GNG2101

# Design Project Progress Update

## E 2.3


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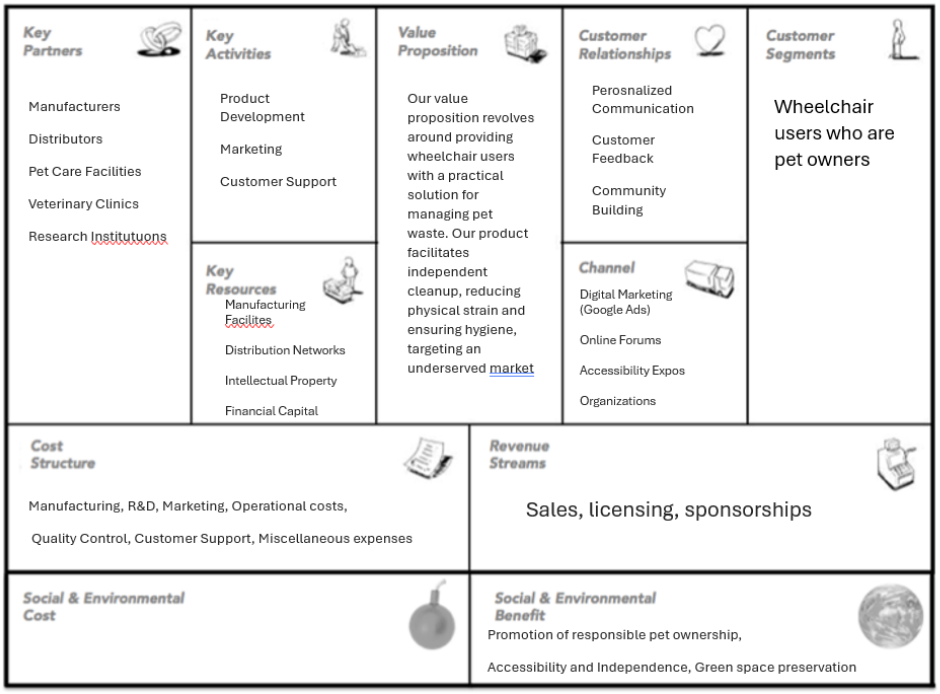
# Business Model Canvas and DFX

## Business model and sustainability report

- **Independence:** Our solution helps wheelchair users to clean up after their pets without assistance, providing self-reliance.
- **Convenience:** Designed for easy use directly from the wheelchair, minimizing physical strain.
- **Hygiene:** Provides a clean and sanitary method for handling pet waste.
- **Inclusivity:** Targets an underserved market.
- **Market Differentiation:** Stands out by addressing a unique need within the market.

**Core Assumptions:**

It is assumed that wheelchair users face challenges in traditional pet waste cleanup methods and that there is a demand for a solution specifically designed to meet their accessibility needs. This is mainly caused by concerns of all pet owners, including wheelchair users, about maintaining cleanliness of their living environments and their community. Another assumption would be the necessity of making sure we comply with current regulations concerning pet waste management products and protection of our intellectual property through patents and trademarks.




**Economic Impact:**

Producing this dog device will require the assembly and manufacturing of many parts. Further, we would need to process the parts to fit perfectly into our designs. As our team would not be able to do both by ourselves if we were to create many pieces of our product, we would need to start hiring. Creating a new job environment for the locals will have a positive impact on our economy. This will allow the people to have more opportunity to find a job that fits their needs and values.

The quality of the product can be at risk when mass producing it. When mass producing a product, we typically use the assembly line for its great efficiency and ease of training for the employees. This technique is great, but also has its flaws. A lot of times when a defect has been detected on a product, that same defect might have happened on thousands more without realizing it. This could lead to large amounts of recalls if it does not meet the quality standards.

**Environmental Impact:**

Dog feces is not able to decompose easily. It may take up to 12 months for the feces to fully decompose. If this occurs, rainwater may wash it away into sewers, causing sewer contamination. As a result, this water will go into lakes or rivers, causing these natural bodies of water to then get contaminated. Our device will reduce this contamination, having a positive impact on the environment.

Mass producing items, such as our dog device, always requires a large amount of materials. No matter how calculated your material order is, the production of any device will always have waste. Thus, during the mass production of our device, this will ultimately result in a lot of waste production. This will cause a negative impact on the environment as the waste will further contribute to landfills.

**Social Impact:**

The goal for our dog device was to aid individuals in wheelchairs to clean up after their dog's feces more easily. As some may find it difficult to bend over to complete this task in a wheelchair, these individuals may ask for help to pick up the feces. Ideally, our device will allow for these people to become more independent as they would be able to clean up after their dogs by themselves, without assistance.

When it comes to designing a device, finding the right balance is crucial. It's important to avoid over-engineering while still ensuring that it remains user-friendly. If a device becomes overly complex, it can hinder the user's ability to operate it independently. This can lead to a loss of autonomy and a greater need for constant assistance, which goes against the device's purpose of empowering users and promoting self-reliance. Therefore, it is essential to approach the design process with care and thoughtfulness, creating a user-friendly interface and intuitive functionality that align with the goal of enhancing independence and ease of use. By doing so, the device not only becomes a valuable tool but also contributes significantly to the user's overall well-being and sense of empowerment.

*AI was used for the above paragraph:*

*ChatGPT 3.5 prompt*

*"make this paragraph longer:*

*If the device is over engineered or too complicated for the users, it could lead to reduced independence since the device will require help to operate. Which goes against the goal of this device."*

*Scriptify prompt*

*"Make this paragraph flow better:*

*When considering the design and functionality of a device, it becomes imperative to strike a delicate balance, ensuring that it neither falls victim to over-engineering nor becomes overly complicated for its users. An excessively intricate device might inadvertently impede the user's ability to operate it independently, potentially resulting in a diminished sense of autonomy as constant assistance becomes necessary. This, in turn, contradicts the very essence of the device's intended purpose, which is to empower users and enhance their self-reliance. Therefore, a careful and thoughtful approach to design is crucial, fostering a user-friendly interface and intuitive functionality that align with the overarching goal of promoting independence and ease of use. In doing so, the device not only becomes a valuable tool but also contributes significantly to the user's overall well-being and sense of empowerment."*

## Design for X

1. **Accessibility:** By designing a dog device for our client, we aim to enhance the accessibility of dog ownership for them. We will ensure that the design considers our client's specific needs, such as the type of wheelchair they use and their varying upper-body strength. This will enable them to spend time with their dog comfortably and independently, fostering a sense of inclusion and empowerment.

2. **Install-ability:** The product's install-ability is a crucial aspect to consider. We will prioritize the ease of attaching and detaching the device from different parts of the wheelchair. By designing a user-friendly installation process, we aim to enable our client to independently install the device without complications or the need for assistance. This promotes their autonomy and convenience.

3. **Reliability:** Our focus will be on designing a device that can withstand regular use and withstand various weather conditions experienced in Canada, including snow, sleet, rain, and freezing rain. By ensuring the device's sturdiness and durability, we aim to instill confidence in our client, assuring them that the device will not malfunction or break during their daily activities with their dog.

4. **User Experience (UX):** We will prioritize factors such as the weight of the device, ease of control, and simplicity of cleaning and maintenance. These considerations will contribute to a smooth and enjoyable user experience for our client when using the device. By minimizing any potential challenges or complexities, we aim to make the task of using the picker less intimidating and more manageable for our client.

5. **Usability:** We will focus on designing a device that is user-friendly for our client. This includes placing the controls within easy reach and minimal upper body strength to operate, while ensuring they can be operated comfortably from a seated position. Furthermore, we will

design the device in a way that allows for easy disposal of waste with minimal contact. By reducing effort and simplifying both tasks, we aim to improve our client's overall experience and make their life and dog ownership easier.

*AI was used for the above section:*

*Scriptify prompt:*
*"I will give you a list of Design for x criteria. The description and justification part were found insufficient. enhance them."*

# Problem Definition, Concept Development, and Project Plan

## Problem definition

### Known Information:

Our client is looking for a newly designed device that will ease their experience of cleaning up their dog's feces about four times each day. After meeting with the client for the first time, we were able to understand their struggles more clearly. Being in a wheelchair limits the client's mobility, thus they are asking for an easy-to-use handheld device that allows them to reach the ground. As the client's arm is about one meter from the ground, the device should be able to extend to at least one meter long. It should be able to easily put on and take off from their wheelchair when needed. This requirement is very important since the client is a dancer, so it must be taken off while they are dancing. They do not require the device to be handheld nor does it have to be electrical, however, if so, it should be lightweight, and the device should be rechargeable.

### Unknown Information:

Some questions that remain for the client is how difficult it is for them to operate their current device. For our next client meeting, we will ask them to demonstrate how they use their current device to get a further understanding of their mobility and strength.

### Problem Statement:

**Title:** Dog poop picker that is wheelchair compatible

Problem statement: As the client is in a wheelchair, they are having difficulty picking up their dog's waste from the ground. To improve their dog walking experience and personal independence, a device is to be made that will reach the ground from their wheelchair and clean up their dog's feces.

| Need | Functional vs. Non-functional vs constraint | Ranking* | Metrics |
|---|---|---|---|
| Withstand regular stress, i.e.using it four times a day. All year round | Functional | 4 | Longevity:<br>Maintenance frequency required under normal use conditions |
| Easy to use with winter gear | Functional | 3 | Accessibility:<br>Ease of use rating in cold weather conditions |
| Compact | Non-functional | 3 | Compactness |
| Adjustable to reach ground level | Functional | 5 | Range |
| Lightweight | Constraint | 4 | Weight |
| Used and/or placed independently when needed | Non-functional | 4 | Independence: User independence rating (e.g., scale of 1-10 on ease of attaching/detaching) |
| Easy to perform maintenance | Non-functional | 2 | Maintenance:<br>Maintenance complexity score (scale of 1-10 e.g., |

| | | | |
|---|---|---|---|
| | | | number of tools required, steps to perform maintenance) |
| Matching flames aesthetic with wheelchair | Non-functional | 1 | Aesthetics |

*Ranking system: The ranking will be done on a scale from 1-5. 5 being most important, 1 being least important.

*ChatGPT-4 Prompt*

*"Find metrics for the table.*

*Change the metrics to one or two words i,e. length ,cost ,weight…"*

**Target Specifications**

| Needs | Metrics | Relation | Value | Units | Test Method |
|---|---|---|---|---|---|
| Withstand regular stress, i.e.using it four times a day. All year round | Maintenance Frequency | <= | 1 | /month | Estimate (The amount of uses before refilling the doggie bags) |
| Easy to use with winter gear | Accessibility Rating | >= | 6 | points | Survey |
| Compactly placed on wheelchair | Compact | Boolean | YES | N/A | Test |
| Adjustable to reach ground level | Range | >= | 1.5 | m | Estimate |
| Lightweight | Weight | < | 3 | kg | Measured weight |
| Used and/or placed | Independence Rating | <= | 8 | points | Survey |

| | | | | | |
|---|---|---|---|---|---|
| independently when needed | | | | | |
| Easy to perform maintenance | Maintenance Complexity | < | 4 | points | Survey |
| Matching flames aesthetic with wheelchair | Aesthetics | Boolean | YES | N/A | Visual |

| | Doody Digger Pooper Scooper | Dog Waste Picker Pet Poop Scooper In Six Claws Design With Long Handle | Spotty Wood Handle Pooper Scooper | Pet Dog Poop Scooper | Beetl |
|---|---|---|---|---|---|
| Metrics | | | | | |
| Maintenance Frequency | 31 | 1 | 0.5 | 1 | 3 |
| Accessibility Rating | 3 | 7 | 5 | 4 | 1 |
| Compact | NO | YES | NO | YES | YES |
| Range | 1 | 0.3 | 1.2 | 0.7 | Bluetooth range |
| Weight | 2 | 1 | 2.5 | 2.5 | N/A |
| Independence Rating | 2 | 1 | 0 | 5 | 10 |
| Maintenance Complexity | 1 | 4 | 1 | 5 | 10 |
| Aesthetics | NO | NO | NO | NO | NO |

| | | | | | |
|---|---|---|---|---|---|
| Total points | 13 | 17 | 16 | 17 | 17 |

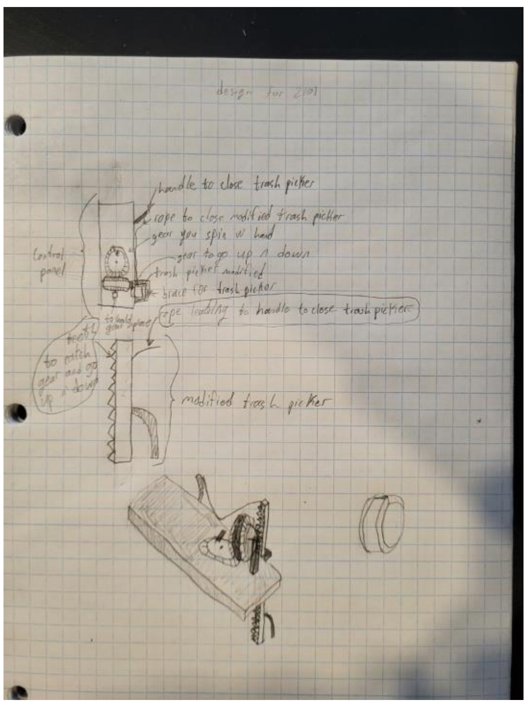
**Benchmarking**

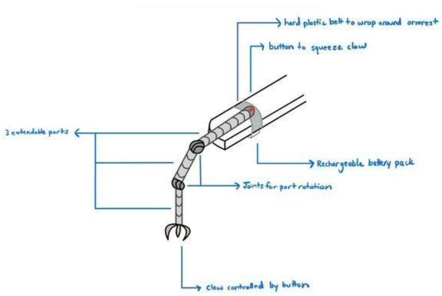
Green: 3

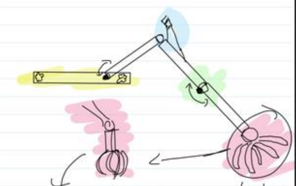
Yellow: 2

Red: 1

## Concept development



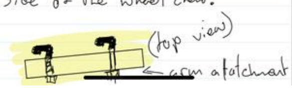


Simple claw design attached to the end of the controlable arm. the claw will be capable of inserting a doggie bag to ensure the dog waste will go directly in the bag.

The arm design will use various springs of gas struts to ease the

mannuvering of the tool. The arm will aslo be capable of folding in various locations to maintain a compact design.

The base plate of the arm will attatch to the tubing on the side of the wheel chair.



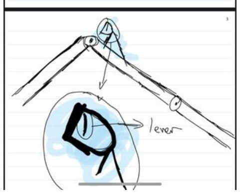

springs of gas struts to ease the

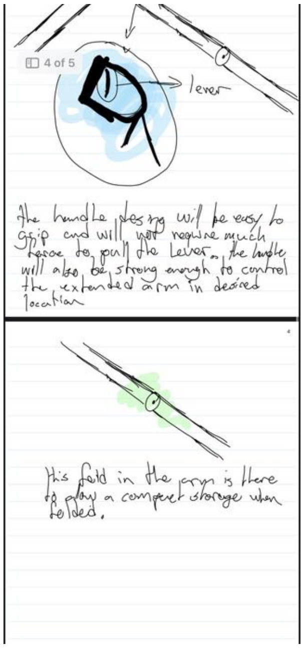
...ing of the tool. The arm will ... be capable of folding in various locations to maintain a compact design.

The base plate of the arm will attatch to the tubing on the side of the wheel chair.

2 of 5


uses simple clamps that tighten when the bolt is threaded clockwise counter clockwise will losen the attachment and can be removed by sliding it to the side/forward.





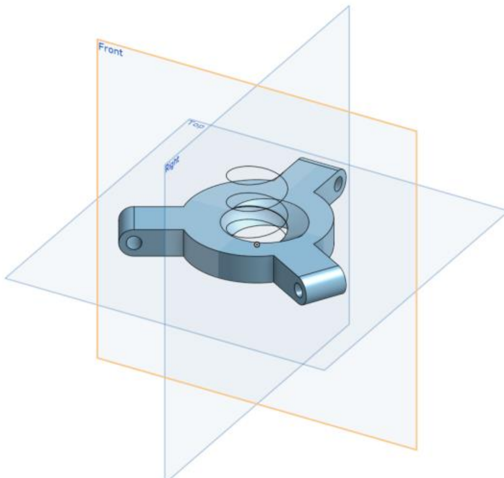

**Project plan**

pooper scooper design 1.pdf

# Detailed Design and BOM

## Detailed design

During the second client meeting, we were asked to present the group's progress on the project. We displayed three conceptual designs, a table showing how we had classified their needs, and the benchmarking done as of then. In general, the client's feedback was very positive with minimal constructive comments. Since they are looking for a device that requires the least amount of hand or arm strength, the client figured the conceptual design that requires turning a gear for the mechanism may be a little difficult for them. Therefore, they suggested combining the electrical button and the grappling hook from two of our ideas and incorporating them into a final design. Further, they have mentioned if the device is fully mechanical or requires some strength, it would be best to have it on the left side. This is important to note, however, we will try to manufacture the device to allow positioning it on either side to widen the demographic of the device. In the event there are individuals like our client who would prefer the device's placement on the right-hand side, we would need to consider being able to place it on both sides.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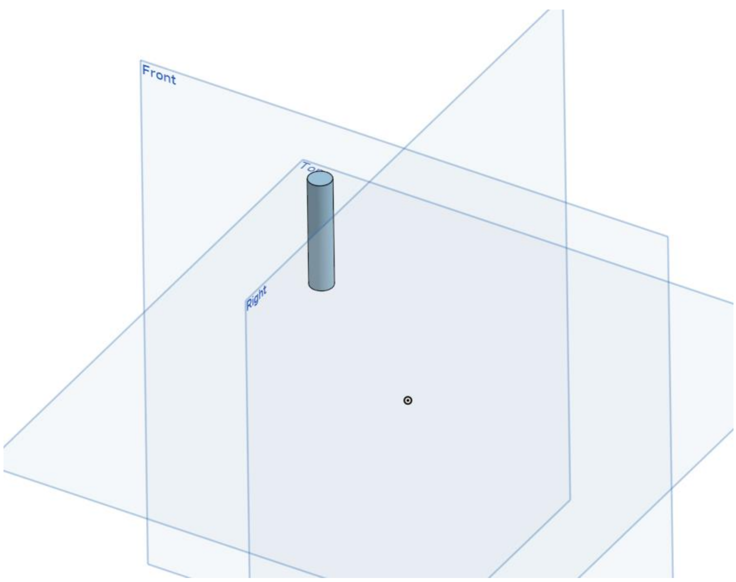
Top
Right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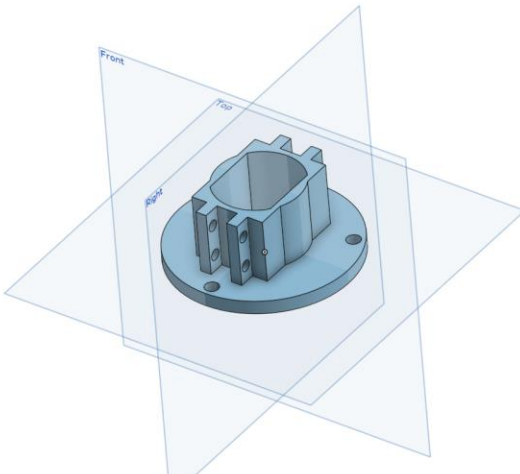
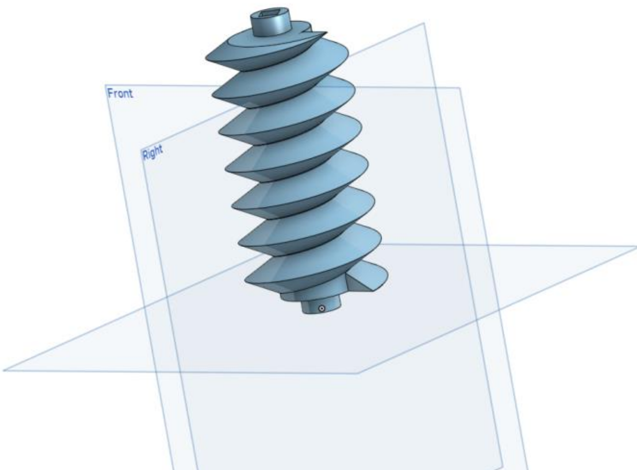



At our disposal, each team member has their own set of skills. Some have been trained for the mill, others have lathe training. One of our members also has a lot of experience in welding. All these skillsets can benefit the creation of our prototypes, and ultimately the final design of our product as well. As the University of Ottawa offers courses for different certifications/training, such as welding, more of our group members could help manufacture the parts of our design that may require this skill. Furthermore, physical skills are not the only ones our group has. Some of the group members are very good at managing time, and getting their tasks done. These individuals are of value to a project like this as every member has their own personal commitments, making it hard to complete tasks on time. The members who are good with time management are always there to give reminders, encouragements and affirmations so that the group can produce the best possible final product.

Since all members of the group have different schedules, the times when some are free to work on the project do not match up with everyone. To successfully complete our plan on time, we cannot rely on working on this project solely when everyone is free. As our group members are taking either 4,5 or 6 courses, we must divide the work into small tasks so we can put it together during the time we are all free. This project should take no longer than one month to construct once we have finished the final detailed design. If each of us can dedicate 1.5 hours of individual work and time for the group meetings, we will finish this project in a timely manner.

Assumptions:

With the new known information after our second client meeting, we were able to determine design requirements that would best suit them. These assumptions were made to ease our product's use, reducing the build time and costs of materials for the prototypes.

Our first assumption was that the device needed to be light enough for our client to remove it from their wheelchair with ease. This is an important factor to consider as this will increase the ease of cleaning, maintaining and widen the overall user base. On the other hand, having lighter materials might negatively affect the durability of our product. Therefore, the use of reliable and strong designs will need to be implemented for our final product.

As mentioned before, our client would prefer to use the product with their left hand. But we will make the design compatible for both sides of the wheelchair to widen yet again the range of our user base.

## BOM

| Quantity | Part Number | Description | Price |
|---|---|---|---|
| 1 | 1 | Main Chair Attachments | |
| 2 | 2 | Main Bolts | |
| 2 | 11 | Main Fasteners | |
| 1 | 3 | Main Housing for the Clamp | |
| 3 | 4 | Claw Fingers | |
| 1 | 5 | Claw Clamping Gear | |
| 6 | 6 | Claw Links | |
| 1 | 7 | Claw Adjustment Bolt | |

| | | | |
|---|---|---|---|
| 1 | 8 | Top Housing Piece | |
| 1 | 314555 | DC Motor | 14.75 |
| 1 | 9 | Motor Adapter | |
| 1 | 10 | Attachment Point | |
| 2 | 12 | Servo Motor | |
| 1 | 13 | Fishing line | 8.99 |
| 60 | 14 | 5mm round magnets | 8.24 |
| 1 | 15 | PLA | |
| 1 | 16 | 1/2 x 1 inch joint pin | |
| 1 | 17 | Male joint (1 inch) | |
| 1 | 18 | Reel housing | |
| 1 | 19 | Reel | |
| 1 | 20 | Power too reel joint | |
| 1 | 21 | 1/2 x 3 inch joint pin | |
| 1 | 22 | Arduino UNO | 5 |
| 1 | 23 | Micro Controller | 5 |
| 1 | 24 | On-Off switch | 6.75 |
| 2 | 25 | Forward-Stop-Backward switch | 7.49 |
| 1 | 26 | Arduino Hosuing | |

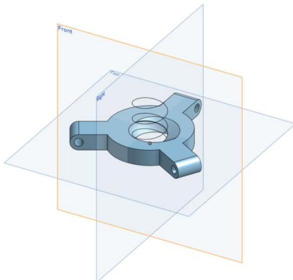
## Project plan update

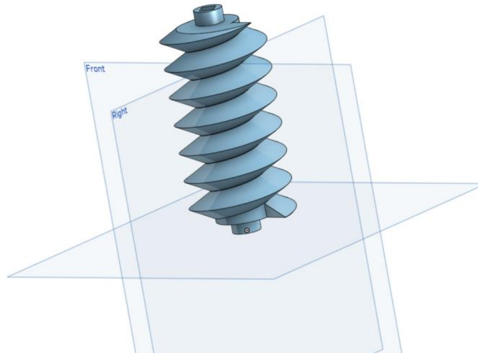
# Prototype 1, Project Progress Presentation, Peer Feedback and Team Dynamics

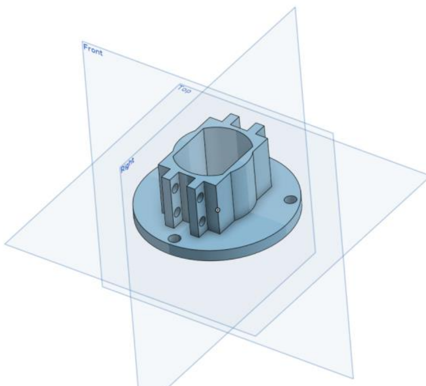
## Prototype 1

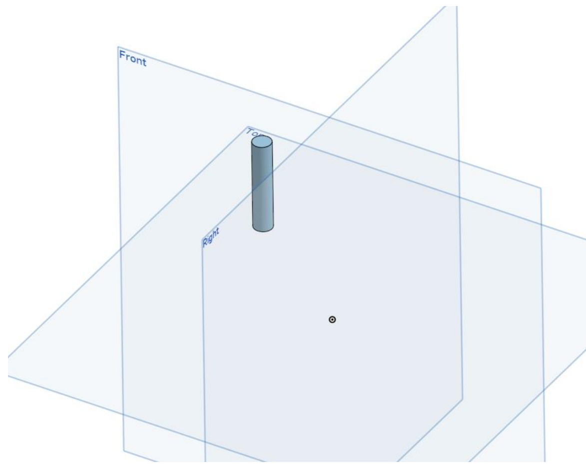
One critical assumption we made in Deliverable D is the weight of the device. For our client to use the device with their limited arm/hand mobility, we had assumed that the device itself is light enough. We can perform a test using this analytical model by seeing the density of the device on OnShape, then figuring out its mass. If this mass is five pounds or below, then the device would have passed the test, and our assumption was made correctly. One of the DFX we had stated from Deliverable B is User Experience. This DFX describes how we will prioritize factors such as the device weight to ensure an enjoyable experience for the user when using our device.

Prototype:








Prototype purpose:

One purpose of this prototype is to let the client visualize the mechanisms behind our device. We can use this online software, OnShape, to interact with the claw and the arm to explore how they will clamp and fold, respectively. However, more importantly, the main purpose of this first prototype is to test whether the weight of our device will satisfy our goal to ease. As it is much easier to alter our design if a weight test is failed virtually, we have resorted to this analytical model.

Test:

| Test | Ideal Characteristics | How to Measure | Test Results |
|---|---|---|---|
| Weight | Successful if the device's weight is under 5 lbs | lbs | 1 kg plastic + 0.5 kg wood + 2.6 kg metal = 4.1 kg = 9.02 lbs |

| | | | |
|---|---|---|---|
| Claw Clamp-ability | Successful if the claw is able to open and close with its current geometry | Yes or No | Yes |
| Arm Retractability | Successful if the arm is able to open (pull out) and close (retract) with its current geometry | Yes or No | Yes |

To improve:

From our testing, we have found that our weight requirement we wanted for the device was not satisfied. To improve this, for our next prototype, we will shorten the arm range by half, ie reduce the length of each arm part by 50%, which will approximately reduce the weight by 1.3 kg (2.86 lbs). Further, this change will improve reliability of the device function. Shortening the arm length will reduce the stress put on the arm hinges. If too much stress is applied, then the hinge will not work, destroying the device functionality. Thus, this arm shortening will be done fr the next prototype.

## Project Progress Presentation

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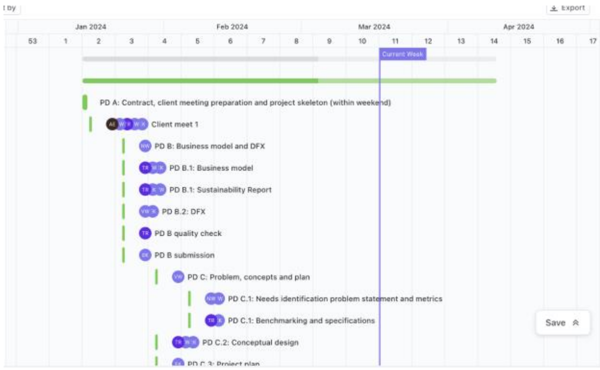
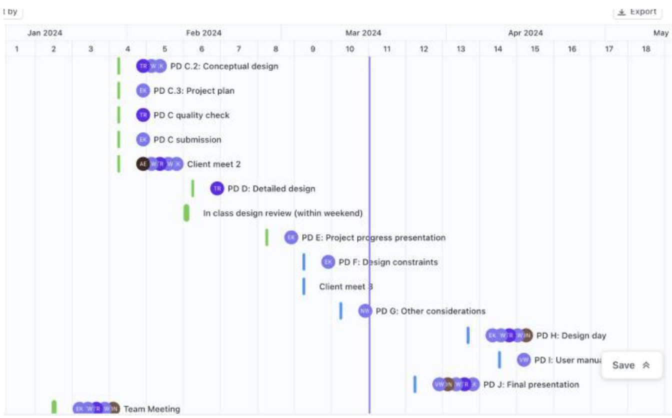
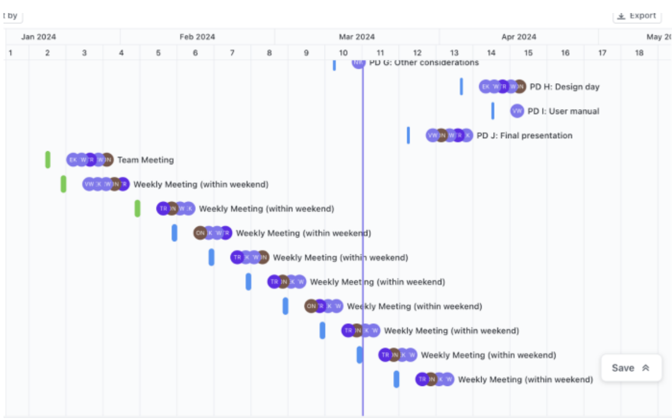
dWOonIJmQPH8/edit?usp=sharing

## Project plan update




# Design Constraints and Prototype 2

## Design constraints

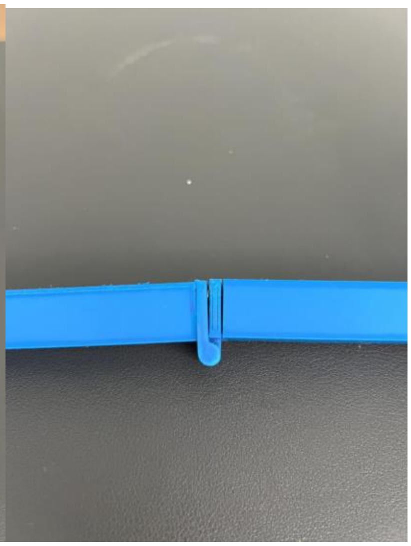
While completing a project that involves designing a product, you will always face a list of constraints that limits your design progress in some way. The more obvious constraints for any project would be the limitations of what it cannot do, referred to as functional constraints. However, there are always aspects that do not involve the project's actual function but still affect how a team should progress with the project's completion. Two examples of non-functional constraints that apply in the case of designing this dog device would be time and budget.

In the industry, teams may have a deadline made input by their clients by which their project must be completed. In our case, since our goal is to present our final product by Design Day, we are constraining the time from the beginning of this course, up until the moment we present at Design Day to finish our final prototype. Our initial thoughts were to 3D print most of the parts of the device, however, this will take too much time and we will not be able to meet our final deadline. To meet this goal, we have decided, instead of 3D printing every part, such as the 3-part collapsing arm, we will compose it out steel tubing. The estimated print time for the arm sums to 19 hours, thus the time required to make the arm will be cut by roughly 90% if steel tubes are used, needing time for sizing and assembly only.

Budget is another widely experienced non-functional design constraint that governs almost all planning for a project, including what materials to use, tools to purchase and features to include in the overall design. In this project, the budget limits the purchase of certain materials that may have improved the design's reliability. Opting for scrap steel tubes and reusing a 0.5 inch smt form a previous lab could reduce the quality of the final prototype but has greatly reduced our expenses.

## Prototype 2

Second Prototype:

While thinking about our client's needs, it is important that we provide a useful but easy-to-use device to allow functionality with minimal strength and effort. Within the design, we must create a mechanism within the hinges so that when the collapsible arm is fully extended, instead of swaying back and forth, it will be fixed in that position. This mechanism must be strong enough to hold itself in place while collecting the dog feces, however it should also require very minimal strength for it to unlock and collapse again. We decided to create our second prototype in hopes of testing the functionality of inserting a magnet within the hinge to lock the arm in place but also allowing easy collapsing. During the third client meeting, the client used the hinge mechanism on our second prototype easily. This confirms this second prototype's purpose, to test whether the hinge can stay in place while open and be closed with minimal strength.

Changes Made From the First Prototype:

Before the client meeting, we had made a few changes to our analytical model of the device to further guarantee the function of the design. To ensure the device does not stick too far out while stored on the wheelchair, we decided to change the diameter of the steel tubes to use for the arm. This has ultimately resulted in adjusting the sizes of the hinge diameter and the arm mount. For the device to require minimal storage space, we have decided, instead of a trifold, the arm will only consist of two folding parts, requiring a shorter reel size for the claw, Further, we have also modeled some of the finer parts of the device such as the reel housing, the arm hinge and the motor housing, before showing the client.

Our first prototype was also missing a lot of critical components to the final design. We had to create a complete design for the reeling system to allow the claw to go up and down. This proved to be harder than expected because the claw also needed to be powered. Since the power cord is also used to allow the z axis movement of the claw, it needs to be rolled up around the reel to allow the proper up and down movement. This is where the power cable could have the risk of twisting off and potentially causing a fire. Considering this, we had to make a “power plate”, this plate has two separate copper rings allowing the possibility of a + and – terminal at a consistent position, even when these rings are turning in circles. Optimally, we would use brushes that are designed to allow constant rubbing against the copper rings while maintaining a proper connection, but due to the time and budget constraint, we had to improvise and simply lay the cable against the copper rings. This will allow the prototype to work but wouldn't be acceptable as a final design.

Arm mounting devices

The prototype 1 arm mounting device consisted of a large bolt that would screw a back plate tight against the two available mounting positions of the wheelchair. This design can work, but it is prone to slip and can be difficult to mount. Due to these two reasons, it wasn't satisfying our client’s requirement. They are only able to use one arm, which has been proven to be difficult during our testing. We weren't able to hold the device in the proper location while screwing the bolt tight. This design is also prone to loosen on its own, which could be fixed using a rubber bushing to increase the friction between the screw and the threaded back plate. However, the client has limited strength and is unable to perform this twisting motion, therefore the additional friction of the screw would only compromise furthermore their ability to remove and mount the device with ease.

Our solution to this problem is to completely redesign the mounting of the device. We came up with the idea of a permanent mounting tool that allows no screwing (after initial installation), would be easy to remove and would allow the client to keep a permanent location of the arm. As seen below on the picture *Mounting device*, this design is small and will stay permanently on the wheelchair. We designed a locking door that is locked with gravity while the door is down and can be opened by turning this door upright and matching the mounting device's shape. This door keeps the mounting assembly from slipping off to the side and removing itself from the wheelchair. This design was tested by our team and proved to greatly improve the ease of use of the mounting and demounting of the whole device.

Changing the arm diameter

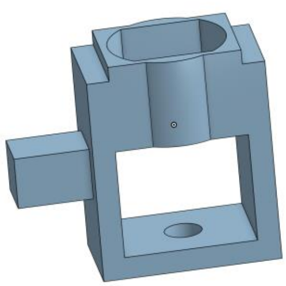
When testing our device, it was clear that the arms were an overkill for our application. In our first prototype, we used 1”x1” steel tubing, this was proven to be more of a problem than anything, only increasing the weight of the device and further straining the joints. To add, it would also increase the price tag of our device as it would cost 49.99$ to get the proper amount, and would weigh around 8.5 lbs. Our solution was to use scrap pieces of ¾ inch galvanized tubing found in a scrap pile. This material was not only lighter, but a lot more cost effective as it was free. When changing the diameter of the steel, we needed to change the diameter of all the attachment points of our hinges and reel assemblies. This resulted in a cheaper prototype and reduced the strain in the joints.

Motor housing

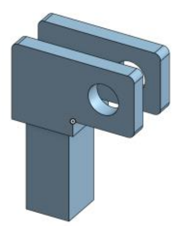
When designing the motor placements, we used a free model online, however the size did not match that of our motor. Therefore, we needed to design the housings on the reel assembly, and the top cap of the clamp. We also never calculated the strength of our small dc motors, so we had to incorporate a gearing box to allow the necessary clamping force to pick up the dog's feces.

Addition of caps for the wheelchair main bar attachment

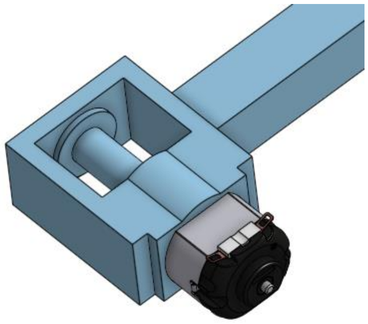
When reviewing our first prototype, it was obvious to see that trying to assemble the main bar together would be a challenging task because of the complexity of the part, especially at the hinge. Thus, it was clear to see that we needed to design a printable part as it would allow us to simply press fit the part into two bars. This redesign also improved the weight of the device, the accuracy and simplicity of assemblage.



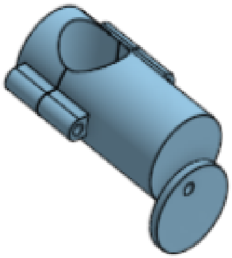
*Reel housing*

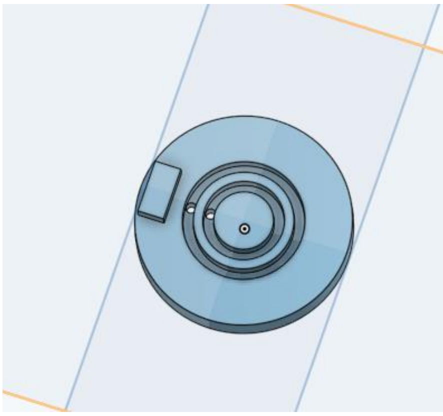


*Arm hinge*



*Motor Housing* *Reel Assembly*





*Mounting device* *Power Connection*

Client feedback:

During the meeting, the client did not have much feedback in terms of our design. They were very satisfied with the improved analytical model, and the easy mechanism for the arm locking and collapsing. One thing we noted however was that, though they may ultimately still need someone to help with mounting and dismounting the device from the wheelchair, the goal is for them to be able to do so independently. This has given us the idea to change the mounting device so that, instead of requiring to screw and unscrew a bolt, the user will simply need to flick a little piece that will essentially 'hook' and 'unhook' the device onto the chair.

Assumptions:

One of the most critical product assumptions we hadn't yet tested is the strength of the collapsible arm. To create a functional design that will be able to hold the weight of the feces, it is essential that we test this. This assumption is related to the device's reliability, as a weak arm will not accomplish the device's intended goal to pick up the dog's waste, thus diminishing its reliability to complete this action.

For strength testing of the arm, we used the improved analytical model of the device.

Tests:

| Test | Ideal Characteristics | How to Measure | Test Results |
|---|---|---|---|
| Hinge magnet mechanism | Successful if the client can open and close the hinge | Yes or no | Yes |
| Strength of collapsable arm | Successful if the arm can handle up to an additional 5 lbs. from the standard weight of the assembly. | Test the strength using the onshape insight application. | |

# Project plan update