GNG2101

Design Project Progress Update

GROUP 3.1

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Table 1. Acronyms

Acronym	Definition
AMC	Arthrogryposis Multiplex Congenita

0 Introduction

This document will follow the progress of our project of designing, prototyping, and manufacturing a dressing tree for our client, who is the father of the user, a 7-year-old girl diagnosed with arthrogryposis multiplex congenita (AMC). This document will be organized in separate sections, with each outlining the phases of our process, from the definition of the problems and our business model to the different ideas, designs, tests, and prototypes. It will conclude with our final prototype design, the design day pitches we had, and the different manuals/videos necessary for the user to correctly and safely operate the product.

1 Business Model Canvas and DFX

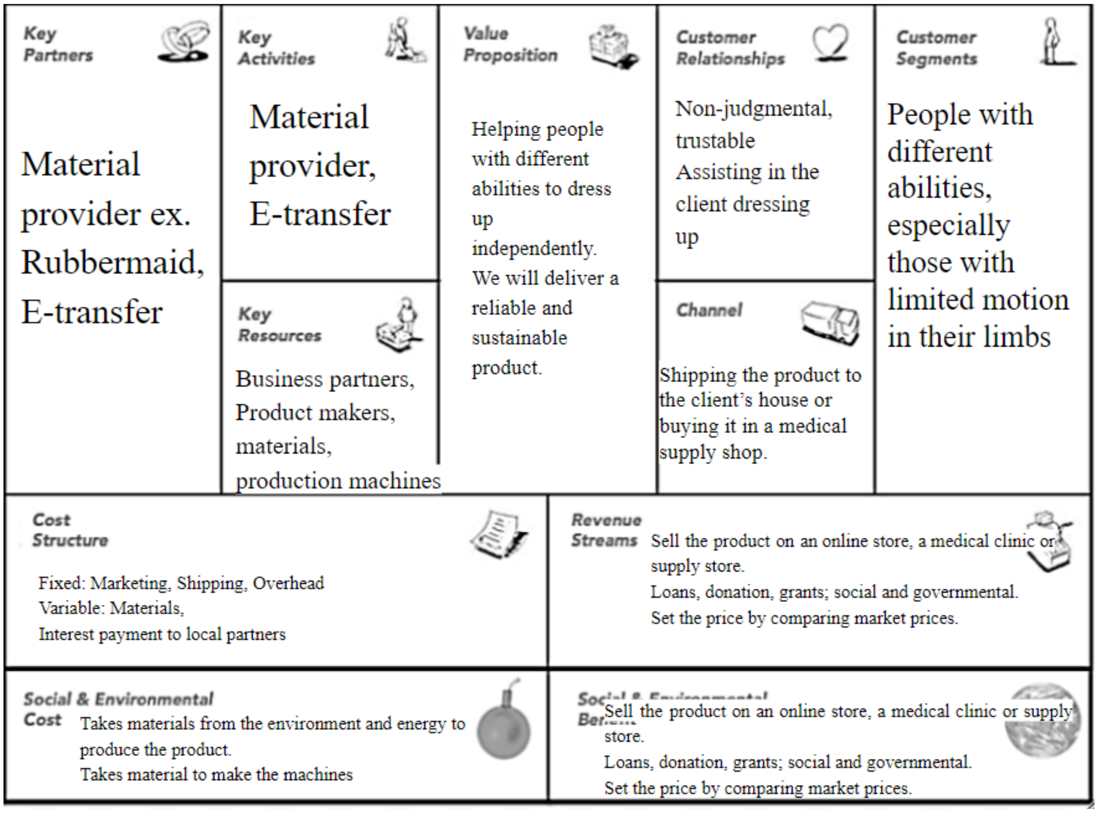
1.1 Business model and sustainability report

Table 1: Triple Bottom Line

1. Identify and describe your value proposition that would be well suited to commercializing your team's product. Discuss the reasons for your choice.

Our focus for the commercialization of our product would be to target people with disabilities, especially people with conditions that affect their limbs. This product will help these people to dress up easily and independently. This proposition will explain that this is the first automated product that is fully accessible for people who have limited force and mobility with their limbs. The product is very reliable and customizable so the users can modify it how they like.

2. Fill in a triple bottom line business model canvas by answering the how, what, who and how much of your chosen business model.



Key Partners

Material provider ex. Rubbermaid, E-transfer

Key Activities

Material provider, E-transfer

Key Resources

Business partners, Product makers, materials, production machines

Value Proposition

Helping people with different abilities to dress up independently. We will deliver a reliable and sustainable product.

Customer Relationships

Non-judgmental, trustable
Assisting in the client dressing up

Channel

Shipping the product to the client's house or buying it in a medical supply shop.

Customer Segments

People with different abilities, especially those with limited motion in their limbs

Cost Structure

Fixed: Marketing, Shipping, Overhead
Variable: Materials,
Interest payment to local partners

Revenue Streams

Sell the product on an online store, a medical clinic or supply store.
Loans, donation, grants; social and governmental.
Set the price by comparing market prices.

Social & Environmental Cost

Takes materials from the environment and energy to produce the product.
Takes material to make the machines

Soc

Be

Sell the product on an online store, a medical clinic or supply store.
Loans, donation, grants; social and governmental.
Set the price by comparing market prices.

3. Describe the core assumptions that you have made in developing your business model canvas and comment on its feasibility. Important: These core assumptions should be based on the business model you have chosen and not on your prototype (e.g. what type of clients do you assume your product will attract?).

The most important part of this business canvas is to concentrate the effort on the main customers. This product will not help most people but will drastically help those in the most need. Most of our marketing aspects will go to target this type of client to get the most value out of our marketing investments. Another big part that came into play in this business canvas is the partnerships that we need to maximize our sales. We would need to find partners for the manufacturing of the products

4. Provide a sustainability report that reflects on at least two of your product's major social, environmental, and economic impacts, both positive and negative. Perform a simple analysis of

these impacts and use this analysis to help you fill in the triple bottom line of your business model canvas.

Social Impacts:

Positive: The dressing tree is assisting in a positive social change. It grants individuals with diverse abilities independence, aiding them to dress themselves easily. This will boost their self-esteem and reduce their reliance on nurses and family. Also, it eases the burden on nurses, parents, and guardians who previously dedicated extensive time to assisting the patient with these tasks. This will give these people more time in their day.

Negative: For individuals with different abilities, the utilization of this new product might initially pose challenges, creating frustration and a sense of dependence on others to teach them. Caregivers and family must invest time and effort into training and assisting with the dressing tree's operation, potentially offsetting some of the time-saving benefits.

Environmental Impacts:

Positive: The dressing will be made of many compartments and materials. It is crucial that the elements of the product are sourced from environmentally friendly resources. For instance, using recycled plastic, reclaimed wood, bamboo, etc. The use of sustainable materials will preserve habitats and natural resources that are vital for the health and quality of life of all individuals. Additionally, when demonstrating positive awareness of the environment, the product will be able to grant aspiration for a better environment.

Negative: The manufacturing process for these machines consumes valuable resources and energy. From raw materials used to create the assembly machines to the production of the dressing trees themselves, there's an ecological footprint associated with their fabrication. The extraction of raw materials, such as metals and plastics, can lead to habitat disruption and resource depletion. Additionally, the energy-intensive manufacturing process contributes to greenhouse gas emissions. These environmental impacts raise concerns about sustainability and the long-term consequences for our planet.

Economic Impact:

Positive: Different dressing trees will have different types of hooks, materials and operations. Depending on the individual, the tree will cater to their needs. Therefore, clients or users can express their personal needs and budgets to generate an ideal dressing tree for them.

Furthermore, a dressing tree will help individuals with different abilities to dress without aid, thus reducing the need for a constant presence of caregivers, which will ultimately conserve money.

Negative: Families and healthcare facilities may face increased expenses when purchasing these specialized devices. The cost of acquiring dressing trees, along with potential maintenance and training expenses, can strain budgets. Families without insurance or medical coverage may have difficulties purchasing this product and maintaining it.

1.2 Design for X

- **Design for: safety** - Since the client will be relying on the dressing tree for day-to-day things, the product will have to be stable, anchored and well-constructed.
- **Design for: quality** - It is vital for the product to be made of the highest quality to be able to serve the user for many years.
- **Design for: maintainability** – In the case of any damage occurring, the client's family members should be able to easily repair any impairments.
- **Design for: simplicity** – With our limited budget and limited time it will be important to design a dressing tree which isn't too complicated to manufacture or assemble.
- **Design for: reliability** – The client wants his daughter to be able to use the Dressing Tree multiple times a day for a long time and keep it functional with minimal need to repair, therefore, we will design a dressing tree which is reliable and allows her expanded autonomy.

2 Problem Definition, Concept Development, and Project Plan

2.1 Problem definition

Problem statement: A need exists for a Dressing Tree product that allows those with multiplex arthrogryposis to get dressed independently and safely.

Table 2 : The Client's needs and problems

Need #	Interpreted Need	Design Criteria	Importance (Scale of 1-5, 5 being Most Important)
1	The Dressing Tree is safe for use	Stability Durability Support	5
2	The dressing tree is modifiable	Adjustably	4
3	The Dressing Tree has stable handles	Stability Variety	5
4	The dressing tree can be used independently	Ease of use Catered to fine motor skills	3
6	The Dressing Tree fits with what she likes	Aesthetics	1
7	The dressing Tree is the ideal size	Floorspace Product Height	4
8	The Dressing Tree is affordable	Cost	3

Table 3 : Metrics

Metric #	Need #	Metric	Importance	Unit
1	2	Product Height	4	m
2	4	Time Taken to Get Dressed	3	min

3	6,7	Floorspace	3	m^2
4	1, 3,	Product Weight	3	kg
5	6	Aesthetics	1	N/A
6	3	Size of the Handles	4	m
7	3	Maximum Force Handles Can Support	5	N
8	1	Tension of Electricity for Motor for Height Adjustment	4	V
9	1, 2, 7	Speed of height adjustment	2	m/s
10	2	Max Height for adjustment	2	m
11	8	Cost	3	$

Table 4: Benchmarking

Dressing tree Specification	Rubbermaid 1784455 Fasttrack Compact Hanging Hook	Rubbermaid 5E11 Fasttrack Multi-Purpose Hook	ALITARE Garage Power Tool Hook	Amazon Basics Wall-Mounted Farmhouse Coat Rack, 5 Hooks, Espresso
Safety	25 pounds max	50 pounds max	50 pounds max	5 pounds max
Cost	$12.60	$26.60	$22.98/2 hooks	$31.31
Modifiability	You can remove the rubber, soft grip, can move the hook	You can move it		
Size/Weight	7.78 x 21.27 x 7.78 cm (about 3.06 in); 0.28 Grams	26.4 x 7.9 x 18.8 Centimeters 399 Grams	24.89 x 16.51 x 15.39 cm (about 6.06 in); 689 Grams	57.4 x 7.1 x 11.7 Centimeters 562 Grams
Material	Aluminum	Aluminum/Rubber	Polyvinyl Chloride	Espresso Wood

Table 5: Target specification

Metric #	Metric	Unit	Marginal Value	Ideal Value	Reasoning
Functional Requirements					
5	Size of Handles (lengths and diameter)	cm	Length: <10 Diameter: <3	Length: 8 Diameter: 2	Cannot be too small, for easy use
7	Force of Handles	N	~800	801	She doesn't fall
8	Voltage of Electricity for Motor	V	10 Nm (torque)		Needs to be safe to plug in a wall for constant use
9	Speed of Adjustment	m/s	~0.1	0.1	Should not be too fast
10	Max Height of Adjustment	m	~4 ft	1 ft to 5ft	Needs to fit in a room
Constraints					
3	Floorspace	m^2	<1	1	Cannot take up too much space
1	Product Height	m	>1.3	2.5	Must be tall enough for her as she grows
4	Product Weight	kg	>22	80	Needs to be stable considering her weight (including growth), Portability comes after safety.
2	Time	s	>10	15	Efficiency and ease of use are important, but does not want to be so fast that injuries occur

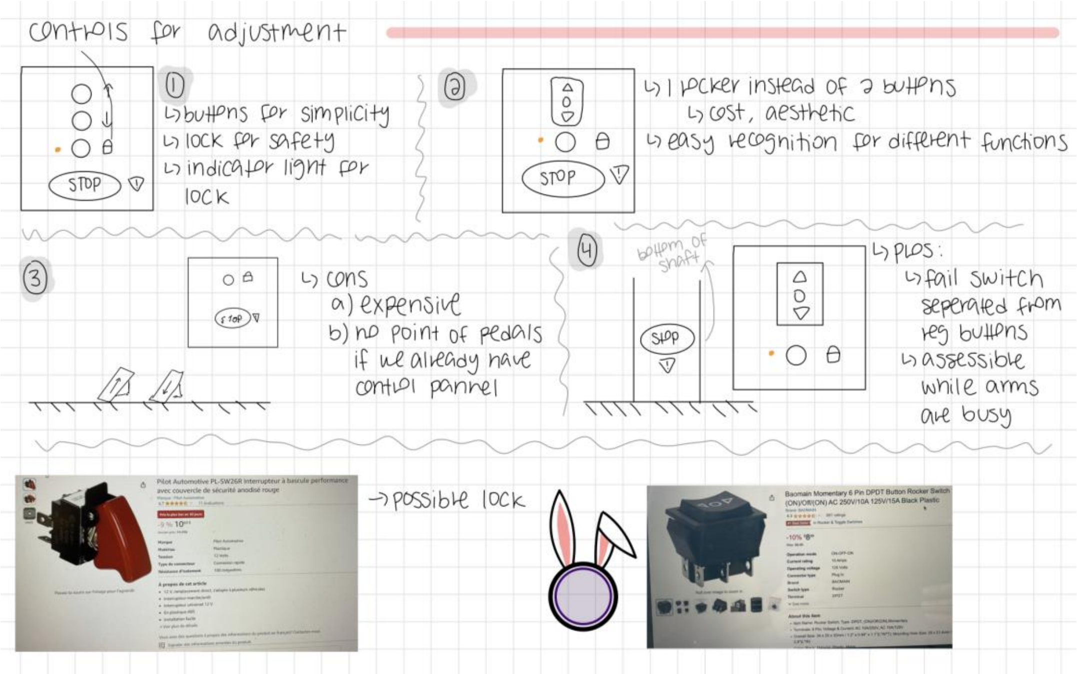
11	Cost	$	<150	125	Client would pay around $150.00 CAD
Non-Functional Requirements					
5	Aesthetics	Yes	N/A	N/A	Fit in her room and with her personal style

2.2

Concept development

1. Based on your problem statement, develop final prototype concepts for each subsystem, as well as the entire assembled system required to solve the problem.

Controls for adjustment:



controls for adjustment

①
- ↳ buttons for simplicity
- ↳ lock for safety
- ↳ indicator light for lock

②
- ↳ 1 rocker instead of 2 buttons
  - ↳ cost, aesthetic
- ↳ easy recognition for different functions

③
- ↳ cons
  - a) expensive
  - b) no point of pedals if we already have control pannel

④
- ↳ pros:
  - ↳ fail switch seperated from reg buttons
  - ↳ assessible while arms are busy

Pilot Automotive PL-SW26R Interrupteur à bascule performance avec couvercle de sécurité anodisé rouge

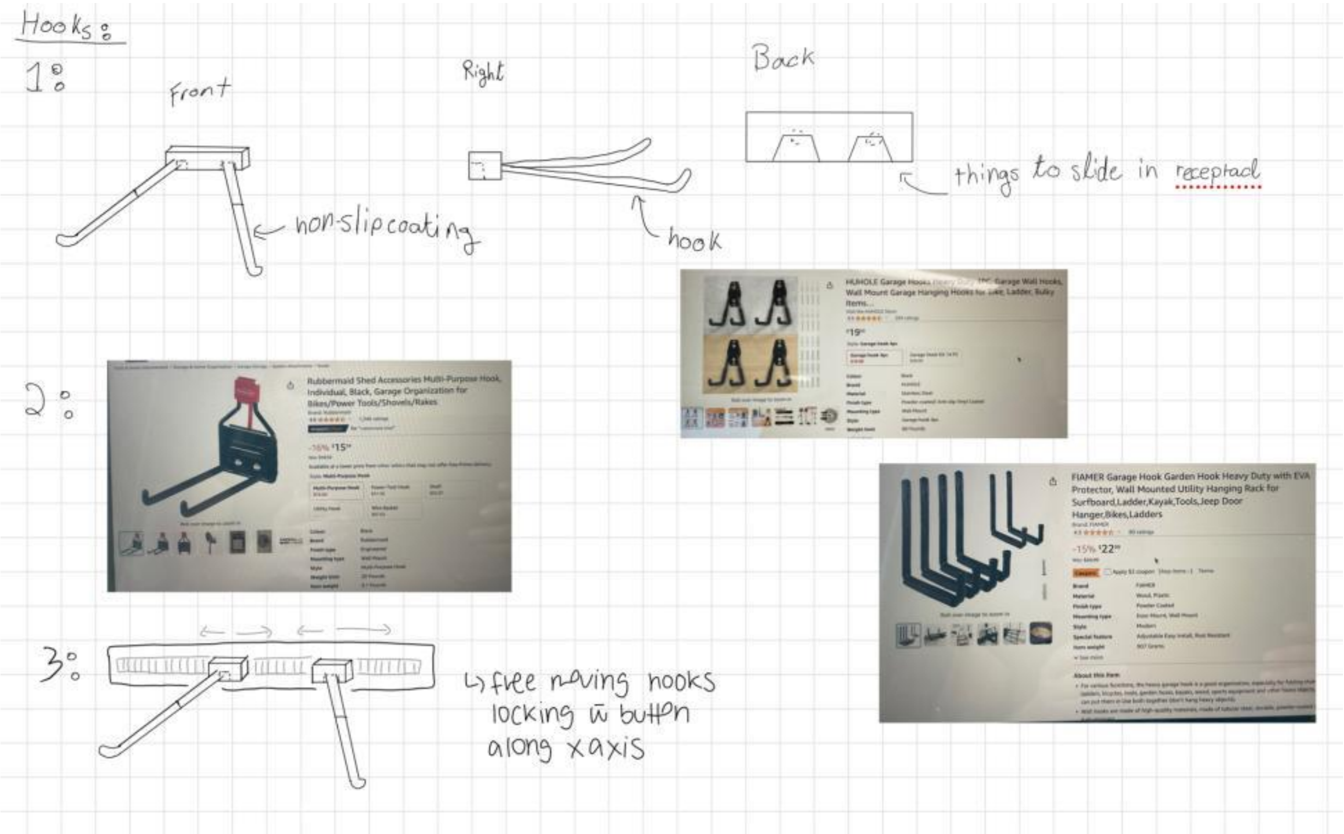
-9 % 10

→ possible lock

Baomain Momentary 6 Pin DPDT Button Rocker Switch (ON)/Off/(ON) AC 250V/10A 125V/15A Black Plastic

-10% 8

Hooks:



Rubbermaid Shed Accessories Multi-Purpose Hook, Individual, Black, Garage Organization for Bikes/Power Tools/Shovels/Rakes

-16% $15

HUHOLE Garage Hooks Heavy Duty 4PC Garage Wall Hooks, Wall Mount Garage Hanging Hooks for Bike, Ladder, Bulky Items...

$19

FIAMER Garage Hook Garden Hook Heavy Duty with EVA Protector, Wall Mounted Utility Hanging Rack for Surfboard,Ladder,Kayak,Tools,Jeep Door Hanger,Bikes,Ladders

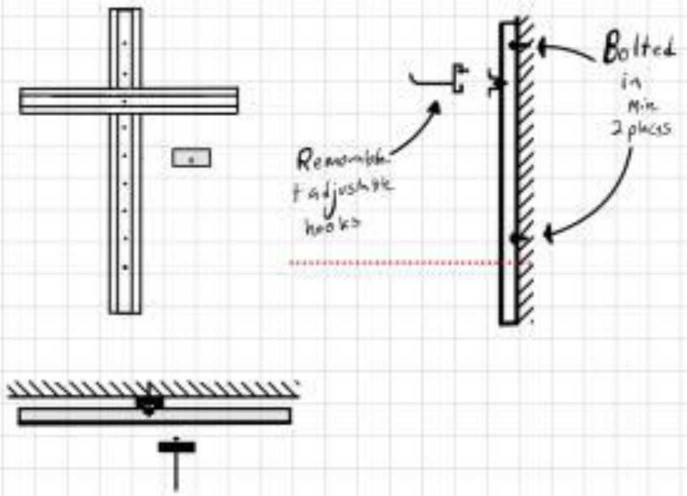
-15% $22

Structures:

STRUCTURES

structures

1. Vertical track bolted to wall with moving horizontal track with gearbox.



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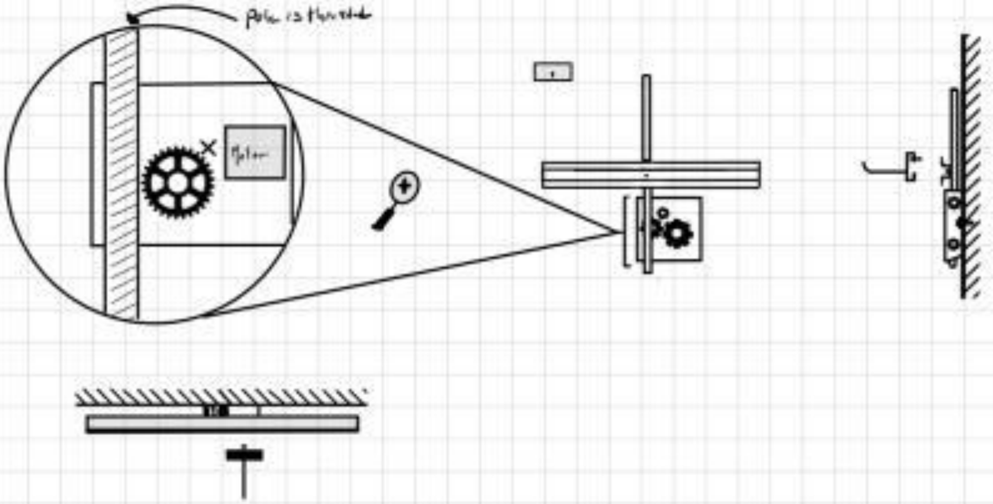
2 Gear box attached to a wall, with moving tree



2. Analyze and evaluate all concepts against the target specifications you defined. Use simple calculations and/or simulations to make decisions. Justify the process and methods used for analysis and evaluation.

Table 6: Control Options

Control Options					
Criteria	Weight	Control 1	Control 2	Control 3	Control 4
Ease of Use	0.25	8	7	7	7
Aesthetic	0.15	8	7	8	7
User Safety	0.45	7	7	7	9
Cost	0.15	7	7	5	7
Final Score		7.4	7.0	6.85	7.9

Questions for evaluation:

Ease of Use

- How user-friendly is the control method?
- Can the client quickly learn and use it effectively?

Aesthetic

- Does it match the client's aesthetic preferences?

User Safety

- How safe is the control method?
- Does it minimize the risk of accidents or injuries?

Cost

- Does the cost justify the performance and safety of the design?
- Does it fit in the design budget?

Table 7: Hook Options

Hook Options				
Criteria	Weight	Hook 1	Hook 2	Hook 3
Durability and Material	0.1	7	6	6
Load Capacity	0.2	8	5	7
Compatibility	0.2	8	6	8
Safety	0.4	8	6	7
Cost	0.1	7	8	6
Final Score		7.8	6.0	7.0

Questions for evaluation:

Durability and Material

- Is the material non-slip?
- Is it durable and resistant to wear and tear?
- Are hooks or coating replaceable?

Load Capacity

- What is the max weight of the hook and support?

Compatibility

- Is the size compatible with the user?
- Can it be customized or adjusted to meet specific requirements?
- Does it work well with the moving mechanism?

Safety

- Are there any guards for sharp edges?

Cost

- Does the cost fit within the budget?

Table 8: Structure Options

Structures Options			
Criteria	Weight	Structure 1	Structure 2
Safety	0.4	5	6
Cost	0.15	3	4
durability	0.3	5	7
Height/Weight	0.15	7	7
Final Score		5	6.15

Questions for evaluation:

Safety:

- How safe is the automated moving part?
- Does it minimize the risk of accidents or injuries?

Cost:

- Does the cost justify the performance and safety of the design?
- Does it fit in the design budget?

Durability:

- Will the product break after a couple of uses?
- Does this increase the quality of life of the user drastically?

Height/Weight:

- Does this design take up a lot of space?

- Does it weigh too much for the performance giving?

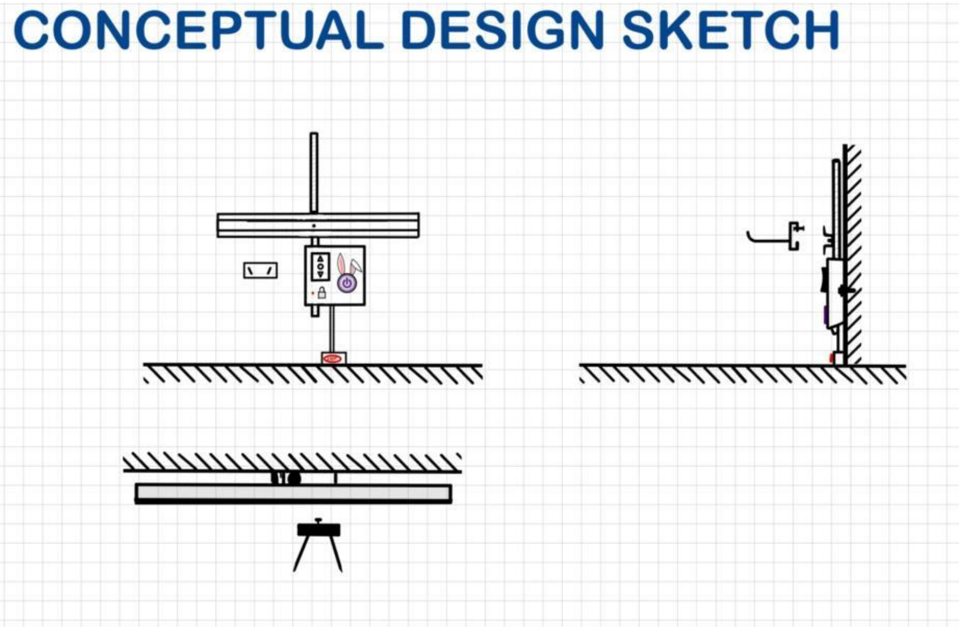
3. Choose one or a few promising solutions you wish to develop further based on your evaluation.

We would like to keep developing the idea of the electric elevation system. This system will be in place to make the hooks able to move upwards and downwards using a switch and buttons. This would make it easier for the user to take the clothes on and off since we are using an automatic tool instead of making the user move up and down themselves. We will see if it is possible to use this tool or if it is over-complicated in the long run.

4. Develop a global design concept which is either an integration or modification of the promising concepts chosen in the previous step, or a brand-new concept created from these ideas. Justify your approach.

To justify the decisions of our concepts, we used a scoring system to determine the best options for each category. The highest option average was decided on every criterion that was crucial to the concept. With this system, we were able to find the best possible outcomes for each category.

5. Visually represent (sketch, diagram, CAD model, etc.) your global concept.



6. Provide a few lines explaining your concept’s relationship to the target specifications, as well as its benefits and drawbacks.

For our global design concept, we will take the option with the best score for every aspect. For the control's adjustments, we decided to go with our 4th concept. This option proves to be the safest with the stop button on the bottom of the machine, which is easier to press in emergency cases. This option also uses the push button which allows too long press to bring the hooks up or down, while also having a lock button to lock the piece in that place. In general, this option is more accessible for the user than the other choices.

For the hooks, we decided to go with the first option. This option is based on the hooks being inserted diagonally on the horizontal plane. This option proved to be the most durable with the materials used, it will be able to carry more load and it is safer for the user.

For the structure of the product, we will take the second option. This option is going to use a gear box and a vertical track which is going to be attached to the wall. The gear is going to be attached to the dressing tree hooks which will allow the gear to go up the vertical track when the power signal from the button is activated. This design is safer and more durable than the other concept, while also providing more usability.

2.3 Project plan

https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=ZQ220noKILncwCovoDnxk2rr6AImfEKT%7CIE2DSNZVHA2DELSTGIYA

3 Detailed Design and BOM

3.1 Detailed design

1. Summarize the client feedback that you received during your second client meeting and clearly state what needs to be changed or improved in your design.

For our client meeting we took the approach of presenting multiple ideas from our 4 different subsystems; controls for adjustment, hooks and attachments, reset button and structures. We ran over our thought process and took the client through the changes that we made from idea to idea. After briefly going over the pros and cons for each idea in each respective subsystem, we asked the client specific questions after he had seen the entire presentation and all our ideas.

As per controls for adjustment, the client liked the 4th idea as it was the only one that specified that the dressing tree would go all the way down to the floor. He then explained that while the fail stop button on the floor would be easier for her to use and is a smart idea in terms of safety, it could be more of an afterthought and the floor length would allow for her to be able to put on socks. He responded positively to the rocker rather than the buttons and liked the idea of the indicator light for the lock mechanism. For the lock mechanism, the client suggested that a switch may be easier for the user to maneuver rather than a button. The client gave their opinions regarding the control panel and suggested that a wired controller would potentially be easier for the user to use as they grow and would cater more to the user's strong fine motor skills. After reviewing with the team and our project manager, we determined that we bit off more than we could chew with our limited budget, time and skills and no matter how many safety factors we included, there was a risk of failure resulting from the motor and outside sources. We decided to scrap the idea of motorized adjustment and possibly come back to using motors within the scope of our abilities once we have a solid foundation and idea. We will keep the idea of an indicator light in mind for locking as well as a fail stop button (to alert family if the user is in distress) and revisit it after the 1st prototype.

For hooks and attachments, he liked the way we stuck to what she already knew with the hooks that they have in their house and changed it by allowing for horizontal motion. The client also made clear that he wanted to have variations of hooks for socks and hats. We decided to circle back to the idea of hats and socks as potential subsystems for prototype 2 in order to build a solid foundation for prototype 1. For prototype 1 specifically, we will stick with the hooks we emphasized in the meeting as it is like what they already have and run with the idea of movement along the horizontal axis.

In terms of structure, the client didn’t have too many suggestions or comments, just that he liked that we kept it simple with the vertical and horizontal axis. We brought up a rough design that utilized the corner of her room to provide a different view of what the dressing tree could be to gauge the client's opinion and work from there. While the client thought that a cautious and calculated structural design using the corner provided strength and stability, they worried about the usability of the dressing tree given it would be less open. From that, we drew the conclusion that using a flat wall would be more versatile.

The last subsystem we had to present was our idea of a reset button. Since the user is a 7-year-old girl, we did not want to overload her with all this new adjustability and mechanisms. Since the user has their hooks mounted to the wall at a distinct height, we brought up the idea of taking that position of the hooks into account with a reset button that would set the hooks back to where the user is used to them being. This allows for the girl to get used to the dressing tree slowly and caters to the specific user by promoting comfortability with the product.

2. Develop an updated and detailed design of your concept, based on your client meeting, which includes:

a. For physical prototypes: Visual representations of the overall concept, as well as each subsystem. Clearly define how each subsystem is linked to other subsystems (including fasteners and electrical wires).

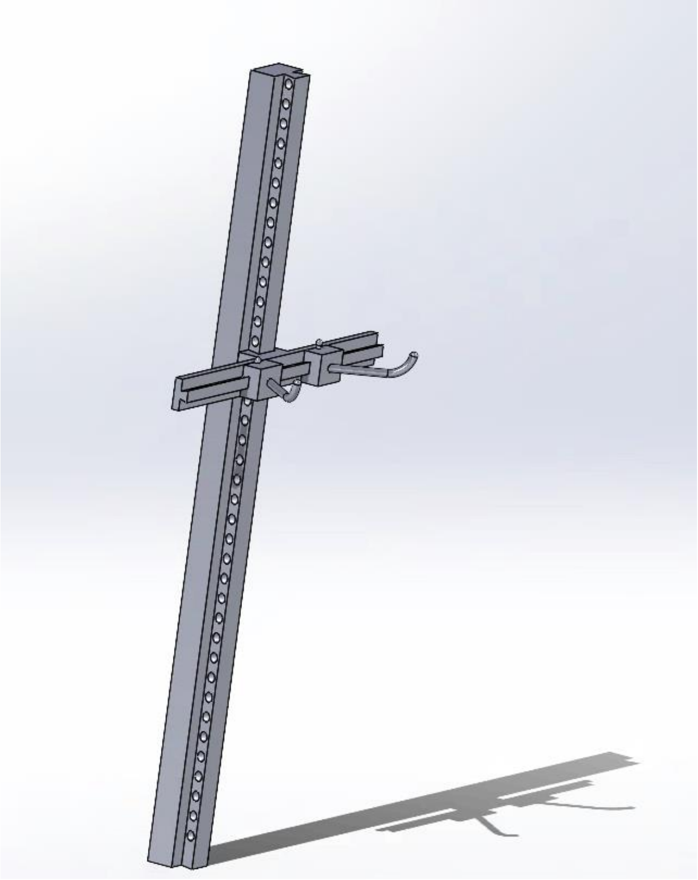


Figure 1: full prototype

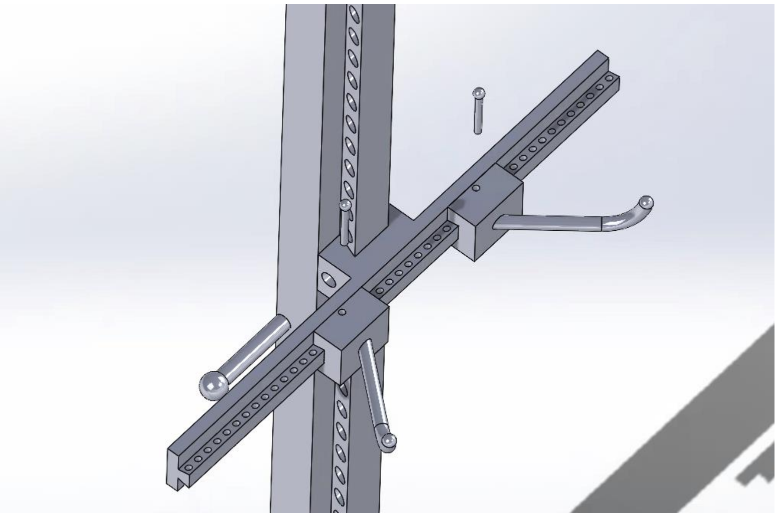


Figure 2: top view of hooks on rails with pins

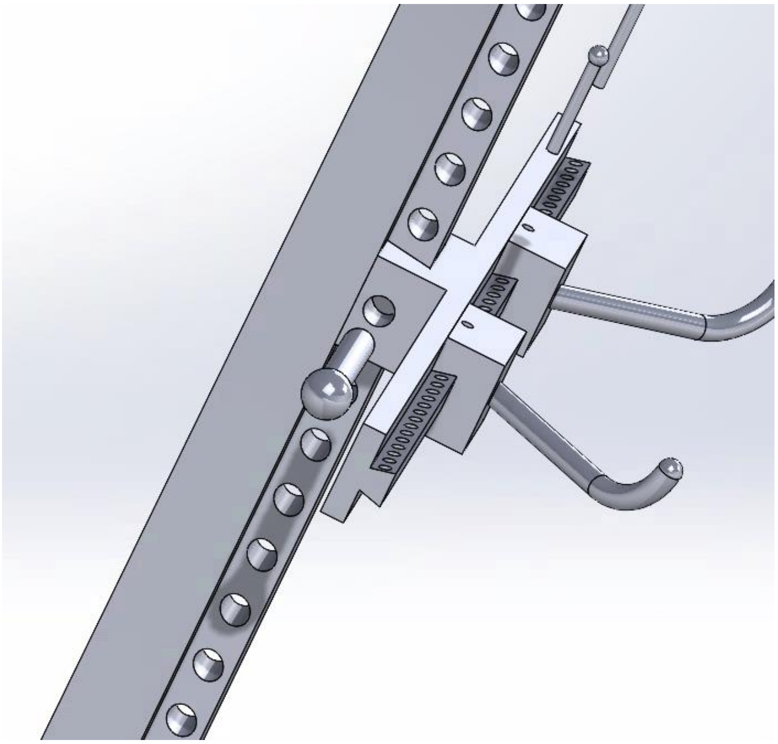


Figure 3: side view of pins for vertical rail

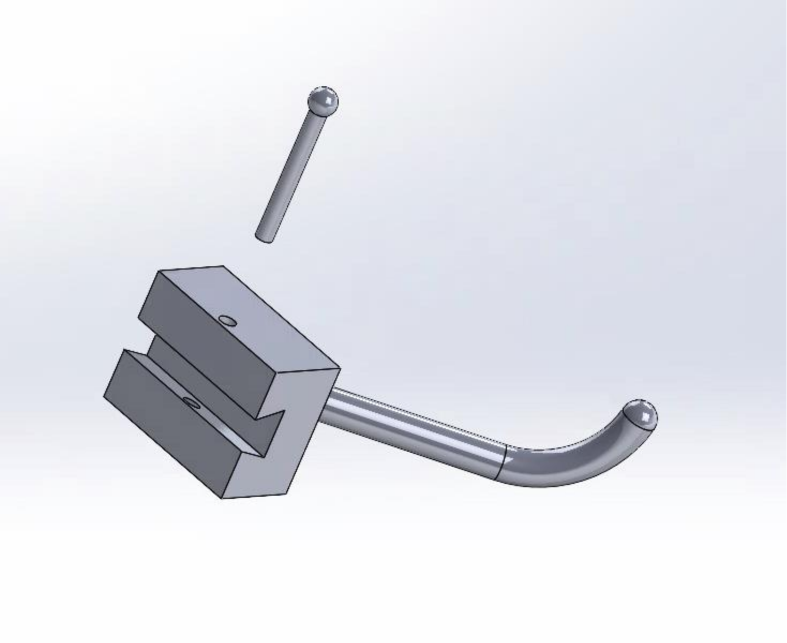


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Figure 4: individual hook and pin

b. For software prototypes: User interface and flow chart diagrams of the overall concept, as well as each subfunction. Clearly define how each subfunction is linked to other subfunctions.

User interface

The user interface consists of a basic control panel consisting of:

Up button – Raises the dressing tree when pressed

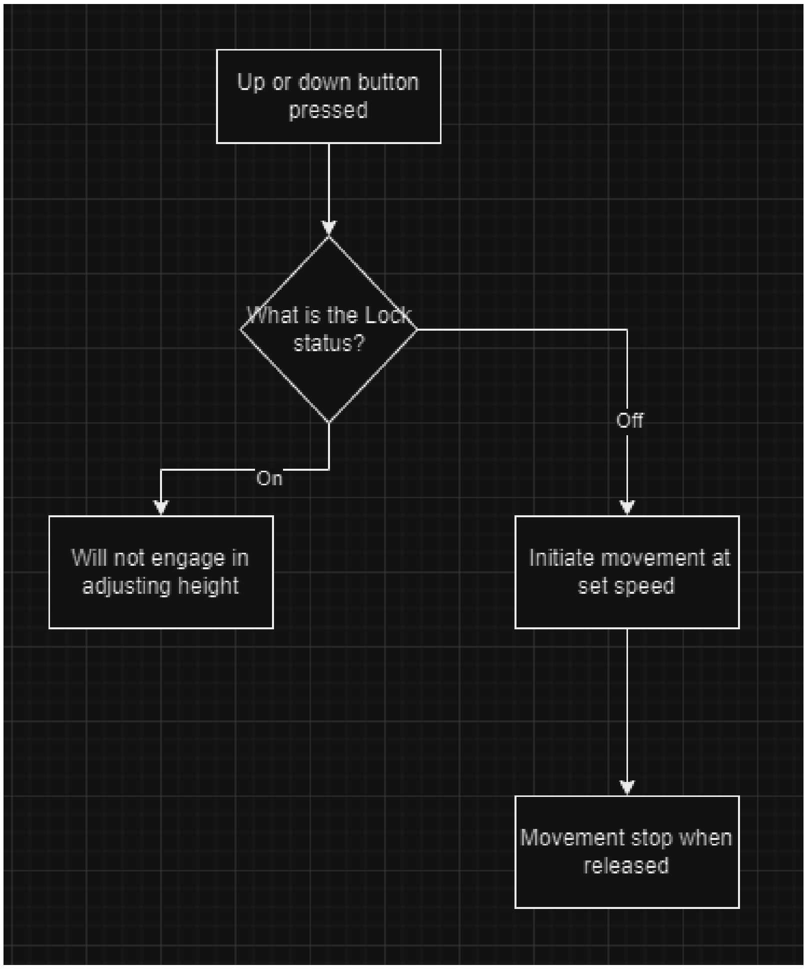
Down button – Lowers the dressing tree when pressed

Reset button – Resets height to set preference when pressed

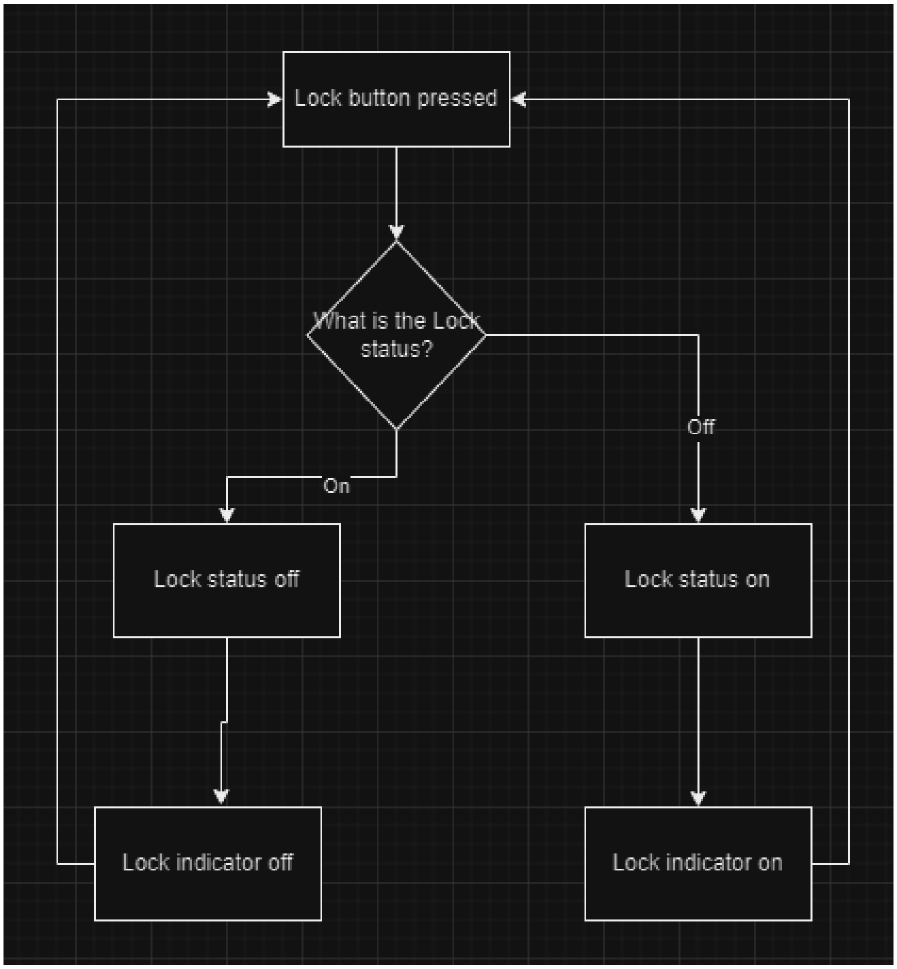
Lock indicator- Shows whether the moving functionality is locked

Subfunction

Height Adjustment – Engage in lock subfunction to verify and controls adjustment speed


Up or down button pressed
What is the Lock status?
Off
On
Will not engage in adjusting height
Initiate movement at set speed
Movement stop when released

Lock – Changes the lock/unlocking indicator and provide lock status to height adjustment subfunction


Lock button pressed
What is the Lock status?
Off
On
Lock status off
Lock status on
Lock indicator off
Lock indicator on

c. See

https://en.wiki.makerepo.com/wiki/Professional_development/Design_thinking/Detailed_designs.

d. Make sure that the level of detail in your design is high enough that you could give your design documents to an external person so that they could fabricate / assemble / program your design with minimal input from your group! Leverage your TA and PM extensively for guidance on this.

3. Provide a detailed list of skills and resources you have at your disposal that will enable you to create your design. If there are skills or resources missing to complete your design, describe how you will obtain them.

Table 9: List of skills and resources

Skills possessed	Skills we need	Resources Possessed	Resources Needed
Lathe Mill Drill press Welding	Decision making Communication Focus	Building machines Material supplier Breadboards	Materials to build Extra tools and machines Ceed makerspace

Code; Arduino SolidWorks/CAD Matlab			

Skills missing:

Decision making: Using a system of voting with group members for our decisions

Communication: Work on effectively communicating with one another and answering questions promptly.

Focus: Focus more on the deliverables and prototypes during the team meetings. We should also separate the tasks more evenly so that we can all work on our individual tasks when we are not in a group. Hold people accountable when they do not complete their part!

Resources missing:

Materials missing: Currently, we do not have all the materials we need to build the prototypes and the final product. We can buy the materials at a provider store like Home Depot or any hardware store. We can also buy materials at the CEED store if we ever need some extra last-minute matter.

Tools/Machines missing: Currently we are not missing tools/machines. We may need a specific machine in the future, but we will use our resources, for example, asking our TA, to locate the missing machines. We can buy missing tools or bring them from home if they are not at the CEED Warehouse.

4. Provide a realistic assessment of the time required to implement your design and the actual time your group and its individual members have at their disposal.

Table 10: Realistic assessment of time

Test ID	Objective	Porotype used	How will the results be used	Start date and duration
1	To communicate the idea of the product in a 3D model. To assure the group members and the client agree on the concept.	Using software like SolidWorks to create a low fidelity prototype.	The results gathered will allow the group to make necessary modifications or improvements regarding meeting the client's needs.	Start: Oct 5th. Duration: Oct 5th – Oct 8th.
2	Demonstrate the dressing tree concept in a low fidelity prototype. The group will focus on locking mechanisms on the hooks.	Using 3D printing, the group will build a low fidelity porotype. The group will be able to display the design concept as well as the locking mechanism.	The prototype will allow the group to determine if the locking mechanics will be safe to use, and if they need any modifications.	Start: Oct 8th. Duration: Oct 8th – Oct 15th.
3	This prototype will focus on adding a subsystem that will allow the user to slip into socks independently and easily. The group will also explore different types of possible hooks.	A medium fidelity prototype that will test whether the subsystem of socks would function in correspondence with the rest of the dressing tree. Additionally, the group will contemplate different hooks if needed.	The results will be used to decide if the sock subsystems will remain in the concepts. Also, the exploration of different hooks will allow the group to determine whether different hooks will be used.	Start: Oct 22 Duration: Oct 22nd to Oct
4	The group will design a high-fidelity prototype. This prototype will encompass all concepts and	A high-fidelity protype that will test the entire dressing tree's function.	The results will be used to determine whether dressing tree functions in accordance with the user and client needs. The results will also be used to present the	Start: Nov 16th Duration: Nov 16th - Nov 29th

	subsystems within the design.		prototype to the client and user.	

5. Define any other critical product assumptions that could affect your ability to implement your design. For example: the acceptable values for a specification, availability of material/component, or critical functionality.

To build this project, our team will have to find certain assumptions that can change the course of action for the construction of the prototypes and final product. One critical assumption for our product's development is the availability of the raw materials and components with the quantities required to build the result. In this case, we are planning to build one of our prototypes with plastic from 3D printing. If we no longer have access to this material, we will have to find a new material to build these prototypes with. In addition, it is possible that our materials in mind for the final product will not be available at that time. If this ever happens, we will have to act quickly to find new and affordable materials to build the product in time. It may also be possible that during the construction of our designs, we may find that the values for the materials and metrics implemented in the past deliverables may not be exact. In the event of this happening, we will have to re-evaluate the marginal values accepted for these components. These assumptions are crucial, especially when the product's design and manufacturing processes rely on these specific assumptions. Unforeseen material shortages or disruptions in the supply chain can significantly impact production and the overall success of the product.

6. Provide a detailed preliminary bill of materials and parts (BOM) for your final prototype, which will be presented to your project managers for approval and purchase. Include web links for each item in your BOM (including $0 items). You will be given up to $50 or $100 (depending on your project) for the development of your final prototype only. Before making any purchases, you must review the following guide: https://en.wiki.makerepo.com/wiki/Professional_development/Project_management/Purchasing_Guide. Tips and tricks for designing and fabricating your prototypes are provided here: https://en.wiki.makerepo.com/wiki/Professional_development/Design_thinking/Design_for_manufacturing. In lecture 10 or 11, your group will meet with your PM/TA/Prof, and you will present your detailed design and BOM to get feedback about the quality of your design and its feasibility, this is called a design review. Please come prepared! Project Plan Update:

3.2 BOM

Item Name	Description	Quantity	Unit Cost	Extended cost
Wood	Used to bolt the dressing tree into the wall.	1	NA	NA
Hooks	To aid in getting dressed	3	$8.05	$26.57

Rubber Coating	To coat the hooks in rubber	1	$8.99	$10.17
Screws and bolts	To connect it to the wall and the hooks.	10>	NA	NA
Paint	To make the product aesthetically pleasing for the client	NA	NA	NA
Bunny stickers	To cater to the user's interest	NA	NA	NA
Steel Bar	For the lock mechanisms, as well as other parts of the product	1	$36.32	NA
Total Product Cost (Before Taxes)				$53.36
Total Product Cost (After Taxes)				$60.3

3.3 Project plan update

https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=kl3rLOJEfMDwLCleNE5DKVj8ItCZzLBJ%7CIE2DSNZVHA2DELSTGIYA

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

4.1 Prototype 1

Metric #	Metric	Unit	Marginal Value	Ideal Value	Reasoning	Prototype testing value
Functional Requirements						
5	Size of Handles (lengths and diameter)	cm	Length: <10 Diameter: <3	Length: 8 Diameter: 2	Cannot be too small, for easy use	Length: 3cm Diameter: 0.3cm
7	Force of Handles	N	~800	801	She doesn't fall	1
9	Speed of Adjustment	m/s	~0.1	0.1	Should not be too fast	0.1
10	Max Height of Adjustment	m	~4 ft	1 ft to 5ft	Needs to fit in a room	20.5
Constraints						
3	Floorspace	m^2	<1	1	Cannot take up too much space	26
1	Product Height	m	>1.3	2.5	Must be tall enough for her as she grows	20.5
4	Product Weight	kg	>22	80	Needs to be stable considering her weight (including growth), Portability	0.095

					comes after safety.	
2	Time	s	>10	15	Efficiency and ease of use are important, but does not want to be so fast that injuries occur	10
11	Cost	$	<150	125	Client would pay around $150.00 CAD	0
Non-Functional Requirements						
5	Aesthetics	Yes	N/A	N/A	Fit in her room and with her personal style	Blue and yellow

Product assumptions:

Size of Handles: Handles should be in the proper size to ensure ease of use

Force of Handles: Enough force to ensure stability and enforce safety

Speed of Adjustment: Moderate speed to ensure safety

Max Height of Adjustment: Should fit in specified height

Floorspace: Should not take up a lot of space

Product height: Tall enough for the client as she grows

Product weight: More than 80kg for stability

Time: Should be more than 15 seconds

Cost: Within $150 CAD

Aesthetics: Should fit room and user preferences

4.2 Project Progress Presentation

https://docs.google.com/presentation/d/190lb55f5SpDF4hQXyGWDXCWjlccs12z_4ElMvCs5Was/edit?usp=sharing

4.3 Project plan update

https://www.wrike.com/workspace.htm?acc=4975842#folder/1214086399/timeline3?spaceId=-1&viewId=202059672

5 Design Constraints and Prototype 2

5.1 Design constraints

1. Identify two non-functional design constraints that play an important role in the development of your prototypes. Justify your reasoning.

Bunny stickers; it is important for the user to feel excited to use their dressing tree. Therefore, implementing aspects the user admires will provide a feeling of eagerness.

Colours; The dressing tree is designed to cater a specific user's needs; thus, it should match their specific room aesthetic.

2. For each design constraint, explain in detail what changes would need to be made to your design to satisfy the constraint.

Design constraints for deliverable C:

Metric #	Metric	Unit	Marginal Value	Ideal Value	Reasoning
Constraints					
3	Floorspace	m^2	<1	1	Cannot take up too much space
1	Product Height	m	>1.3	2.5	Must be tall enough for her as she grows
4	Product Weight	kg	>22	80	Needs to be stable considering her weight (including growth), Portability comes after safety.

2	Time	s	>10	15	Efficiency and ease of use are important, but does not want to be so fast that injuries occur
11	Cost	$	<150	125	Client would pay around $150.00 CAD

Floorspace:

3 ft wide and around 1 foot and half

<1 meter^2

This satisfies the constraint

Product height:

4 ft tall (around 1.2m) for the al extrusion + extra heights.

This would satisfy the marginal values but not the ideal value.

We do not need the tree to be 2.5 m tall.

Product weight:

1.75 kg/m of Al extrusion

4 ft is around 1.2m and 3 ft is around 0.9144 m

1.75x(1.2 + 0.9144) = 3.7002 kg which is around 8.2 lbs

We have at least 3.7 kg of aluminium extrusion in the product.

We still need to add the hooks, pins, and other things to the product.

The values in our original product assumptions for the product weight are overvalued, this product should not weight over 15 kg.

Time:

We cannot test the dressing time for the user at this time.

We will be able to test it for prototype 3.

Cost:

This project should cost us around 100 $. This should not go over 150 $, as the client suggested he would pay for.

Aluminium extrusion:

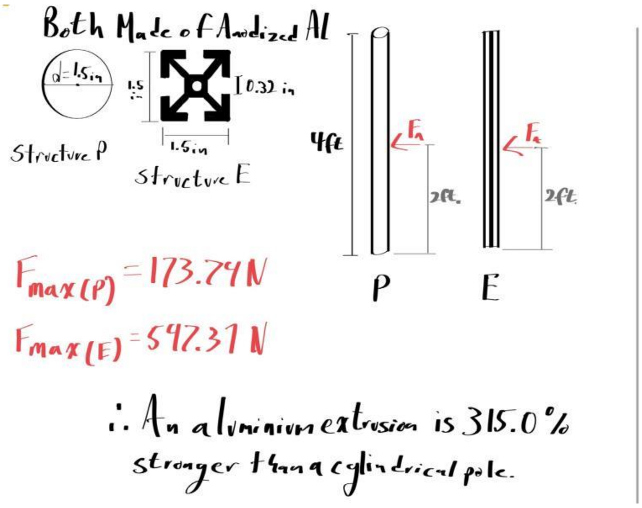
3ft: 20$ each

4ft: 30$ each

(From the McMaster-Carr store)

We are ordering two 4ft and one 3ft. This would cost us 80$.

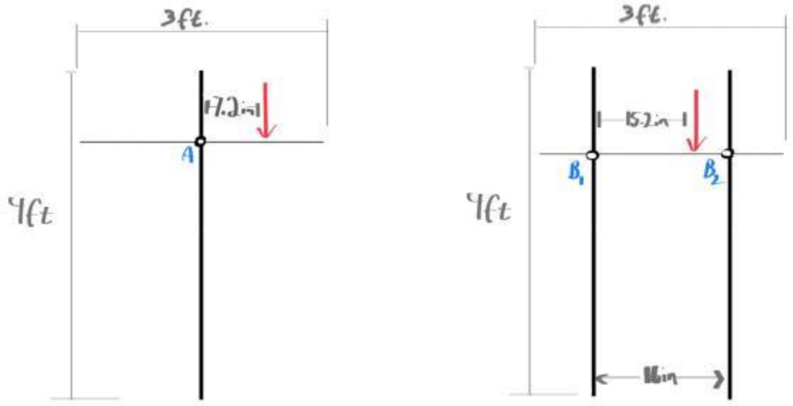
3. Provide proof (e.g. analysis, simple calculations and/or simulations, research) to demonstrate the effectiveness of your changes in satisfying the constraints. Justify the process and methods you used.



$F_{max(P)} = 173.74\,N$

$F_{max(E)} = 547.37\,N$

∴ An aluminium extrusion is 315.0% stronger than a cylindrical pole.



Based on the following assumptions (healthline.com)

→ Average shoulder width of a woman: 14.4in

→ Average mass of a woman: 170.8 lbs ≐ 77.47 kg

$$F_{weight} = 77.47(9.81)$$
$$= 760.02\,N$$

Having two vertical support beams eliminates a moment around joint A.

4. Update your detailed design accordingly.

SolidWorks assembly: prototype 2.zip

5.2 Prototype 2

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

We have not received any client feedback recently. However, after the presentations during the lab, we received feedback from both the TA and the Prof. The group was told that the structure of the dressing tree did not seem to be very stable. Therefore, the group has updated our design to be more reliable to adhere to clients' needs. Instead of a cross like structure, the group will be now testing a different structure that contains two vertical beams with a horizontal post that will connect them. Furthermore, the group needs to improve the manner in which the user will be able to move the hooks post, depending on the height needed.

2. Define the most critical product assumptions that you have not yet tested.

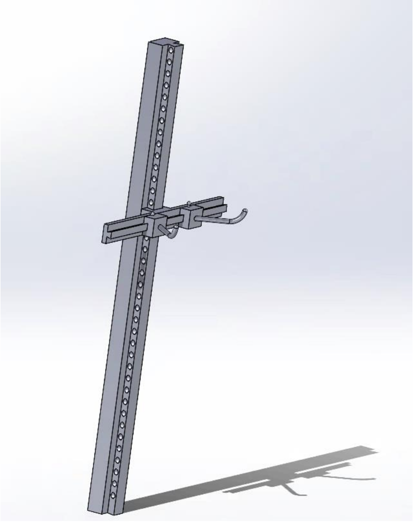
We have yet to test the security of the structure of the dressing tree. After receiving constructive feedback from the TA, the group decided to explore different possible structures. There was concern regarding the dressing tree not being stable, which can lead to injures and other unfortunate events. Thus, we have decided to redesign the structure of the product to assure it provides maximum security and stability. Since the client has highlighted that safety is a number priority for him, the team must be able to create a product that can endure a decent of weight and does not topple over. Therefore, the new design will feature two beams connected with a bar that will maintain the hooks, in contrast to a cross structure. This will provide more support to the dressing tree when the user is getting dressed and therefore will not budge. Through the second prototype, the new structure will be tested on its stability.

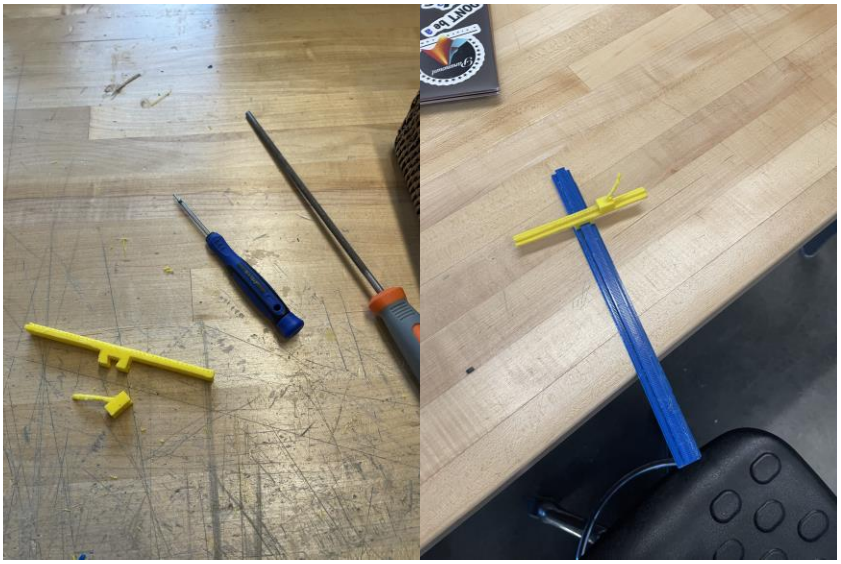
3. Develop a second set of prototypes that will help you on your way to creating your final prototype and test the critical product assumptions along the way.

Our previous prototypes were a SolidWorks model that was later 3D printed. These prototypes allowed the group to receive vital feedback that will be implemented into the next prototypes and final design. Additionally, the previous porotypes allowed the group to understand the dressing tree goal and the importance of making it as easy to use as possible. After 3D printing the porotype, it came to the group's attention that the cross structure lacked stability, therefore, the group was able to change the structure before being too committed to the previous cross like structure.

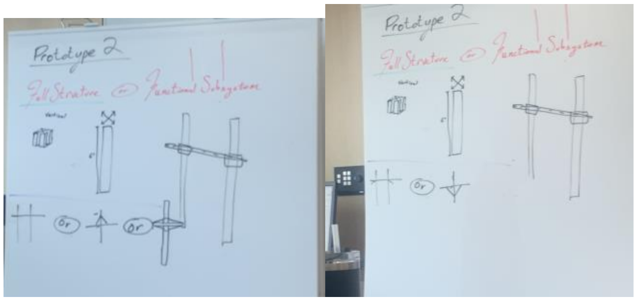
Our latest porotype is also a 3D printed object. After taking into consideration the feedback given, the group decided to implement a more stable structure. After going through several ideas; documented below, the group appointed on the first drawing. There was some hesitation because the other dressing tree group has a similar design, but the group is confident to make our structure possess a distinct aspect in the structure. This structure will be cheaper to create, more stable, and will be able to be mounted more securely.

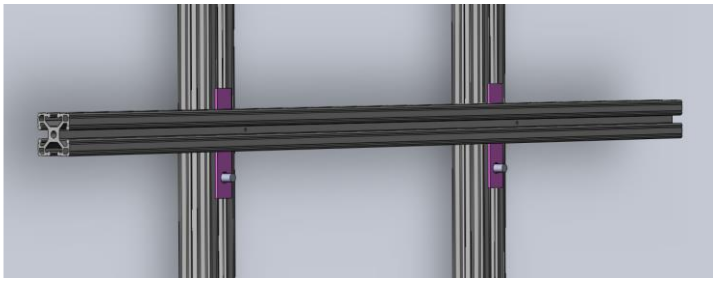
Previous Porotypes:

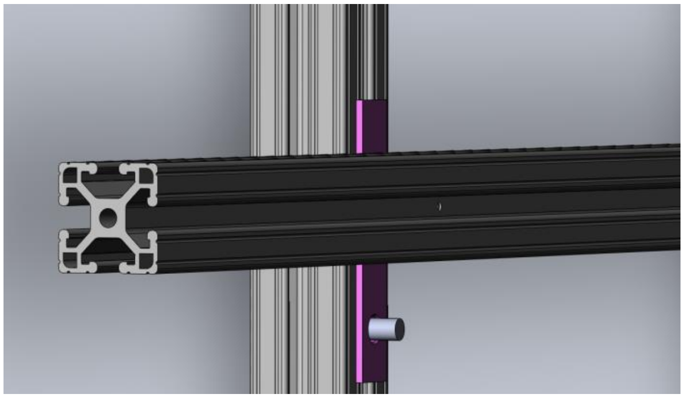


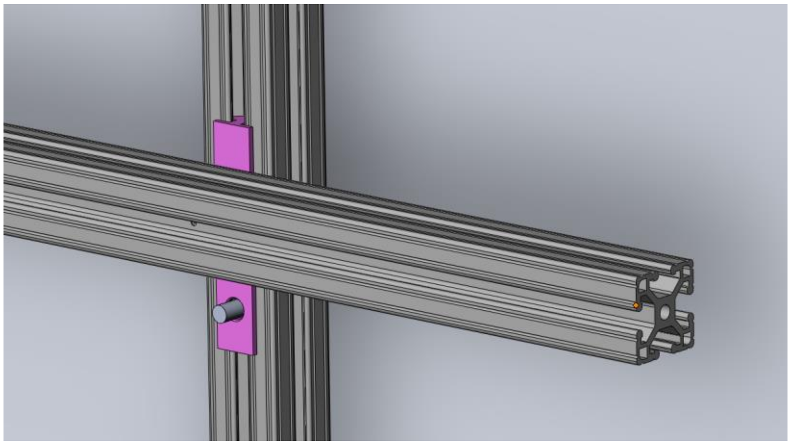


Prototype 2:


Prototype 2
Full Structure ⇐ Functional Subsystems
Vertical
Or
Or

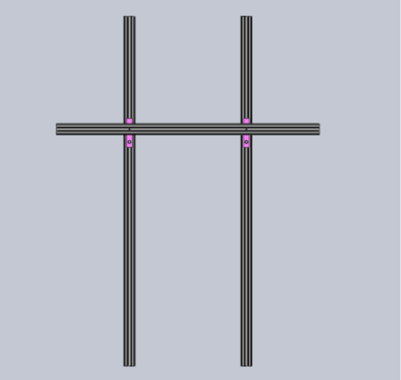




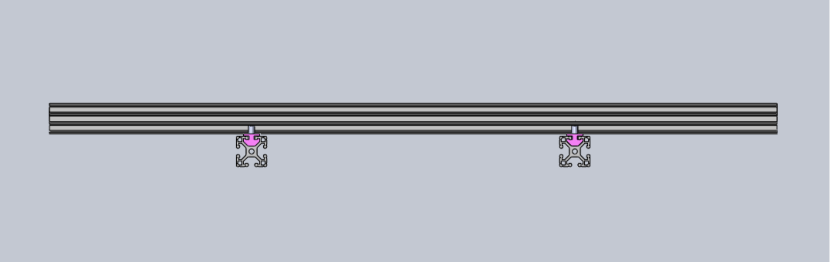


4. Document your latest prototype(s) using as many sketches/diagrams/pictures as required and explain the purpose and function of your prototype(s).

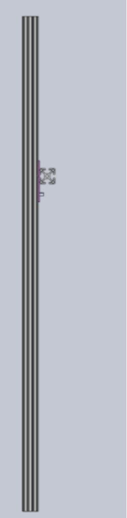
Front:



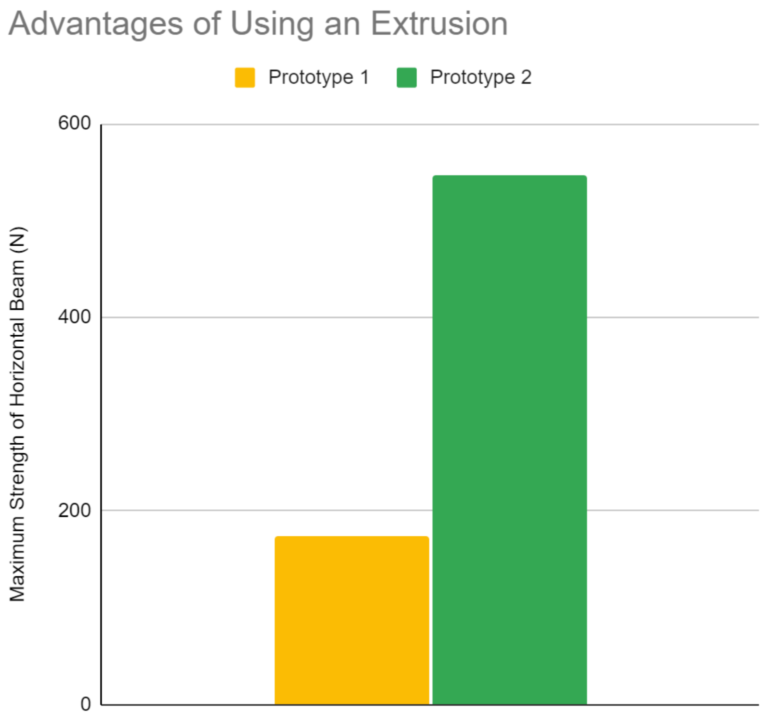
Top:



Sides:



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



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

During our next presentation, the group will present the structure that has been recently alerted to be the dressing tree. Here, we will gather feedback from the client regarding the improved dressing tree and implement it into the next and final protype. We will ask the client if he prefers the old model with only one aluminium extrusion in the middle compared to the new model with the two aluminium extrusions connected to the horizontal bar.

5.3 Project plan update

6 Other Considerations

6.1 Economics report

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

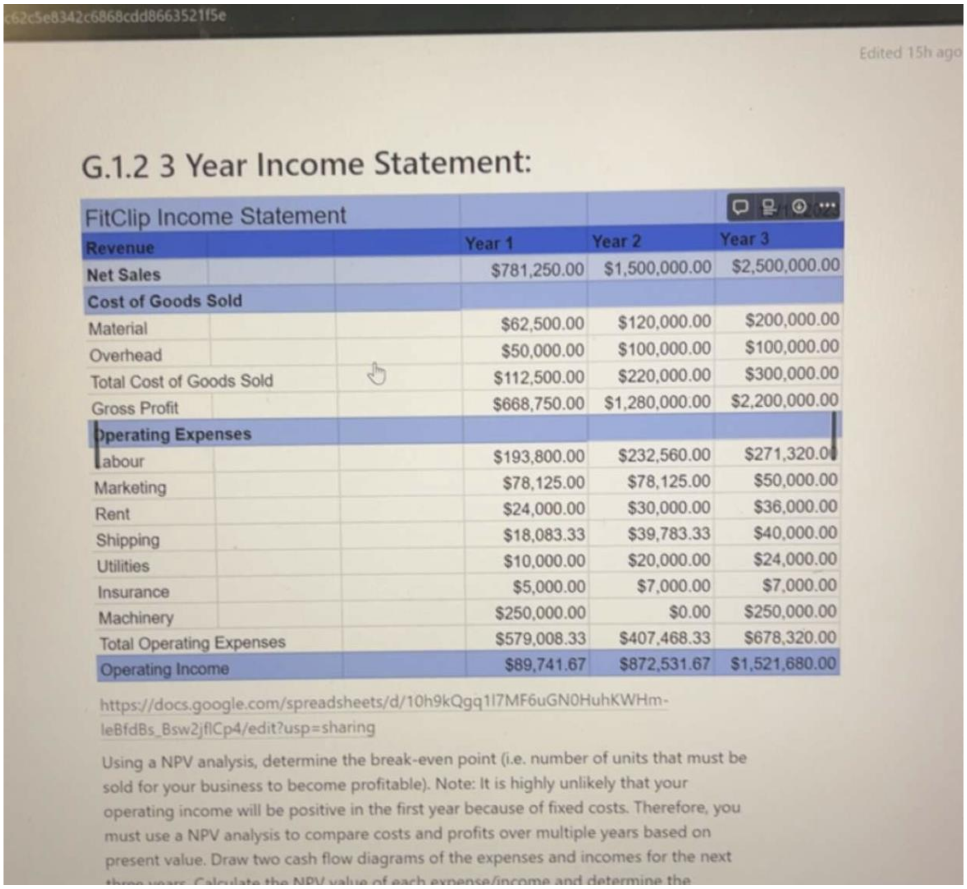
Variable: Material, labour, shipping, utilities for production

Fixed: Rent of machines, rent of facility, Loan

Material Cost: $118 per unit

Marketing Cost: rheumatologist offices; $100 for an ad on tv.

Shipping Cost: $50/unit



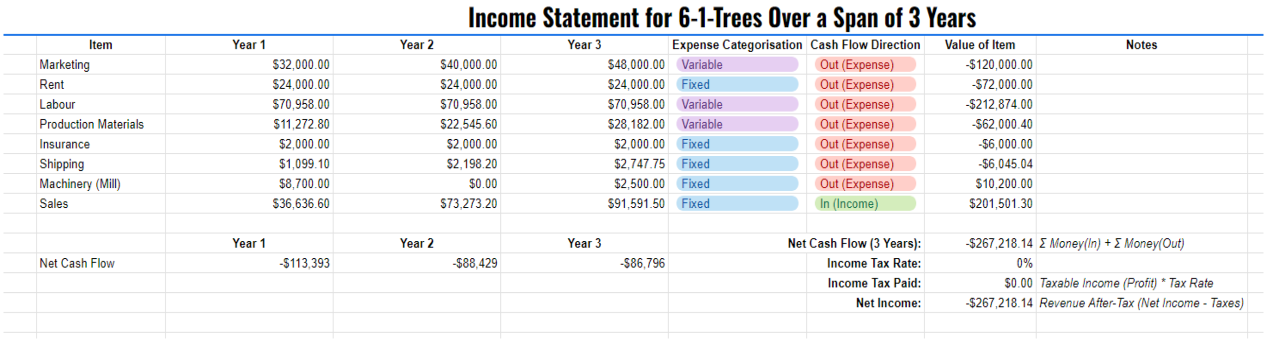
G.1.2 3 Year Income Statement:

FitClip Income Statement			
Revenue	Year 1	Year 2	Year 3
Net Sales	$781,250.00	$1,500,000.00	$2,500,000.00
Cost of Goods Sold			
Material	$62,500.00	$120,000.00	$200,000.00
Overhead	$50,000.00	$100,000.00	$100,000.00
Total Cost of Goods Sold	$112,500.00	$220,000.00	$300,000.00
Gross Profit	$668,750.00	$1,280,000.00	$2,200,000.00
Operating Expenses			
Labour	$193,800.00	$232,560.00	$271,320.00
Marketing	$78,125.00	$78,125.00	$50,000.00
Rent	$24,000.00	$30,000.00	$36,000.00
Shipping	$18,083.33	$39,783.33	$40,000.00
Utilities	$10,000.00	$20,000.00	$24,000.00
Insurance	$5,000.00	$7,000.00	$7,000.00
Machinery	$250,000.00	$0.00	$250,000.00
Total Operating Expenses	$579,008.33	$407,468.33	$678,320.00
Operating Income	$89,741.67	$872,531.67	$1,521,680.00

https://docs.google.com/spreadsheets/d/10h9kQgq1I7MF6uGN0HuhKWHm-leBfdBs_Bsw2jflCp4/edit?usp=sharing

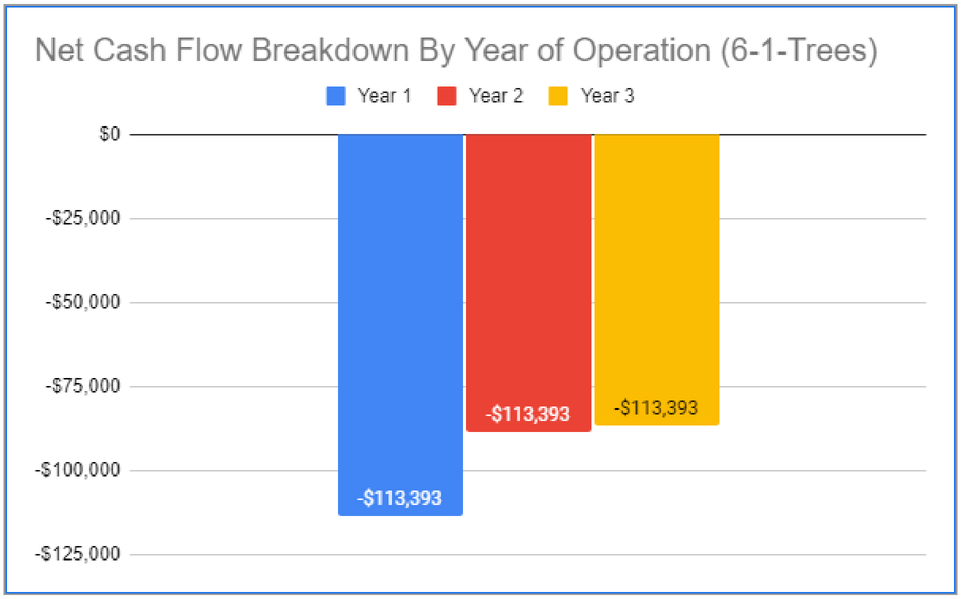
Using a NPV analysis, determine the break-even point (i.e. number of units that must be sold for your business to become profitable). Note: It is highly unlikely that your operating income will be positive in the first year because of fixed costs. Therefore, you must use a NPV analysis to compare costs and profits over multiple years based on present value. Draw two cash flow diagrams of the expenses and incomes for the next three years. Calculate the NPV value of each expense/income and determine the

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

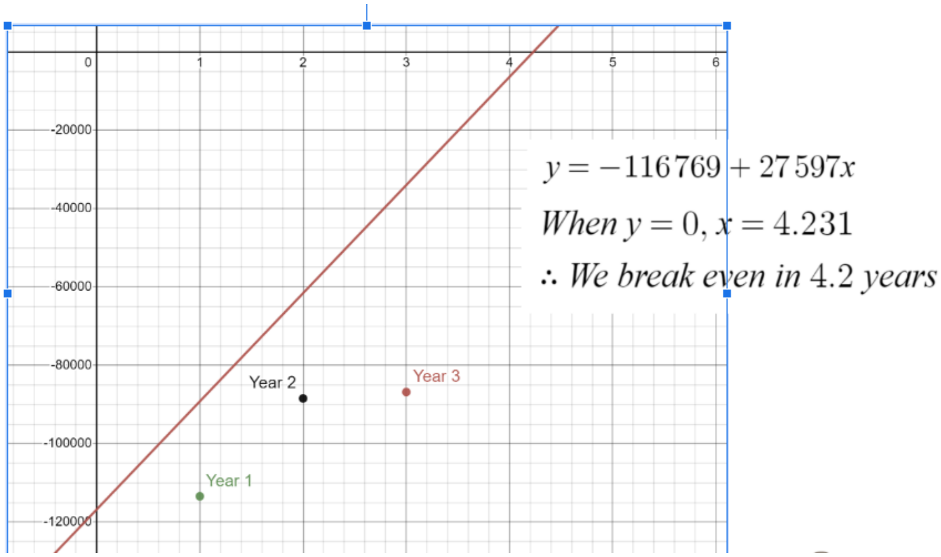


Income Statement for 6-1-Trees Over a Span of 3 Years

Item	Year 1	Year 2	Year 3	Expense Categorisation	Cash Flow Direction	Value of Item	Notes
Marketing	$32,000.00	$40,000.00	$48,000.00	Variable	Out (Expense)	-$120,000.00	
Rent	$24,000.00	$24,000.00	$24,000.00	Fixed	Out (Expense)	-$72,000.00	
Labour	$70,958.00	$70,958.00	$70,958.00	Variable	Out (Expense)	-$212,874.00	
Production Materials	$11,272.80	$22,545.60	$28,182.00	Variable	Out (Expense)	-$62,000.40	
Insurance	$2,000.00	$2,000.00	$2,000.00	Fixed	Out (Expense)	-$6,000.00	
Shipping	$1,099.10	$2,198.20	$2,747.75	Fixed	Out (Expense)	-$6,045.04	
Machinery (Mill)	$8,700.00	$0.00	$2,500.00	Fixed	Out (Expense)	$10,200.00	
Sales	$36,636.60	$73,273.20	$91,591.50	Fixed	In (Income)	$201,501.30	
	Year 1	**Year 2**	**Year 3**		**Net Cash Flow (3 Years):**	-$267,218.14	*Σ Money(In) + Σ Money(Out)*
Net Cash Flow	-$113,393	-$88,429	-$86,796		**Income Tax Rate:**	0%	
					Income Tax Paid:	$0.00	*Taxable Income (Profit) * Tax Rate*
					Net Income:	-$267,218.14	*Revenue After-Tax (Net Income - Taxes)*



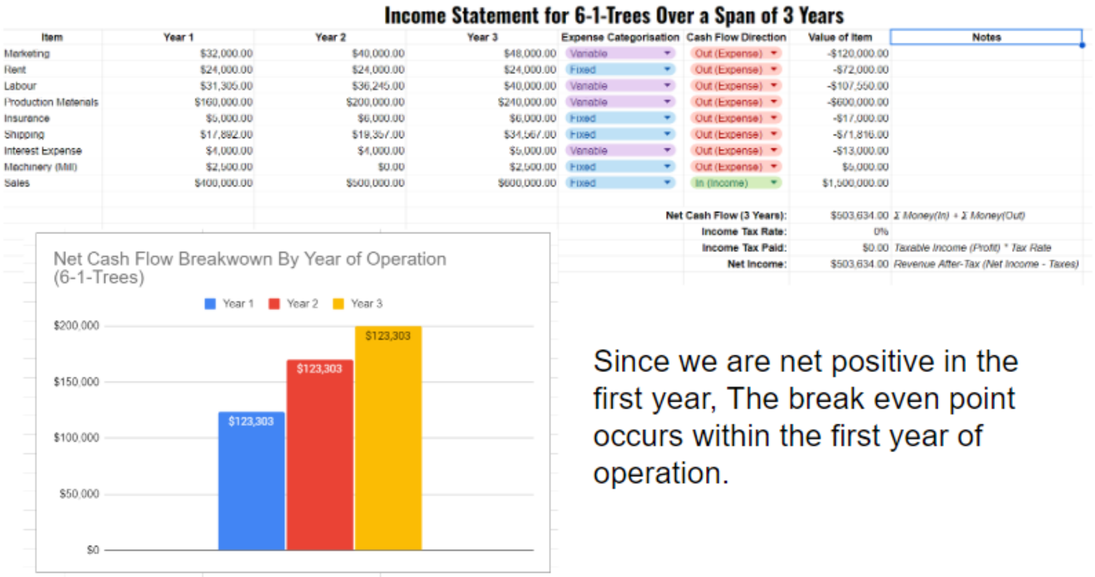
3. Using a NPV analysis, determine the break-even point (i.e. number of units that must be sold for your business to become profitable). Note: It is highly unlikely that your operating income will be positive in the first year because of fixed costs. Therefore, you must use a NPV analysis to compare costs and profits over multiple years based on present value. Draw two cash flow diagrams of the expenses and incomes for the next three years. Calculate the NPV value of each expense/income and determine the differences and then the break-event point.



$$y = -116769 + 27597x$$

$$When\ y = 0,\ x = 4.231$$

$$\therefore We\ break\ even\ in\ 4.2\ years$$



Income Statement for 6-1-Trees Over a Span of 3 Years

Item	Year 1	Year 2	Year 3	Expense Categorisation	Cash Flow Direction	Value of Item	Notes
Marketing	$32,000.00	$40,000.00	$48,000.00	Variable	Out (Expense)	-$120,000.00	
Rent	$24,000.00	$24,000.00	$24,000.00	Fixed	Out (Expense)	-$72,000.00	
Labour	$31,305.00	$36,245.00	$40,000.00	Variable	Out (Expense)	-$107,550.00	
Production Materials	$160,000.00	$200,000.00	$240,000.00	Variable	Out (Expense)	-$600,000.00	
Insurance	$5,000.00	$6,000.00	$6,000.00	Fixed	Out (Expense)	-$17,000.00	
Shipping	$17,892.00	$19,357.00	$34,567.00	Fixed	Out (Expense)	-$71,816.00	
Interest Expense	$4,000.00	$4,000.00	$5,000.00	Variable	Out (Expense)	-$13,000.00	
Machinery (Mill)	$2,500.00	$0.00	$2,500.00	Fixed	Out (Expense)	$5,000.00	
Sales	$400,000.00	$500,000.00	$600,000.00	Fixed	In (Income)	$1,500,000.00	
					Net Cash Flow (3 Years):	$503,634.00	*Σ Money(In) + Σ Money(Out)*
					Income Tax Rate:	0%	
					Income Tax Paid:	$0.00	*Taxable Income (Profit) * Tax Rate*
					Net Income:	$503,634.00	*Revenue After-Tax (Net Income - Taxes)*

Since we are net positive in the first year, The break even point occurs within the first year of operation.

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

All our assumptions are based on research.

Machinery:

We are buying a mill and a saw in the first year of production. We found a mill: Craftex CX Series for 2500$ and the saw is 6200$. We will buy a second mill for the third year of production. This equals to 8700$ of equipment during the first three year of production.

Labour:

We are going to hire 5 workers to produce our product. We are going to pay them a salary of $3/hour. This equals to $15/hour. Since there is an average of 2087 working hours per year, this would equal to $31305 per year in labour.

Sales:

1st year : 282

2nd year: 564

3rd year: 704

To find these numbers, 0.12% of people are born with congenital rheumatological disorders in Canada of the 0.12%, around 25.3% experience mobility issues within the joints in their elbows and knees, making them the perfect users for our product. Of the population of Canada, we end up with around 6039 possible sales from market reach. With these calculations, we can determine the number of sales that we are going to make every year.

We are selling each sale at $130 each. In our first year, this equals to $36,636.60. In our second year, we are going to sell $73,273.20 worth of dressing trees and in the third year, we will sell $91 591.50.

Labour:

We are paying our workers a little over the minimum wage of 17$/h and we have 2 workers, so this makes 34$/h. Since there is around 2087 working hours in a year, this makes 70958 $ per year in labour cost in every year.

Material:

It takes 40 $ per unit

Material: 11272.80$

2nd year:

Material: 22545.60$

3rd year:

Material: 28182.00$

Marketing: 8 % of revenue

1st year: 32 000$

2e year: 40 000$

3rd year: 48 000$

6.2 Intellectual property report

Explore intellectual property databases (i.e. patents, industrial designs, integrated circuit topographies, trademarks, copyrights, creative commons, or open source software)

Multi Fastener Dressing Apron

Dressing Aid

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

1. Multi fastener dressing tree; This patent has an interesting goal to allow those with fine motor skills to both fasten and unfasten clothing. Whilst the dressing tree and multi fastener dressing apron differ in many aspects, they both cater to those with final motor skills, and aim to make getting dressed independently and safely. Although the physical aspects are very different, the end goal is similar. The apparatus according to claim 1 further comprising: hook portions configured on the framework to engage a top edge of a panel and allow at least a portion of the framework to rest against one side of the panel.

In the dressing tree patent, they use hooks on each side of the panel which are very similar to our design. This might affect us with intellectual properties in the long run since the hook placement is very similar in both designs. The end goal in this patent is to help people dress up independently.

6.3 Project plan update

Add your wrike snapshot link. Don’t forget to include assignees.

7.4 Updated BOM

Item Name	Description	Quantity	Unit Cost	Extended Cost
Aluminum Extrusions	T slots, 1000mm x 20mm x 20mm	2	18	36
Toggle Clamp Vertical	6 inch	2	10	20
Toggle Clamp Horizontal	5 ½ inch	2	5	10
T Nuts	From the TA, used to insert into aluminum extrusions	Around 20	14.04$	15.86$2
Steelworks Weldable Steel bar	For welding/repair/ fabrication. 4 x ¼ inch (thickness)	1	21	21
Steelworks Weldable Steel Flat	For welding/repair 3 feet x ½ inch x 1/8 inch (thickness)	1	7	7
Wood	2 x 4 x 2 feet	1	4	4
Bolts	To bolt into the wall			
Screws	To screw in clamps onto sliding piece			
Paint (Iced Lilac)	To paint the dressing tree	1	11.99	$13.55
Mastercraft Wall Mount Foldable Horizontal Bike Hook / Bike Hanger, Up to 23-kgs	Hooks used to be attached to the beam.	1	19.99	$22.59
Handy Hook	Hooks attached to the second beam.	2	6.99	$13.99
Metal Bars/plate	To attach to the aluminum extrusion	11	1	$11
Total cost				173.13

7 Design Day Pitch and Final Prototype Evaluation

Explain why the problem is important (“So What?”). This will require some research and rehearsal. You need to be very crisp and clear about what problem you have solved and what work you have done. 2. Explain the basic user requirements and why solving the problem is important (“Who Cares?”), as well as current solutions and alternatives. 3. Explain the differentiation in your design or the key aspects that make your final prototype better than other solutions on the market (“Why you?”). 4. Provide a demonstration of your functional final prototype in action.

Hello judges, professors, and fellow students, I am Grace, and I am part of the 6-1-trees team. We have built an innovative dressing tree to help a 7-year-old child with arthrogryposis multiplex to get dressed with ease and independence. Many people have different abilities that might not allow them to perform daily tasks alone, they might also have fine motor skills. Therefore, we created a product that will provide support using two hooks attached to a beam. The user will drape the desired article of clothing over the hooks and maneuver themselves with the help of the hooks. It is important that the dressing tree does not require much parental or caregiver assistance as this product is not only aimed physically at making those with different abilities' lives easier, but also provides an emotional sentiment of independence. Our team took inspiration from Lego sets in the manner that Legos can be put together in so many ways to create one specific product with one goal. We recognize that every individual has different needs, strengths and weaknesses, so, our product dressing tree is designed in a way that makes customization effortless. The user only requires a small 4mm Allen Key to modify the dressing tree to their own preferences. Some users require the hooks to be higher than others, therefore, the beams can be implemented at different heights. Also, due to its compact size, the structure can be effortlessly relocated in the user's space. Unlike larger dressing trees, only a drill and couple screws are required for moving this structure. The aesthetic of the dressing tree is also important to consider; since this product is designed for a 7-year-old girl, we kept in mind her favorite color and we’re planning on adding stickers of her favorite animals to make the experience of using the product enjoyable and exciting. This is also another aspect unique to our dressing that other dressing trees do not have. Furthermore, we take pride in the components and materials used, we aim for a sustainable product, thus we reused wood from previous home projects to assure no contribution to harming the environment. The components used to construct the dressing tree are all off the shelf-items that have been designed to come together and function as a dressing tree. For instance, the hooks used are taken from hooks mounted to hold a bicycle that one of the group members had at home. In case any materials happen to fracture, replacing them is very easy as the materials used are easy to find and replace. Finally, this dressing tree is designed with an economic sustainability mindset; this product is adjustable to cater to the growth of the user, assuring it to be a beneficial longtime presence. Now we will demonstrate the dressing tree.

8 Video and User Manual

8.1 Video pitch

https://drive.google.com/file/d/1qlZYjxtGh9x6kACFGLyNxRxYEdMpQl6O/view?usp=drive_link

8.2 User manual

This User and Product Manual (UPM) provides the information necessary for individuals with arthrogryposis multiplex congenita (AMC) to effectively use the 6-1-Tree Dressing Tree and for prototype documentation. This product effectively allows users with different abilities to get dressed independently and efficiently.

By using a system of hooks, the user will be able to drape their desired article of clothing on the curved shape of the hooks. The user will then slide into the article of clothing with easy. This will allow for minimal use of joints and muscles.

It is assumed that the user with AMC will have assistance when assembling the dressing tree as well as moving the bars when needed as the horizontal and vertical beams as well as tightening the screws will be difficult to put together for those with AMC.

This document will provide the user with clear information regarding the dressing trees assembly, function, troubleshooting as well as any other considerations. It is highly recommended to read this document before assembling the dressing tree to consider the different aspects of its function. The safety of the user and client is a vital aspect taken into constant consideration, thus, the client and/or user should be familiar with all aspect of the document, if there are any uncertainty, please reach out to the support number or email, our team will be happy to assist you.

The product of this document is intended only for the 6-1-tree dressing tree client and user as it may contain confidential or proprietary information. Additionally, any information provided by the client or user is confidential and will not be shared with any institition unless granted permission.

9 Overview

A product is needed for a client looking for a product that will allow his seven-year-old daughter, the user, with arthrogryposis multiplex congenita (AMC) to get dressed independently. This is important as it provides people with different abilities a sense of independence as well as makes time to get dressed quickly. This also allows caregivers and parents to focus their time and attention on other situations.

The needs of the user are that the product must be safe, adjustable, can be used independently as well as space adequate. To begin, the dressing tree should be stable enough to not tip to the sides or be able to be pulled down from the hooks. The dressing tree is structured in a manner that assures safety and support to the user. Additionally, the dressing tree is aimed to be a sustainable product; thus, it is built in a manner that allows the user to adjust the horizontal beams holding the hooks. This allows the user to maintain the dressing tree as they grow; and avoid repurchasing a dressing tree in a different size. Furthermore, the dressing tree caters to those with fine motor skills. The user should not require much strength to be able to get dressed using the product. However, the user would require assistance when assembling the dressing tree as well as shifting the horizontal bars to the desired height. Finally, the dressing tree is fairly compact, it does not take much floorspace or wall length. This allows the user to enjoy a variety of options in regarding to the placement of the dressing tree. Furthermore, the light weight allows the dressing tree to be easily moved from one place to another without trouble.

The 6-1-Tree dressing tree differs from others as it is customizable for each user. From the variety of hooks used, to the decided length of the horizontal beams, this dressing tree is designed to supply a comfortable experience for each user. Additionally, the materials used to construct the dressing tree are all off the shelf components, this highlights the simplicity of the design and uncomplicated idea. The dressing tree should not be an overwhelming experience, rather it is aimed to make the user feel confident and assertive. Furthermore, the 6-1-tree dressing tree has two distinct types of hooks; each set of hooks can be used for different articles of clothing. For instance, the hooks used for shirts differs than those used for socks.

The key features of the dressing tree are the two different horizontal bars holding different hooks. This will allow the user to be able to decide the placement of two different sets of hooks; aimed at helping the user get dressed in different garments. The placement of the two beams also saves time and energy of caregivers/parents as it is not simply one hook that must be moved frequently. As there are two beams, the flexibility of the two allows for more usage of the product.

The architecture of the structure consists of off the shelf materials. For the all the vertical beams; the horizontal and vertical, Aluminum Extrusion was used to create a stable structure that will provide the necessary support. Additionally, small metal plates and screws were used to secure the horizontal beams to the vertical ones. The hooks used have rubber at the end to assure the client experiences comfort when using the dressing tree.

9.1 Conventions

Since this dressing tree is very customizable to each user, it is important to be able to mark the preferred place of placement of the hooks. Therefore, there will be a poster provided to allow each user to mark their preferred placement.

9.2 Cautions & Warnings

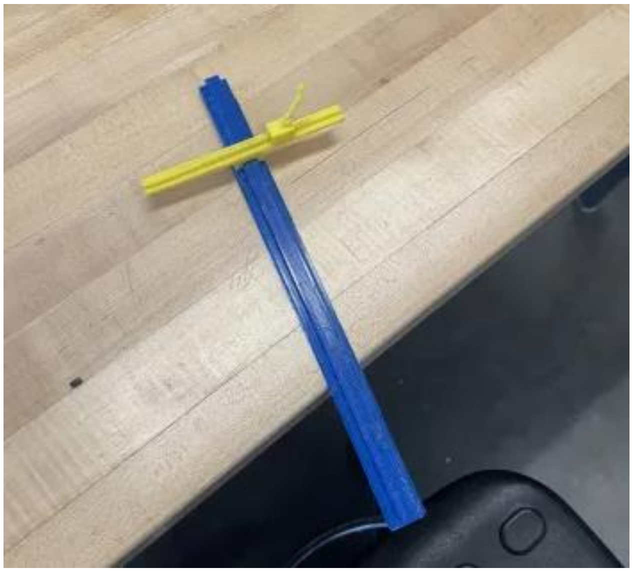
Although the dressing tree is not heavy, individuals with AMC might require assistance assembling. Do not attempt to construct without support.

Assure that the dressing tree is used only for its purpose and not other dangerous activities.

Assure only one individual is using the dressing tree at a time.

Assure the dressing tree is bolted securely into the wall.

Assure the screws are tight.



10 Getting started

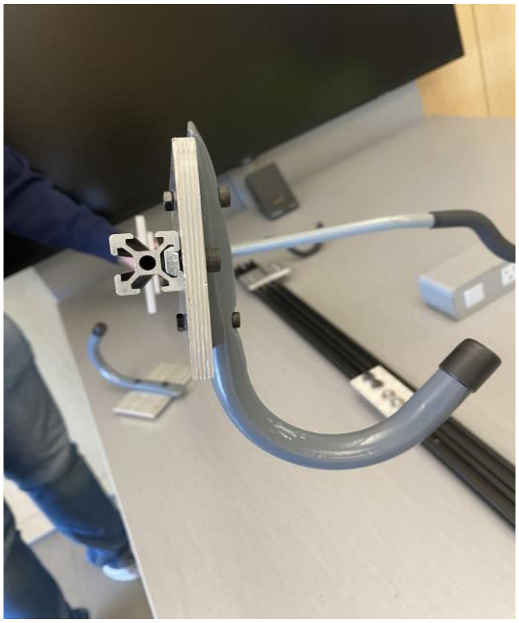
The assembly process of the dressing tree is fairly simple. All that are needed are a 4mm Allen key along with a drill for quick assembly.

To begin, remove the components from the respective package and lay them out.

Next, begin with bolting the dressing tree to the wall using the long 8 mm screws; it is recommended to use a drill.

Then, figure out the desired length the horizontal beams will be at. Assure the client is comfortable with the height. Insert the horizontal beams through the vertical ones using the t-nuts and the Aluminum extrusion ‘path’, tighten them using the 4mm Allan key.

Finally, insert the hooks on to the horizontal beams the same manner in the step before, assure the user is comfortable with the space between each hook.



10.1 Configuration Considerations

The configuration of the dressing tree is two vertical beams mounted to the wall, then there are two horizontal beams with hooks attached. The horizontal beams attached to the vertical beams can be moved up and down the length of the vertical ones. Additionally, the hooks can be moved left and right on the vertical beam to suit each user. To build the dressing tree, only a 4mm Allen key is needed; if desired a drill will be of much assistance.

10.2 User Access Considerations

Although this dressing tree is built for individuals with AMC; anyone who has fine motor skills and needs assistance whilst getting dressed can be of benefit from this dressing tree. Additionally, this dressing tree can be used in hospitals and facilities to allow individuals with different abilities the chance to experience independence whilst getting dressed.

10.3 Accessing/setting up the System

To set up the dressing tree; a 4mm Allen key is required to screw on the horizontal bars to the vertical ones. Additionally, a drill might aid in screwing in the screws. To begin, bolt the two vertical beams at the desired length to the wall, using the 4 wood pieces provided. Next, insert the bottom horizontal beam through the top of the vertical ones; assure they are aligned correctly. To insert the horizontal beams, use the Al extrusion to guide down the t-nuts down the vertical beams. Use the 4mm Allen key to lock the t-nuts into the desired place. Next, repeat the last two steps with the top vertical beam. One both the beams are secured; insert the hooks into the horizontal beams and tighten them in the desired place.

Since the dressing tree is designed to be customizable for each user, its features are designed for personal use. For instance, the hooks are made to be able to slide along the horizontal axis. This is because everyone has a different preference regarding where they want their hooks to be. Moreover, the horizonal beams are adjustable to suit the height of the users, to adjust the beams to the preferred height, simply use a 4mm Allan key and screw on it on at the correct height.

10.4 System Organization & Navigation

3.4.1 Main component/structure

The main component of the dressing tree is the structure, both the vertical and horizontal beams. The vertical beams are bolted to the wall whilst the horizontal beams are inserted into the vertical ones and are screwed in.

3.4.2 The attachments of the dressing tree are the hooks. They are attached to the vertical beams in a manner that always them to move to be at a desired length. However, due to safety reasons, both hooks are not able to be on the same size as that will cause unbalance in the structure.

10.5 Exiting the System

The dressing tree does not need to be put away after each use as it needs to be used constantly. However, if the client/user wants to make the dressing tree more compact; taking off the hooks using a 4mm Allen key would reduce the space it takes up. Additionally, the user can take off the bottom of the aluminum extrusion with an Allen key to make the dressing tree shorter

11 Using the System

To be able to change the height of the horizontal beams, one must use a 4mm Allan key to unscrew screws on the vertical metal plate. Next, the individual will decide where the horizontal beams with the hook will be placed. Once decided the horizontal beams will be screwed in tightly on each different vertical beam.

To change the position of the hooks on the vertical beams, the user is able to unscrew the screws indicated using a 4mm Allan key. Then, the individual will move the hooks to the desired place, there they will use once again the 4mm Allan key to screw in the hooks in the correct position on the beam.

11.1 Hooks

The hooks used for this system are on the horizontal bars. The horizontal beams are connected to the beams on the vertical beams. The user will be able to use the hooks to be able to get dressed independently. The hooks are slightly curved up to allow for easy access to the articles of clothing. The hooks are curved to a degree that allows effortlessness when getting dressed. Additionally, the hooks are coated with a layer of rubber material. This allows the hooks to be gentle and warm for the user.

12 Troubleshooting & Support

The dressing tree might show signs of malfunction if the dressing tree is put together incorrectly. It is important that everything is secure to allow for maximum safety. Additionally, the hooks must be in the correct distance to allow the user to get dresses easily. If the users are having any trouble; it could be due to the hooks being at a distance to large or small for the user, thus some trial and error is needed. Additionally, the horizontal beams must be at the correct location as well; so, the user does not struggle.

However, if there is a suspicion in one the parts being incorrectly built, the 6-1-trees team is ready to assist both virtually and in person.

12.1 Error Messages or Behaviors

It is vital that the horizontal beams are secured correctly as it provides the correct amount of security when in use. If they are not secured safely, they will wobble and not allow the user to get dressed independently. Additionally, the distance between the two hooks must be adequate, if not, the user will not be able to get dressed comfortably.

12.2 Special Considerations

Some users might desire more hooks other than the standard ones, or different types of hooks, made of different materials, or made at different sizes and lengths. Therefore, our website provides a variety of hooks to choose from. Additionally, the height of the dressing tree can always be alerted to suit different individuals.

12.3 Maintenance

This dressing tree is designed in a manner to be durable and sustainable for a lengthy period of time. It requires minimal maintenance once set up. However, the horizontal bars will need to be moved to the desired height of the user occasionally. Additionally, it is important to keep the bar in a clean state to assure the hooks and horizontal bars are able to move with ease.

12.4 Support

In the event of any emergency, please call 613-301-3737 for immediate assistance, and speak to our production support. If there is an injury, please call your local Police immediately.

If you would like to contact the system support group, please email pfour008@uottawa.ca for assistance related to assembly. sboud075@uottawa.ca for assistance related to the vertical and horizontal beams. gfitz024@uottawa.ca for assistance related to the hooks. oxu020@uottawa.ca for assistance related to safety and other concerns.

Please provide a clear description as well as any attempts to resolve the issue. Additionally, adding pictures if possible; will allow for a faster solution process. Our team will be happy to help with any issues or concerns.

13 Product Documentation

The final design was built by using Aluminum extrusion as the structure of the dressing tree. Both the vertical and horizontal beams are made from that material. The aluminum extrusion was cut into 5 feet for the vertical beams. Next, the horizontal beams were cut into 3 feet. Then, the bike holder hooked purchased was cut into two pieces through the middle. The hooks had to be welded onto metal plates to allow for security. Metal plates were also cut to be able to attach the hooks to the Al extrusion. The hooks had to have been drilled into to allow the metal plates to be attached to them through the back. Then the metal plates had to be drilled into to make holes that will allow the hooks to be attached. After that, screws had to be cut into the correct length to be able to be attached into the hooks. Blocks of wood have been cut and attached to the back of the metal plates for easy installation onto the wall. Finally, all the parts were ensembled together; the horizontal beams were glided through the tea nutes into the vertical beams and tightly secured using the 4mm Allan key, this step was also used when the hooks were glided onto the vertical beams.

13.1 Structure

13.1.1 BOM (Bill of Materials)

Item Name	Description	Quantity	Unit Cost	Extended Cost
Aluminum Extrusions	T slots, 1000mm x 20mm x 20mm	2	18	36
Toggle Clamp Vertical	6 inch	2	10	20
Toggle Clamp Horizontal	5 ½ inch	2	5	10
T Nuts	From the TA, used to insert into aluminum extrusions	Around 20	14.04$	15.86$2
Steelworks Weldable Steel bar	For welding/repair/ fabrication. 4 x ¼ inch (thickness)	1	21	21
Steelworks Weldable Steel Flat	For welding/repair 3 feet x ½ inch x 1/8 inch (thickness)	1	7	7
Wood	2 x 4 x 2 feet	1	4	4
Bolts	To bolt into the wall			
Screws	To screw in clamps onto sliding piece			
Paint (Iced Lilac)	To paint the dressing tree	1	11.99	$13.55
Mastercraft Wall Mount Foldable Horizontal Bike Hook / Bike Hanger, Up to 23-kgs	Hooks used to be attached to the beam.	1	19.99	$22.59
Handy Hook	Hooks attached to the second beam.	2	6.99	$13.99
Metal Bars/plate	To attach to the aluminum extrusion	11	1	$11
Total cost				173.13

13.1.2 Equipment list

The equipment used is

A mill

A metal cutting bandsaw

A wood cutting bandsaw

A drill press

A Drill

A 4mm Allan key

13.1.3 Instructions

To start the build of this product, we must cut the aluminum plates at every couple inches. With these plates, we must then mill holes to insert the screws connected to the tee nuts into the plate. In this dressing tree, there are three different measurements of plates.

Firstly, the back connectors are used to connect another piece of the aluminum extrusion to the main one-meter pole. The measurement of this plate is 3inches on the horizontal and and 2 inches on the vertical. We will drill four holes at one inch on the vertical axis and at 0.325, 1.075, 1.925, and 2.575 inches on the horizontal axis.

Secondly, the second aluminum plate is designed to be able to place the dressing tree on a wall. These plates will be screwed to a wooden block that can then be screwed into the preferred wall. For these plates we must drill 4 holes to be able to place the screws inside. We will drill holes at the x axis of 0.55in and at 2.45in, while the y-axis will be at 0.667in and 1.333in. Note that four plates are needed in this part for secure stability with the wall.

The third set of plates are used to connect the vertical aluminum to the horizontal one. For these ones, set the y-axis at the center of the plate at 2in and mill holes at 0.37in, 0.74in, 2.26, and 2.63in. Another 4 holes are needed at an x-axis of 1.5in and at y-axis of 0.533in, 1.067in, 2.934in, and 3.467in. Note that two plates like these are needed for one horizontal bar to connect to the vertical beams. If more horizontal bars are required, more plates are also needed.

A final set of plates must be fabricated as well, but this part is based purely on the user's preference. These plates are the holders for the hooks, so naturally not all the plates are going to be identical. In this case, two sets of hooks were built, one bike holder hook and another tool holder hook. The bike holder hooks were welded onto the al plate and the tool hooks were connected to the plate by screws. There are multiple ways of inserting these hooks into the system.

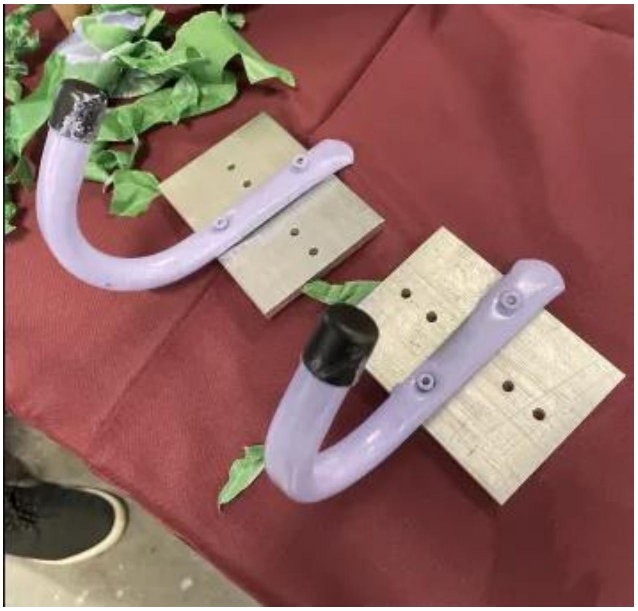
To continue, 4 blocks of wood are required to connect the dressing tree to the wall. These blocks can be any dimension as preferred, but the block in this project had dimensions of 5in in length, 2in in height, and 4in in width. The next step is to mill holes inside the wood blocks at the screws placed on the second set of aluminum plates. Note that this is done easier by marking the screw places and then filling instead of finding adjusting the axis on the mill.

Next up, the aluminum plates must be inserted onto the aluminum extrusions. To do this, tee nuts with the right dimensions for the al extrusions and screws that fit inside the milled holes are both needed. Insert the screws into the al plate holes and screw just a little to be able to fit plates inside the al extrusion rails. When the plates are at the right position, tight the screws until the plates stop moving. The same thing must be done on the other extrusion bar. Now the horizontal bar can be inserted on these two vertical poles with the tee nuts as well.

The hooks are now able to be inserted onto the horizontal bars in the same way as the aluminum plates were inserted on the vertical poles. These hooks can then be tightened and untightened at any time to place them to the user's needs.

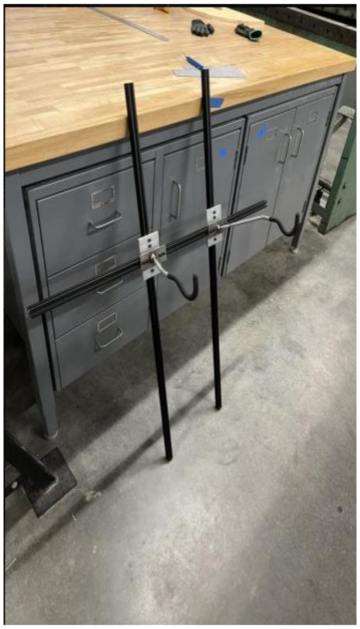
Lastly, the dressing tree must be mounted on the wall to be functional. To do this, find a good spot to place it. The dressing tree is 1.5 meter high and 1 meter wide, so a big amount of space is required. Place the blocks at the right location for the dressing tree and screw two screws on each wood block. Then add the dressing tree on top of the wood blocks by inserting the the back screw inside the wood block holes. Then screw small screws between the al plates to the wood.

The dressing tree is now ready for use. For aesthetic purposes, paint and sticker decorations can be easily added to dressing trees to make it more personal and enjoyable.



13.2 Testing & Validation

The tests done on the prototype for the final design are a weight test to be able to assure the dressing tree can withstand the weight of the user. This has been done through calculations and testing. The group had an individual with AMC attempt to use the dressing tree; as it was easy for the user to slide into the garments, it was clear the prototype was able to function correctly.



14 Conclusions

In conclusion, the 6-1-Tree Dressing Tree represents a groundbreaking solution for individuals with arthrogryposis multiplex congenita (AMC), offering them the independence and efficiency they deserve in the daily task of dressing. This User and Product Manual serves as a comprehensive guide, ensuring users and caregivers understand the assembly, functionality, and maintenance of the dressing tree.

The dressing tree's unique design, featuring customizable hooks and adjustable horizontal beams, sets it apart from conventional solutions. Its thoughtful construction, utilizing off-the-shelf components and a stable aluminum extrusion structure, emphasizes simplicity without compromising effectiveness. The inclusion of rubber-coated hooks prioritizes user comfort, showcasing the product's commitment to user-centric design.

The manual provides detailed instructions on assembly, user access considerations, and troubleshooting. Safety precautions and guidelines are underscored, emphasizing the importance of securing the dressing tree to the wall and ensuring proper assembly to prevent accidents.

Notably, the system's adaptability extends beyond AMC users, benefiting anyone with fine motor skill challenges. The commitment to sustainability, ease of use, and personalized configuration positions the 6-1-Tree Dressing Tree as a versatile and inclusive solution.

As the dressing tree becomes an integral part of users' daily routines, the support infrastructure is robust, helping through both virtual and in-person channels. The emphasis on user support, customization options, and durability aligns with the overarching goal of enhancing users' independence and overall quality of life. The 6-1-Tree Dressing Tree is not merely a product; it is a testament to inclusive design thinking, empowering users to navigate life with increased autonomy and confidence.

APPENDICES

15 1 APPENDIX I: Design Files

Table 3. Referenced Documents

Document Name	Document Location and/or URL	Issuance Date
6-1-Trees Makerepo	https://makerepo.com/yamamalsaadi/1912.61trees	28/11/2023
Dressing tree project page	https://makerepo.com/project_proposals/372	16/08/2023
SolidWorks files	Final Prototype.zip	10/12/2023