Project Deliverable D: Detailed Design, Prototype 1, BOM, Peer Feedback and Team Dynamics

Group 8: BRAKEthrough Solutions
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Introduction

This document outlines the feedback from the second client meeting, our first prototype and how it was received, comparison to target specifications, and our next steps based on the client feedback. Since the core design was decided to be inadequate, the ideation process of a new core concept is detailed with a description of our future in prototype development. A new concept is illustrated, the bill of materials is provided and the team name and slogan are declared. This week, we plan on starting the development process of the new core concept design prototype.

Problem Statement

The client needs a safe and reliable remote braking system for his son's pediatric gait trainer, the R82 Crocodile. It can be activated from a distance to let him practice walking independently—most existing brakes are manual and require the guardian to be within arms reach. This will be achieved by having a Bluetooth remote activation of a mechanical spring-based friction braking.

Client Feedback Summary

The second client meeting focused on getting feedback from our client on the first prototype and finding out if our client would allow us to have a braking system dependent on a battery supply. The client advised us that the braking system could not use the reverse-stop screw on the back wheel of the gait trainer as a fastener because it could possibly affect the warranty—meaning the first prototype would not attach to the gait trainer the way the group originally planned. Instead, the client suggested that the braking system would attach to the frame of the gait trainer.

Furthermore, the client emphasized that they wanted variable braking that would depend on the pressure applied to a button. This design criteria does not align with the first prototype as the prototype is a mechanical brake that applies the same force each time the brake is used. Additionally, as the gait trainer is portable and can be folded, the braking system must be portable and removable when the gait retainer is dissablemed and should not impact the folding mechanism of the walker. Moreover, the clients final request that the braking system would have remote controlled forward and backward stopping, full brakes and disengagement.

Finally, the client did not mind if the braking system relied on a battery power to brake as long as the braking system could be charged and ideally, last a full day and include a battery indicator. In summary, because of the information gained from the client meeting, the group will have to come up with a new concept that satisfies the new design criteria.

Prototype 1: The Mechanical Brake

Figure 1

Figure 2

Figure 3

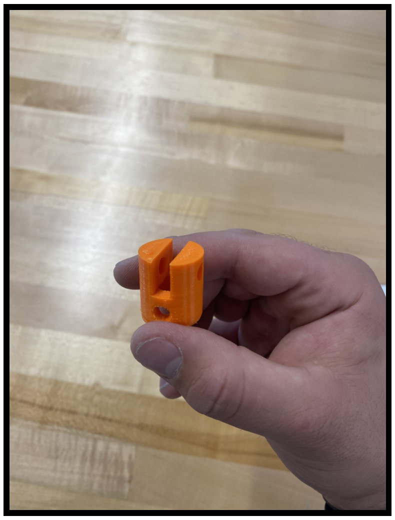


Figure 4

Figure 5

Prototype Description

Our initial design concept was centred heavily around the criteria provided by the client in the first meeting. The client requested a safe and simplistic system that would remotely stop a user in a pediatric gait trainer. Our initial thoughts were a system that would not be dependent on a battery, but instead be almost entirely mechanical. This would allow for a reliable and constant braking force that would not fade with battery life.

After much debate, the design shown in the images above was decided on. This design uses potential energy of springs to apply a braking surface to the wheel of the gait trainer. In image (a) the full assembly is shown. It can be seen here that the outer casing of the brake has four rings in which the springs would hook into. These springs would be in constant tension due to a retention clip that would sit firmly in the notched portion of the casing shown in image (b). When the user wanted to activate the brake, a button on the remote would be pushed, which would instruct a servo or linear actuator to move the retention pin. By removing the retention pin, the cylinder head, as seen in image (c) and (d), would be allowed to drop. This would release some of the springs potential energy, pushing the brake surface (bottom of image (a)) into the wheel. The brake would be mounted low enough on the frame to not allow for the springs to lose all of their tension, therefore apply a braking force to the wheel.

What we considered to be the biggest downfall of this design was the reset process for the brake. In the initial client meeting, the client requested that the brake be activated and deactivated remotely. Because of this design's independence from a battery, it was not pragmatic to deactivate the brake remotely. Instead, the user would have to manually reset the brake by pulling up on the handle portion of the brake seen in image (e). This would replace the tension in the springs, and bring the cylinder head up past the retention clip again, which would clip under the cylinder head, restoring the brake to its ready position.

First Prototype Assumptions

Our first prototype was a low-fidelity non-functional prototype that helps answer key questions about our final design. There were a few major hangups we had about the braking system such as making it battery powered and able to disengage remotely. We initially thought about a remote-operated battery-powered design that would activate servo-motors or linear actuators, but it came with a serious concern: if the battery was low, the braking system could disengage or lower the braking force required to stop the trainer.

With this primary concern, we assumed an ideal solution would be a mostly mechanical system that wouldn't falter if the battery life was low. As a consequence, it was difficult to create a mechanical design that could be disengaged remotely so the first prototype had a manual brake disengagement (by pulling up on the brake handle). Finally, the team assumed a non-variable braking system that stopped both ways would be good enough for meeting our client's requirements, so we made the design with only full brake engagement in mind.

Lastly, due to our delay we were regretfully not able to produce a high functionality prototype. This prevented us from being able to do any testing and we thus have no testing table. However we plan to do further testing on the second prototype. This testing would include braking force measurements, reaction time, and seeing if the design interferes with the gait trainer assembly.

Target Specification Comparison

Design Specifications	Relation (=, < or >)	Value	Units	Verification Method	First Prototype	Comments
Functional Requirements						
Braking Distance	<	Ideal: 1 Acceptable: 2	m	Testing	N/A	Non-functional prototype
Range of Transmission	<=	Ideal: 10 Acceptable: 8	m	Testing	N/A	Non-functional prototype
Speed of Transmission	<=	Ideal: 0 Acceptable: 500	ms	Testing	N/A	Non-functional prototype
Constraints						

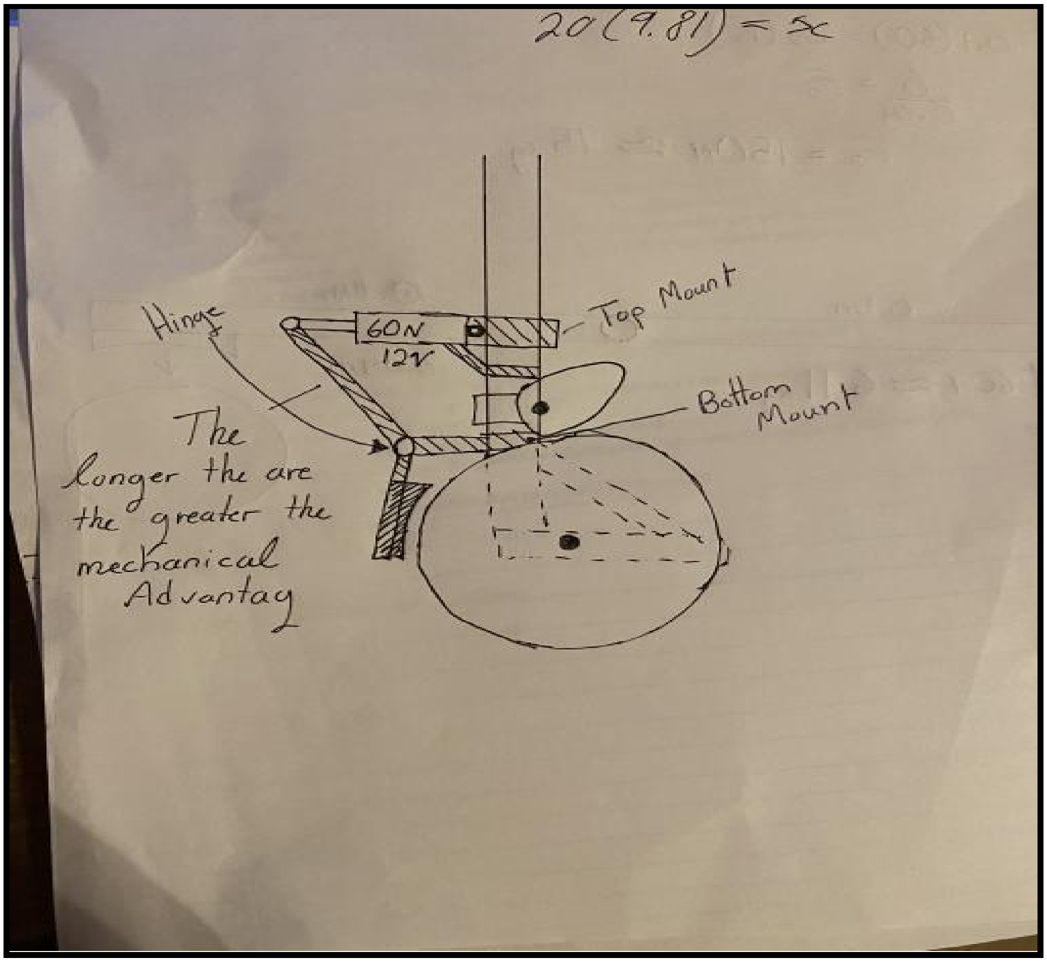
Cost	≤	Ideal: 100 Functional: 150 (with permission)	CAD	BOM Estimation	$0	Prototype 3D printed for free from Makerspace
Battery/power life	>	Ideal: 12 Acceptable: 8	hours	N/A	N/A	Non-functional prototype
Non-functional Requirements						
Mass	<	Ideal: 3 Functional: 5	lbs	Measuring	~1	Made from 3D printer material

Evolution of Ideas based on Client Feedback

Based on the client feedback, we have been brainstorming for a new design which satisfies as many client needs and design criteria as possible, while remaining feasible for the budget and time constraints. One of such ideas involves a linear actuator. Since the client mentioned that they didn't mind if the braking system relied on battery power, we decided to refactor the spring-loaded mechanism into one that is primarily based on a linear actuator and mechanical advantage, as shown in the figure below.

Figure 6 - Sketch of the Linear Actuator-driven braking mechanism

It is also in the plan to have the anti-rollback mechanism (reverse stop) be remotely togglable. This could be achieved in a variety of ways, including a servo motor controlling its position or having an actuator affect its rotation.



Another brainstormed idea involves using the already existing Crocodile hand brakes. The existing hand brakes function by pulling on a tension cord, which pulls the reverse-stopping mechanism into the wheel, preventing any movement. The primary concern with this idea is that the exact specifications of the hand brake are unknown (the client doesn't have them), it would have to be for R82 Crocodile-specific hand brakes, and it is unclear whether or not it affects the reverse-stopping mechanism's intended mechanics.

As a consequence of these changes, the remote controller must be modified to allow for variable braking and reverse stop toggling. Also, with the battery life being an important factor in the safety of the design, indicators of low battery life are high-priority on the controller. An updated mockup with new proposed controller button functionality is shown in the figure below.

Figure 7 - Rough design of the controller with updated button functionalities

Although no prototype of any of the new brainstormed designs could be prepared for this deliverable, the new ideas have expanded upon the original design through feedback response and weighing the importance of design criteria and client needs.

Next Client Meeting Plan

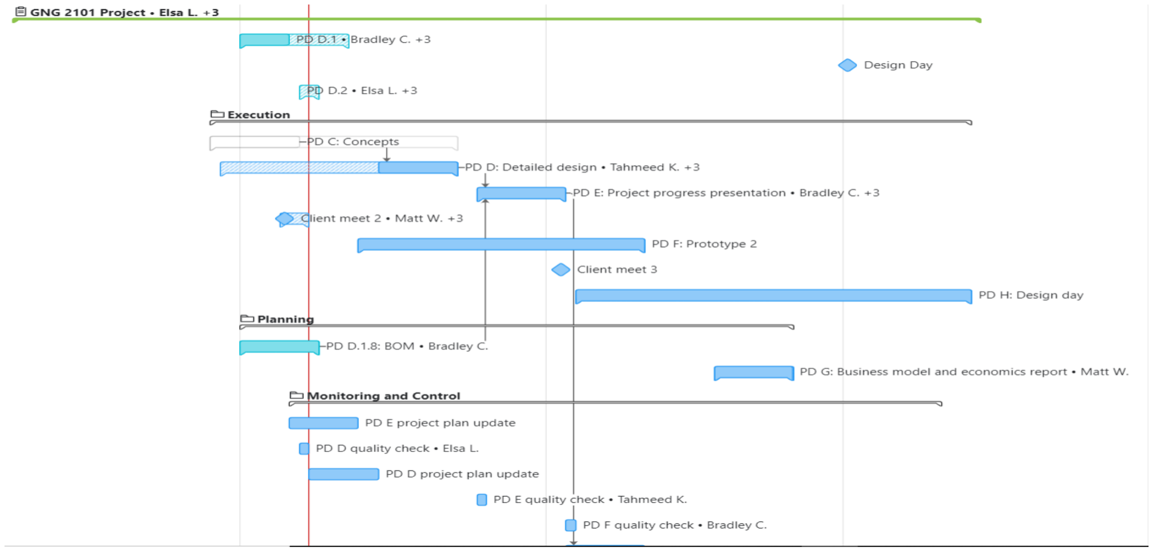
We'd like to have a new prototype for our clients for the next meeting, ideally a battery-based solution that fixes the issues with our first prototype, including adding variable braking intensities, brakes in only the forward/reverse directions, and ensuring the system attaches to the main frame of the gait trainer. Along with this we plan to work around the issue of a non-removable standard brake, and deliver to the client a solution that uses the front or back face of the wheel as the braking face. We plan to demonstrate our second prototype to the client via solidworks animation.Our hopes are that from the second meeting we get confirmation to begin construction of a physical, high fidelity, and comprehensive prototype.

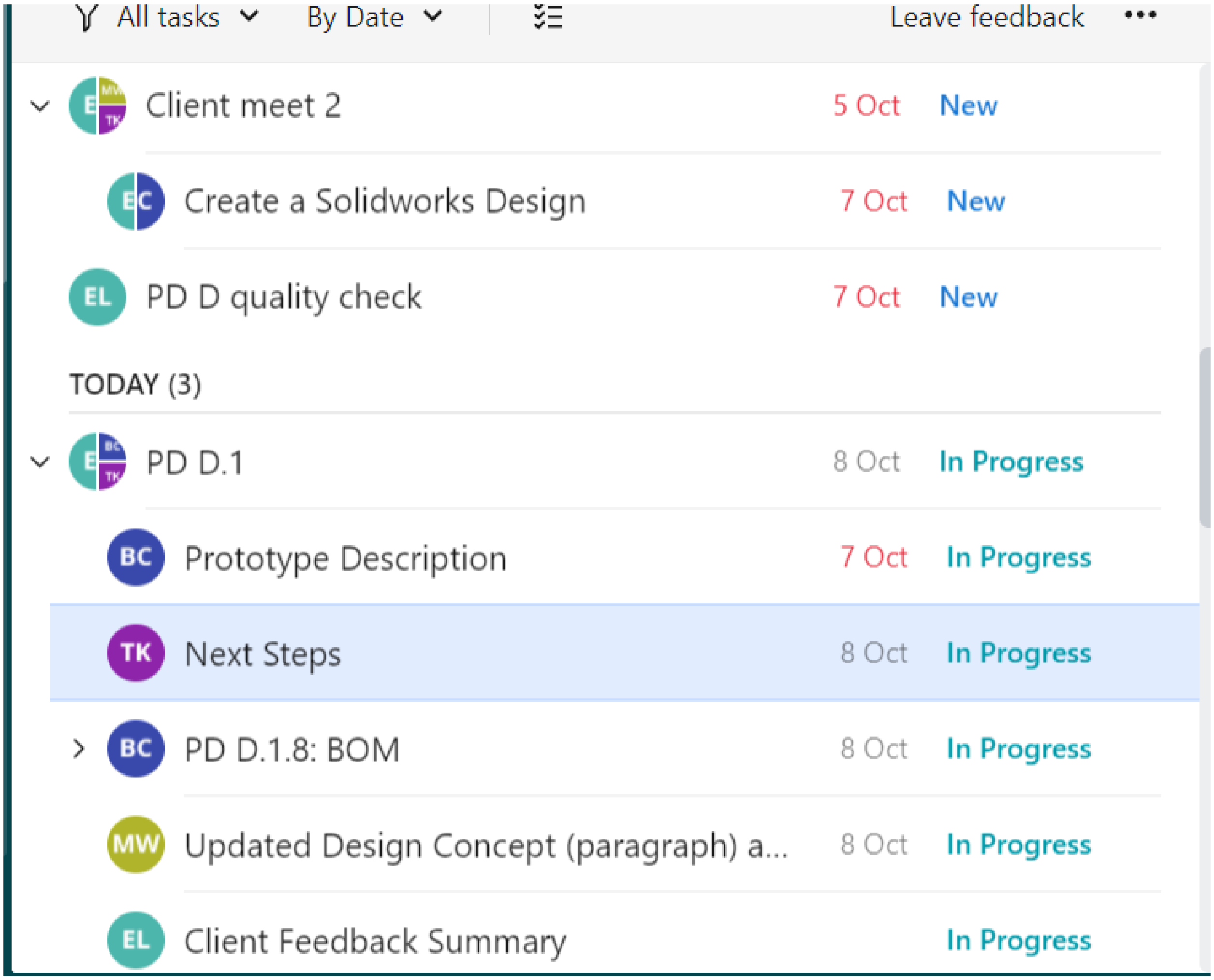
Bill of Materials

Item	Description	Quantity (Approx.)	Price	Source
Aluminium Flat Bar	Used to make a mounting system for the brake.	3' ($0.11/ft)	$3.96	Makerstore
Micro Linear Actuator/Push Pull Solenoid	Used to engage and disengage brakes.	1	$25-$30	Makerstore
9V Battery	It's a battery!	1	$1-$4	Makerstore https://makerstore.ca/shop
Bluetooth HC-05	Allows for bluetooth communication using Arduino	1	$12.99	MakerLab
12V Battery	Again, it's a battery.	1	$8.95	Amazon https://www.amazon.ca/Energizer-A23-GP23AE-Alkaline-Batteries
Arduino Nano	Used for logic and communication.	2	$8.00	MakerLab
Pushbutton	Digital Button	2 – 3	Free	Owned by multiple Team Members
Potentiometer	Analog potentiometer dial for force selection.	1	Free	Owned by Tahmeed
RGB LED	LED with ability to change colors for battery indication.	2	Free	Owned by multiple Team Members
Arduino Casing	Protects arduino	1	Free	3D Printed in L'Abbe
Controller Casing	Protects arduino in controller	1	Free	3D Printed in L'Abbe
Total			$68.85 (Approx.)	

This BOM is not exhaustive and may change pending future updates. Its goal is to document what materials are known to be needed at the current time. We intend to update and expand it in the near future.

Wrike Update





Team Name and Slogan

Name: BRAKEthrough Solutions
Slogan: *Take a Brake*

Conclusion

This document outlined the functional decomposition for our client's gait trainer, which breaks down the product into various subsystems and defines their boundaries. Afterwards, each group member came up with a minimum of three product concepts, which vary in scale between a function sub-system to a global concept. Finally, the team chose a few of these product concepts and created a global concept based on that will be developed further on future prototypes with the appropriate sketches and justification.