Midterm 1 Report

Team No. 20

Development of Consumer Grade Levitating Hoverboard

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ABSTRACT

After several months of research, Group 20 has narrowed the selection process of a levitating hoverboard by analyzing the market need from various tables and charts of data. Using the HOQ and morphological chart, three designs were created. Due to the fact that this hoverboard is a new product, analysis on each step of the way must be completed. Similar to a start-up company, a product is introduced, in which the company has done extensive research before-hand to ensure that no failures will occur. This stage is known as the research and development of the product. The next area that requires analysis is the manufacturing side, and how each sub-component will be made or if the component will be supplied from a vendor. At the immediate moment, calculations are still being done and simulations will be conducted in order to have factual evidence that no data resembles a product failure. In the upcoming months, this levitating hoverboard will be introduced and provide safety and entertainment to all children around the world.

ACKNOLODGEMENTS

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1. Introduction

The idea of some kind of levitation hover board was unheard of until the movie: Back To The Future was filmed in the 1980's. Throughout the series, Marty McFly traveled around town on his hover board, which looked very similar to a skate board, but with no wheels. Since then, scientists, engineers, handymen, and others have attempted to create an actual performing model, but few have truly succeeded. In recent news, Lexus successfully created a hover board made from super cooled magnets and liquid nitrogen. Though, the track they tested their prototype on had magnets underneath the surface to help oppose the force, hence the levitation. Another company that created a successful levitation hover board is Hendo Hover. Both seem to be lacking a steering mechanism though so direction is still of importance.

It is a slow transformation, but futuristic looking devices are starting to emerge when it comes to transportation. Nearby locations that do not necessarily require vehicles have allowed people to use bicycles, skate boards, roller blades, and much more. Bicycles have evolved over the years with gear mechanisms and aerodynamics. Skate boards were created as a different means to get around quicker than walking as well, utilizing the board and trucks for steering. Afterwards, scooters emerged, changing the toy industry due to an easier turning mechanism (handle bars). From scooters, Segway created personal transportation mechanisms used anywhere from security to personal use. The latest, possibly the most "futuristic looking" mechanism that has been designed is the hover board, created by HX, though it does not levitate. This design incorporates self-balance to determine speed and direction. One thing is still missing though, the levitation aspect.

It is believed that a design that can include the true levitation affect can greatly alter the transportation industry. This mechanism will include a rechargeable feature in an easy and convenient portability setup. A design has already been constructed, but this will be a base model for further implementation. Studies of aerodynamics can enhance the travel distance; materials will determine costs but conditions must be met whether environmental or any other surrounding conditions so the lifetime of the levitating hover board will last. Many components will be analyzed before the actual design process and manufacturing actually begins.

2. Project Definition

The ideology of the project is to build an air powered device that can function not only as a recreational device, but also as short-range transportation. The principal that will make this idea possible relies on an upward force that pushes against gravitational force and makes the device float. Air, applied with different pressure ranges, is the prime component that creates the upward force. The air supply can be sourced from several optimum options of machines. When the air is propelled, a downward thrust is created; the capability of this force will determine how much levitation is obtained.

The levitation not only depends on the force, but also on different factors such as weight, balance, and loads. There are other physics principles that can be used to create "levitation", such as magnetism and chemical reactions. These principles are not going to be taken into consideration due to the fact that they aren't cost effective, which is one of the goals.

The concept of the levitating hoverboard comes from the original model of the larger existing hovercrafts. A hovercraft is a medium of mobility that is sustained on a pad of air that is provided by a powered fan, which is placed on the craft. Hovercrafts were originally designed to travel over water surfaces by floating on a coat of air, which reduces friction between the device and surface. The project's design will follow a different scope from hovercrafts by being smaller, portable, easier to use, and able to go on land [1].

2.1 Need Statement

There are only two prototypes of commercial floating hoverboards, the Hendo Hoverboard and the Lexus Hoverboard. Both models budget starts around $10,000 and are not available for purchases yet nor targeted for people who are not trained for its use. The physics principles behind these mentioned prototypes are what make it so expensive and only directed to professionals. For this reason a simpler and inexpensive approach can be used to create an innovative product for a vast market [2]. Furthermore, several homemade hoverboards attempts aren't too practical. The simpler models with low-cost applications of physics principles don't possess steering control systems and need Team No. 20 Levitating Hoverboard 3 to be plugged into the wall, which restricts mobility. Because of this, a better prototype can be created in order to resolve these constraints.

2.2 Background Research

People are always looking for the most innovative gears out there in the market. The success of technologic gadgets/toys around young generations seems to keep growing. The idea of a floating hoverboard can overcome the current success of “wheel” hoverboards. By the end of 2015, 40,000 wheel hoverboards were coming into the U.S. each day. While nobody tracks total sales, manufacturers have shipped more than $2 billion worth of hoverboards over the past year and a half, by Fortune’s estimates. According to statiscticbrain.com the average retail sale price of a “wheel hoverboard” is $386.

Since the main competitor is the wheel hoverboard, the project’s design will be entering an existing market and attempt to dominate it with its innovation. Therefore, the same market can be accounted for the floating hoverboard. The targets of this recreational idea are people from the ages of five years old and up. With a realistic scope of people over 70 years old not being able to use it because of physical limitations, the project’s age range can be based for research purposes [3].

According to the US Census, as for 2010 the population number of people of ages from 5 to 69 years old was 260,711,455; this would be absolute market size of the project. As for an exact market size, a more extent research has to be done to know what number of this population quantity wouldn’t be taken into consideration. Different social classes, special needs people, handicaps, and many other factors might reduce this number [4].

2.3 Goal Statement and Objectives

The objective of the project is to create an air powered hoverboard that can be used for recreation or short-range transportation. For this, modification of the simpler/homemade prototypes and incorporation of innovative ideas are going to be used so that the design can be safe, enjoyable, and functional. The engineering characteristics that will estipulate the design of the prototype will be influenced by the customer’s voice. In order to achieve the mentioned assessments, surveys and analysis of data would need to be performed. The overall engineering design will consist mainly in a wireless blower, as well as an efficient rechargeable battery or something similar that can power it. An operating system that replicates these components in a more efficient way can be built. The team will conduct tests and trials to decide which alternative is better to achieve the operating system objective. Additionally, a steering system needs to be generated, tested, and applied. The whole design will to be aesthetically appearing and follow an ergonomic design.

2.4 Constraints

One of the most considerable constraints is the balance of the entire prototype. Previous attempts were successful on stability because the board itself was round and only had the load of one person on the middle. By adding components such as a steering wheel and an operating system, which encompasses a battery and a blower, an uneven load across the board could be created. These are conceptions that need to be taken into consideration and worked through testing of designs and calculations. Along with the balance, comes the ability to hold certain amount of loads.

Another significant constriction is sound. Some blowers and fans can be very loud when they are on use. Also, the airflow created from the blower creates a cushion of air below the board itself and if it comes into heavy contact with solid surfaces, it can create a loud sound. For this reason, the different types of terrains become a problem as well. It is desired that the prototype can be able to ride over various types of land without any interference and/or excessive noise production and if it comes into heavy contact with solid surfaces, it can create a loud sound. For this reason, the different types of terrains become a problem as well. It is desired that the prototype can be able to ride over various types of land without any interference and/or excessive noise production.

2.5 House of Quality (HOQ)

A House of Quality was created as part of the Quality Function Deployment (Figure 2). The proposed customer requirements (CR) are listed on the left, while the engineering characteristics (EC) occupy the top row. The numbers obtained for the CR were obtained from a survey done by the group members to 100 people between the ages of 12 and 50; the scores of this survey are further explained after the HOQ explanation in Table 1.

Group 20 went through and decided upon correlations among the EC's ranging from strongly negative to strongly positive. Afterwards, Group 20 went through the body of the HOQ and used critical thinking to decide upon relationship strengths between the CR's and EC's by using strong (9), moderate (3), and weak (1) relationship values. There were other criteria represented in different symbols and colors used to analyze the roof of the HOQ and the quality characteristics (Figure 2).

The template for the HOQ was sourced from QFD Online [# reference]. Using an established template with mathematic functions for the desired calculations included allowed the team to obtain more accurate results. The template automatically calculated the relative weight on the bottom of the HOQ when it examined the team's analysis results for the body of the structure. The relative weight obtained gives a number to each quality characteristic. The characteristics with the higher values represent the features that need to be taken as a priority for the design of the prototype of the project. These chosen characteristics are meant to satisfy both customer and engineering's independent priorities of design at the same time.

Figure 1 – Legend for House of Quality

Max Relationship Value in Row	Relative Weight	Weight / Importance	Direction of Improvement: Minimize (▼), Maximize (▲), or Target (x)	▼	x	▼	▲	x	▼	▼	▲	x	x	▲	x
			Quality Characteristics (a.k.a. "Functional Requirements" or "Hows") / Demanded Quality (a.k.a. "Customer Requirements" or "Whats")	Weight	Dimension	Cost of Production	Life Cycle	Speed	Safety Risks	Emissions	Efficiency	Load	Number of Colors	Battery Life	Output force of blower
9	6.1	5.6	Aesthetics			▲			▲				⊙		
9	9.5	8.8	Durability	▲		⊙	⊙		⊙		○	⊙		▲	
3	9.2	8.4	Ease of use	▲	○			▲	○			▲			▲
9	7.9	7.2	Capability	○	○	⊙	▲	○	▲	▲	⊙	○		⊙	⊙
9	8.3	7.6	Portability	⊙	⊙	○			▲		▲				
9	6.4	5.9	Size	⊙	⊙	○		○	○	▲	▲				○
9	4.9	4.5	Capacity		▲		○	○	▲		⊙	⊙		▲	⊙
9	5.6	5.2	Noise			▲		▲				○			⊙
9	9.8	9.0	Performance	○		⊙	⊙	○	○	⊙	⊙	⊙		⊙	⊙
9	6.7	6.2	Weight	⊙	⊙	○	○	⊙	▲		○				
9	7.9	7.2	Life Cycle	▲		⊙	⊙			○	⊙	○		⊙	○
9	9.5	8.7	Safety		▲	▲		○	⊙			⊙			○
9	8.2	7.5	Low Cost	▲	○	⊙		▲	▲		○		○	○	○
			Max Relationship Value in Column	9	9	9	9	9	9	9	9	9	9	9	9
			Weight / Importance	280.3	282.9	474.5	287.6	199.2	289.6	125.7	362.1	377.2	79.3	268.5	358.9
			Relative Weight	8.3	8.4	14.0	8.5	5.9	8.6	3.7	10.7	11.1	2.3	7.9	10.6

Figure 2 - House of Quality

Understanding the potential audience for the product increases chances for a successful outcome. Finding an audience that has an interest and those that understand its need was a priority. The engineering criteria's that was formed was based on public feedback through a survey that was created. The results from the survey were analyzed, and it was noticed that performance, durability, and ease of use was the top 3 criteria our audience chose. The result from the survey is ranked with respect to importance, which is shown below in Table 1 [6].

As for the results of the house of quality, the outcomes are going to help in the design process of the project. According to relative weight results it can be seen that the cost of production is the most important thing to focus on; it got the highest percentage out of all, a 14%. Following the highest score is efficiency with a 10.7% and the output force of the blower is very close with just a 10.6%. Subsequently is the consideration safety risk with an 8.6% along with lifecycle with an 8.5%. The rest of the results can be directly seen from Table 2 [5].

Table 1 – Survey Results for Customer Requirements.

	Total	Score
Aesthetics	90	5.58
Durability	92	8.75
Easy to Use	94	8.43
Capability	91	7.21
Portability	90	7.58
Size	97	5.87
Capacity	98	4.54
Noise	91	5.16
Performance	91	8.95
Weight	96	6.19
Life Cycle	98	7.23
Safety	97	8.73
Low Cost	97	7.51

Table 2 - Relative Weight Results from House of Quality [5].

Relative Weight Results			
Engineering Characteristic	Result (%)	Engineering Characteristic	Result (%)
Weight	8.3	Emissions	3.7
Dimension	8.4	Efficiency	10.7
Cost of Production	14.0	Load	11.1
Life Cycle	8.5	Number of Colors	2.3
Speed	5.9	Battery Life	7.9
Safety Risks	8.6	Output force of the blower	10.6

3. Preliminary Design

3.1 Concept Generation

The first part of concept generations begins with brainstorming. Brainstorming is used to solve complications and to effectively provide solutions to those constraints that appear. Some initial constraints that were encountered for the designs were the geometry of the body, the material needed and the run time for the hover board. Many of the ideas that were presented through brainstorming gave team 20 an overall concept to how the design of the hover board should look like. All ideas were narrowed down to feasible ideas so that a morphological chart can be constructed. From the morphological chart three preliminary designs were sketched out using CAD software.

3.1.1 Morphological Chart

Brainstorming helped team 20 to come up with the final efficient concepts that might need to be taken into consideration in order to achieve our goal. Table 3 shows the final morphological chart that includes the selected ideas in order. The concept designs were constructed by selecting characteristics from the mentioned chart and Table 4 shows the results for the selections.

Table 3 – Morphological Chart

Attribute	Alternates			
Board Shape	Circular	Rectangular	Elliptical	Custom
Number of Motors	One (inflate and propel)	Two (one to inflate & one to propel)	Three(one to inflate & two to propel)	Three (one to inflate/propel & two to steer)
Motor(s) Location	Internal	External	Internal and External	
Energy Source	Electric	Gas		
Power Bank Type	Built-in battery	Gas Tank	Interchangeable batteries	
Propulsion Method	Directed Vents	1 dedicated blower	2 dedicated blowers	
Steering	Lever/Rudder	Foot Controls	Brake Lines	Lever/Pivot
Terrain	Land	Water	Land and Water	
Riding Style	Standing	Seated		

Table 4 – Results from Morphological chart

	Design 1	Design 2	Design 3
Board Shape	Circular	Rectangular	Rectangular
Number of Motors	Two	Three	Two
Motor(s) Location	Internal and External	External	Internal and External
Energy Source	Electric	Electric	Electric
Power Bank Type	Built-in battery	Built-in battery	Built-in battery
Propulsion Method	One dedicated blower	One dedicated blower	One dedicated blower
Steering	Lever/Pivot	Lever/Rudder	Lever/Rudder
Terrain	Land	Land	Land and Water
Riding Style	Standing	Sitting	Standing

3.1.2 Concept Designs

With the final decisions seen in the previous section (3.1.1), conceptual designs were sketched in CAD. The sketch of the first consisted of a circular base, which was considered an option because of its uniformity and its ability to be easily stabilized. The weight will be distributed more evenly throughout the systems. The air blower will be located toward the back of the system, where it provide thrust to project it forward. A turning lever will be present where the person will stand. This will turn the hover board left or right based on customer request. The first design is shown in Figure 3.

Some of the advantages that the first design has are the ease of production and use of the product itself. Since the prototype has simple parts to be assembled into it, the production of the hoverboard becomes more inexpensive. Also, with fewer parts on the product the load of itself will be lower; which means that it will be able to hold more load from the user. Cost effectiveness and capacity of load are two of the characteristics that team's hoverboard should possess since it scored the highest on the HOQ study. The third characteristic from the HOQ results, efficiency, isn't completely fulfilled with this first design. Since the prototype only has a fan for thrust and a lever to control it, the round design makes it problematic for the board to do dramatic turnarounds.

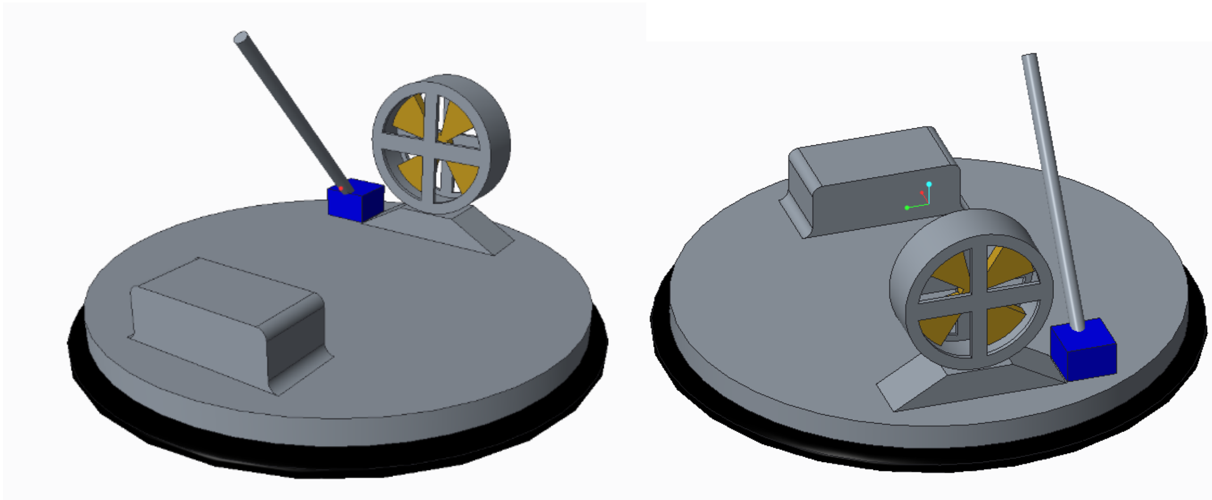

Figure 3 - First Preliminary Design

The second design took the concept of a hovercraft; its sketch can be seen in Figure 4. However, this system will be smaller than a usual hovercraft and provide more maneuverability for the performance of the system. There will be three external air blowers, two located towards the front of the system, and one towards the back. Similarly, the air blower toward the back will be used for forward thrust. The other two air blowers located in the front right and left will provide thrust to the left or right position to allow the user to steer. In the middle of the design is a carved out section, specifically for the comfort and experience of the user.

The benefit of the second design is that it fixes the efficiency problem from the first design. The two blowers located at the front for steering will let the user have complete control of the direction and turns of the hoverboard. The only problem of fixing the efficiency problem is that the other two goals, cost effectiveness and load capacity, are affected. Having more than one blower will add more weight to the model, which will reduce the capacity of load allowed for users. Moreover having three fans will need more power and therefore a higher spec power bank will be needed. The mentioned characteristics and considerations add more value to the cost of the product, as well as the whole complex design itself.

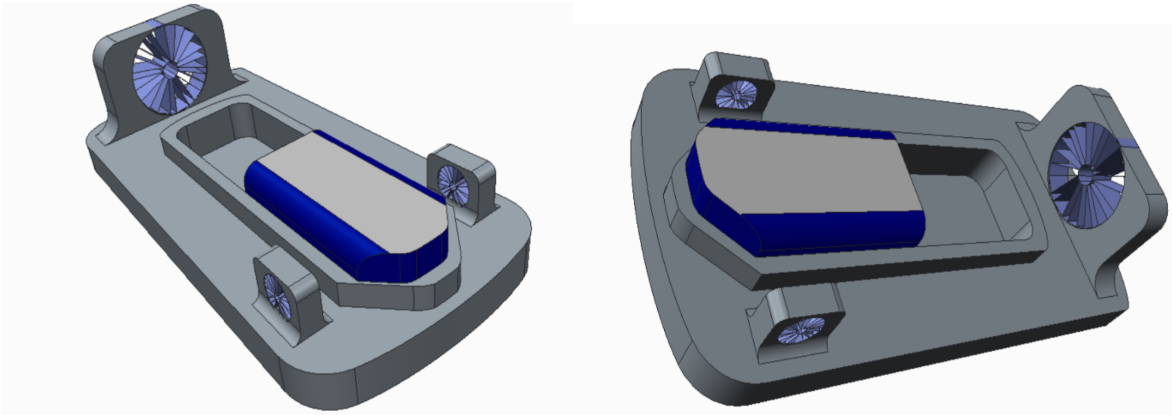

Figure 4 - Second Preliminary Design

The third preliminary design consisted of a rectangular base and can be observed in Figure 5. There is one main air blower that is located towards the back of the hovercraft. This design incorporates a rudder that is located behind the air blower. The rudders are used to redirect the thrust angle, so the hovercraft can steer left or right based on the end user. The user will be able to steer the hover craft by pressing brake handle calipers that will cause the rudders to move.

The benefits of the last conceptual design is the rudders, which offers ease of maneuverability; this increases performance and efficiency. The rectangular shape of this design attributes to the performance of the prototype as well since, unlike the circular first design, this one is more stable. Furthermore, the brake handle calipers will not only bring a new concept to the overall designs, but it will also contribute to the improvement of efficiency. Being able to stop the hoverboard from moving and comfortably steering it with the handle calipers adds a safety value to the project.

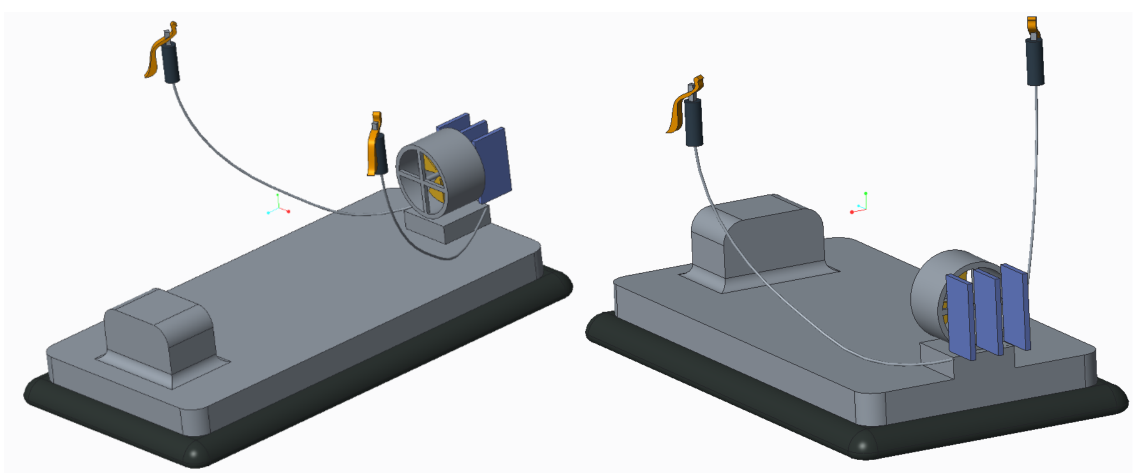

Figure 5- Third Preliminary Design

Team 20 primary goal at this point is to choose a design that has more advantages that contribute to the customer and engineering requirements, than disadvantages. Our design dimension will have a 2:1 ratio, mainly for purpose of stabilization of the hoverboard. The final design will presumably incorporate the different mentioned features that attribute advantages. To ease further calculations, the team will focus for now in the implementation of a rectangular board for the prototype.

3.2 Preliminary Calculations

Team 20 came up with dimension for the hover craft in order to choose the air blower required to create lift. It was concluded that the length and width of the hover board was to be 1.2192 m and 0.6096 m, respectively. These dimensions were based also on a ratio of 2:1, as previously stated. The depth of the hovercraft, also known as the hull, was determined to be 4 inches. With an arbitrary estimated weight of 118 kg (260 lbs) and the above dimensions, the downward load would create a pressure of 1160 N. The inflating blower will need to match that in order for operation to occur.

The hovercraft will incorporate a skirt, which will be attached underneath. The skirt is a durable, tear resistant material, which provides air cushion for the hover craft. The skirt will need to hold a certain air pressure without rupturing. The team determined that the air gap will be 0.5 inches, the distance from the ground to the hovercraft.

The team used an online hovercraft lift calculator to estimate the necessary power needed to produce the desired lift and after inputting the above parameters, it was found that a blower with a 4 hp output was needed. This seemed very high, and thus the calculator was double checked with an existing hovercraft prototype found online. After entering these dimensions, the horsepower dictated by the calculator was off by a factor of 2. Although the online calculator was initially misleading, this at the very least reveals that the horsepower provided by the inflating blower will need to be between 2 and 4 hp.

3.3 Potential Build Materials

When it comes to the materials selection of a design, specifically a levitating hoverboard, two important factors come into play- stiffness and strength. Between these two characteristics, stiffness is the more important of the two due to the fact that the platform in which customers will stand on, should not deflect, and if so, very minimally. This deflection may cause issues with the air flow or excessive friction between the skirt and ground. Multiple characteristics pertaining to the design effect the decision based off of the stiffness. In the automotive industry, minimizing the mass is the goal. It reduces cost, and it improves gas mileage, which in today's world, everyone desires.

The material selection process in our levitating hoverboard will be conducted very similar to companies in the automotive industry, which is to minimize the mass of a stiff object. The analysis will be conducted only for the board, which will be treated as a rectangular plate, therefore our goal is to select a material by minimizing the mass of a stiff rectangular plate. Once the equations are completed, a material index emerges from the final equation. This material index, represented by a sloped line, easily identifies numerous materials that will act the same when it comes to a mathematical standpoint.

Though, the selection will be based upon the design and the purpose for the design. In this case, a material that satisfies the stiffness requirement with a minimal mass, also being durable with a sufficient thickness. Materials that came of interest included carbon fiber reinforced plastic, polystyrene foam with epoxy resin, fiberglass, and several others. Further calculations will be completed so that there is viable evidence as to why a certain material was chosen based on the previously stated characteristics as well as a monetary characteristic as well.

4. Methodology

4.1 Work Breakdown Schedule

For the first phase of the project, which consist of Fall 2016 semester, team 20 will focus on creating a parameterized CAD prototype for the levitating hoverboard. To have a better overview on the steps that needs to be taken to achieve the model, a Work Breakdown Schedule was created and can be seen in Figure 6. In order to achieve the goal for this term the team should focus on two main things, accurate research and a design concept that would result from the study of the subject.

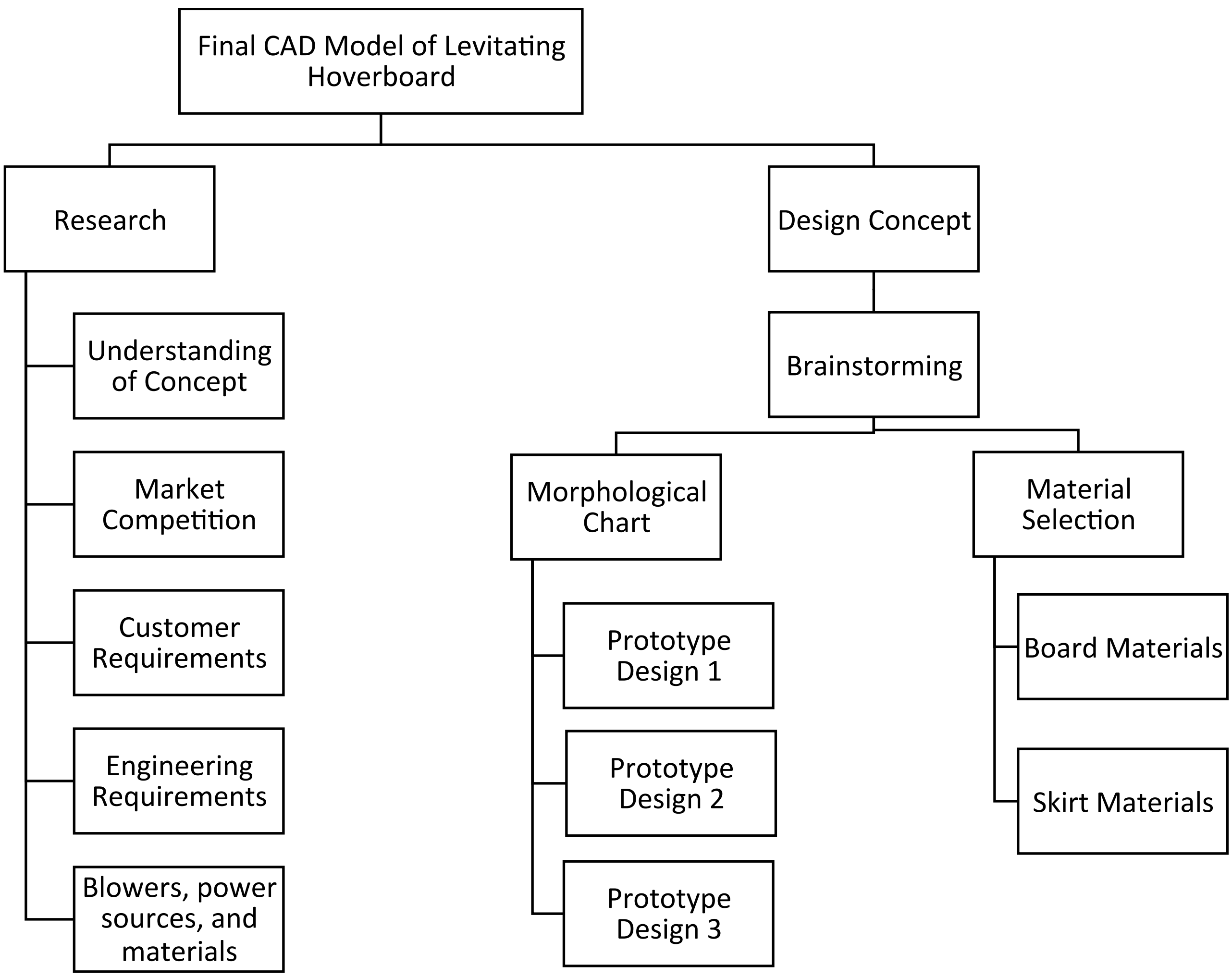

Figure 6 – Work Breakdown Schedule

4.2 Gantt Chart

The success of any project relies on the planning behind it. For this reason the team generated a Gantt Chart (Figure 7); in order to have a superior visual representation of the project's structure that needs to be followed. In order to develop the chart, the team first identified the different tasks that are needed to fulfill the scope of our venture. A reasonable and realistic period of time was assigned to each task, which all together the team thinks will wrap into what the team is expecting at the end of the term.

The initial part of our define phase takes place during August and November, represented in green bars in Figure 7. The first task identified as "essential" for the initiation of the project was the research of related background information. Research has been going on since the beginning of the term, August 5th, 2016, and is considered to finish around the end of November. While the background examinations are ongoing and a better understating of the project is attained, the focus of the research will be on optimal materials for two weeks (October 1st 2016 until October 15th, 2016). Different concepts of design begin after optimal materials are studied. A final decision on the project's design is chosen at the end of the research period.

Following the initial part of the define phase is the development of concept period during the month on November, which is represented in blue bars in Figure 7. This section focuses first on the creation of a basic CAD model for our final product, which is expected to be finished on November 20th, 2016. Calculations for operation and measurements of the prototype begin at the same time that the basic CAD model starts because they rely on each other. Final measurements need to be set between November 15th, 2016 and the deadline of the basic computer model. From November 21th until the end of the month, the team should already have a final parameterized CAD model of what our future prototype will consist on.

Having a final parameterized CAD will allow the team to focus on the acquiring portion of the project at the beginning of December, which is represented by red bars in Figure 7. A purchase order will be created and requested at the beginning of December 2016 as well as our final report and presentation summarizing our work. Obtaining the necessary materials at the end of this term will allow the team to be ready for the construction, execution, and improvement of the prototype next term (Spring 2017).

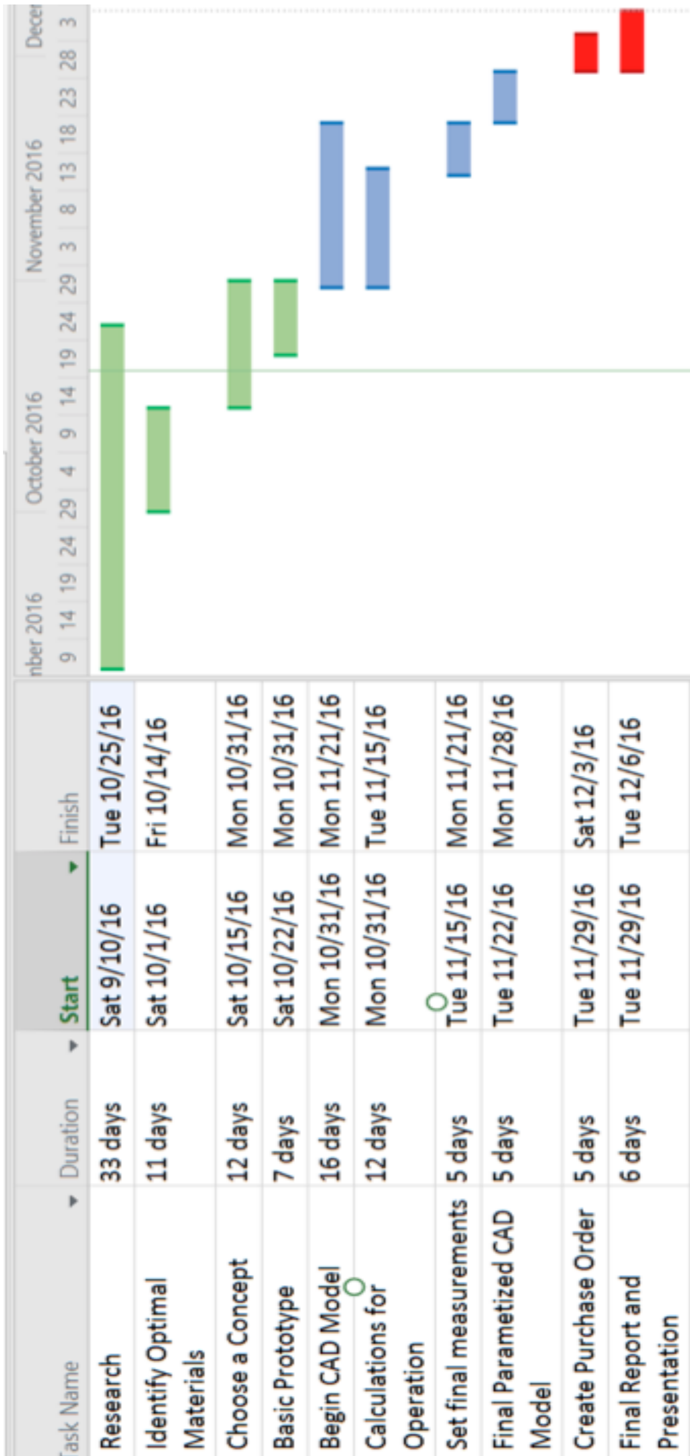

Figure 7 - Developed Gantt Chart.

5. Conclusion

The goal of this project is to innovate and produce a fully functional, battery operated, marketable hoverboard capable of hovering on a cushion of air. A number of initial concept designs have been modeled and analysis of each will be needed in order to select the most practical. A morphological chart will be used to make the fairest selection possible. In order to achieve the design goals, a Gantt chart was used to organize and plan the project. All designs considered must have a wireless blower that will be used to generate the lift needed to support the user's weight. The output force of the blower will equal the user weight to maintain a certain height, and be more mobile for a finite amount of time. The overall design will also include a rechargeable battery as a convenient, safe, and accessible power source for the targeted audience. Any hoverboard selected must carry 1 person, approximately 130 – 180lbs, for a period of at least 15mins in order to conform to our HOQ. This will, in theory, allow it to compete with other locomotive toys such as wheeled hoverboards, and gas-powered hovercraft in the future.

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