NORTHERN ARIZONA UNIVERSITY

GoBabyGo-D

GoBabyGo

Preliminary Report

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EXECUTIVE SUMMARY

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1 BACKGROUND

1.1 Introduction

Go Baby Go(GBG) is a project that aims at helping the children that are disabled to move just like normal children. This is by making them toy cars that they can ride on by themselves without the help of any other person. This is not a commercial exploit and the cars that are made through this program are given out for those who are in need. Our team is one of the many teams across the world that is doing this kind of work.

We intend to make a unique design of a child toy car. The team will come up with its own prototype, find the funds that are to be used to make the design then go ahead and do the work. We hope that after the completion of the project, we have helped one more baby to be able to ride on itself. This project is also a chance for us to give back to the society what it truly deserves and by giving them an avenue to give through this project.

The baby go baby project started with a research on the development of young children and how it affects their lives in the future. This was done by the pioneer of the project named Professor Cole Galloway from Delaware University. Per Galloway, if a child has a vibrant childhood, they tend to have a more normal adulthood. He said that children ought to play and have all the fun in the world and even if they are disabled and if they do, they will be no different from any other children when they grow up.

Some of the benefits that the child will get is having a better intellectual capacity. When children are playing, and moving about and discovering things, it builds their intellectual capabilities. The second benefit is that it leads them to being able to relate well with other people. When children are playing, they can make friends something that they will be able to do in the future if they are able to have fun with the cars in their young age. Finally, it will be a form of rehabilitation to the children. It will help to strengthen their weak bones. One of the main goals is to make them feel that they are normal and have the ability to interact with other kids.

1.2 Project Description

Children with limited mobility often do not receive the much-needed exposure to socialization to appropriately cognitively develop. Existing research shows that equipping young children with self-control of their own environment can have meaningful impacts on the long term outcomes given such impairments as cerebral palsy or muscular dystrophy. The Go Baby Go (GBG) project that started at the University of Delaware has developed a set of DIY cars for families with children with mobility restrictions. These cars have been designed on commercially available ride on toy car platforms (like Power Wheels) and have been deployed worldwide by the GBG team. These cars have shown to be a cost-effective means of enabling young children to move and interact with their peers.

"The goal of this project will be to design and build a new version of the GBG retrofits – specifically to design a universal control for children with extremely limited mobility of their arms and/or legs".

1.3 Original System

This project involved the design of a completely new <Pressure Pad Go Baby GO>. The project involves a lot of new designs that the team has accomplished in order to build a new highly developed go baby go car. Other retrofits of Go Baby Go are mostly old fashioned since they all depend on a car and some modification done to them.

1.3.1 Original System Structure

The original system is something unique that is something completely different from all ideas designed for GBG. It's going to be a toy car with a lot of modifications. The GBG team would like to establish a toy ride that satisfies the needs of the disabled child with the newest technologies such as a hand pressure system that makes the child wander around by themselves without the help of a parent and a new technology that would use renewable energy sources as a part of the car to make it environmentally friendly. This is just one of the modifications that the team will develop throughout the project. The objective of this project is to build a cheap cost car with the latest technologies to help serve the child better.

2 REQUIREMENTS

The GBG team met with the client Dr. Oman to get briefed on the current customer requirements based on the project description that was provided to the team. These customer requirements must be met by the final product.

2.1 *Customer Requirements (CRs)*

The GBG team has five main customer requirements (CR) which will be weighted using a scale of 1 to 5 (5 = top), depending on the importance of each CR.

In the table provided below (Table 1), there is a list of customer requirements – each requirement has a brief description to clarify customer requirements clearly.

Table 1 Customer Requirements

Customer requirements	Description
Power system	**The system should include an acceleration controller, cruise controller, and safety breaks**
Physical	**The system should have comfortable seats, trunk mobility, and legs supporting**
Operating system	**The system must be easy to operate, so the child can use it easily**
Financial	**The system must be low cost that not exceed $ 400**
Safety	**The system should ensure the safety of the child, by having seatbelt harness and bars.**

2.2 Engineering Requirements

The following Engineering requirements were created by GBG team to achieve and ensure the whole five main customer requirements.
In the table provided below (Table 2), there is a list of Engineering requirements, each requirement has a brief description to clarify engineering requirements clearly.

Table 2 Engineering Requirements

Engineering requirements	Description
Weight (lb.)	**The final solution should not exceed 60 Ib. as a total wait, so it can be easy to move or carry**
Price/cost ($)	**The final solution should be less than $400 as a maximum cost for the device**
Smooth sides (rad)	**The system should have smooth angles to ensure safety from sharp edges**
Suspension (lbf/in^2)	**The system should have springs to ensure there is no jerking motion while using the system in curved roads**
Store energy (w)	**The system should generate and store electrical energy**
OSHA Standards	**The system should meet OSHA's standards to ensure the safety of the child**
Multiple speeds	**The system should have at least 3 different speeds (low, medium, high)**
Steering options	**The system should have new idea of steering options instead of the regular steering wheels**

2.3 Testing Procedures (TPs)

Testing procedures focuses on how attributes is helping in how to cover the ranges of engineering requirements. Every engineering requirement has a design link. Below a table of each engineering requirement with how it meets towards design link.

Table 3 Testing Procedures (TPs)

Engineering requirements	Description towards testing procedures
Weight (lb.)	**Weight somehow related by the material used or the size of the design, taking the weight of each material will be used to consider if it exceeds the target or tolerance**
Smooth sides (rad)	**checking the goods that the team is going to buy for the project, team found there is no sharp edges for the pieces they are buying.**
Store energy (w)	**Typical to the design the team building, the battery age is 1 hour, through having a recharger for the battery, team figured they can add 15 mints more**

2.4 Design Link (DLs)

Design link introduces how each engineering requirements is being satisfied through constructing the proposed design. Every engineering requirement has a design link. Below a table of each engineering requirement with how it meets towards design link.

Table 4 Design Link (DLs)

Engineering requirements	**Description towards design link**
Weight (lb.)	**The final design meets greatly with the weight, mostly to our predictions based on researches, the weight will be within the**
Price/cost ($)	**The final solution budget was successful by reaching our target which was 350$**
Smooth edges (rad)	**The design have smooth angles that ensured the safety of the child and reached the target by having a curved edges**
Jerking motion	**Initially our final design have no jerking motion, which covers the target of jerking motion, there might be new challenges when we build the design**
Store energy (w)	**The design storing the energy using a battery. The battery can not be charged while driving, team covered the ER but did not**
Multiple speeds	**The final system have no speed options which is better than the teams target, as it accelerates from zero to the maximum speed**
Steering options	**The final design have a one way of steering options, which is driving using a sort of pad to control the design**

2.5 House of Quality (HOQ)

The current house of quality is a diagram which helps in determining how the customer needs are being valued and weighted with regards to the product.

Table 5 HOQ

Customer Requirement	Weight	Engineering Requirement	Weight << (60 lb)	Price/cost << (400$)	smooth edges >> (no 90° angle)	jerking motion << (no jerking motion)	Store energy >> (1 hour)	Multiple speeds >> (2 speeds)	steering options >> 2 ways	OSHA Standards >>
1. Power system										
a. Control acceleration	5		9	5	0	0	9	9	9	9
b. Cruise controller	3		9	5	0	0	9	5	5	9
c. brakes	5		5	0	5	5	5	9	5	9
2. Physical										
a.Comfortable seats	5		1	5	9	5	0	0	0	9
b. trunk mobility	4		9	0	0	0	0	0	0	0
c. legs support	3		0	9	9	0	0	0	5	9
3. Operating system										
a. easy to operate	5		0	0	5	1	0	9	9	9
4. Financial	5		0	9	0	0	9	0	0	0
5. Safety										
a. Seatbelt harness	5		0	0	0	0	0	0	0	9
b. bars	3		9	5	9	0	0	0	0	9
Units			lb	$	rad	N/A	W	m/s	N/A	N/A
Target			45lb	350$	90	no	1.5 hrs	3	2	N/A
Tolerance			55 lb	380$	80	less	1.25 hrs	2	1	N/A
Testing Procedure (TP#)			5	4	1	4	5	5	5	N/A
Design Link (DL#)			4	1	7	6	5	2	3	N/A

3 EXISTING DESIGNS

There are many existing designs for GBG created out of similar ideas of a wheel chair, toys and mobility games. Three different ideas caught the group's attention: the scoot, the current GBG retrofit (electric car) and the scooter. These products have some disadvantages that need to be fixed or improved. The team will start to think briefly in order to create a new idea for mobility that could meet the clients need. The existing design element of this project is important for the team and will be helpful for the future of this project.

3.1 Design Research

On November 2015 Go Baby Go organization was created. This organization is taking care of children with special needs to make them feel like normal children by building mobility to let them play [6]. Kids with special needs are part of the community so Go Baby Go program will get them achieve their dream and play as and have fun. The organization facing some difficulties on designing Go Baby Go Devise because every single child has a particular need. Also, the group facing that challenges too.

While research most of the Ideas are similar to each other and most of them are expensive. The group has a limited budget to make a new design with all specialty that required from the client so in this research missed all too expensive idea of GBG. Most of the research was from online websites and most of the team members got a lot of Ideas since they learned ME286 class at the Northern Arizona University. There are other universities have GBG program, it seems that all schools were beating each other to create a new design that can be useful for kids. Almost all university do not have a unique design for GBG just a toy car that have new modified Idea.

3.2 System Level

The GBG project requires a main system of mobility to transport a child from point A to point B. The current systems mainly depend on using a retrofit with tires to transport the child. The main system level will be dependent on the customer requirements and on how it relates to the requirements. Accordingly, there are many different systems that were used for each retrofit. For example, wheelchairs rely on human energy in order to move a patient from point A to point B.

The 3 main system designs which will be discussed in the subsequent pages are the following:

1) Scoot
2) Current Go Baby Go retrofit (electric Car)
3) Scooter

3.2.1 Existing Design #1: Scoot

The scoot is a current main system that is used for both normal and disabled children to transport them from a point to another. This system could be used in three different ways – the first method is that it can be used by crawling. Crawling will help the child in exploring and strengthening the upper body muscles such as the abdominal area [2]. The second way to use this system is by scooting. Scooting allows the child to move while sitting up straight and using their legs. This will help the child move more freely to explore outer surroundings. The final way to use this device is by riding it. The device allows the parent to add a tire on each side which will make the device act like a wheelchair. This system will depend completely on human energy since there are no electrical components involved and the child will have to move physically by himself or herself to maneuver it.

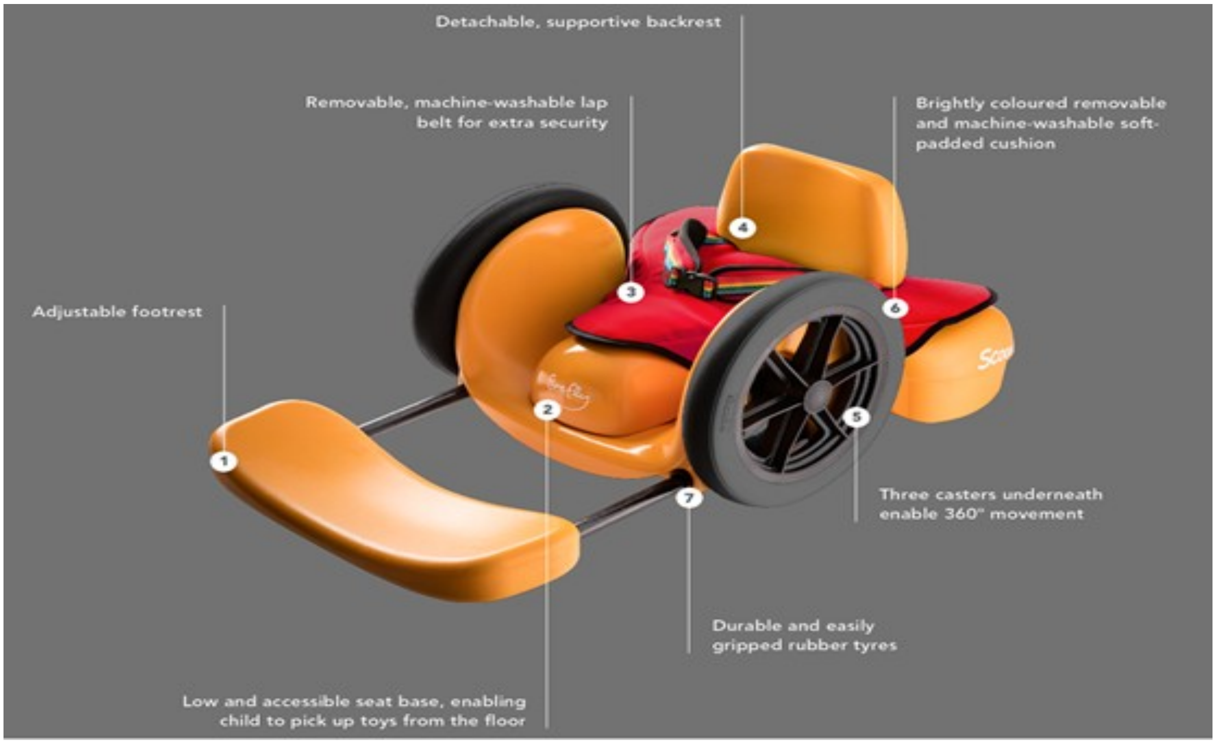


Figure 1: Scooot[2]

3.2.2 Existing Design #2: Current Go Baby Go Retrofit (Electric Car)

The current design for the GBG project is a great system for use by disabled children to socialize and transport themselves freely and independently. Current Go Baby Go retrofits are based on electric toy cars that are modified based on each requirement [1]. The cars are cost-- effective and do not cost much compared to medical solutions that cost much more than the GBG retrofits. This current system relies on electrical power that is controlled by the child in order to accelerate and decelerate. The present solution mostly does not control acceleration – it is only adjusted to one speed. Each retrofit is designed differently depending on the disability of the child.

Figure 2: Current GoBabyGo Retrofit [1]

3.2.3 Existing Design #3: Scooter

The final existing system that is used is the toy scooter. The chosen system is a three-- wheeler retrofit that depends on human energy in order to move [3]. This device is mainly used to transport the child from one point to another using the three wheels attached. Additionally, there is a stick which allows the parent to control the movement of the child with regards to the direction of the scooter. This will give the parents more control over the child in terms of their movement and will therefore not be able to meet the requirements for most disabled children.

Figure 3 Scooter[3]

3.3 Subsystem Level

Any machine or mechanical design must contain a support system for main system mobility – for example, controlling parts and energies. For this GBG project the team will follow the sponsor's requirement with regards to the design in order to help normal and disabled children. During the research stage, there were three main categories of subsystems that the team explored: human power, electrical power and main control system

3.3.1 Subsystem #1: Human Power

Human power represents energy that is transferred from the human body to power a machine into operating. This may involve using one's arms and legs [4].

3.3.1.1 Existing Design #1: Arms

As shown below in Figure 4, arms are the source of human power of the scoot's main subsystem. It works when a disabled child pushes and rolls the scoot's wheels in order to move from one place to another.

Figure 4:Scooot Wheels [2]

3.3.1.2 Existing Design #2: Legs

Figure 5:Scooter Pedals[3]

Legs are the most efficient power source for many transport machines, such as a scooter. In the scooter's existing design, we can see that children have the ability to move the scooter by pushing the pedals.

3.3.1.3 Existing Design #3: Human muscles

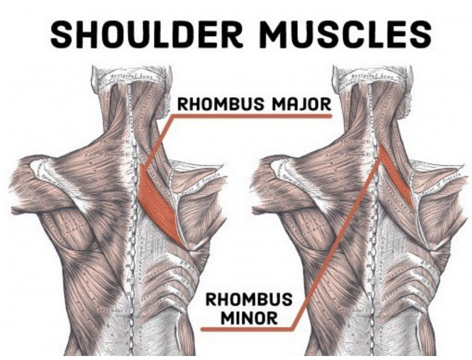


Figure 6 Shoulder Muscles [7]

Human muscles is another source of human power. For example, children's that do not have arms and legs they can use the shoulder muscles as a human power body part. Moving the muscles sideways and the design will move is one of the human body powers.

3.3.2 Subsystem #2: Electrical Power

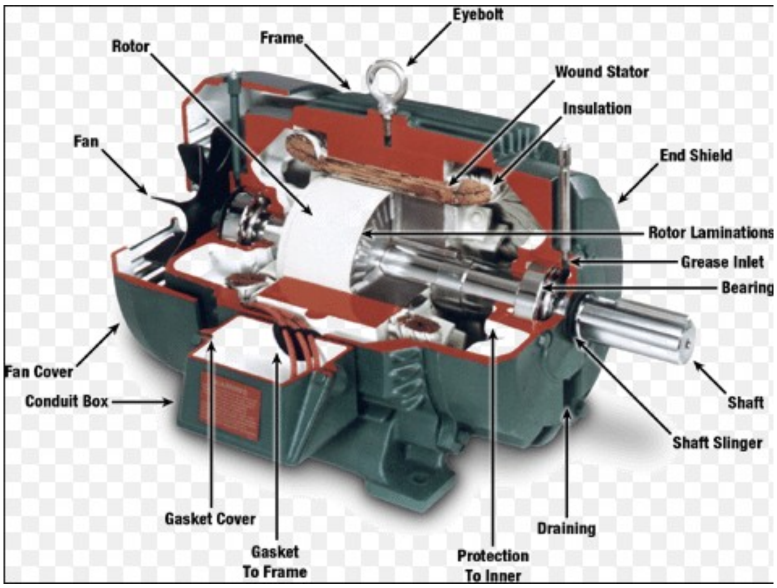
Electricity has been used in everyday human life consistently because it is a strong source for machines. There are two existing designs which showcase the usages of electrical power – this report will now outline two of those: batteries and electric motors.

3.3.2.1 Existing Design #1: Battery

Batteries are good sources of energy. They have chemical energy contained within the case which can be converted to electrical energy. Some batteries can be recharged as well.

Figure 7 Batteries [8]

3.3.2.2 *Existing Design #2: Electric Motor*



Using an electric motor as a subsystem converts electricity to mechanical energy. Therefore, this piece of machinery will help with the GBG future design.

Figure 8 Electric Motor [9]

3.3.2.3 Existing Design #3: Solar Panel System

Solar panel system works by collecting photons from the sun, then release electrons from the solar panel to the wires or any electrical device to run the machine.

Figure 9 Solar Panel System [10]

3.3.3 Subsystem #3: Main Control System

Every device should have a spatial control system – in cars, this allows the rider to control the vehicle and display its duration. For this subsystem, a steering wheel and pressure pads have been deemed to be the most effective for the purposes of the GBG project.

3.3.3.1 Existing Design #1: Steering Wheel

Most vehicles have steering wheel to control it, and the team might use this control system for the car.

Figure 10 Steering Wheel [11]

3.3.3.2 Existing Design #2: Pressure Pads

Self-- balancing scooters have become very popular today. They operate according to a clever idea – the pressure pads are fixed around the scooter. They work by having many small systems implemented under the pads, so that human balance and nerves from the body control how the scooter operates – to move, stop, steer and rotate [5]. The team is interested in using this notion by designing a hand pressure pad instead of self- balancing pressure pads which require the use of the legs. These hand pads will help children who suffer from disabilities involving their legs so that they can control the car by using their hands instead.

Figure 11 Pressure Pads [14]

3.3.3.3 Existing Design #3: Joystick

Joystick control system have been used for video games, but in our case using a joystick as a control system for the car designs. By select any button on he joystick the car will start work and by moving it the car will move for the directions the person choose.

Figure 12 Joystick [12]

4 DESIGNS CONSIDERED

The hypothesized functional model is an important aspect of this report because it is what challenges you to know and understand the way your project works and functions. As for the material, energy, and signals used in the device you created. It tells you clearly what is inside your project, how it works, and what comes out of it. Creating the functional model has given our team the ability to understand how to work the device and how it will operate without the use of some sources of the device. Engineers are supposed to know how to reverse engineer their projects, with the black box and hypothesized functional model you are certainly able to achieve the qualified standards for any device. The models clearly give you true understandings in determining the inputs, outputs, and the sub functions of the project its self. The team learned exactly how to deal with the pressure pad and the signals that moves it. In reverse engineering, you need to know the ins and outs of the signals its self to have a better moving of the project. The group also learned if in any case the project becomes expensive there are parts that can be reduced to lower the cost. A functional model has taught us a lot and how to take care of many parts of the project.

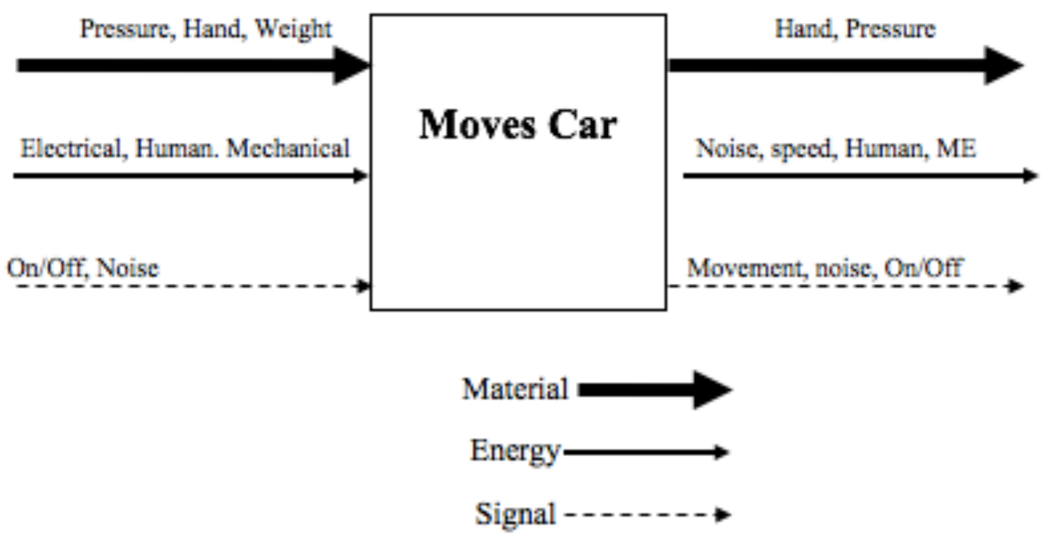


Figure 13 Black Box Model

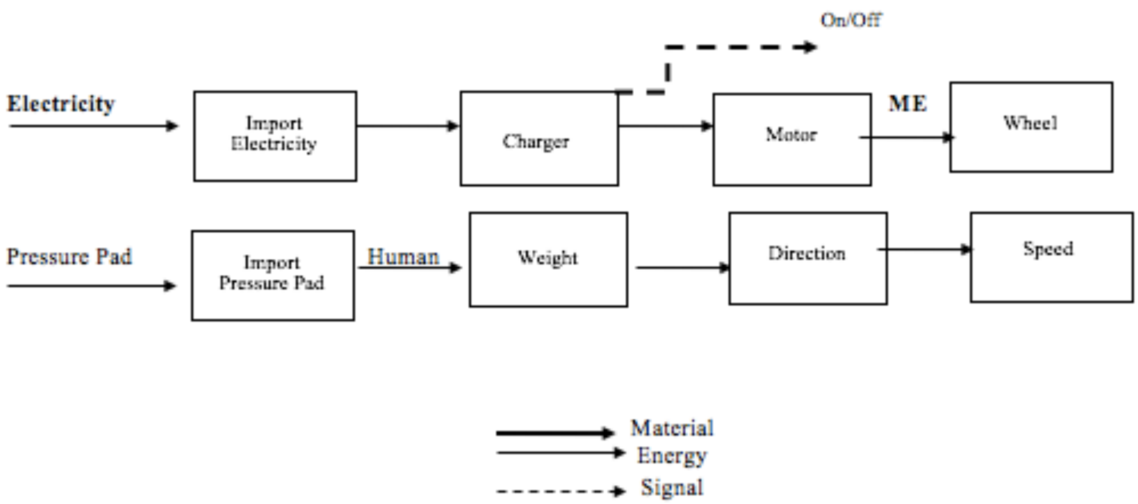


Figure 14 Functional Model

4.1 Design #1: Suspension Seat

In this design there is a screen control system, back support seat attach to the seat with safety bars, and between the seat and the tires they are attached to a suspension system.

Advantages: 1. No jerking motion due to suspension system.

2. Safety Bars.

Disadvantages: 1. The height of the seat might not be pleased to the children due to not touching the ground.

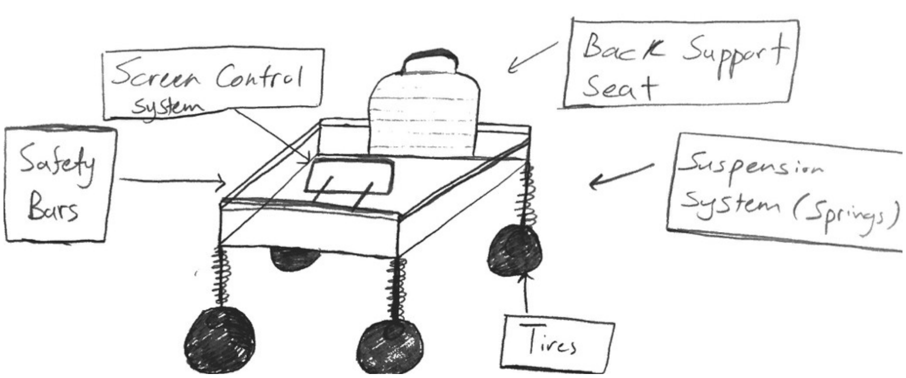


Figure 15 Suspension Seat

4.2 *Design #2: Hover board Bed*

This basic design is all about self balancing hover board pads system, so its tires attached to chain gear system with the actual tires therefore, when the tiers on the self balancing hover board pads tiers rotate the actual tiers rotate also.

Advantages: 1. Due to seat belt it will add more safety for children's.

2. The child will ride the seat easily because the car has low height.

Disadvantages: 1. The chain gear might fail.

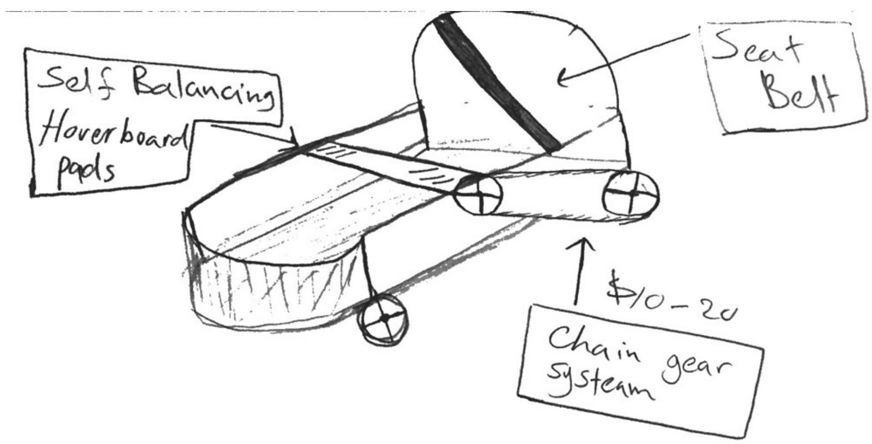


Figure 16: Hover board Bed

4.3 *Design #3: Monitor scooter*

The design has a normal scooter design but there are some changes to it. Instead of scooter steering wheel the team decided to have a monitor touch screen system. Another change is having a comfortable seat with seatbelt harness.

Advantages: 1. By having the touch screen so it is easy to control.

2. Extend the safety by having a seatbelt.

Disadvantages: 1. The weight of the user might affect the balance of the chair.

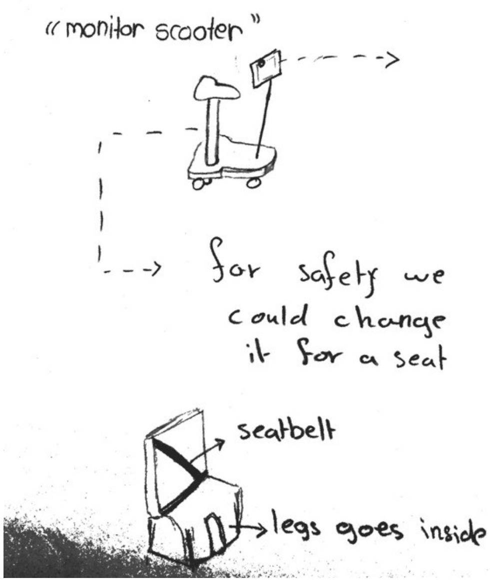


Figure 17 Monitor scooter

4.4 Design #4: Electric Scoot

This a scoot design that from the benchmarking but instead of physical use, the team added a hand pressure pads control system to make electric scoot.

Advantages: 1. Comfortable seat.

2. The child can feel the ground.

Disadvantages: 1. It is too low device have to elevated a bit.

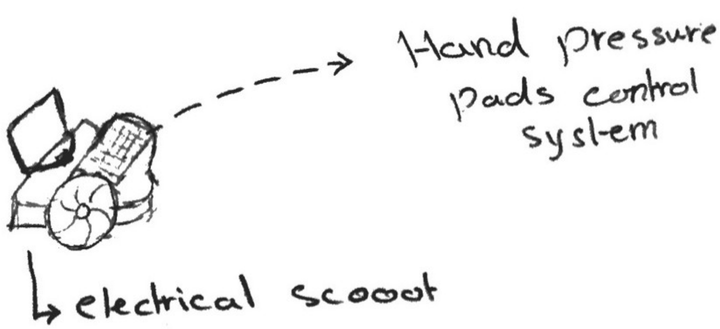


Figure 18 Electric Scoot

4.5 *Design #5: Hydraulic Baby Walker*

This CV has a hydraulic system so the child has the choice to move freely and the baby walker also has control panel system.

Advantages: 1. With the hydraulic system the child going to feel freely.

Disadvantages: 1. There is not enough safety features therefore, the guardians need to watch out of them.

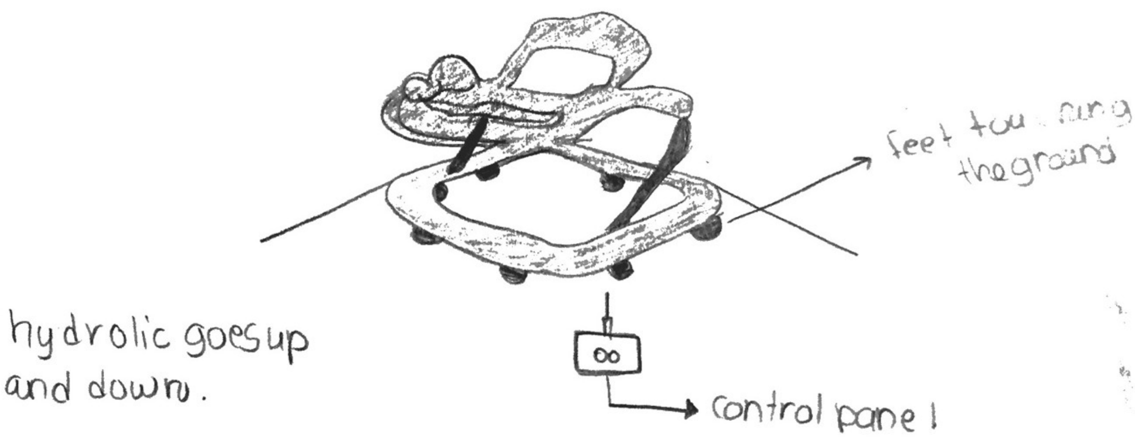


Figure 19 Hydraulic Baby Walker

4.6 Design #6: Baby Walker

This design is a normal baby walker but the team want to add an engine and can be controlled by control panel.

Advantages: 1. The child has the ability to control the baby walker.

Disadvantages: 1. The engine is underneath the child without a safety box.

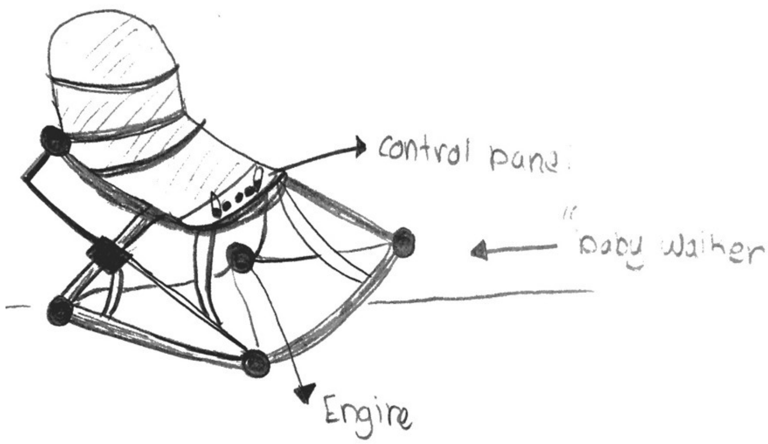


Figure 20 Baby Walker

4.7 Design #7: Speed and direction Controller

This design has a speed and direction controller system by using the feet therefore, the steering wheel is fake. Also the design has a both auto and remote control brakes.

Advantages: 1. Comfortable seat.

2. Remote control brakes for guardians.

Disadvantages: 1. Due to the car move using feet, it is distracting to have a feet brake too.

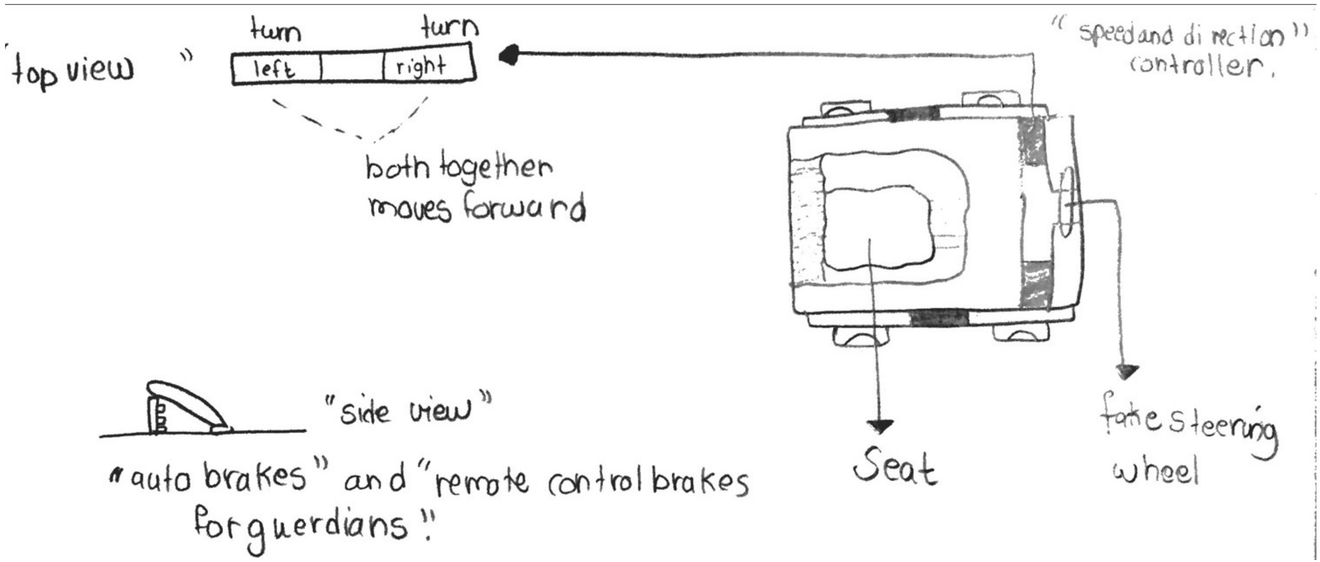


Figure 21 Speed and direction Controller

4.8 Design #8: Superman Bed

The idea of this design is came from a hospital bed. So the child can lay down on their belly and use the control steering wheel, that attached to the engine too.

Advantages: 1. Comfortable use by lying down.

Disadvantages: 1. The bed is too big to control.

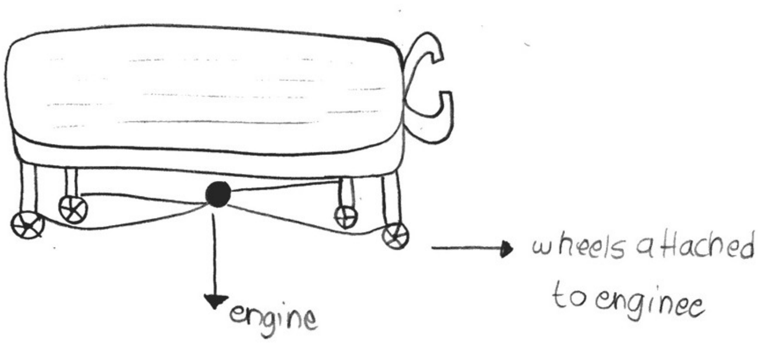


Figure 22 Superman Bed

4.9 *Design #9: Pumping Ball*

This ball design is can be used over water and grass. There is an oxygen motor for the user to breath and air pump for the ball.

Advantages: 1. It gives a change for the child to use their physical body.

2. Easy to use in the pool.

Disadvantages: 1. The ball can break easily.

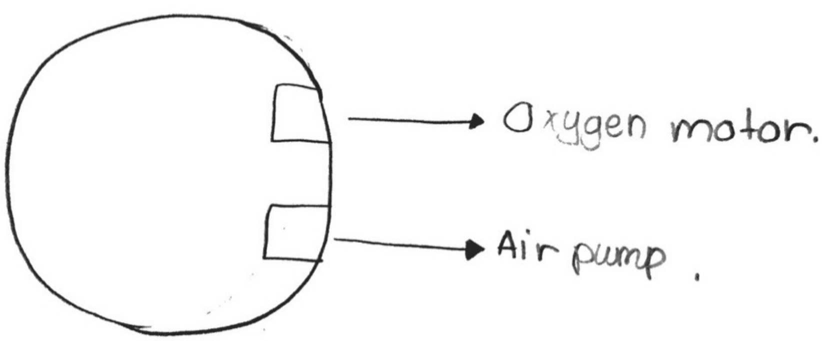


Figure 23 Pumping Ball

4.10 *Design #10: Scooter*

On this scooter design it has a comfortable seat with harness seat belt and a scooter steering wheel. Also this design has a three wheels for stability.

Advantages: 1. Comfortable seat.

2. Not dangerous to use.

Disadvantages: 1. The steering wheel is too high to reach.

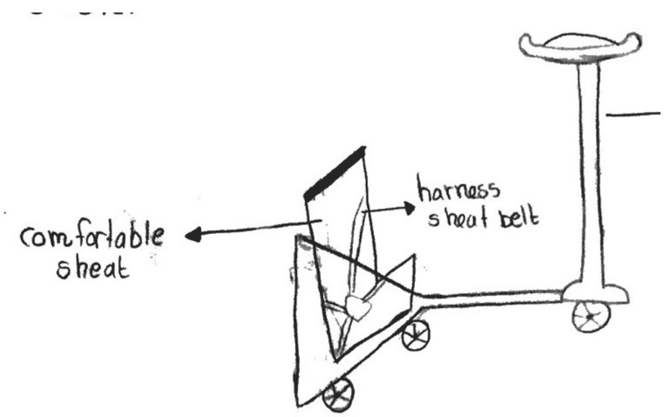


Figure 24 Scooter

5 DESIGN SELECTED

5.1 Rationale for Design Selection

5.1.1 Pugh Chart

The team has created a total of 20 concepts in order to finalize the design of the project. The concepts were created based on different customers such as normal children and children with disabilities. The team then chose the top 10 design in order to compare them using the Pugh chart below. The Pugh chart comparison was depending on the criteria below where all designs were compared to CV9 design. CV9 was chosen since the design was an out of the box design and the lowest in meeting the Pugh chart criteria. The chart below will display the most creative designs in order of having most positive signs. The winning designs in the Pugh chart were CV's 2;; 4;; 5. The winning designs later moved to be compared in the decision matrix in order to choose the final design

Criteria

a. All materials and construction cost must be under $1500

b. Development risk (will it work? What are the chances it won't?)

c. Technical difficulty (Does the team have the skills/resources to create the CV?)

d. Schedule risk (will the team be able to finish the device by the due date?)

e. Does it meet the customer requirements?

f. Does it have jerking motion?

g. Is it accurate?

h. Is it made of standard components?

Table 6 Pugh Chart

Concepts	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
a	+	+	+	+	+	+	--	+		+
b	--	S	--	--	+	--	--	--	**D**	--
c	--	+	--	--	+	+	--	+		+
d	S	S	S	S	S	S	S	S	**A**	S
e	+	+	+	+	+	+	S	--		S
f	+	+	--	+	S	S	+	S	**T**	+
g	+	+	+	+	+	--	+	--		--
h	--	+	+	+	+	+	+	+	**U**	--
Σ +	4	6	4	5	6	4	3	3		3
Σ--	3	0	3	2	0	2	3	3	**M**	3
ΣS	1	2	1	1	2	2	2	2		2

5.1.2 Decision Matrix

After considering the three designs from the Pugh chart CV 2; 4; 5. The team used decision matrix (table 7) with the same criteria that has been used in the Pugh chart. The criteria weight has to be sum of 1 therefore, the team weighted the most importance to less importance for each criterion. After weighting the criteria, the team considered a raw weight out of 100 for each CV with each criterion. Then the teams used the weight criteria and multiplied it with the raw weight to get the final weight of each CV. Finally, by sum up the final weight the team gets the total weight for each CV, and ranked each CV from the highest total weight. The final design that the team will design is CV4 the electrical scoot.

Table 7 Decision Matrix

Designs		CV2		CV4		CV5	
Criteria Weight							
All cost must be under $1500	0.1	80	8	85	8.5	40	4
Development risk	0.2	80	16	90	18	40	8
Technical difficulty	0.25	80	20	80	20	60	15
Schedule risk	0.15	90	13.5	100	15	75	11.25
Does it meet the customer requirements?	0.1	85	8.5	85	8.5	70	7
Does it have jerking motion?	0.05	100	5	100	5	80	4
Is it accurate?	0.1	70	7	75	7.5	30	3
Is it made of standard components?	0.05	85	4.25	85	4.25	100	5
Total Weight	1		82.25		86.75		57.25
Relative Rank			2		1		3

5.2 Design Description

5.2.1 Hoverboard Analysis

5.2.1.1 Introduction

Since its introduction, hoverboard has demonstrated widespread popularity across the country and globe in equal measure. The hoverboard is also known as two-wheeled and self-balancing scooters. Over the last few years, the production of hoverboards has skyrocketed following a massive consumer demand for the technology, especially in 2015. However, the mass production has led to the poor production of some Hoverboard brands. As a result, the popularity of the technology took a turn for the worse as several incidents of fire were reported across the globe.

5.2.1.2 Problem statement

Hoverboards have been catching fires all over the country and across the globe in equal measure. This has led to the issuance of several bans across numerous countries and states. Apart from the UK, several states in the U.S have issued regulations to ban the production, sale and use of hoverboards in public area [14]. The bans are as a result of safety concerns from Hoverboard fires as well as several injuries associated with the technology. While Hoverboard is a two-wheeled and self-balancing device, the safety and balance of the rider are not guaranteed.

These fires have been associated with the complications as a result of Lithium-ion batteries. The batteries are made of a flammable electrolyte and very slim covers. While hoverboards are safely designed, the complications as a result of Lithium –ion battery renders them unsafe for use. However, it is imperative to note that the way the batteries are used and packed in the Hoverboard is also a source of the problem. The main reason for hoverboard fires is due to the fact that the batteries used are more powerful as compared to those used in laptops and smart phones. Additionally, some of the batteries are of poor quality.

This project will attempt to address the current issue of hoverboard fires by assuming a novel design that regulates the power consumption of the technology. Also, several design modifications will be made to the type of power source used for the hoverboard design.

5.2.1.3 Components

A hoverboard, a two-wheeled, auto-balancing scooter, is made up of several different components: steel or aluminum frame with a central pivot, two wheels, a logic board, two gyroscopes, a lithium-ion battery pack, a motor, pressure pads, infrared sensors, a charger and a plastic shell. Additional accessories may include a remote control, Bluetooth and LED lights. The logic board is used to regulate the speed of the hoverboard. It is also used to control the tilt of each wheel.

The hoverboard technology employs the use of a self-balancing steering system that is same as Segway unit. The pressure sensors configured on the technology are used to control the board. It is controlled through pressure sensing switch pads which are situated under the foot deck of the board. When the pressure pads are pressed backward or forward, they compress the switches beneath them thus blocking light from light from reaching a light sensor. An internal LED is used to generate light used in the pressure sensors. The board continues to remain immobile as long as the light is hitting the detector. The logic board is used to active the matching motor to rotate in a specific direction when a section of the light is obscured from reaching a sensor.

5.2.1.4 Control logic

The operator can employ the use of this logic to control the speed of the board by shifting the amount of pressure in each foot pad. Additionally, the user can employ the use of the same logic to regulate the direction of movement through the use of opposite foot motion. The logic board plays a significant function in the operation and design of the board. It is responsible for the control of tilt and compression variables. These variables allow the user to utilize the logic board to change the direction and speed of the hoverboard [14]. Alterations of the tilt variable are used to control the direction of the two-wheeled, auto-balancing scooter, while the alterations of the compression variable are used to regulate or alter the direction of the hoverboard.

5.2.1.5 Lithium Ion Battery

Hoverboard employs the use of lithium-ion battery pack as the main source of power. The lithium-ion battery pack is made up of a collection of individual lithium-ion cells. The battery pack used in hoverboards is rated for 36 V and has several thousand mAH capacities. The technology requires a lot of power since it is used for movement. Lithium-ion battery is basically used for energy storage. It is used to transform chemical energy into electrical energy through a chemical reaction. Lithium ions move from the anode to the cathode through an electrolyte during the discharge phase. On the other hand, the opposite process occurs during the charging phase of the battery. Lithium ions move from the cathode, through an electrolyte, to the electrode. This process converts the chemical energy stored in the battery to electrical energy which is used to power the hoverboard.

This design will employ the use a fuse to prevent the overcurrent discharge or overcharging of the lithium-ion battery. Apart from a fuse, the design will employ the use of a cut-off switch to regulate the amount of current drawn from the lithium –ion battery. A cut-off switch or a fuse plays a significant role in regulating the rate and level of charging as well as the amount of current drawn from the battery pack. As a consequence, it addresses the current issue with hoverboards by preventing unwanted and explosive chemical reactions within the battery. It is imperative to also note that faults with the hoverboards can be attributed to the damages within the battery cells and the insulating material inside the battery which can result in internal shorting, thus lead to a fire.

There are several standards and tests that can be used to assess the design and aptitude of a battery to sustain normal operations and various types of misuse [13]. Customers and users of hoverboard can identify whether a product has attained the applicable regulations and rules through the use of the CE marks or statewide acknowledged testing lab mark. The standards for lithium ion battery, UL 142, demands charge-discharge cycle testing, in addition to impact, shock and crash tests.

5.2.1.6 Equations for calculations and assumptions

To address the problem associated with the hoverboard fires and explosions, it is imperative to analysis the amount of power stored or that can be drawn from the battery without causing overcharging or overheating. Additionally, it is crucial to determine the duration that the batteries used in the hoverboard should be charged.

The discharge time of lithium ion battery is the mAh or the Ah rating divided by the current drawn by the hoverboard [13].

$$\text{Discharge time} = \text{current capacity of the lithium} / \text{load current}$$

For instance, if the electrical components of the hoverboard draw a load current of 300 mA and the lithium-ion battery is rated 2200 mAh, then the discharge time of the battery can be determined by the quotient of the two current ratings as follows;

Discharge time = 2.2/0.3 = 7.3 hours.

On the other hand, the time taken to charge the lithium –ion battery depends on the charge current and the battery chemistry. The duration of charging is determined by the quotient of the battery rating and the applied current. That is;

Charging duration = battery current rating/ the applied current

The equation used in determining the charging duration assumes that charge is 100 percent efficient. However, the lithium –ion batteries used in hoverboards are not ideal batteries. As a consequence, the equation is used to determine an estimate of the actual charging time. It is significant that to keep the charging duration of the battery within the determined range so as to prevent overcharging the cell [13]. This equation plays a significant role in preventing fire and explosions associated with overcharging lithium-ion batteries sued in hoverboards.

Additionally, it is worth noting that lithium-ion batteries have almost 100 percent charge efficiency. However, energy charge efficiency relies on charge rate. In most cases, higher charge rates are associated with lower efficiencies due to increases in resistive losses towards the end of the battery charging phase.

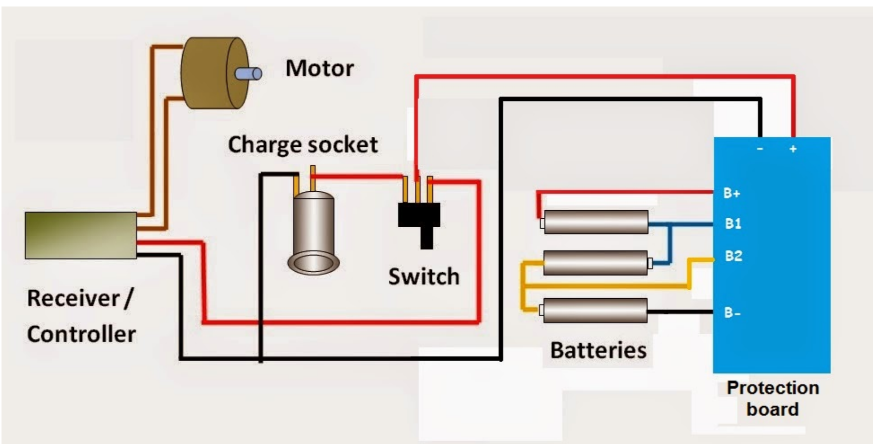
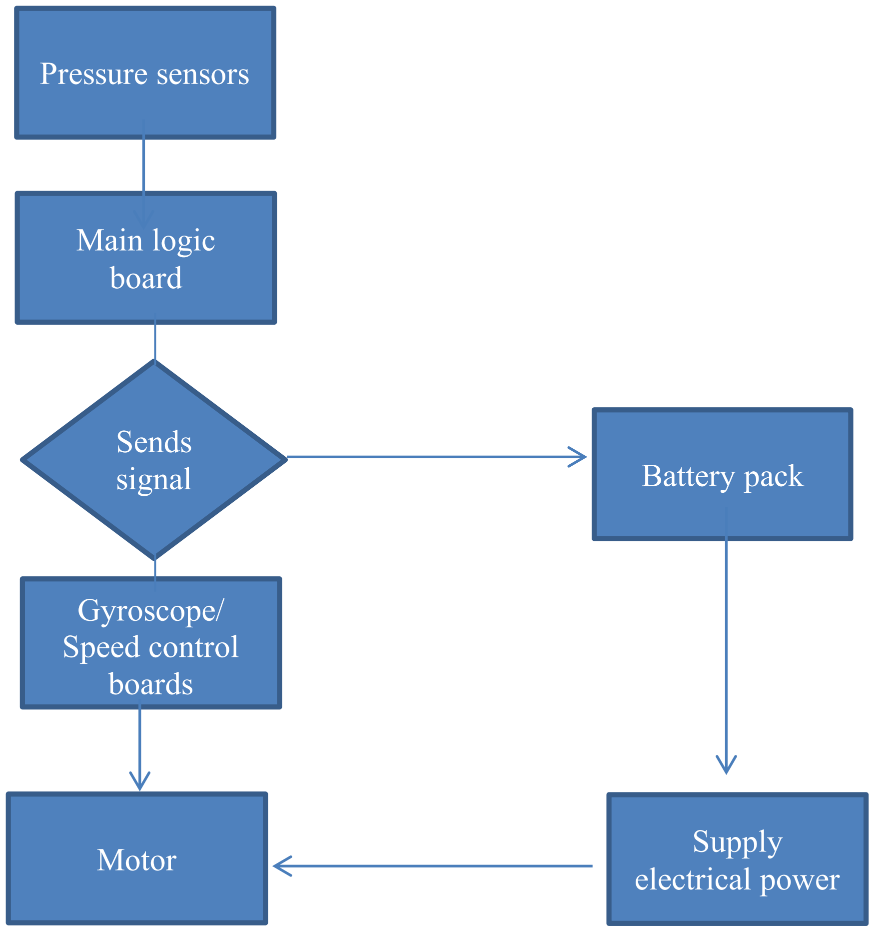


Figure 24: A diagram for balanced charging system for a hoverboard.[13]

5.2.1.7 Lithium-ion operating temperature

The performance of the hoverboard and any other electrical device that uses the lithium-on battery is affected by the operating temperature of the battery. It is crucial to point out that the working temperature of lithium-ion battering is a significant factor that affects the performance of the hoverboard. The battery temperature of lithium-ion varies during discharging and charging processes [14]. These variations in temperature call for analysis of battery heat production rate. The rate of heat generation in Lithium –ion batteries is affected by numerous factors such as; battery aging effect, the operation current, temperature, and state of charge. The produced heat during charging and recharging is made up of reaction heat and Joule heat.

Flowchart



5.2.1.8 Details of physical modeling

There are several components that will be used for physical modeling of the hoverboard project. A hoverboard, a two-wheeled, auto-balancing scooter, is made up of several different components: steel or aluminum frame with a central pivot, two wheels, a logic board, two gyroscopes, a lithium-ion battery pack, a motor, pressure pads, infrared sensors, a charger and a plastic shell. Additional accessories may include a remote control, Bluetooth and LED lights. The logic board is used to regulate the speed of the hoverboard. It is also used to control the tilt of each wheel.

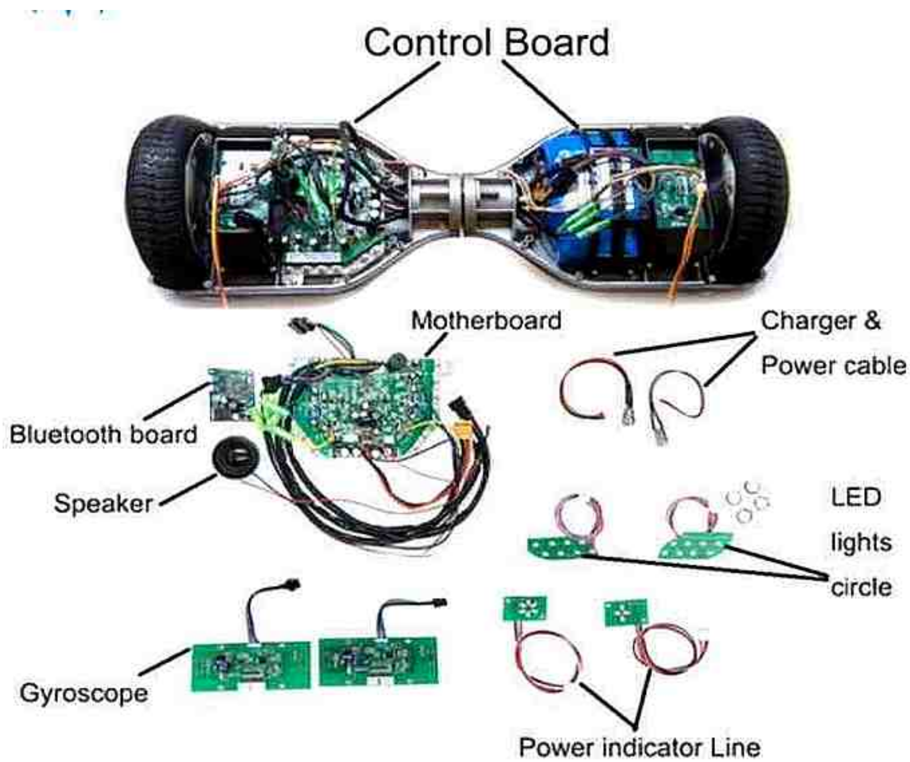


Figure 25: a Physical component of a hoverboard.[16]

The motor: It is the actuator which is used to convert the electrical signal from the battery to mechanical motion, thus driving the hoverboard. The most significant factor to consider is the power of the motor. It is imperative to select a motor with at least 300 watts in order to provide sufficient mechanical energy to drive heavy loads [15]. The motor will be connected directly to the wheel to provide a drive train. It is this direct connection between the motor and the wheels that allow the hoverboard a rapid response.

5.2.1.9 Conclusion

Hoverboards offer an alternative source of light and short distance transport. As compared to another type of scooters, it's a simple and light design that provides numerous benefits to users. It is imperative to minimize the power consumption by utilizing energy efficient components such as motors and sensor, so as to mitigate potential overcharging of the battery.

5.2.2 Weight Analysis

5.2.2.1 Introduction

The Go Baby Go project is a project that focuses and aims on children with disabilities and limited movement. This project will help children with limitations in movement to move freely and will ease the process of moving and living normally. Team 9 in the Go Baby Go project has designed some different concepts that involved more than 20 designs in order to find the best suitable design to fit the needs of the customer. The final solution that the team came up with was a creative design that used a hover board in order to move the concept from a point to another. This analytical report will mainly concentrate on the weight analysis of the device. Different perspectives of the weight analysis will be covered such as the average weight of the child and comparing the minimum and maximum weights of users to operate the sensors of the hover board.

5.2.2.2 Average Weight of Child

Since the design of the Go Baby Go project will be used by normal children and children with disabilities, the average weight of normal children will be compared in order cover the analysis. The project is mainly focused on children with disabilities but the project might still be used by normal children. The research is mainly focusing on children from the age of 2 – 12 years old. Figure 1 below shows the average weight of normal children from the age of 2 – 12 years old for both females and males.

Table 8 Average Weight of Children [18]

Female Children			Male Children		
Age	Weight	Height	Age	Weight	Height
2 yrs	26.5 lb (12.0 kg)	33.7" (85.5 cm)	2 yrs	27.5 lb (12.5 kg)	34.2" (86.8 cm)
3 yrs	31.5 lb (14.2 kg)	37.0" (94 cm)	3 yrs	31.0 lb (14.0 kg)	37.5" (95.2 cm)
4 yrs	34.0 lb (15.4 kg)	39.5" (100.3 cm)	4 yrs	36.0 lb (16.3 kg)	40.3" (102.3 cm)
5 yrs	39.5 lb (17.9 kg)	42.5" (107.9 cm)	5 yrs	40.5 lb (18.4 kg)	43.0" (109.2 cm)
6 yrs	44.0 lb (19.9 kg)	45.5" (115.5 cm)	6 yrs	45.5 lb (20.6 kg)	45.5" (115.5 cm)
7 yrs	49.5 lb (22.4 kg)	47.7" (121.1 cm)	7 yrs	50.5 lb (22.9 kg)	48.0" (121.9 cm)
8 yrs	57.0 lb (25.8 kg)	50.5" (128.2 cm)	8 yrs	56.5 lb (25.6 kg)	50.4" (128 cm)
9 yrs	62.0 lb (28.1 kg)	52.5" (133.3 cm)	9 yrs	63.0 lb (28.6 kg)	52.5" (133.3 cm)
10 yrs	70.5 lb (31.9 kg)	54.5" (138.4 cm)	10 yrs	70.5 lb (32 kg)	54.5" (138.4 cm)
11 yrs	81.5 lb (36.9 kg)	56.7" (144 cm)	11 yrs	78.5 lb (35.6 kg)	56.5" (143.5 cm)
12 yrs	91.5 lb (41.5 kg)	59.0" (149.8 cm)	12 yrs	88.0 lb (39.9 kg)	58.7" (149.1 cm)

Children with disabilities do not average on a certain weight depending on each disability. Some children with disabilities weigh less than normal children as it all depends on the situation of the child. The average weight of the normal child or the child with disability will play a huge role in moving the device from point A to point B. This is due to the motion of the of the hover board that mainly depends on the motion sensors and pressure pads to move.

5.2.2.3 Minimum & Maximum Weight of User

The hover board is an important part in the design of the Go Baby Go project and the team's concept. The design is basically consisted of two different parts. The first part is the seating part where the child sits and operates the device to move. The second part of the device is mainly the hover board where it controls the movement of the device to other locations. The hover board is usually moved by applying the users pressure on the pressure pads using his legs. In the design, the hover board will be controlled by the user using their hands instead of their feet to control the hover board. Figure 26 below shows the final conceptual design for the Go Baby Go project.

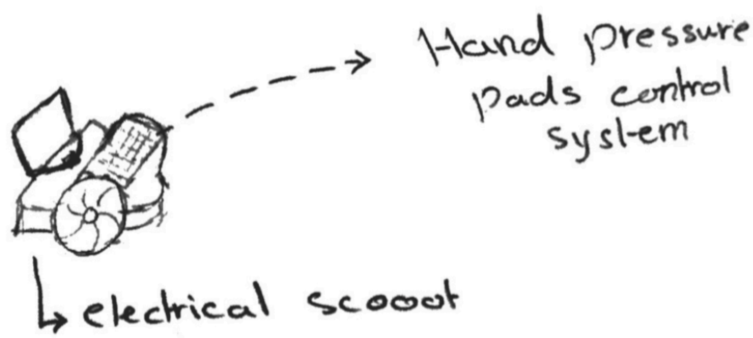


Figure 46: Final Design of the Go Baby Go Project

As shown in the design, the user will be able to sit in the middle with the legs below the hover board and the hover board will be controlled using the user's hands. In order to move the hover board, the pressure pads need a certain amount of pressure to move in different directions. There are two types of weights to determine the pressure delivered, durability and movement of the hover board. The first type is to determine maximum weight that the hover board can withstand. The second type is to determine the minimum weight to operate the device. Figure 27 below will show the main parts of the hover board.

Figure 27: Hover Board Main Parts [17]

Hover Board Main Components [17]:

1. A steel frame with a central pivot
2. A logic board
3. Two gyroscopes
4. Two infrared sensors
5. Two electric motors (located inside the wheels)
6. Two tilt/speed sensors (located inside the wheels)
7. Charging port
8. Power switch
9. A battery pack
10. LED lights
11. Pressure pads
12. A plastic shell

There is a speed sensor in the tires of the hover board that detects the amount of RPM's in the tire. This will be sent to the two gyroscopes where they will be calibrated to the user using the device [17]. This is where the weight is used to move the pressure pad. The maximum weight used in order to move the hover board is different depending on the components used in each company's production line. Each company uses different types of batteries, speed sensors, and pressure pads. Additionally, the type of wheels used in each hover board will determine the durability of each hover board depending on the weight. The weight limit of the user averages around 220 lbs (100 kg) and can go up to 325 lbs (147 kg) [3]. Since the design built by the team depends on having the user to use his hands instead on using of his legs, the minimum weight will be more important in this situation. To find the minimum weight of using the hover board, the team was able to get a hover board and test it using hands. This testing procedure was performed by having a team member sit on a chair with the hover board laying on the member's lap. Pressure was then applied by the team member using hands to see if the tires will move or not. The results were that device moved using hand pressure to get it as close as possible to the final design in figure 27.

5.2.2.4 Conclution

In conclusion, the hover board was the main component of the weight analysis in order to find the maximum and minimum weight to operate the hover board. The team was able to test the hover board using hand pressure instead of finding the minimum weight of operation. It was determined that the maximum weight for the user was not a problem that the team faced since the average maximum weight was determined to be 220 lbs (100 kg) which is high compared to the average weight of the child. There were different numbers when finding the average weight of the child depending on having a normal child or a child with disability. All in all, furthermore testing is required to have better results and to compare amounts of pressure required to move the device.

5.2.2 Budget Analysis

5.2.3.1 Introduction

Northern Arizona University participated in the GoBabyGo (GBG) program which was established at different universities across the US. This program created to help support kids with special needs to help them move and act like typical kids. This analytical paper discusses budget and cost analyses used to create a device that facilitates this.

From the decision-making process that involved a Pugh chart and a decision matrix, the process narrowed down to two main options that would enable us to come up with a GBG design that fulfills the client requirements as well as the engineering requirements. The decision-making tools also assisted in making decisions that were within the budget. With the consideration of all these factors, CV4 was selected on the criteria that it performed highest on the decision-making matrix. However, noticing the small difference between CV2 and CV4, the client proposed that the two conceptual ideas should be combined to devise a better product on a budget of $1,500. Therefore, to account for the amount required for the design and construction of the GBG design, it is necessary to consider the engineering requirements to develop the budget for the whole project. The design elements in comparison with existing models that dictate the overall cost for both the concepts are discussed below:

5.2.3.2 Background

The purpose of the project is to combine hoverboard technology with scooot® design. Two designs were chosen that integrate these technologies. The first, CV2, is based on Hoverboard design, while the second, CV4, is based on scooot® design.

CV2 Hoverboard [19]

That is the new and recent design of a scooter driven by a LED light. The LED light is a sensor that allows the user to be able to ride it using their emotions as it connects to the learning mode. Below are its engineering requirements:

- Hard ABS Outer Body Casing
- Aluminum Wheels with Rubber Tires
- Maximum Weight Limit: 220 lbs (100kg)
- Minimum Weight Limit: 44 lbs (20kg)
- Speed: 2 – 8 mph (3 – 12.8 km/h)
- Range: Up to 7 – 12 miles
- Charging Time: ~1 Hour
- Learning Mode
- Bright LED Lights (Headlights)
- Battery: Top Quality Brand Lithium with Sentry Shield
- Power: 100 – 240 Volts
- Size: 23w x 4h x 7d (inches)
- Product Weight:22 lbs (9.9kgs)[20]

CV4 Scooot® [21]

This kind of device is manually operated and designed to help primarily children with disabilities to be able to maneuver around. The scooot® is comprised of the following parts:

- Adjustable footrest
- Low and accessible seat base.
- Lap belt.

- Detachable.
- Three casters.
- Soft padded cushion.
- Gripped rubber tires [21]

On their cost comparison, below is a table 9 showing the costs of CV2 and CV4 that are both available in the market.

Table 9: Price variations of main component of CV.

CV type	Market name	Cost
CV2	Hover Board	$199-$499
CV4	Scooot® 3-in-1	$595

5.2.3.3 Material and Cost Analysis

As mentioned earlier the group decided on a new design that incorporates the ideas of both the CV4 and CV2. The design disadvantage the group is trying to avoid in CV2 is the use of a lithium battery, known to be very dangerous and possess significant risk to the user. Therefore, the team considered a CE FC ROHS battery as a safer idea.

The operation of the device will be managed from a pressure Pad to control the device as the LED head lights will help the kids move by providing better lighting in the direction of travel. The project will involve assembly of parts which are readily available on the market. For benchmark purposes, the table in Appendix A shows a catalog of the parts of for the new designs vis-a-vis their images and markets.

Table below is the budget analysis of all materials that we will use so far in our project. The team started ordering the first item which was the K'Nex® building sets to make the prototype. This table lists actual price, expected variance, and final cost of each component. Expected variances might include price changes from the supplier such as shipping charges, tax rates, item cost, etc.

Table 10: Budget Analysis Table:

Type of Items	Actual Cost	Expected Variance	Final Cost
Back booster	$54.97	+$10	$64.97
Hover board - Smart Balance Scooter	$199.99	+$20	$219.99
LED motorbike headlight bulb	$30.99	+$10	$40.99
Lap Seat Belt	$16.96	+$5	$21.96
VIIVRIA® 9 in 1 Balance Scooter Circuit Repair Kit Board Main	$49.99	+$5	$54.99
RocketBus Replacement 6.5" Inch Power Motor	$39.95	+$5	$44.95
(CE FC ROHS)36V 4.4Ah 158Wh Battery	$84.99	+$5	$89.99
D@Boards Replacement Rubber Parts for 2	$14.98	+$5	$19.98
Smart Self Balancing Scooter (Adapter)	$9.64	+$5	$14.64
K'NEX Combat Crew 5-in-1 Building Set	31.50	+$17.5	$49
TOTAL COST	**$533.96**	**$87.5**	**$621.46**

5.2.3.4Conclusion

The overall budget analysis took into consideration other budgetary expenses such as price fluctuation on the high side and shipping costs for those parts that are not locally produced. The estimates were made in consideration of other commodities and terms dictated by vendors that were factored into the expected variance column to come up with the final cost as shown in Table 8. The final budget totaled $621.46 which is less than the budget ceiling provided, thus making it viable. This budget analysis is not final; it may change in the future depending on team and design requirements.

5.2.4 Website Analysis

5.2.4.1 Introduction

Each team member has his own analytical report to research on. Website analysis is what this report will cover going through some details. Having a website for the project is a preform of a high professional work. Where the website includes all things such as difficulties, challenges, and other things. The report basically will cover things are existed or will exist in the website.

5.2.4.2 Background

This analytical report about website analysis considered as a short component, since it does not need a lot of researches or mathematical equations. Using a website for the project is a major thing, through the website the team can show how he did the project and what was the challenges while making the device, and providing all researches, details, photos and team info in the website. There is a lot of good and bad websites. For bad websites, there could be a difficulty in using the website, having technical issues, lake of information or anything else that makes the website looks bad and less professional. On the other hand, good websites having a good main page, briefed description of the projects, organized website info flow, and all info covered with good representing. There was many surfing around, such as University of Delaware websites, checking how the good website looks like, and trying to determine what kind of website could perform the project in a good shape.

Through creating a website, there was many challenges that were faced, such as learning on how to use DREAMWEAVER software, it cost around $153.95 for a full package, but luckily it is provided through the university [26]. Another challenge is how to organize the information about the project so the surfer can understand how things are. How the main page looks like? and is it providing icons for whole sections? These difficulties were faced during the creating processes of the website. Also the website should use font, colors, and italics in a professional way to ensure that the surfer is comfortable with surfing the website, sometimes shiny colors and small fonts could make the surfer uncomfortable.

5.2.4.3 Conclusion

In conclusion, the website will be a portfolio of the team's documents and proposals. In addition, it will illustrate the team's effort that is contributed towards fulfilling the requirements of the project. This website will be the team's future reference that will be pointed out during the team's professional career and it will cover project details in professional organized way.

5.2.5 Materials to be used for the project

5.2.5.1 The chassis of the scoot

The chassis of the scoot will be the functional backbone of the scoot. It will be the metallic base on which the components of the scoot will be marred to. First, the wheels will be mounted on the chassis from the underside of the chassis. In our case, we shall have a pair of caster wheels and a Hoover board on the underside. On the upper side of the chassis, we shall have the other components fixed. These include the headrest, the sitting area, the pushing sections of the scoot.

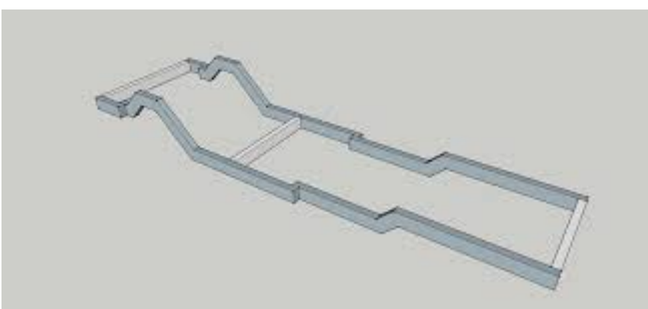


Figure 28: Chassis

5.2.5.2 Plastic seat and the head rest

In the model of our scoot, we shall need to make the scoot to have a headrest and the sitting rest to be made of the same continuous component. This will reduce the necessity of having to rivet the seat to the chassis at so many points. The headrest and the sit are both made of plastic. The use of plastic is to be able to cut down on the costs of the device that they are wearing. With the two being conjoined, the sit pad is the one that will need to be riveted to the bottom

.

Figure 29: Seat

5.2.5.3 Machine washable strap

The scooter will be riding by small children. The small children do not have a sense of safety and precaution taking when they shall mount on the scout. This calls for the need of having a strap that will saddle the child to the seat of the scout. This strap will could be made of nylon, or cotton or any other material. However, whatever material that is used here should be strong and flexible to enable the finally, this strap may need a joinery. This is because; this trap will not be used like the seat belt of a car. The strap will have to cross several times over itself so that it holds the child firm.

Figure 30: Strap

5.2.5.4 Paddle cushion

Our desire is to make riding the scooter to be an experience for the kid. We will therefore need to make the sitting on the scooter to be as soft as possible. Using paddle cushion is a way of making sure that the kid has a soft sitting and a head rest too. The cushion can be put on the sitting area and the headrest of the scout.

5.2.5.5 Casters underneath

Basically, the casters are made in such a way that they can turn at angles that are as large as 360 degrees. The casters have rubber tubing on the outer surface with a metallic housing that holds the axis of the small wheels of the casters. The casters will be placed near the ear of the scoot. This is because; the scoot will need to make turnings that I are important for me turning of the scout. Small children need to turn randomly whole driving and this the perfect

Figure 31: Caster

5.2.5.6 Hoverboard

We said that the caster wheels cannot be used for on all the wheels of the scout. This is because, at some point, there will be a need to have some two steady wheels that will keep the scooter steady. The wheels of a Hoverboard would be the perfect match for this function. This is because they are steady and can be easily directed to go to a certain direction from their turning moments. This will be provided by the caster wheels.

Figure 32: Hoverboard

6 *Proposed Design*

6.1 Prototype

Because the electric scoot was the final selected concept, it was chosen for the proof of concept prototype. Figure shows the team prototype was created by using K'NeX with some duck tape and construction paper. For this moment the power supply is the human power; one of the team member use his/her hand to push the scoot to move.

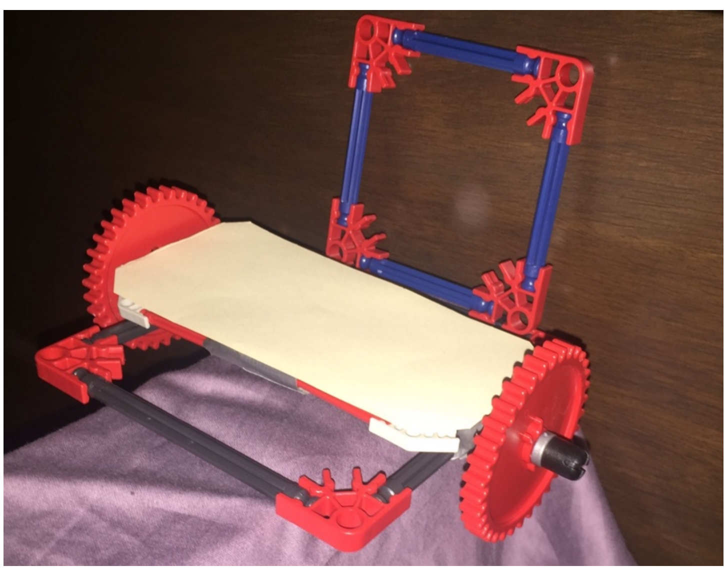


Figure 33: Final Design Prototype

6.2 Solid Work Design (CAD)

The following figure shows the design we are going to use for the project. It consists of a chair two wheels and a pressure pad. The team has created this drawing to enhance a better picture for the project. The front view of the project shows exactly how the project will look like.

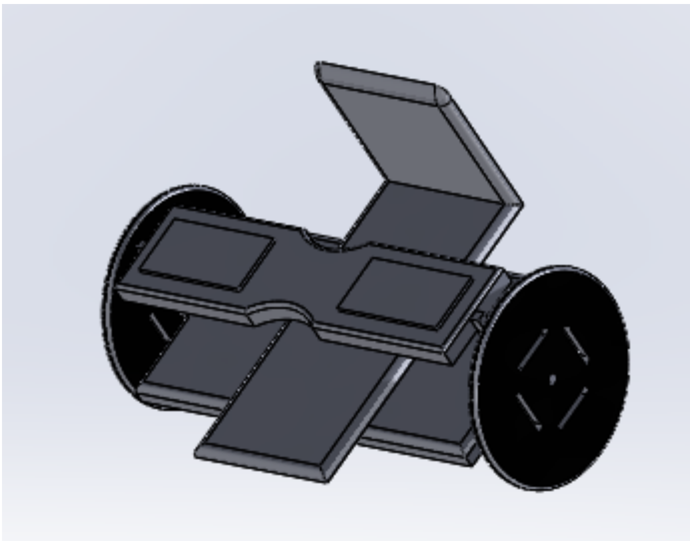


Figure 34: CAD Final Design

6.3 Bill of Materials

In appendix A shows the parts the group decided to use in the final design for this project. The majority of the parts can be purchased online. The price for each part listed includes an allowance for price variances, such as taxes, shipping, changing price, etc. The vendors listed here have sufficient supply to allow for ordering additional quantities in the event of damage or design aesthetic improvements. These parts will provide additional safety features and high quality design to allow for a broader market.

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8 Appendices

Appendix A

Parts	Image	Market	Price
Graco Affix No Back Booster – Davenport[22]		Wal-Mart	$64.97
BAA SHOP Two Wheels Mini Smart Self Balancing Scooter (Adapter)[23]		Amazon	$40.99
D@Boards Replacement Rubber Parts for 2 wheel self balance scooter hoverboard[23]		Amazon	$21.96
(CE FC ROHS)36V 4.4Ah 158Wh Battery Pack for 6.5" Classic Electric Scooter Hoverboard[24]		PandaWill	$54.99
RocketBus Replacement 6.5" Inch Power Motor Wheel for Self-Balance Smart Scooter IO Hawk PhunkeeDuck Swagway Hoverboard[23]		Amazon	$44.95

VIIVRIA® 9 in 1 Balance Scooter Circuit Repair Kit Board Main Hover Board replacement parts 2 Wheel 6.5"[23]		Amazon	$89.99
Cloudings(TM) 16 * CREE 80W LED Motor Bike/Moped/Scooter/ATV Headlight Bulb BA20D H6 Car LEDs Lamp Lighting[23]		Amazon	$19.98
Lap Seat Belt, Chrome Lift Latch, 60 Inch Length[23]		Amazon	$14.64
K'NEX Combat Crew 5-in-1 Building Set[23]		Amazon	$49