

GNG2101
Design Project Progress Update

TEAM FLEXTECH E1.2

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List of Acronyms and Glossary

Table 1. Acronyms

Acronym	Definition
GHG	Greenhouse gas; gases that trap heat in the atmosphere, (e.g., CO ₂ , methane).
LCA	Life Cycle Analysis
DFX	Design for X

Table 2. Glossary

Term	Acronym	Definition

1 Introduction

Deliverable B discusses sustainability, the life cycle analysis, and design for x. The sustainability report discusses the sustainability of many different aspects of the product as well as how the product will function. The LCA goes into the scope as well as the different stages of the life of a product that is currently on the market. Finally, the DFX goes through the design for 5 different “x’s”. Deliverable C organizes various client needs and turns them into various problem statements, to which we can define metrics and target specifications from. We then dive into concept development and develop final prototypes for each solution, further refining our solution into a global solution that we can use to create models, sketches and renderings of an idea. We then can relate our global solution to our existing DFX and target specifications and finally update our MS Project plan to follow our timeline of creating things.

2 Sustainability Report and DFX

2.1 Sustainability report

Our product is a foot exercise device that is designed to assist those with mobility challenges in performing dorsiflexion and plantarflexion exercises to improve muscle and tendon health. The device will have mechanical components and electrical components to deliver guided movements to the user.

The device will contribute to many positive social impacts. The assisted exercises will allow individuals with mobility challenges to build muscle and tendon strength which will reduce muscle atrophy, develop cardiovascular health, and improve their quality of life. The device is also a crucial steppingstone for rehabilitation and restorative care, introducing individuals to a long journey of

healing, potentially giving user independence. The foot assist can also have a negative social impact, as prolonged reliance might discourage users from pursuing other therapeutic care methods, leading to a fixed perspective.

The choice of design and materials of the foot assist device can lead to a positive or negative environmental impact. The foot assist can be designed for long-term use with recyclable and sustainable materials to minimize waste and reduce landfill accumulation. The device is small, lightweight, and compact, minimizing material usage and reducing production demands, which in turn lowers raw material excavation and GHG emissions. Unfortunately, the device will also be composed of electronic components which require a strict recycling and repurposing procedure and may be subject to improper disposal.

The device may serve as economic relief for individuals who rely on expensive and frequent physical therapy sessions, helping them reduce expenses. The high production costs of the foot assist may create financial challenges, however, as it is marketed as a medical device, it could be covered by insurance or government subsidy programs, making it less of a financial burden for individuals in need. The foot assist could incur additional charges or difficulties during its prolonged usage due to part replacements, battery replacements, or malicious practices like planned obsolescence.

Table 3: Triple Bottom Line

Triple Bottom Line	Positive Impact	Negative Impact
Social	Improved quality of life	Variable ease of use
	Rehabilitation gateway	Over-reliance

	Raises accessibility awareness	Therapeutic inertia
Environmental	Recyclable materials	Electronic waste
	Compact design	Contributes to GHG emissions
	Energy efficient design	Resource excavation
Economic	Reduce therapy sessions	Expensive initial costs
	Eligible for subsidy	Expensive maintenance costs
	Creates job opportunities for designers	Susceptible to malpractice

The social, environmental, and economic sustainability constraints can be defined by analyzing the positive and negative impacts of each category. The foot assist should be designed with ease of use, accessible instruction and simplified user interface in mind to maximize its social benefits. The device will be manufactured using recyclable materials to minimize its material and electronic footprint and proper disposal methods will be reinforced to improve its positive environmental impact. Finally, for economic sustainability, production will be optimized for cost efficiency while ensuring a high quality and durable design.

2.2 LCA report

The LCA analysis will be based on a product that exists on [Amazon](#) that is similar to what we plan on designing.



Figure 1: Electronic Ankle Trainer

The differences being that ours will be customized to the client's size and specifications: that our product will be used when lying down in bed, it will only be used on the right foot, and it will be more affordable.

Note: This is a slightly more complicated process for this product as it is manufactured, whereas when we do an LCA for our product most of our components will be 3D printed or manufactured by ourselves. (much less impact on the environment)

2.2.1 Objective and Scope

Set system boundaries and perspectives: Cradle to Use

- Raw material extraction (plastics as its the main body of the product).
- Production processes (forming plastic, molding).
- Distribution and transport (amazon distribution).
- Use phase (cleaning and maintenance).

We decided to do cradle to use instead of cradle to cradle or cradle to grave because our product is intended to be used by the client only and therefore cannot be reused by others when our client is done with it.

2.2.2 Inventory Analysis

Raw Materials & Production Processes:

Plastics: Most widely used hard plastic is PE (polyethylene) plastic. Polyethylene starts with naphtha, or petroleum, which is extracted from crude oil and heated to release ethylene, through a process called fractional distillation, which forms branch-like structures to become polyethylene. Crude oil is a fossil fuel, we extract fossil fuels through mining and drilling and then burn them to produce electricity or refine them for use as fuel (naphtha). During Production processes in a factory, small plastic pellets of polyethylene are used. The pellets are poured into a reactor, melted into a thick liquid to cast into a mould. An example of this is injection moulding.

Distribution and Transportation:

For amazon products there would be a lot of transportation of the product from where its manufacture to an amazon warehouse then shipped to the user.

2.2.3 Impact Assessment

Note: My analysis of the quantitative values of impact are for a portion of the material extraction and production, is a best estimate, there are many small processes that occur that use a lot of water and energy that add up over time.

Raw Materials:

When fossil fuels are burned, they release carbon and other greenhouse gases into the atmosphere, which contributes to climate change. According to the EPA, approximately one ounce of carbon dioxide is emitted for each ounce of polyethylene (PET) produced. ([source](#)). This is product is 14.5 pounds which around 85% of it is plastic. Meaning 12.325 pounds or 197.2 ounces of plastic, or 197.2 ounces of carbon dioxide per Ankle Flexor

Production Processes:

If we assume that the plastic is made by injection moulding, “the emissions factor is around 1.83 [kg CO2 equivalent per kg product] for an Allrounder.”([Cradle-to-Grave of Injection Molding Machines](#)). This means that for the product chosen 5.44 kg or 191.89 ounces of CO2 is produced per the production of one Ankle Flexor.

Distribution and Transport:

To estimate the amount of impact transportation of this product will have we will assume that device is manufactured in Toronto, sent to an amazon warehouse in Ottawa, then finally shipped to the client somewhere else in Ottawa. For the average transport truck, it requires 40 liters of gasoline to travel 100 km. The trip that this device would have to take is around 500 km, meaning 200 liters of gas is needed for the trip. The process of producing and transporting gasoline produces between 3.35 and 6.7 pounds of CO2 per liter of gas. CO2 is also produced when the gasoline is burnt (when you drive your car). 20 pounds of CO2 is produced when burning 3.785 liters of gasoline. When 200 liters of gasoline are burned 1,056.8 pounds of CO2 is produced. This is equivalent to

Table 4. Summary of LCA

Life Cycle Stage	What is doing the Impacting	Measurable Impact (CO2 Produced) per one Product
Extraction of Raw Materials	Plastic	<u>197.2 ounces</u>
Production Processes	Plastic	<u>191.89 ounces</u>
Transportation & Distribution	Gasoline	<u>16908.8 ounces</u>
	Total=	<u>17,296.8 ounces</u>

2.2.4 Interpretation

This is where you “step back” and check (like with Concept Selection) whether the results of the tools “make sense” and decide what your “next steps” should be

1. Choice of Materials

The use of polyethylene plastics has a large impact on the environment. An option to limit this impact would be to use different materials such as biopolymers, reusable nonfragile glasses, or potentially differing the way these plastics are manufactured.

2. Manufacturing

Injection molding is not the most environmentally friendly process for manufacturing hard plastics. A more environmentally friendly option would be 3D printing (this is what we will do with our model).

3. Use phase

The use phase of this product does not have an environmental impact at as the person using it only needs one unless it breaks.

4. Transportation

The transportation phase has the largest environmental impact out of the entire process. A way to lessen this impact would be to ship directly from the manufacturer to the customer.

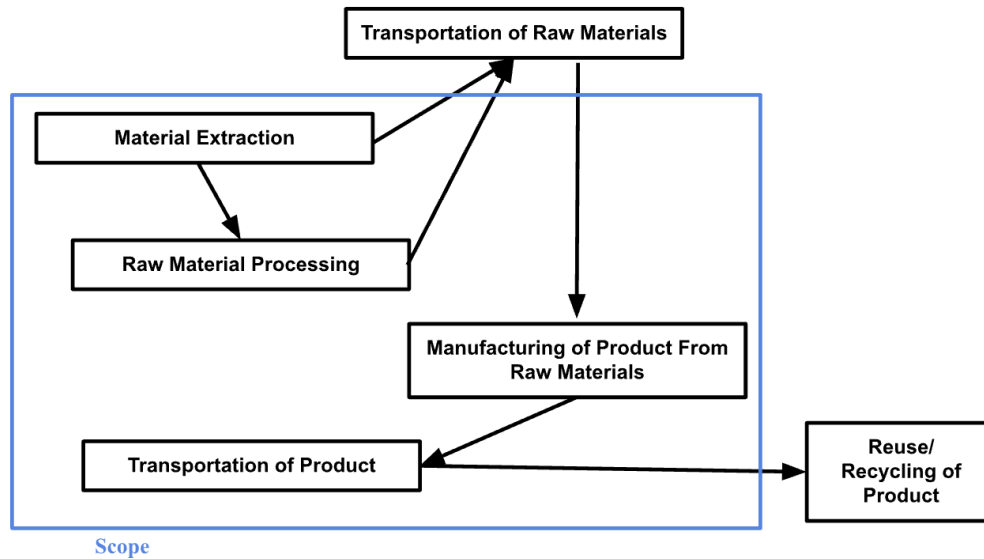


Figure 2: Scope of LCA

2.3 Design for X

a) Based on our research and comments from the client, the 5 most important factors in our design of a foot flex assist device are:

- a. Design for Cost
- b. Design for User Experience
- c. Design for Safety
- d. Design for Reliability
- e. Design for Simplicity

b) Common objectives/needs, examples of metrics, examples of constraints and examples of design criteria (function and non-functional requirements) for **Design for Cost** include:

a. Utilizing affordable material [Functional Requirement]:

- i. Current devices on the market utilize expensive polymers, metals and electronic circuitry. By limiting our device to simple, quality plastics, woods, and cushioning, we can save a large sum of money, especially since the device would

be used at most, half an hour a day and require little maintenance to prepare and clean.

- ii. Electronics can be limited to being Arduino powered with simple servo motors, rather than complex machinery requiring special computer chips and processors. This will reduce costs and keep the device simple to use.

b. Reducing unnecessary features [Constraint]:

- i. The only features necessary are an on and off switch, time setting, angle setting, and speed setting. Heating is optional but appreciated.
- ii. Devices on the market not only target the foot but build the device up to the knee joint and assist with knee/leg postoperative rehabilitation, as well as ankle stiffness, arthritis, ligament injury, and fractures. By limiting our device solely to the client's needs (the dorsiflexion of the right foot), we can save money on materials, engineering designs and preprogrammed exercises.

c. Simpler mechanisms [Function Requirement]:

- i. By reducing the different options and mechanisms of the foot flex assist device, we can save money on complicated mechanisms that provide too many options for a 30-minute foot flexion exercise. Complicated mechanisms require more resources and time to construct, so limiting the device to simple mechanisms will save money.

d. Limit to right foot only [Constraint]:

- i. Client has mentioned left side mobility is much greater than right side mobility and doesn't require assistance. She has asked for the flex to be solely focused on the right foot, so by tailoring the device to be compatible with the right foot and

not compatible with both feet, we can save unnecessary materials, resources and differential programming, which would all require extra costs to implement.

e. Costs must be around \$50 per unit for production [Metric]:

- i. The current products on the market cost around \$530. We want to make our device smaller, efficient and more affordable by using smarter materials, mechanisms and design choices.
- ii. This includes using 3D printed parts, making the overall device and mechanisms simpler, and using an Arduino for the electronic component of our device. Using these constraints, we can manage a unit price of approximately \$50.

c) Common objectives/needs, examples of metrics, examples of constraints and examples of design criteria for **Design for User Experience** include:

a. Reduce number of buttons [Functional Requirement]:

- i. By reducing the number of buttons, we can make the user experience easier and faster, which should be a priority for a simple foot flex assist device that the client uses for at most, 30 minutes.
- ii. We don't want to over-complicate our design and have the client struggle to figure out how to use the device with too many features, designs, and buttons. The client's age is pretty old (possible meaning the client may not be as tech savvy), and with the limited mobility in the body, pressing too many buttons or exerting too much force may be too hard on the client.
- iii. The only buttons that should be present are an on/off switch, time setting, and possibly an angle setting, speed setting, and heat setting.

b. Comfortable and easy to put on [Functional Requirement]:

- i. The device should be very comfortable for the client. Soft materials should be used such as cushioning, cotton, and silks, while rougher and blister inducing materials (as mentioned by the client) should be avoided such as rubbers, wools, and hard materials. In addition, the client mentioned heating features, so the device should be warm and use insulating materials while maintaining a proper temperature to not overheat and produce too much sweat.
- ii. The device should also be simple to slip into without complicated mechanisms to strap the foot inside. Ideally, the client should only need to slip in her foot and maybe tighten the device around. Having a lock system, laces, or anything that requires the client or their caretaker to put additional work to lock the device on should be avoided.

c. Easy and convenient charging station [Non-Functional Requirement]:

- i. The charging station should be near the bed and be small. Being near the bed would allow our client to charge the device without having to travel far (due to her limited mobility). Having a small device will also not take up as much space in the bedroom, leaving more empty space to store additional items or necessities our client may need.
- ii. A wireless charging station is ideal as it avoids the client plugging in wires and bending down (due to her limited mobility). The client should be able to place the device on a charging disk or plate and have the device charge automatically.

d. Easily cleanable [Non-Functional Requirement]:

- i. The device should be easily cleanable from sweat, debris, and smell. To make an effective cleaning experience, removable inner pads can be used and wiped with

a cleaning agent. Additionally, there can be retractable pads that can be thrown into a washing machine.

- ii. To prevent the device from needing to be cleaned often, there should be inner ventilation of the device to prevent too much heat and sweat build up.
- iii. What we want to avoid in the cleaning process is having the client pick up the device and reach into the foot socket of the device to scrub the device clean. This would mean more mobility issues for the client and extra effort to scrub the device from the inside.

a) Common objectives/needs, examples of metrics, examples of constraints and examples of design criteria for **Design for Safety** include:

a. Reducing tightness of device [Function Requirement]:

- i. Since the client broke her neck 4 years ago, resulting in limited mobility everywhere under the neck, safety is very important in reducing the risk of further injury to her existing injuries.
- ii. Having the foot flex device too tight can cause blocked circulation and numbness of the right foot. With limited mobility, additional numbness and blocked blood flow would further hamper her mobility and make her uncomfortable, possibly becoming dangerous.
- iii. Tightness may also damage the skin of her foot, and in case of an emergency where the device needs to be taken off, over tightness can prevent an easy slip off and the device may be forced off, causing damage to the wearer and the device.

- iv. A metric used to measure this could be how many newtons of force the device exerts on the ankle

b. Less blister inducing materials [Constraint]:

- i. The client had mentioned blistering as a concern and requested softer materials over harder materials such as rubber. Blistering can cause uncomfortability and may make the client's already sensitive foot and skin more susceptible to ailments in her daily life (showering, etc.).
- ii. To prevent blisters, softer materials that glide over the skin are to be used such as cottons, silks, and cushioning. We will avoid materials that cause resistance to the skin such as rubbers and polymers.

c. Controlled variables (speed, heat, angle) [Metric]:

- i. Having full control over necessary variables is key to the safety of our client. We want to ensure the client has control over how fast the device flexes, how large the angles are, and the temperature of the heat, as having a device that flexes too fast or widens at a sharp angle can be very dangerous when breaking the physical limitations of our client.
- ii. We will have an interface that will slowly allow the client to adjust to their customized settings, being careful not to jump between settings too fast and allowing the client to see which is to her preferred comfort. This will allow the client to find the best settings for her comfort and reduce physical damage on her feet.

- iii. A metric used to measure this is the angle must not exceed 50 degrees or more from rest. The angular speed must also not exceed 0.5 rad/s and the heat must not exceed 25°C.

d. Emergency stop [Constraint]:

- i. In case the device suddenly malfunctions or has a defect, our system will need an emergency stop. The emergency stop should stop all action (angle changing, heat, etc.) and should return the device to its original position so the user can easily slip out.
- ii. If there were no emergency stops, any defects that cause harm could be amplified to a greater extent.
- iii. In case of an emergency, the device should stop within 0.5s

d) Common objectives/needs, examples of metrics, examples of constraints and examples of design criteria for **Design for Reliability** include:

a. Ensure long term performance with minimal failures [Functional Requirement]

- i. Failures could include device losing power, not rotating the right amount, and material failures. By reducing the number of failures, we can ensure that the device will not harm the user.

b. Mean time between failures [Metric]

- i. Measure the expected time between failures in the different systems

c. Material limitations [Constraint]

- i. Certain materials could degrade over time causing them to need to be replaced.
By ensuring we use a quality design with quality materials this will increase long-term reliability.

d. Design for heat regulation [Non-Functional Requirement]

- i. During operation certain parts may heat up (ex. The motor or power block) therefore if we take this into account during the design we can ensure that materials aren't degrading unnecessarily due to heat.

- e) Common objectives/needs, examples of metrics, examples of constraints and examples of design criteria for **Design for Simplicity** include:

a. Reduce design complexity for easier maintenance [Non-Functional Requirement]

- i. By using a simple design, we can ensure that the device is easy to repair in the case of failures.

b. Assembly time and Number of parts [Metric]

- i. Measure how long it takes the user to set up the device (seconds (s))
- ii. Count how many different parts the device has and attempt to keep them to a minimum

c. Performance Requirements [Constraint]

- i. Increasing simplicity must not compromise the essential functionality and features of the device.

d. Use a modular design to make repairs easier [Non-Functional Requirement]

- i. By making independent parts and systems it can be very easy to replace pieces that break.

3 Problem Definition, Concept Development, and Project Plan

3.1 Problem definition

3.1.1 Prioritized needs/problems of the client

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

Table 5: Need Statements

Client Statement	Need Statement	Ranking
“Much more mobility in the left side of body compared to right”	The device prioritize functionality for the right foot	3
“Needs to have an option to select different times like 15 minutes”	The user interface of the device allows the option of selecting custom time.	4
“Entirely push button, use a button to turn on, select how many minutes, and how much heat to provide [optional, but nice to have].”	The remote of the device includes buttons for power, duration, and heat adjustment.	4
“Can use a physical remote to turn the device on and off”	The device is paired with a remote control for operation.	4
“Scared that the device could get to hot and burn her”	The device contains safety features to prevent overheating.	5
“... be cool to have a heat function”	The device includes a heating feature for the ankle.	2
“... use a material that doesn't cause blisters”	The device is composed of materials that prevent irritation and discomfort.	5

“I need the device to be simple to use”	The device has an easy to use and comprehensible user interface.	4
“When I use the device, I will wear a sock”	The device accommodates users who wear socks.	3
“I lie down on my bed when I need this exercise”	The device operates when the user is lying down.	4
“My foot size is a lady 8 ½ - 9”	The device fits a user who has a lady's foot size of 8 ½ - 9.	4
“Typically, I need 30 minutes of dorsiflexion and plantarflexion exercises per day”	The device can operate for 30 minutes straight without error.	3
“I have poor circulation in my right hand and right foot”	The device is loose fitting to prevent tightness that can cut off blood circulation.	4
“Foot flex assist devices on the market are too expensive”	The device is low cost compared to other products on the market.	5
“I have a caretaker to assist me with my problem each day”	The device can be handled by others to put on the user.	4
“I need to clean the device every once in a while”	The inside of the device is simple to clean.	4




3.1.2 Problem statement

A need exists for our client (Jan) to exercise her right foot with dorsi and plantar flexion exercise 15-30 minutes a day with a remote foot flex assist device that is safe to wear, comfortable to use, and low cost on the market.

3.1.3 List of need inspired metrics + benchmarking with similar solutions

Table 6. Benchmarking

Product Name	Pictures	Final Specs	Comments
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Ankle Rehabilitation Training Device [Brand: WESTN]		<ul style="list-style-type: none"> - Electric remote control - Large wide-angle training (30° plantarflexion, 40° dorsiflexion) - 360° rotating footrest - Hollow design - Adjustable foot support - No cost displayed 	<p>The rectangular box prism where the leg rests is a good addition for counterbalance for the motor. A heating pad could be integrated in the rectangular component and the angular component. The straps also make the device much hollower and simpler to clean. Uses minimal materials where it can, and I like the use of foam as the choice of comfort material.</p>
Ankle Rehabilitation Training Device [Brand: WESTN]		<ul style="list-style-type: none"> - Electric remote control - "Full angle" training (45° plantarflexion, 50° dorsiflexion) - High-quality material that is bend-resistant and wear resistant. Metal reinforcement provides reliable force absorption and sponge pad is optimal cushioning. - Hollow design - Adaptable trainer that can be used for many purposes - Costs \$529.99 CAD 	<p>Like the design of metal framing, as it's sure to provide support and absorb as much force from the flexion motion. Seems a tad bulky and heavy, especially since the client will be laying on her bed using the device. Like the versatility of lying down or sitting while using the device, and like the design and user experience of the electronic remote.</p>
Electric Ankle Trainer, Foot Rehabilitation [Brand: DAZULI]		<ul style="list-style-type: none"> - Smart electric wired controller - "Bidirectional" training (40° plantarflexion, 30° dorsiflexion) - Interval exercise (30° - 40° interval exercises) with 3-speed choice regulation. 	<p>I like the idea of a three-speed regulation where you click the button to go slow, medium or fast, rather than using numerous buttons for too many precise speeds. Slightly cheaper than the others and uses less material all together. Can be used laying down or standing up, though not</p>


		<ul style="list-style-type: none"> - Hollow ergonomic design - Adaptable trainer that can be used for many purposes - Costs \$475.99 CAD 	much cushion is observed in the pictures.
Total Ankle Trainer Ankle Exerciser [Brand: Total Ankle Trainer]		<ul style="list-style-type: none"> - No controller, fully manual - Manual training (60° plantarflexion, 60° dorsiflexion) - Utilizes elastic bands, straps, and polymers that you rock with your feet. - Hollow ergonomic design - Promotes dorsiflexion isolation training for weak toes and ankles. - Costs \$465.00 USD 	Despite not being specific to the problem we are solving, there are many elements we can take from this product to incorporate into ours. It's an extremely simple design utilizing simple rocking mechanics. Our patient will not have the ability to move her feet on her own, but we can incorporate the range of motion used in this device for our product.

Table 7. Metrics

METRICS DESCRIPTOR	UNIT
Size (Volume) of device	Centimeters cubed (cm ³)
Amount of Rotation	Degrees (°)
Temperature (if heat pad is incorporated)	Degrees Celsius (°C)
Power requirement	Kilowatt hours (kWh)
Weight of Device	Kilograms (kg) or Grams (g)

How much time to set up the device	Seconds
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3.1.4 Set of target specifications

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

Table 8. Metric Descriptions

Metrics ID Number	Metrics Descriptor	Unit	Marginal Values	Ideal Values
1	Device Weight	Kg	3	2
2	Adjustability (Foot Size)	Shoe Size (US)	6-10	4-12
3	Assembly time	Minutes	5	1.5
4	Range of Motion	Degrees (°)	80	90
5	Maintenance frequency	Uses	500	1000+

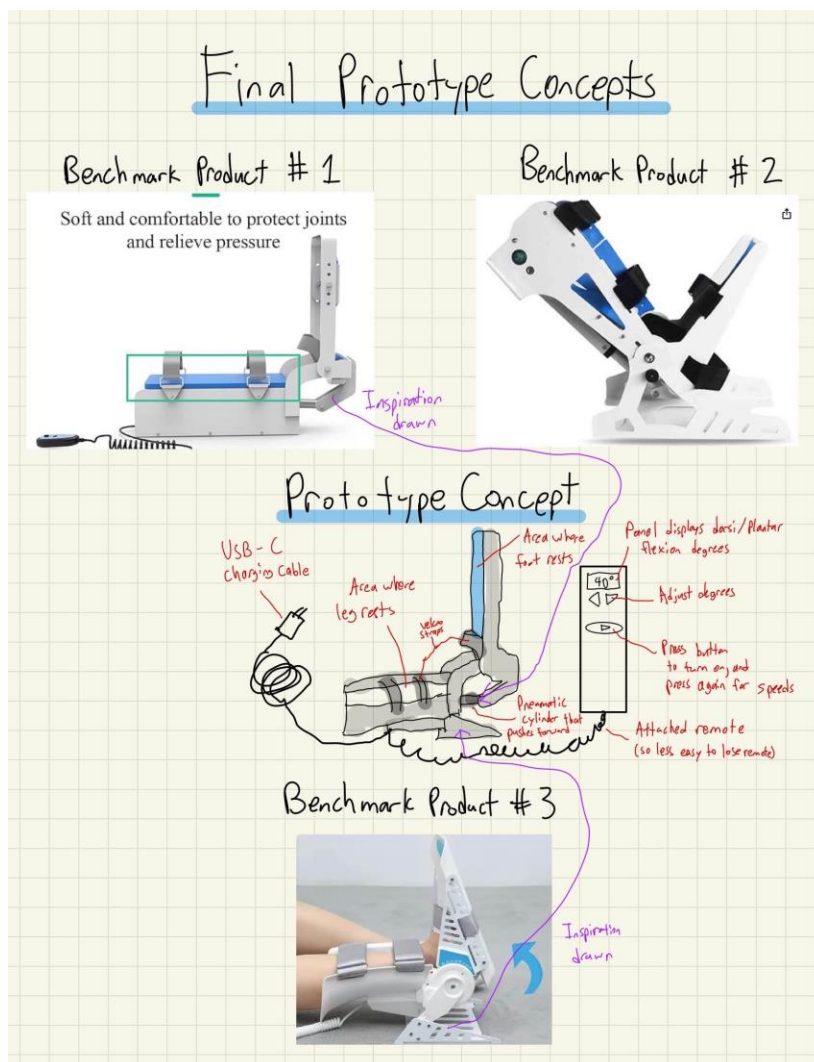
3.2 Concept development

3.2.1 Final prototype concepts for each subsystem

Based on our problem statement, we have developed a few final prototype concepts for each subsystem, as well as the entire assembled system required to solve the problem.

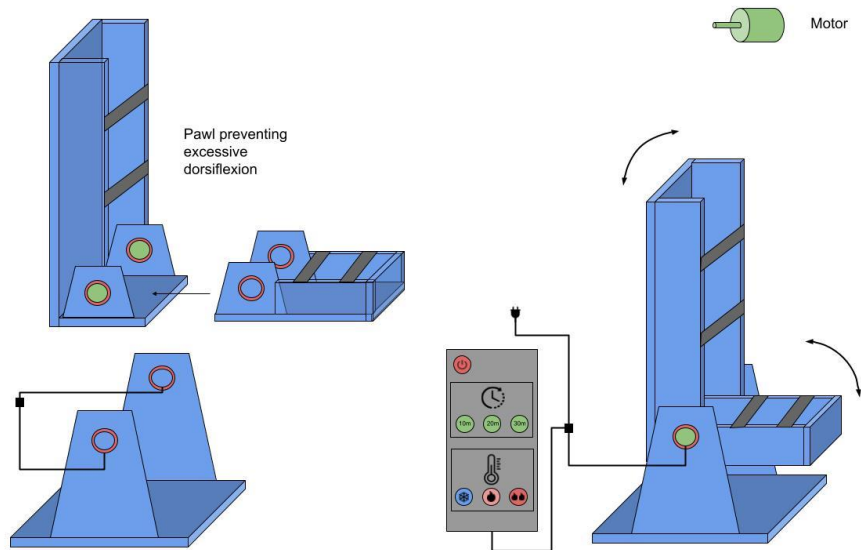
Prototype Concept #1:

Figure 3: Prototype Concept #1



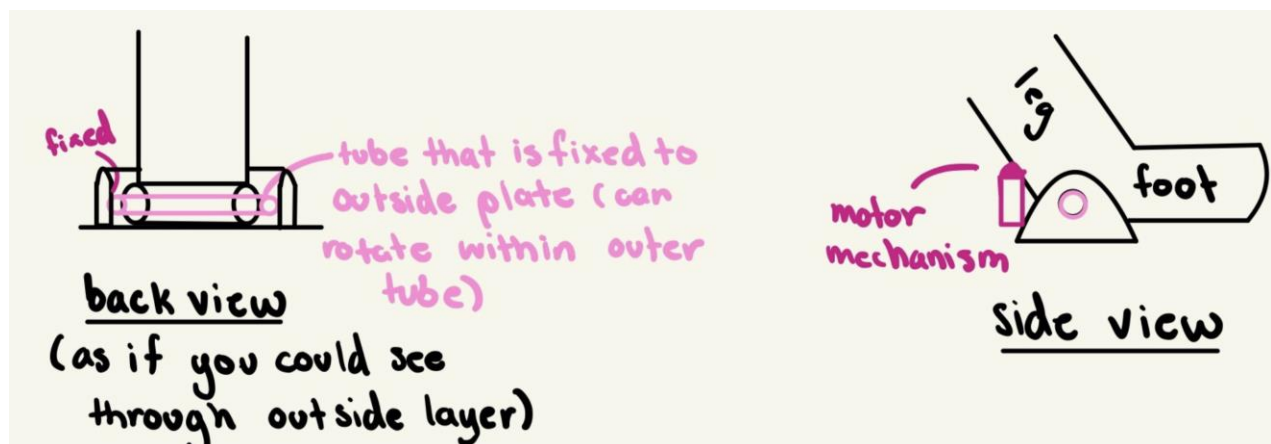
Prototype Concept #2:

Figure 4: Prototype Concept #2



Prototype Concept #3

Figure 5: Prototype Concept #3



3.2.2 Analysis of concepts against target specifications

Table 9: Target Specifications

Metric ID	Concept #1	Concept #2	Concept #3
1 (Weight)	1 (2.9 kg)	2 (2 kg)	2 (2 kg)
2 (Adjustability)	2 (4-12)	1 (6-10)	2 (7-9)
3 (Assembly Time)	1 (4 min)	2 (1.5 min)	1 (4 min)
4 (Flexion Angle)	2 (70°)	1 (50°)	1 (60°)
5 (Maintenance)	1 (700 uses)	2 (1200 uses)	0 (400 uses)

Total Scoring

Table 10: Scoring

Concept	Total Score
1	7
2	8
3	6

Conclusion: Concept #2 performs best overall, scoring highest across the most important metrics.

Calculations and Justifications:

Metric 1: Device Weight

- For Concept 1: Weight = 2.9 kg. (Marginal value is **3 kg**, so it passes.)
- For Concept 2: Weight = 2 kg. (**Ideal** specification met.)
- For Concept 3: Weight = 2 kg. (**Ideal** specification met.)

Metric 2: Adjustability

- Concept 1: Range = Shoe sizes 4–12 (**Ideal** specification met).
- Concept 2: Range = Shoe sizes 6–10 (Marginal value met, not ideal).
- Concept 3: Range = Shoe sizes 4-12 (**Ideal** specification met).

Metric 3: Assembly Time

- Concept 1: Assembly time = 4 minutes (Marginal value met).
- Concept 2: Assembly time = 1.5 minutes (**Ideal** specification met).
- Concept 3: Assembly time = 4 minutes (Marginal value met).

Metric 4: Flexion Angle

- Concept 1: Flexion angle = 70° (**Ideal** specification met).
- Concept 2: Flexion angle = 50° (Marginal value met, not ideal).
- Concept 3: Flexion angle = 60° (Marginal value met, not ideal).

Metric 5: Maintenance Frequency

- Concept 1: Maintenance = 700 uses (Between marginal and ideal).
- Concept 2: Maintenance = 1200 uses (**Ideal** specification met).
- Concept 3: Maintenance = 400 uses (**Fails** marginal specification).

Final Decision

Based on this analysis Concept 2 is recommended as it meets or exceeds marginal values in all metrics and meets **ideal** values for multiple metrics. Concepts 1 and 3 are reasonable fallback options as well but do not perform as well as concept 2.

3.2.3 Promising solutions of interests

Many of our preliminary concepts have many similar features, many of the differences lying in the motor mechanism/joint that will allow the foot to flex. Some of the different ideas were a simple hinge joint, a rotating dowel, or the motor acting as the joint. Our concepts are for the base and boot of the device, and that it should be remote controlled, as these are direct needs of the client which should be implemented in all our preliminary concepts.

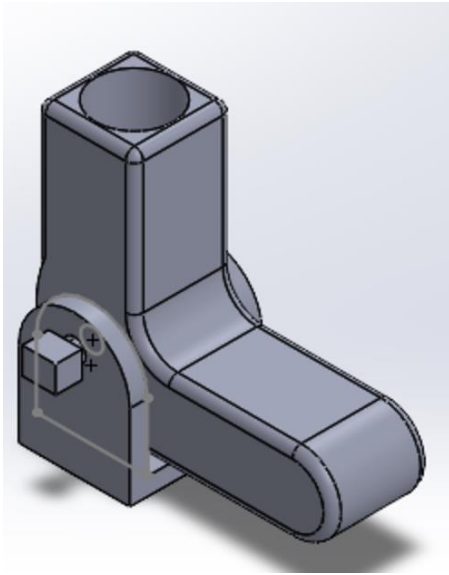
3.2.4 Global design concept

The global design concepts are combinations of the different ideas from our preliminary ideas and sketches. Our strategy was to determine which ideas we believe were the most effective for each portion of the design. We then combined these ideas in order to develop the best design possible. We have chosen to go with a design that is similar to Concept #2 because this concept scored the highest overall through our metric grading system and was a simple, effective design the team liked. We had two members (Stella and Jordan) of the team design CAD models based on the preliminary sketches. One representing a preliminary concept and one representing our global concept.

3.2.5 Visual representation of the global concept

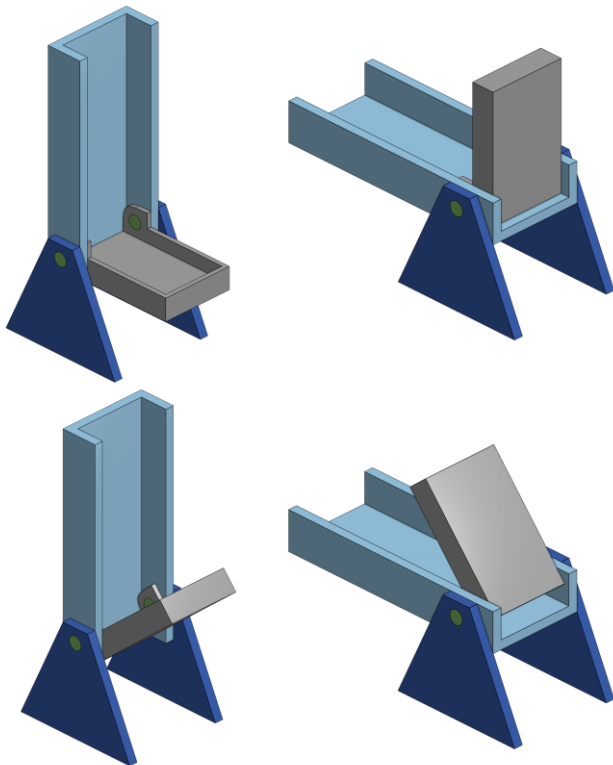
CAD Model #1

Figure 6: CAD Model #1



CAD Model #2

Figure 7: CAD Model #2



[OnShape Link](#)

3.2.6 Concept's relationship to the target specifications

The conceptual designs are accompanied by a remote that lets the client control the duration, temperature, and power of the foot assist device. This addition was highly requested and allows for a more flexible and customizable experience.

The designs are symmetric for functionality in both feet. However, they should prioritize comfort and a proper fit for the right foot as the client requested. Revisions will be made to the design to reflect this interpreted need.

The foot assist concepts have a very accessible and simple user interface so that the device is comprehensible and easy to use.

The device is equipped with a heat setting to soothe the foot as requested by the client. This system can be harmful to the user if not properly calibrated so rigorous testing will be done.

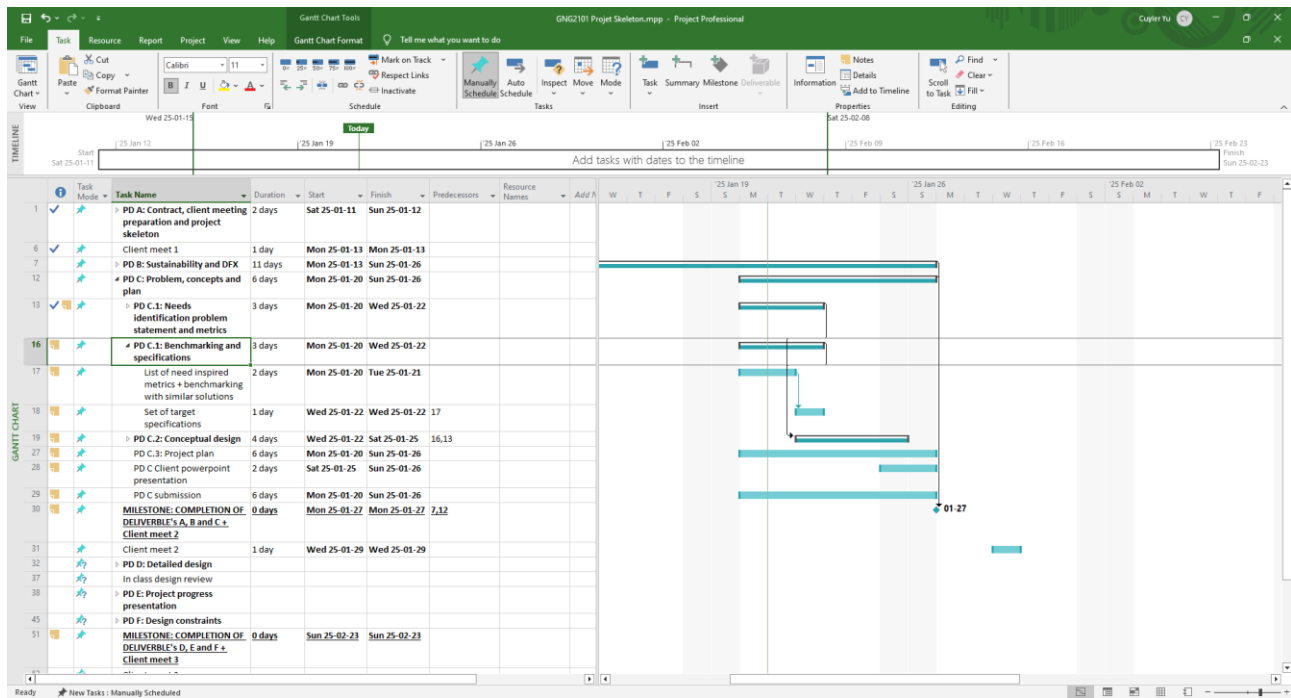
Some drawbacks to this design are that we may need a higher power output in order to power stronger motors. Therefore, the device may need to be plugged into an outlet rather than running on batteries. Additionally, there may be difficulty adding foot straps into the design since there is no easy way to implement them with the architecture of the design. This will be a problem we may need to problem solve and take inspiration from our preliminary concepts that did incorporate this feature smoothly.

3.2.7 Concept's relationship to DFX factors

With its remote control that lets users adjust power, temperature, and duration, the foot flex support device offers a highly personalized user experience while maintaining ease of use and an easy-to-use interface. Although the symmetrical design fits both feet, according to customer input, the right foot's comfort and fit are given priority. To prevent injury, the heat setting is rigorously tested to ensure safety will be a priority. The open concept design allows the device to fit comfortably on the client's foot without causing over tightness. Reliability is guaranteed by long-lasting parts and less frequent maintenance. The design's simplicity and streamlined form simplify manufacture and assembly without sacrificing performance or usability, reflecting the emphasis on cost effectiveness. The overall design of the device is also attributed to its cost being much cheaper, yet effective at completing the necessary task of dorsi/plantar flexion exercises for the client.

3.3 Project plan

Figure 8: Project Plan



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