat dissipation
4. The wider the maximum cup hole radius (centimeters), the better, use material that does not conduct heat very well so that the cup holder does not become very hot

# Problem Definition, Concept Development, and Project Plan

## Problem definition

1. List and prioritize client needs/problems and define all relevant known and unknown information.

**Cup Holder Requirements:**

|  |  |  |
| --- | --- | --- |
| **#** | **Need** | **Imp** |
| **1** | Must attach securely to the right side of the wheelchair frame | **5** |
| **2** | Adjustable placement for easy access near the client's face and | **4** |
| **3** | Cerebral palsy restricts left hand mobility, requiring the cup holder on the right side | **5** |
| **4** | Holder fits a specific cup and be semi-removable with a secure clamp mechanism. | **3** |
| **5** | Sturdiness is critical to withstand rough rides on public transport (OC Transpo). | **5** |
| **6** | Made of durable materials | **5** |
| **7** | Tuck-away functionality when not in use | **4** |
| **8** | Solution should be affordable, ideally under $1,000. | **3** |
| **9** | Can be used for and withstands cold and hot drinks | **3** |

**Problem Definition:**

Develop a sturdy, versatile and accessible high cup holder for a user with mobility and eyesight limitations.

**Metrics and Units:**

**Durability:**

Metric: Resistance to impact and stress.

Unit: Load capacity in kilograms (kg)

**Adjustability:**

Metric: Range and ease of positioning.

Unit: Degrees of rotation or movement in centimeters (cm).

**Attachment Security:**

Metric: Stability under stress.

Unit: Force required for detachment (kg).

**Ease of Use:**

Metric: Simplicity of installation and adjustment.

Unit: Client survey or survey of people (timed)

**Compatibility:**

Metric: Fit for various frames and cup sizes.

Unit: Clamp size range (cm), maximum cup diameter (cm).

**Cost:**

Metric: Price relative to alternatives.

Unit: CAD$

|  |  |  |  |
| --- | --- | --- | --- |
| **#** | **Metric** | **Unit** | **Imp** |
| **1** | Resistance to impact and stress. | Material toughness | **5** |
| **2** | Range and ease of positioning. | cm | **4** |
| **3** | Stability under stress. | Force required for detachment | **5** |
| **4** | Simplicity of installation and adjustment. | seconds | **3** |
| **5** | Fit for various frames and cup sizes. | cm | **5** |
| **6** | Price relative to alternatives. | Canadian dollars | **5** |

4. Develop a set of target specifications (both ideal and marginally acceptable values). Provide reasons for your choices.

|  |  |  |  |
| --- | --- | --- | --- |
| Metric | Ideal | Acceptable | Reason |
| Durability | 3kg | 1.5kg | Needs to hold a variety of drinks and withstand rough rides on public transport. |
| Adjustability | 360 degrees of rotation | 180 degrees | client needs to adjust the holder for comfort. |
| Attachment Security | 10kg for detachment | 8kg | Must be stable during rough conditions (OC Transpo) to avoid spilling or detachment. |
| Ease of Use | Install and adjusted within 2 minutes | 4 minutes | Client may need to adjust or remove the holder regularly, so ease of use is critical. |
| Cup Size Accommodation | 10cm diameter and less compatible | 8cm | Needs to fit the client’s specific cup and accommodate most cup sizes. |
| Cost | <$50 | <$60 | Client prefers solution less than $1000 but competitors are within $40-$60 |

## Concept development

1. Based on your problem statement and the DFXs in PD B, develop final prototype concepts for each sub-system, as well as the entire assembled system required to solve the problem.

1. **DFS:**

**Sub-system: Clamp-System for removability:**

* Opt for a screw-in type clamp system to remove the need for much strength and can be tightened and loosened with one hand.

1. **DFQ:**

**Sub-system: Hard plastic material/potential lightweight metal such as aluminum**

* High quality impact resistance materials should be used to build the cup-holder, the material needs to have an adequate level of thickness and should consistently stay rigid and solid when met with force. Use heat resistant inner/non conducting material (such as silicon) so that the cup holder doesn’t get hot when a drink is placed on it, this is mainly for user protection.

1. **DFAes:**

**Sub-system: Minimalistic design**

* The cup holder should aim to maintain a uniform black coloured design that blends well with the wheelchair. The cup holder should maintain a relatively low-profile and not obstruct the user from doing any tasks.

1. **DFAdj:**

**Sub-system: Swivel Arm Mechanism**

* The cup holder should incorporate some form of rotating mechanism that will allow the user to move the cup holder away while still being accessible to be rotated back.
* The cup holder may require an additional arm attachment that can move vertically to allow the cup to be closer to face. One way this can be implemented is by using a swivel arm that can be locked using a hand screw/thumb screw similar to the clamp, this may reduce the simplicity however so opting for something that doesn’t require locking such as a ball and socket joint mechanism.

1. **DFU:**

**Sub-system: Variety of diameters**

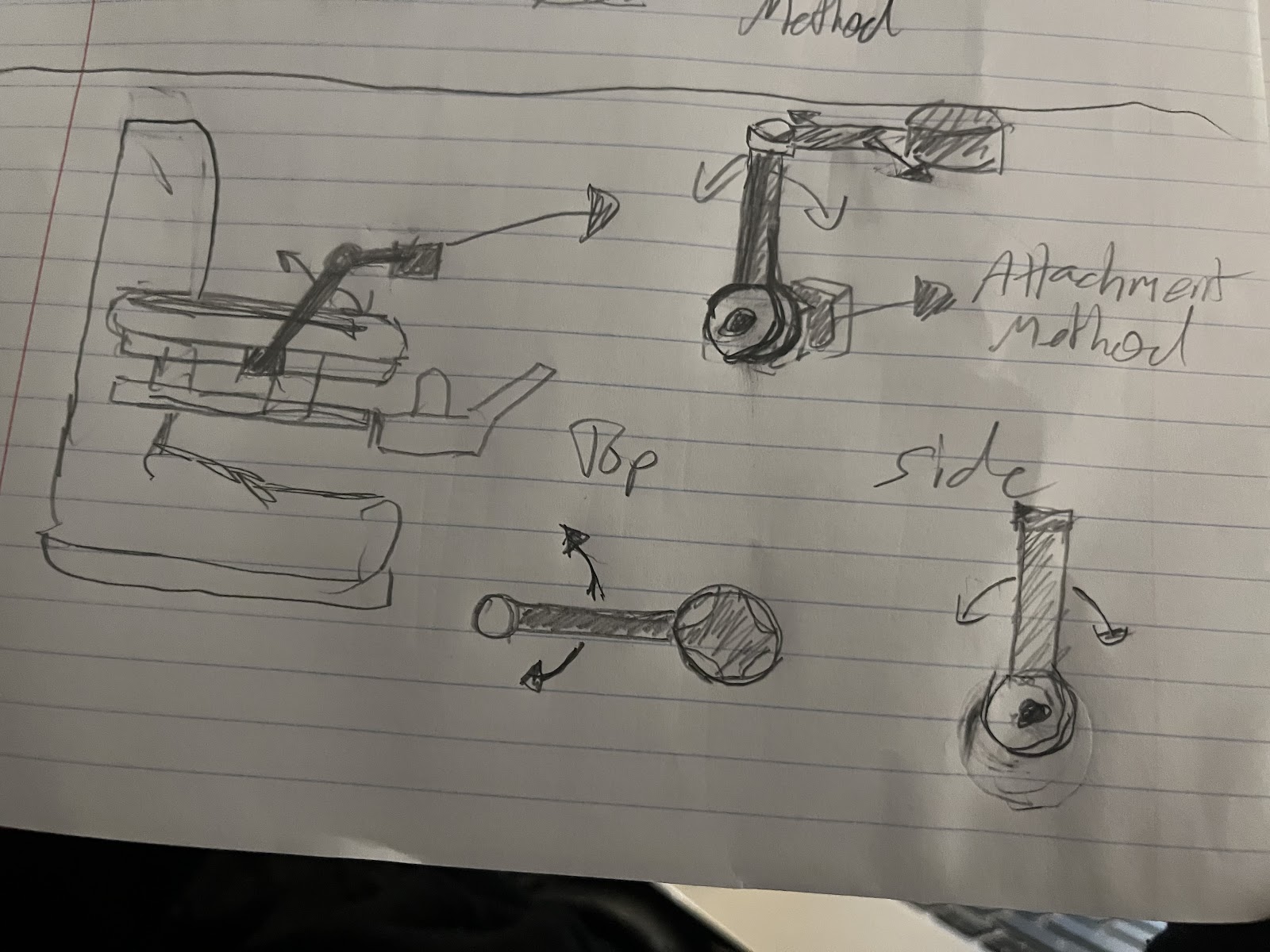
* The cup holder could contain layers of different diameters to ensure any cup size would fit. For example, if the cup holder measure 10cm in height, then starting from the bottom 1-3cm will have a diameter small enough for small cups and this diameter will incrementally increase to accommodate for a large variety of cup sizes.
* An alternative solution that could save space is to have a mechanism that can adjust the diameter of the cup holder to ensure it holds onto the cup tight regardless of size. (Likely to be **avoided** since it may make the cup holder harder to use especially if the user cannot see the mechanism)

**Entire Assembled System Concept:**

The end result of incorporating all these subsystems is a cup holder that meets all the needs of our client. It is a simple, minimal black high cup holder that can easily attach and detach from the wheelchair using the hand-screw tightening clamp. It has an adjustable arm that can be rotated at a wide degree angle and can additionally move upwards to be closer to the user’s face. The cup holder itself uses a sturdy thick heavy plastic design with a heat-resistant inner silicon material which will ensure that it can withstand day-to-day usage and remain functional after impacts. It has varying diameters to allow for multiple different bottles and cups to be used in case the bottle needs to be switched out or replaced. It is simple to use with as little need for user actions as possible.

**Swivel arm concept:**

Our chosen design, which is subject to change, would be a cup holder that can be adjusted using a hinge swivel arm that is attached with two different hinges. One hinge can swivel upward and downward which can be adjusted with a handle. The cup holder itself will use a ratchet system to rotate the whole thing forward and back. This is necessary as the client can only use one hand to rotate the holder. It will be tightened onto the frame of the wheelchair using a handheld tightening clamp and plastic latches.



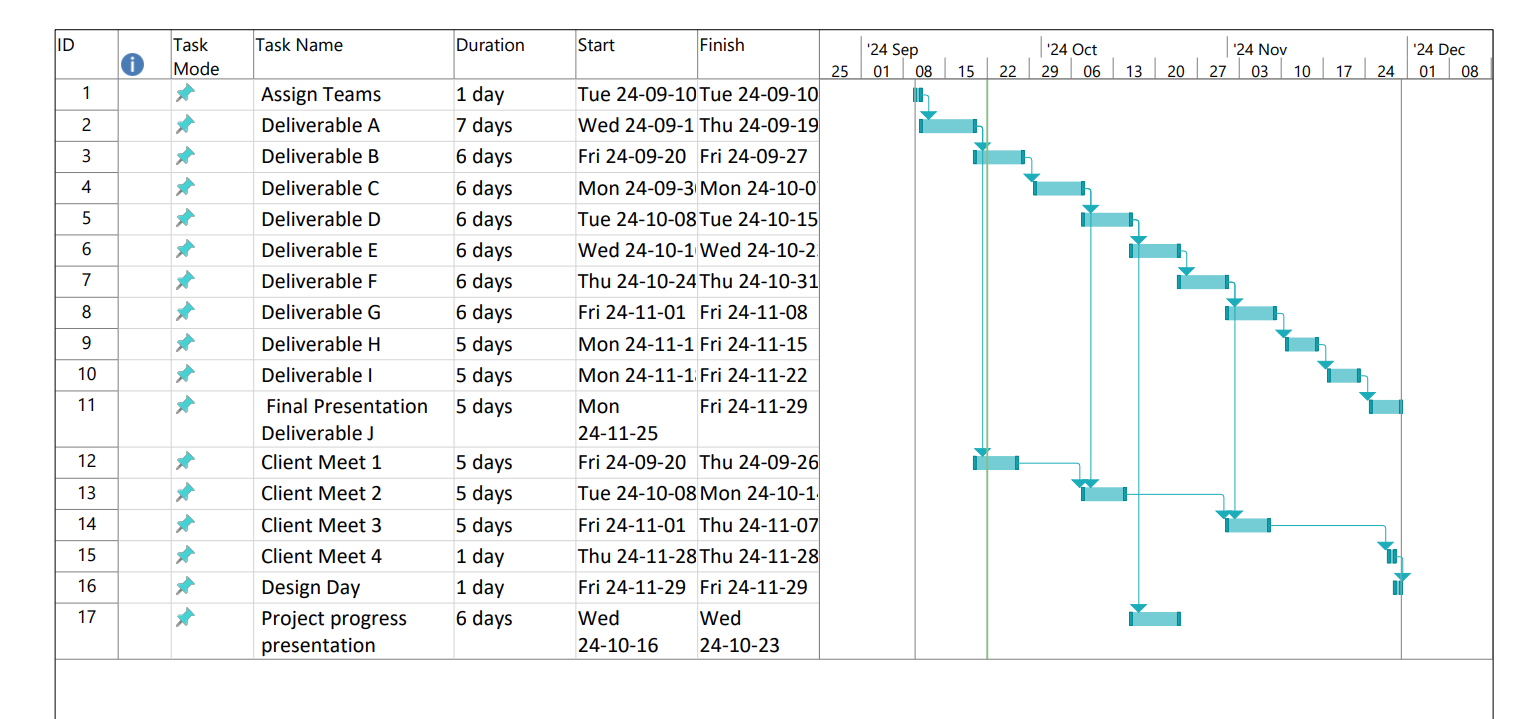
**Concept Specifications:**

* Swivel arm allows for degree of mobility, the clamps can be adjusted or loosened with one hand for accessibility
* Recycled materials help with sustainability
* Thickness helps ensure durability
* Hard to manufacture due to many moving parts
* Hard to obtain recycled materials

**Chosen Concept and DFX:**

The concept design closely follows the DFX factors that were listed above. Simplicity was considered when designing aspects such as the clamp and variable diameter. It uses durable materials, is adjustable, has a sleek aesthetic and is highly versatile for usability.

## Project plan



# Detailed Design and BOM

## Detailed design

**Client feedback:**

After we completed our client meeting, we found that the client was impressed with our ideas so far and we received a lot of positive feedback for our current concept. The main feedback received was durability focused. The client prefers durability and use of use over anything. They stated that they would prefer metal as it was the most durable material but other materials are fine where necessary. We discussed an additional holder to attached to the cup holder directly in order to completely secure the bottle to the holder. However, the client mentioned it would not be necessary because he will be mostly stationary when using the cup holder, and will be tucked away when transporting. This tucked away setting requires some sort of swiveling arm.

We also brought up the idea of having the cup holder arm attached to the left side of the chair. As he mainly uses his right arm and the controls for the chair are on the right side. We noticed there is a lot going on and could get in the way of the functionality of the chair. The purposed idea was to attach to the left side and go all of the way across the client's body and be in reach of their right arm for easy access to the drink.

**Detailed design:**

Simple attachment:

A sketch of a machine

Description automatically generated with medium confidence

Swivel joint:

A drawing of a patient's surgery

Description automatically generated with medium confidence

Telescopic pole:

A drawing of a machine

Description automatically generated

Attachment method:

A metal tube with red and orange screws

Description automatically generated

**Considerations to meet DFX factors:**

When designing our concept, we need to keep in mind the the DFX factors we mentioned in part 2, namely Design for Simplicity, Design for Quality, Design for Usability, Design for Adjustability, Design for Aesthetics. In order to achieve these, we must make sure we design it in a way that is easily usable for the client, without extremely complicated mechanisms. So we would use a simple adjustment mechanism as well as pivot joints. We must create it out of stable materials, aluminum and wood held together with screws and clamps, so the prototype is durable and can withstand different bumpy conditions. We also need to create a mechanism so it can be adjustable to the client’s needs. These are the most important factors to keep in mind. Another factor that is less important is aesthetics, which means we would create with the client preferred color, black, and make it take the least room possible. Aesthetics is not as important as the other factors, because aesthetics doesn’t improve the actual functionality of the prototype.

**Skills and resources needed:**

Knowledge of mechanics and statics

Mill

Lathe

3D printer

CAD

**Time Required:**

A realistic time required to implement this design would be around 3 weeks, so we would have enough time to order the equipment after they have been approved, and actually build the prototype while having enough time to focus on our other university courses.

**Critical product assumptions:**

Availability of aluminum bar of specific length

Prices of materials

Strength of clamps

## BOM

S

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Item name | Description | Measure units | Quantity | Unit cost | Extended cost |
| Cup holder part | Plastic holder | Unit | 1 | $10.00 | $10.00 |
| Pivot joints | Metal joints | Unit | 3 | $6.00 | $18.00 |
| Aluminum Bar | Metal rod | CM | 3 | $6.00 | $18.00 |
| Clamp | Steel clamps | Unit | 1 | $14.00 | $14.00 |
| Screws | Metal screws | Unit | 6 | $0.05 | $0.30 |
| Total product cost (without taxes or shipping) | | | | | $60.3 |
| Total product cost (including taxes and shipping) | | | | | $68.14 |

## Project plan update

Add a screenshot of your gantt chart.

# Conclusions

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

In this state of the project, we realized that we need to start innovation now. So we got together and brainstormed all the possibilities, and used the methods discussed in class. The main brainstorming activity that we did was get in a circle and just start talking about the possibilities of the high cup holder. The group kept building off each other's thought and were constructive the entire time and now we have a baseline and an agreement of what the product is going to look life for the client. Later we talked about how the swivel arm is going to allow for more moment of the cup to get closer in reach of the client. It is going to swivel at the bottom of the chair for the holder and cup to move upwards and sideways swivel that moves the cup horizontally for the client to easily reach the cup comfortably. The color of dark black being used to match the aesthetic of the wheelchair for the client was taken in for consideration. We also spoke and wrote about how the entire cup holder is going to be difficult to manufacture because of the number of moving parts within the system. Also because of the constant travel on the public transit system and the rough terrain that it is, we decided to make the cup holder out of thicker material to suit the active routes. And add extra support to the places that need it. In the progress section this will be our third Deliverable C so progress has moved to 2024-10-01. So we are ahead of schedule and are on track to deliver the prototypes soon and have our second meeting with the client in upcoming weeks.

# Bibliography

Insert your list of references here.