Deliverable C - Conceptual Design, Project Plan, and Feasibility Study

Group 8
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List of Tables

List of Figures

Introduction

This document outlines 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. This week, we plan on continuing to work on the first prototype and discuss improvements to our ideation.

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.

Design Criteria

Table 1- Needs Statement and Translated Design Criteria

Client Need Statements	Design Criteria
The braking system is safe and reliable.	Safety.
The braking system is durable and long-lasting.	Durability.
The braking system can be activated from a distance.	Remote braking.
The braking system is attachable and detachable while maintaining the trainer's state.	Portable.
The braking system functions in various common walking environments.	Environment versatility.
The system stops the trainer with controlled deceleration.	Gradient braking.
The system is adaptable to multiple versions/models of gait trainers and users.	Adaptability.

In the table above, the needs statements were translated into design criteria. Subsequently, the design criteria were used as guidelines during the brainstorming process.

Functional Decomposition

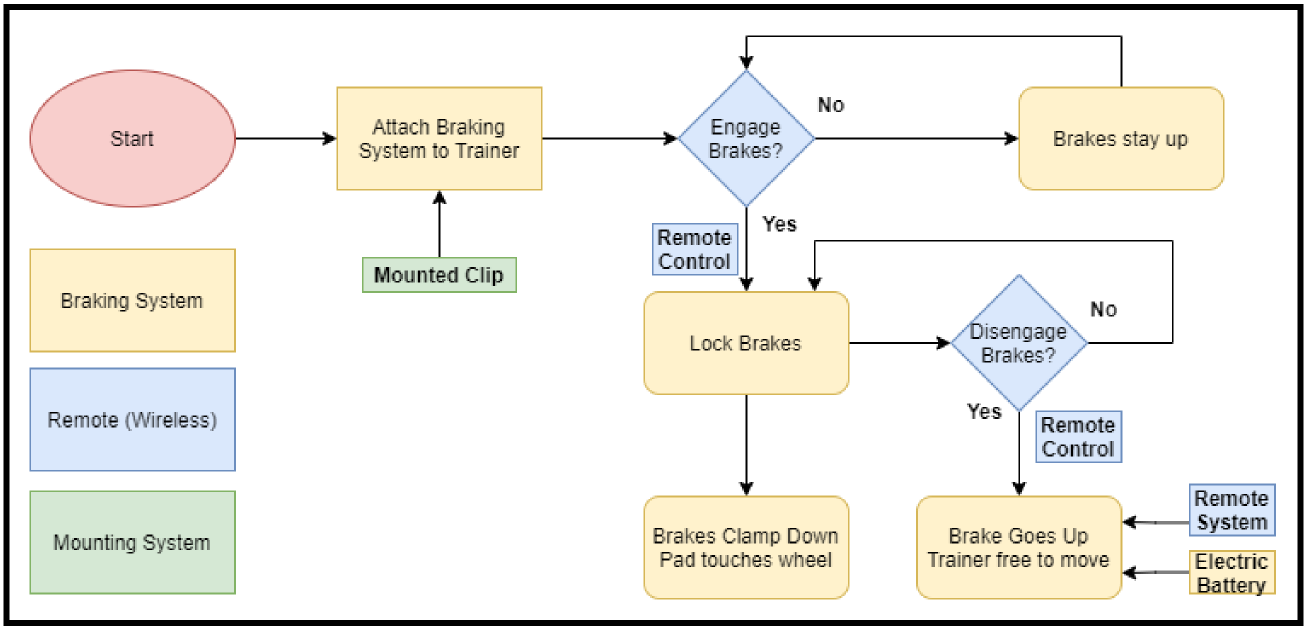
Based on the client requirements, the team came up with a list of tasks that the gait trainer should achieve and a breakdown of the systems that should be implemented into the gait trainer.

Table 2 - Functional Decomposition and Subsystems

Design Criteria	Subsystems
Safety.	Braking System (Mechanism attached to Trainer) 1. Type of brakes 2. Activation method 3. Can safely stop the gait trainer
Remote braking. Safety.	Remote (wireless) (Controller, Bluetooth) 1. Control Remote a. Remote layout/design 2. Wireless communication a. wireless module b. wireless standard
Portable. Safety.	Mounting System (Physical attachment to trainer) 1. Is removable from the frame. i. Clips on with a frame mount. 2. Does not alter the frame in any way.

A flow chart was created to clearly illustrate how different parts of the gait trainer interact with each other. Each step is color coded to one of the three subsystems detailed in table 2 as shown in the legend in the corner.

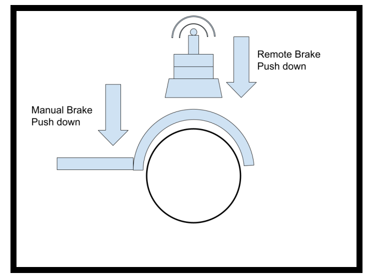
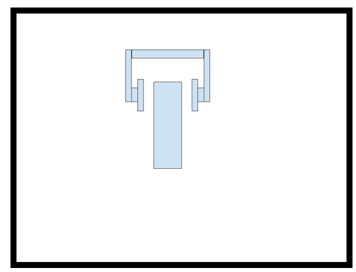
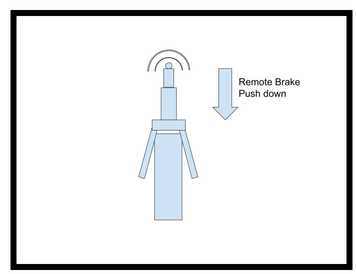
Figure 1- Flowchart for Functional Decomposition

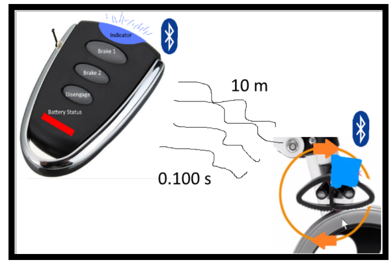
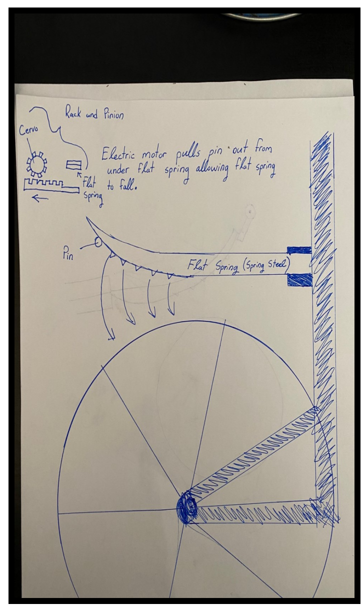


Conceptual Design

Table 3 outlines the individual concepts each group member came up with, which vary between a functional subsystem to a global concept.

Table 3 - Conceptual Designs

Person	Sub-System	Concept	Sketch
Tahmeed	Braking System	Manual Brake on front and that can be pushed down from remote-controlled piston “Groove on Wheel” design allows for manual braking as well	
	Braking System	Pistons clamp together on back wheels to brake. Similar to caliper brakes on a bike. Where the clamps come together should be adjustable on the z-axis. Cross section of the clamps could be rectangular or pointed. Likely could use a servo motor attached to string to clamp the two	
	Braking System	Two “arms” that extend and clip on together on the side of the wheel. Difference between this and the previous design is that the arms and the crutch itself slows down the wheel. Similar to a v-brake on a bike with the same string mentioned in the previous concept.	
Matt	Braking Controller	Holdable in one hand. Two braking speed options, plus a disengage button. Uses Bluetooth communication to transmit button data. Has indicators for Bluetooth status and Battery status. Battery is easily replaceable, and an on/off switch is present for battery conservation.	

<table>
<tr><td rowspan="2">Matt</td><td>Braking System</td><td>Servo motor which responds to Bluetooth transmissions. A stopper is rotated onto the wheel with varying force depending on the button pressed. When the brakes are disengaged, the stopper is rotated out of the way. When turned off, its natural state is disengaged.</td><td>
</td></tr>
<tr><td>Stopper Attachment</td><td>Attaches at the same spot of the reverse stopper. The reverse stopper can be unscrewed and detached to add the Servo-based braking system. It does not damage the gait trainer or affect the warranty to attach and detach the system.</td><td></td></tr>
<tr><td>Brad</td><td>Mechanical Braking System</td><td>This is not as much a system as it is a concept. The idea is to design a system in which only the activation and deactivation of the brake is done through electrical components. The braking system would be naturally inclined to be in a braking state, where for instance a servo would release a system's mechanical potential energy, which would apply the brakes. This eliminates the need for a constant power supply from the battery to apply the brakes. The drawing on the right uses the idea of a flat spring which is held out of its natural shape by a pin. The pin is then removed by an electrical cervo, causing the brakes to activate. The flat spring concept is impractical as it will eventually lose its elasticity, however it still demonstrates the idea.</td><td>
</td></tr>
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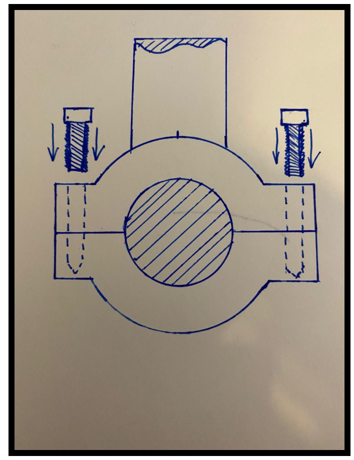
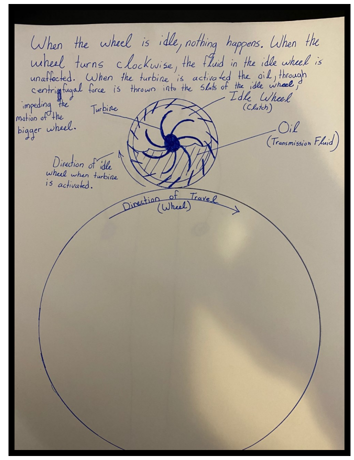
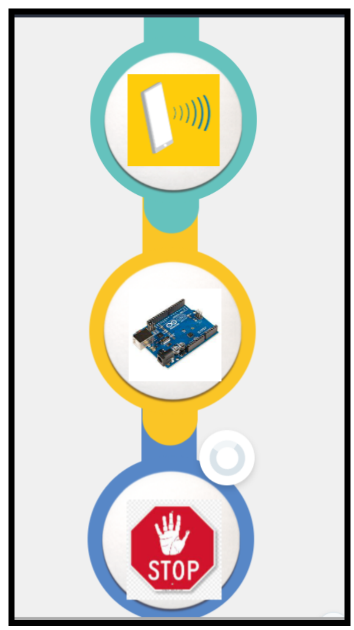
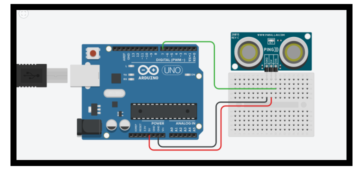
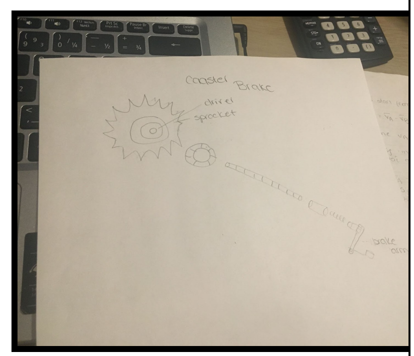
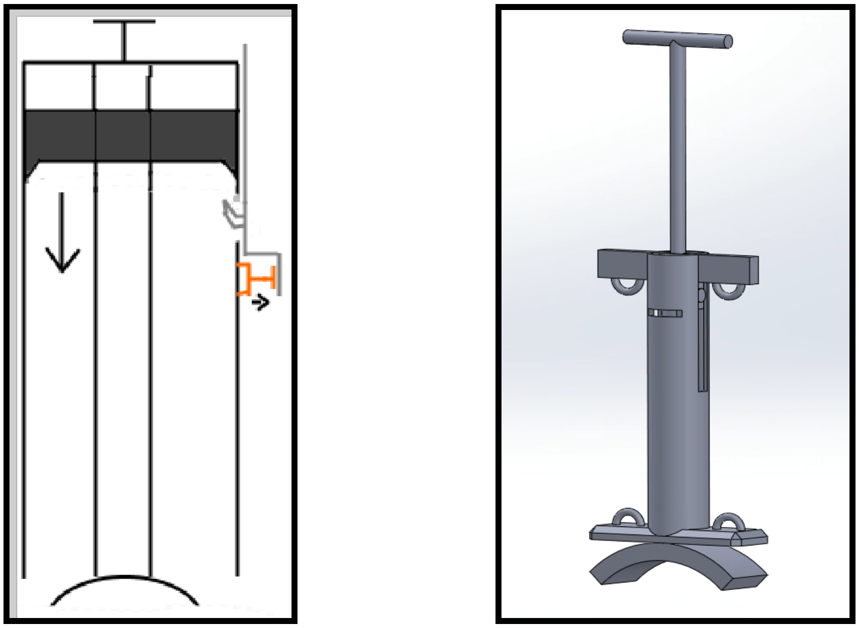
Brad	Mounting	This is a possible mounting solution for the braking system. Here two pieces of metal are machined to fit snugly around the back of the gait trainer's frame. They are fastened via allen screws on the left and right of the shaft.	
	Fluid Clutch Brake	This concept uses the idea of a fluid transmission system. When the wheel is moving forward, the idler wheel rolls with it not creating any resistance. When the turbine within the idler wheel is activated, the transmission fluid is thrown outward due to centrifugal force, entering the fins on the outer case. This creates resistance between the idler wheel and large wheel, decelerating the gait trainer. The issue with this design is that it may, once the gait trainer has stopped, begin to accelerate it backwards.	
Elsa	Global Concept	The remote braking system would have a remote control or app that would connect to an Arduino that would activate the brakes on the gait trainer. Preferably, the locks would be on the back wheels so as to not make the child fall forward.	

Elsa	Global Concept	Using sensors and an arduino, the brakes would automatically stop the gait trainer in case the guardian is not paying attention. Ideally, a remote would accompany the device in case the guardian does need to stop the gait trainer. This concept would be similar to anti-locks in a car.	
	Braking System	The wheels would not be able to move backwards by using a coaster bake similar to the ones on a bike. It would take some work to integrate it on the gait trainer.	

After analysis of the ideas for the braking controller, it was decided by the team that Matt's design satisfies both the client needs and target specifications for remote activation. Research indicates that Bluetooth has a range of about 10 m, which is the ideal target specification for remote braking range. Bluetooth transmission time seems to lie between ~50 ms and ~300 ms, which fits well within the acceptable transmission time specification. Also, a power switch allows for better battery preservation, and a Battery Status indicator promotes the safety of the overall system.

In terms of the braking mechanism, we decided as a group to combine a few of the ideas to best fit the most important client needs. In particular, we prioritized "The braking system is safe and reliable". We wanted a braking system that would not get weaker and the battery power depletes; therefore we would need a mechanical system that does not require much power to engage. Our overall concept ideas evolved over time and often combined elements from multiple initial concept ideas. We combined some concepts from Tahmeed's first Braking System, Brad's Mechanical Braking System, and Matt's Stopper Attachment. We settled on a spring-based mechanical system that applies pressure directly to the wheels of the trainer. This way, the braking distance specification can be met by simply testing different size/tension springs. With a primarily mechanical braking system, it would also conserve battery life, contributing to the battery life specification. The main drawback of this design is that the brake should be manually disengaged, which while intuitive, is not remote. The rough design sketches and visuals are shown below:

Figure 2 & 3: Conceptual Design



Conclusions and Reflections

To conclude, as a group we have discussed various ideas and concepts for how the gait trainer braking system would function and be designed. From the 12 individual concepts generated and target specifications, we narrowed our idea down to one global design that encompasses and expands on 3 of these concepts. The global concept was analyzed based on the target specifications and client requirements. We used knowledge from the previous course, GNG1103, to help guide us do the functional decomposition, generate the concepts and analyze the global solution as we had previously done so in our projects last year.