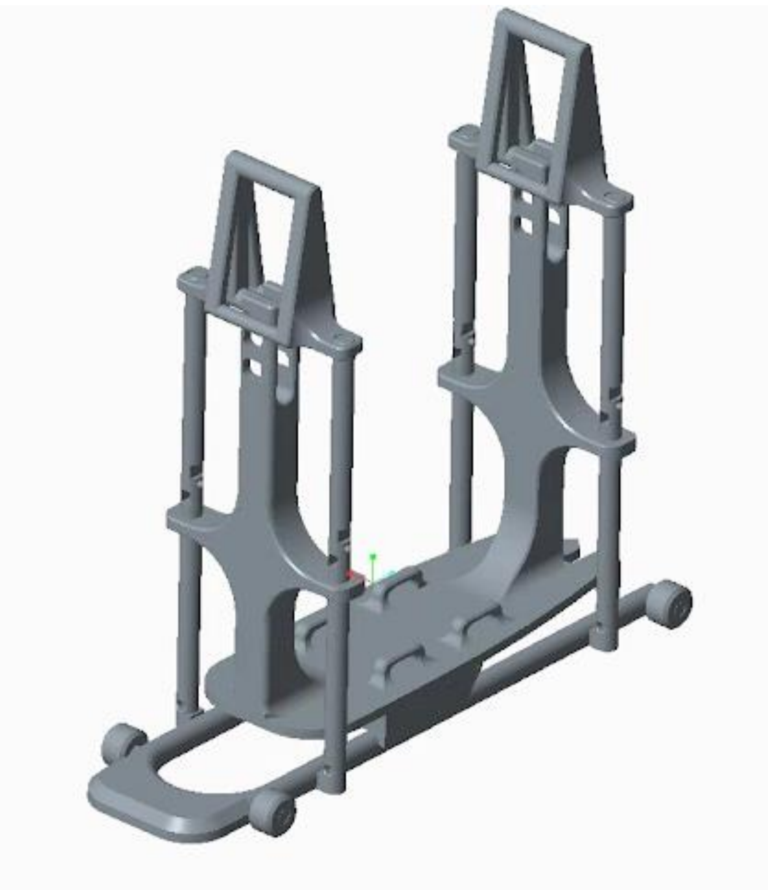
# Longboard Leaper

**ME 270 Design Project Final Report**

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## Problem Statement:

Due to its size and primary function, vertical motion has been restricted on longboards. While skateboards are smaller and more maneuverable, longboards are larger, heavier, and they weren't created to get off the ground. Instead, they were meant for smooth travel and cruise. More specifically, it is very difficult for longboards to clear obstacles larger than two inches off the ground.

Having had personal experience on campus, we needed a solution to this problem. Instead of having to get off the board, pick it up, and set it down, we wanted a mechanism that would seamlessly enable one to get over an obstacle without all that work. This would also make longboard travel more time efficient.

## Market:

As far as research goes, we were not able to find any other company that has attempted to solve the problem of the vertical motion constraint. Many have attempted to improve the ride quality but none have attempted a board that can clear larger obstacles. Some examples of improved ride quality products are suspension trucks. Much like a suspension unit on an automobile, these companies attached a spring/shock mechanism on the trucks of the board for dampening purposes.

***Figure 1. Type 1 Suspension Trucks***

***Figure 2. Spring and Shock Suspension Trucks***

After researching the market, we realized our problem has never been solved, while the problem is still very prominent. We are considering a very niche market however the problem still exists and long boarders are looking for a solution to this problem.

## History:

As mechanical engineers, it is a part of our job description to be innovators and creators. As we have learned through the course of this project, these skills are the furthest thing from innate abilities and furthermore extremely hard to get in tune with. However, to become successful engineers, these skills must be worked on and tweaked until mastery is attained. The worst feeling for a writer is to sit down behind the screen and stare at a blank page. The same is the case for us engineers. The worst feeling is not knowing what to do, what to create, what to innovate, and that is exactly where we began this project. A blank slate.

As engineers, our golden egg comes in the form of the Engineering Design Process. Our job begins and ends within this process. Without this, we are not engineers, we are not innovators, we are not creators. As stated before, we began this project with a blank slate and our first job was to find a problem. We needed to figure out something that people struggle with daily. A hassle that has prior solutions that need revamping or more preferably an issue that has slipped through the cracks. Now the key to finding an issue is to establish a target buyer. Within our brainstorming, we decided that since we are college students on a college campus then the best target would be the average college student. Once establishing this, we were then able to start brainstorming ideas for possible issues that college students face. We first brainstormed categories that these possible problems would fall into. These categories were broad such as *quality of living*, *convenience*, *transportation*, *organization*. We then tried to come up with problems that could fall into these categories and that affect the typical college student incessantly. We ended up settling on tackling an issue within the transportation of college students.

We decided that the main types of transportation for college students are motor vehicles, bicycles, longboards, and those lovely two feet under you. Obviously, the best form of transportation and often the most out of reach for students are motor vehicles. With that in mind, we decided to throw that area of interest out the window. We then thought about our legs and concluded that the bicycle was created to innovate this area of interest. So, if we wanted to create a new form of transportation that would rival the bicycle, not only would that be expensive but also ludacris. However, we could innovate the bicycle. Shortly after, we realized that it truly already exists in its most optimal state and anything other than reinventing the wheel would come short of truly innovating the bike. This left us with one area left and that was the longboard market.

While brainstorming about the longboard and determining what can be improved, we came to realize that the longboard was an innovation off the skateboard that allowed for increased speed, agility and balance. However, while innovating these aspects, the longboard did lose one important feature of the skateboard and that was movement along the z-axis. The longboard is a creature trapped in the x-y plane. The one groundbreaking innovation would be to grant it access to the z-axis by making the longboard leap. Upon further research into this issue and by talking to other college students who avidly use the longboard as their source of transportation from place to place around campus, we found that not having access to the z-axis does indeed make the average long boarder's life a headache while riding. Dodging obstacles, getting over curbs, and riding over cracks and bumps in the road all lead to possible injury for the long boarder. While improved truck suspension is a possible solution, there's no solution for the larger obstacles that create larger disasters. At this point we determined that this would be the issue that our project would tackle.

Taking our problem to the drawing board, we decided that our product must meet specific criteria for it to truly be an innovation that enhances the long boarder's ride. Firstly, the product must accommodate people of all heights and weights. It must be easy to use and able to be used while riding without compromising the rider's balance. It also must be able to be used repeatedly and quickly. These criteria formed the basis of our project.

Our next steps encompassed rounds and rounds of brainstorming for each part of each design possibility. We sketched all possible designs, one from each person, and then furthered the brainstorming process to see which parts of which designs can be combined and innovated further into one design concept. This is how we arrived at our first prototype design. This design seemed much more theoretically possible in our heads than it did on paper. We decided to use a compression spring system to propel a lever arm into the ground and thus striking the board into the air and over the obstacle.  Not one part of this design would work in any way, shape or form as we were told in our presentation.  The compression spring would never be able to harness enough energy to propel a 160-pound person into the air or even the board alone. It would be impossible. Another major issue that we found through this design and would be an issue till the end was the repetitive nature of the device. We needed this device to put a college student in the air over and over and over at the push of a button. If we were going to use springs, we would somehow need the spring to retract immediately after being fired off to be ready for it to go off again.

Walking out of our first presentation was a disaster. We contemplated trashing the entire idea to tackle a different problem completely non-related to the longboard. However, after deliberation we concluded that it would be the easy way out if we did that, so it was back to the drawing board again. Through our development of the second prototype design, we decided to throw away the compression spring idea and instead use a tension spring. We believed that if we could harness the energy of a tension spring, they would propel someone up and over any obstacle. Although it seemed like a foolproof plan, this design did lack the diversity of our weight criteria. If this design would work, we would have to tune the springs to launch the heavier person at the minimum height possible thus propelling the lighter person much, much higher. We decided that we would have to overlook this and instead go on with our plan. Our second prototype ended up utilizing a pedal, pulley system, and springs. We designed the mechanism to work like a piston. You would push down on the pedal thus moving a link downwards, causing the pulley to rotate and thus cocking back the springs to be fired off. It seemed perfect with the exception of the necessary force needed to be applied to the pedal for the springs to be cocked back. This oversight cost us the functionality of our mechanism. We decided that our future design could implement a multi-pulley system that can offset the necessary force applied to the pedal. Even with this possible solution at hand, the second prototype was again chalked up as a failed mechanism. Our next steps could either be to further attempt to fix the second prototype or trash it and start new again with a better design. We chose the latter option.

## Final Prototype Design:

Our final prototype design is a piece of work with each part of the assembly being inspired by a different known mechanism used in different environments but with the same function. Throughout the project, we tried to create a mechanism that would fit under the board and would make some sort of contact with the ground to create the leaping motion that we needed. Back during the research stage of our project, when we were looking for possible ways for the board to leap into the air, the one video we found and watched over and over was that of a skateboarder doing an ollie. The ollie is the most basic trick that allows a skateboarder to jump in the air. The ollie consists of the skateboarder pushing his back leg into the back-end of the board towards the ground thus popping the front-end up like a teeter totter on the playground at your elementary school. The skateboarder then pushes his front leg down after the board is in the air in order to pop the back-end of the board upwards, thus creating the jumping motion. Throughout the project, we analyzed how the board moves during this trick, however, when designing the final prototype, we analyzed how the skateboarder's legs move. In doing this, we designed the final prototype to have some sort of knee bending motion integrated into the mechanism. This led us to the idea of having four legs with knee joints right around half-way down the length of the legs.

Designing the final prototype around these legs would be difficult because when analyzing the ollie, the legs were the driving force behind the motion of the jump. With this, the enigma arose when thinking of how these legs can power enough energy to lift a person into the air. And that was when the lightbulb went off. *Lift*. This whole time we were trying to utilize some sort of force acting in such a way that the impulse between the lever and the ground would power the board to jump over the obstacle. But what if we designed a mechanism that lifts the board and person upwards while making contact with the obstacle itself to make the board fly forward. With this in mind, we built around the legs and came up with the idea of having a chassis underneath the actual board that would strike the obstacle. This chassis would be connected to the legs directly. Together the motion of the legs and the chassis would mimic that of the ellipticals at the gym. They would bend upon impact with the curb thus propelling the chassis backwards and board forwards.

This sounded like a good idea; however, the question arose of how to create enough clearance between the real board and the chassis underneath for the board to make the jump over the curb. This was answered back in the gym again. Dips are an exercise where you hold yourself up on two bars parallel to your sides. You then bend your elbows downwards to lower your entire body and then push back up. Imagine the parallel bars in gymnastics. Now imagine trying to get down by bending your elbows and then lifting yourself back up by straightening them again. This is the exact motion that we wanted to use in our design. So far, we knew that the legs had to withstand our weight and that they would bend when the lower chassis would strike the curb. So, if we created handles that held the two front legs together and the two back legs together then we could push down on these to lift our legs upwards, thus creating enough clearance between the chassis and board. We would of course have to add straps to the top of the board for our feet to go into so that we would be able to lift the board upwards when we lifted our legs.

This mechanism gave us our design. We would have these handles attach to the legs which also hold them in place. The legs would attach to the chassis. When you push down on the handles to withstand your body weight, you would be able to lift your legs and the board upwards enough for the chassis to strike the side of the curb and throw the actual board and person forward safely over the curb.

The last and final piece of the puzzle was just retraction. This problem didn't seem much like a problem at all. With our mechanism, we would only need the chassis to retract in the x-y direction. In doing this, we needed a compression spring and block system between the bottom of the board and the chassis. This would allow for the chassis to spring back forwards into its original position after impact with the curb. The rider would only have to pull back up on the handles causing the legs to re-straighten and align the chassis to be in its original position under the board.

All in all, the design would work perfectly in theory and application if we just tweaked it a little bit more. I would, however, chalk this design up as a success since it would most definitely work. It is the most innovative and plausible design of ours and would work perfectly.

## Critical Aspects and Innovation:

**What Worked**

- Deliverance of Power: we were able to find a mechanical system that could translate all the work vertically downwards.
- Retraction of Device: a spring system was incorporated to reload the device. When the front bumper makes contact with a curb, the bumper is pushed back and the spring gets loaded for another use.
- Cheaper Cost: when prototyping, we were trying to use torsion springs, multiple spring holders, and pulleys. However, we were able to eliminate those by making a simpler design
- Easier Use: loading the spring was the most difficult feature as we needed a clever way to do it without having to put in more time and work. Now, all one has to do is hit a curb for automatic retraction and push up on the handles.
- Less moving parts: like explained before, the prototypes had multiple torsion springs, pulleys, and strings. With the final product, we were able to eliminate the multitude of moving parts and simplify it to fewer moving parts. The smaller number of moving parts also meant more reliability.

**What didn't work:**

- Quicker Retraction to prevent falling over: the time required to retract the device is too large and it does not work consistently. Due to the weight distribution of the board, top being too heavy, the board is harder to maneuver and falls over easily.
- Greater applied force: the board requires a great deal of $F_A$ (Applied Force). This is due to the user having to lift up his/her own weight, the entire Longboard Leaper mechanism, as well as the longboard itself.
- Stability: as mentioned above, the ratio of the top to the bottom is too large. In addition, the two posts and handle attachment adds too much weight to the board which makes the trucks move too easily. Even when we attempted to tighten the kingpin to make the trucks move less, the top weight was too large for precise maneuverability of the board.
- Smaller/ leaner parts

# DOE:

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variables** | | **low** | **high** | | | | | | | |
| Strength of Spring | | Bruce's | Ours | | | | | | | |
| Degree of Compression | | 50% | Max | | | | | | | |
| Placement of Spring | | Center Board | Edges | | | | | | | |
| **Test** | $x_1$ | $x_2$ | $x_3$ | $x_1x_2$ | $x_1x_3$ | $x_2x_3$ | $x_1x_2x_3$ | **Height(in)** | **Height (in)** | **Average** |
| 1 | -1 | -1 | -1 | 1 | 1 | 1 | -1 | 0.0000 | 0.0000 | 0.0000 |
| 2 | -1 | -1 | 1 | 1 | -1 | -1 | 1 | 0.0000 | 0.1000 | 0.0500 |
| 3 | -1 | 1 | -1 | -1 | 1 | -1 | 1 | 0.0000 | 0.1500 | 0.0750 |
| 4 | -1 | 1 | 1 | -1 | -1 | 1 | -1 | 0.0000 | 0.0500 | 0.0250 |
| 5 | 1 | -1 | -1 | -1 | -1 | 1 | 1 | 0.2000 | 0.1000 | 0.1500 |
| 6 | 1 | -1 | 1 | -1 | 1 | -1 | -1 | 0.1000 | 0.0000 | 0.0500 |
| 7 | 1 | 1 | -1 | 1 | -1 | -1 | -1 | 0.2500 | 0.2000 | 0.2250 |
| 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0.2000 | 0.0000 | 0.1000 |
| **Main:** | **E1** | **E2** | **E3** | **E12** | **E13** | **E23** | **E123** | **Yave** | | |
| | 0.375 | 0.175 | -0.225 | 0.075 | -0.225 | -0.125 | 0.075 | 0.11125 | | |
| | | y = | **0.11125** | + | **0.1875** | $x_1$ | **0.088** | $x_2$ | | |

***Table 1: DOE***

The maximum height is wanted, so this is the quantity that needs to be maximized.

Quantified Result: Distance off of ground

Variables tested: Strength of Spring, Degree of compression, Placement of Spring.

As one can see, the initial testing of the prototype did not perform nearly as well as planned. The heights reached were almost negligible compared to the height needed to pass over a curb. The entire board as a whole did not manage to make it off the ground, only certain areas of it. It was from this DOE that the decision to change the design was made. Springs obviously would not be able to propel a human. A more physical approach was needed, which is what inspired the final result.

## Manufacturing:

Manufacturing the longboard leaper proves to be a lengthier process because of the sheer size and components of the product.

*Figure 3: Final Cad Assembly*

Below is the exploded view of the product, with the individual parts color-coded with the manufacturing process decided upon.

| Item | Part | Quantity | Material | Manu. Process | Cost |
|---|---|---|---|---|---|
| 1 | Handle | 2 | ABS | Inj. Molding | 0.53 |
| 2 | First bar-link | 4 | AL. | Bar/tube machining | 0.05 |
| 3 | Second bar-link | 4 | AL. | Bar/tube machining | 0.09 |
| 4 | Base | 1 | Steel | Casting | 7.35 |
| 5 | Elevator | 1 | ABS | Inj. Molding | 1.45 |
| 6 | Wheels | 4 | ABS | Inj. Molding | 0.25 |
| | | | | TOTAL COST: | 9.72 |

*Table 2: Manufacturing*

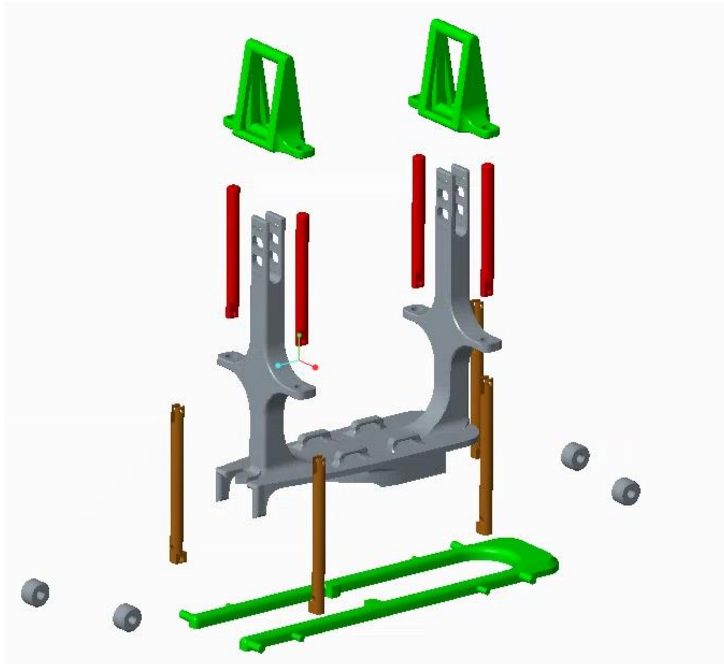

***Figure 4: Exploded View***

When deciding the manufacturing process, the biggest consideration came from the ability for the design to not fail while under stress. It is for this reason that the base of the product would be casted, as that would provide the greatest strength. Bar/Tube machine would be done on the lifting mechanism to prevent failure if made with plastic extrusion. Ideally, the elevator would be casted rather than injection molded as that part would endure the most stress when hitting the ground, but assembly and manufacturing costs would increase. The cost analysis of each part was completed using aPriori, at 10,000 completed products a year for 5 years.

When it comes to assembly, the time isn't as bad as initially thought of. The greatest hassle is connecting the lifting bars to the massive base.

*Table 3: Design for Assembly*

| Step | Part | α- symmetry | β-symmetry | Handling & Alignment Time(s) | Handling & Alignment Total | Insert & Secure Time(s) | Insert & Secure Total | |
|---|---|---|---|---|---|---|---|---|
| 1 | Main Base | 360 | 360 | 0.5(fetch) + 2(Sym)+ 0.5(size)+0.3(A.R.) | 3.3 | G.P.(0.5) + Difficulty(0.4) | 0.9 | |
| 2 | First Bar-link | 360 | 0 | 0.5(fetch)+1(Sym)+0.5(size)+0.3(A.R.) | 2.3 X 4 | G.P (0.5) + S. Hole (0.7) X 2 + Difficulty (0.4) | 2.3 X 4 | |
| 3 | Second Bar Link | 180 | 0 | 0.5(fetch) + 0.5(Sym)+ 0.5(size)+0.3(A.R.) | 1.8 X 4 | G.P (0.5) + S. Hole (0.7) + Turning Insertion (1) + Final Tight. (7)+ Difficulty (0.4) | 3.3 X 4 | |
| 4 | Handles | 180 | 0 | 0.5(fetch) + 0.5(Sym)+ 0.5(size)+0.1(A.R.) | 1.6 X 2 | G.P.(0.5) + Med. Pin (0.1) X 2 + Snap (0.3) + Difficulty (0.4) | 1.4 X 2 | |
| 5 | Elevator | 360 | 0 | 0.5(fetch) + 1(Sym) + 0.5(size)+0.3(A.R.) | 4.8 | G.P.(0.5) + S. Hole (0.4) X 4 + Med. Pin (0.1) X 2 | 2.3 | |
| 6 | Wheels | 0 | 180 | 0.5(fetch)+1(Sym) +0.5(size) + 0.3(A.R.) | 2.3 X 4 | G.P.(0.5) + Med. Pin (0.1) + Turning insertion (1)+ Final tight. (2) | 3.6 X 4 | Total Time |
| | | | | | 36.9 | | 42.8 | **79.7** |

Some improvements could be made to the current design to shorten/simplify assembly. Combining the handle and bars would be ideal, since any weakness of that connection may compromise the operation of the Longboard Leaper. The same could be said for the elevator and second bar-link. Snap-fits would be harder to incorporate due to the high forces the Longboard Leaper has to endure during operation, so any snap fits may fail.

# Logistics:

The final cost of the project took up the entire two hundred dollar budget allocated. Below is the final distribution of the costs:

**ME 270 Waterfall Budget Example**

| | Base | Cost (down) | Cash Back (up) | Line 0 | Line 1 | Line 2 | Line 3 | Line 4 | Line 5 | Line 6 | Line 7 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Expenses:** | $ **200** | | | $200 | | | | | | | |
| Springs | $ 165 | $ 35 | | $200 | $165 | | | | | | |
| Rope | $ 159 | $ 6 | | | $165 | $159 | | | | | |
| 3D Printed Parts | $ 129 | $ 30 | | | | $159 | $129 | | | | |
| Hardware | $ 89 | $ 40 | | | | | $129 | $ 89 | | | |
| Construction Wood | $ 39 | $ 50 | | | | | | $ 89 | $ 39 | | |
| Wheels | $ 27 | $ 12 | | | | | | | $ 39 | $ 27 | |
| Apoxy/Paint | $ 2 | $ 25 | | | | | | | | $ 27 | $ 2 |
| **Remaining** | $ - | $ 2 | | | | | | | | | $ 2 |

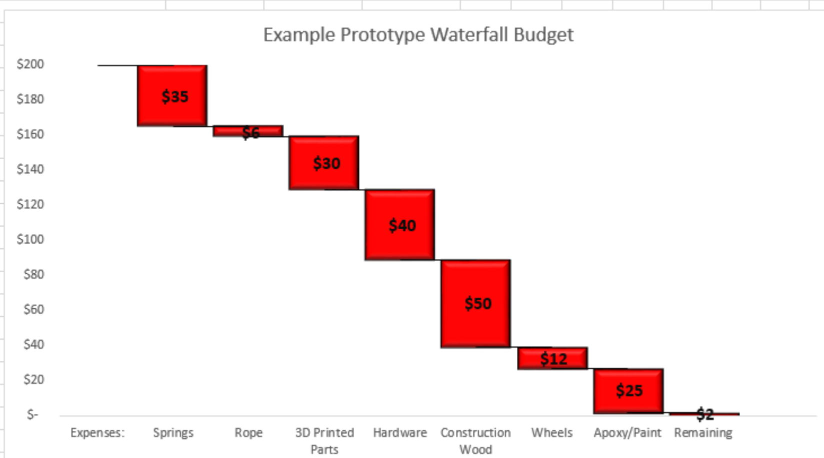


*Table 4: Budgeting*

As one can see, the majority of the cost came from the construction wood used in the prototypes and final product. Ideally, the wood would be replaced with metal counterparts, so the cost would be more expensive than shown. A decent amount of the budget was used in the scratched prototype, so resources for the final product were limited. Overall, the budget was a little too tight for comfort.

When it comes to planning, the GANTT chart provided an organized method of ensuring that the schedule was met (or at least as well as possible). The most time consuming task was no doubt the construction of the final product. Cadding the product did not take as long as thought due to simultaneous work on it. Finally, the purchasing of materials proved to be a major snag in the project. Delays with ordered parts as well as creative improvisation of parts needed caused major delays in the project.

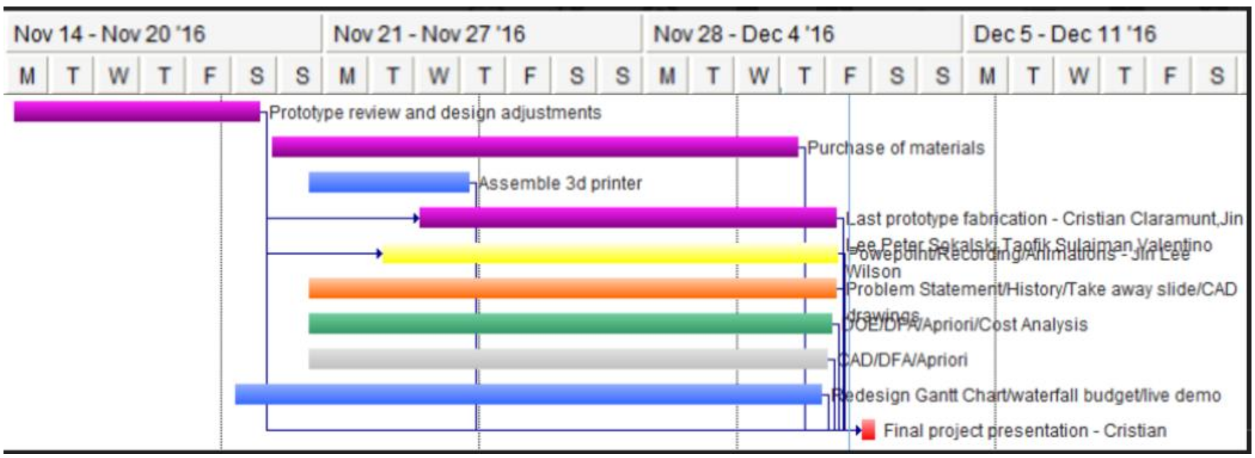


***Table 5: GANTT Chart***

## Conclusion:

In conclusion, this project proved to be a greater challenge than the brainstorming sessions in the beginning would suggest. The product evolved from an impossible compression propelled spring to a better but more space consuming torsion spring set up and concluded with the physically induced force inspired by the Ollie skateboarding trick. The final product still may not work properly, but definitely more likely to work than the previous iterations. Springs did not seem feasible whatsoever for lifting a human and board off the ground. Overall, the project was difficult, but a very fun and neat project to work on and think about!