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Lawn Mower Lift

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Brandon Lockhart: Report, 3D Model, Charts, Calculations
Kody Teets: Report, Charts

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Mechanical Engineering Department
University of Akron
Spring 2017

Lawn Mower Lift

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Department of Mechanical Engineering

Honors Research Project

Submitted to

The Honors College

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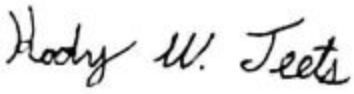

Executive Summary

Our team of engineers were given the task of coming up with a design project and designing the system, creating calculations, and brainstorming ideas. We set out to design a riding lawn mower lift. The purpose of this design was to assist in general maintenance like replacing blades, oil changes, etc.

To accomplish this task, our team started to brainstorm ideas and make sketches to look at all the options. We then did research and looked at different size lawn mowers and looked at the specifications. This helped our team to be able to design the size of platform needed to accommodate the size of the tractors. Then, calculations were performed to see the lifting power needed for the mower. Once all of the decisions and calculations were made, we designed the 3D model of our design.

As a result, our team of engineers have produced a lawn mower lift concept that is both functional and user friendly. This will help the customer have a more functional and more ergonomically friendly design to work on any repairs. We designed the lift to have the front end lift up significantly more than the back end so the user can change blades on a mower easier. Also the user could make the front and back end level to get under the vehicle to change oil or perform general maintenance with more room to work with under the vehicle. Once the concept was developed, we expanded our capabilities to other small motorized vehicles with four wheels, like four-wheelers, go-carts, or side-by-sides.

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Introduction

Our team of engineers began the process of designing a lawn mower lift by looking at many angles and different product range. Our team began to look at what products are available in the market and how we could design a lift to best suit customer needs in a cost and performance perspective. The goal of our lawn mower lift is to be able to lift the front end of the mower to be able to change the blades on the mower. Our team of engineers also decided that lifting the back end of the mower up a little bit would make it ergonomically better on the user.

Background

Our team is very hands-on and wanted to design something that would actually be useful. Car lifts are common, but what about the people that like working on smaller vehicles like lawn mowers and four-wheelers? We set out to make a simple and affordable but also practical lift to make this type of work easier. I believe if the lift works and is actually manufactured, we would all enjoy having it as another tool in the garage. Because the project had somewhat of a practical use to us, it made the work more interesting.

Simple Design Brief

Our team came up with an idea to create a lawn mower lift and make it ergonomically friendly for the user, make is safe, and make the product cost effective.

The system level of design must be made with safety in mind and satisfy criteria of customers.

Expanded Design Brief

Our design must take multiple factors into consideration. One of the biggest factors is how to lift the mower up in the front and in the back. Our team is weighing the decisions for the front lift to be a winch, a pulley, or a come-along. Also, the back lift is another decision needing to be made, the team is looking at options such as, no lift, low profile bottle jack, floor jack, and a winch. The size of the overall lift needs to be taken into consideration. Our team thinks the lift should not be too large but we also believe we want it to be a reasonable size for a larger product range and not specific to one. With having the front and back end lift up, the user can easily level the vehicle out and get underneath the vehicle to change oil. The front lift will have the vehicle lift approximately three foot off of the platform. The back platform will lift the mower up about fifteen inches. This will put the vehicle at an angle for easier maintenance.

We then have discussed amongst ourselves to figure out what we want our final output of the overall system. This includes how easy it will be to lift and lower the mower. The platform is also designed to accommodate for different types of mowers not just one brand specific. As the design phase went on, our team of engineers also realized that the lift could be used for a larger product range. The lift could be used for four wheelers, side-by-side, and go-carts. We also looked into the mobility of the overall

product, we designed the product that if need be could fit into the back of a truck and be hauled around.

Product Description

The desired lawn mower lift will have a platform of four foot by eight foot. This will help accommodate a large range of products. Also, with making the product to those restrictions, it will be able to fit reasonably well in the bed of a truck to be mobile. The winch will need to lift a weight of approximately 600 pounds. The winch selected is rated at a load of 2000 pounds. The back end platform will have a jack under it that can accommodate up to 4000 pounds, so that will be sufficient in lifting a mower or vehicle on the platform. Using all of these products, this will make this mechanism durable, safe, and user friendly. The design of this product can also be modified to be able to change for other types of small motor vehicles.

Conceptual Design

After evaluating customer needs, our team of engineers began brainstorming concept solutions of how to lay out the design of our lawn mower lift. Our first task we had to consider was how to get the lawn mower onto our actual device. We decided that the best option was to drive the lawn mower onto the lift. Another function was how do we lift the lawn mower up into the air. This included idea such as a winch, a jack, a pulley system, and a come-along, Then we needed to decide if we had a winch, how we would power the winch. Our options included, a battery, a wall outlet, or manually

crank the winch. Next we looked at the type of material we would want to make our lift out of to make sure we have a sturdy enough lift. Different materials could include aluminum, steel, stainless steel, or plastic. Finally, we wanted to look at different ways to fasten the material together. We looked at either welding or fastening with bolts. After brainstorming all of these different solutions for each function of our lift, a morphological chart will be constructed to help organize all of the ideas.

Morphological Chart

We created a morphological chart of the main components of the lawn mower lift. Our engineering team came up with an array of solutions for each component. We have a total of 288 total possible solutions for our Lawn mower lift from the table below.

Sub-Functions	Options			
Front Lift				
Power Source (if winch)				
Back Lift			No Lift	
Material			Stainless	
Fastening Frame				

Figure 1 - Morphological Chart

Objective Tree

Our team of engineers created an objective tree to look at all the advantages to this product and the benefits to the customer of this product.

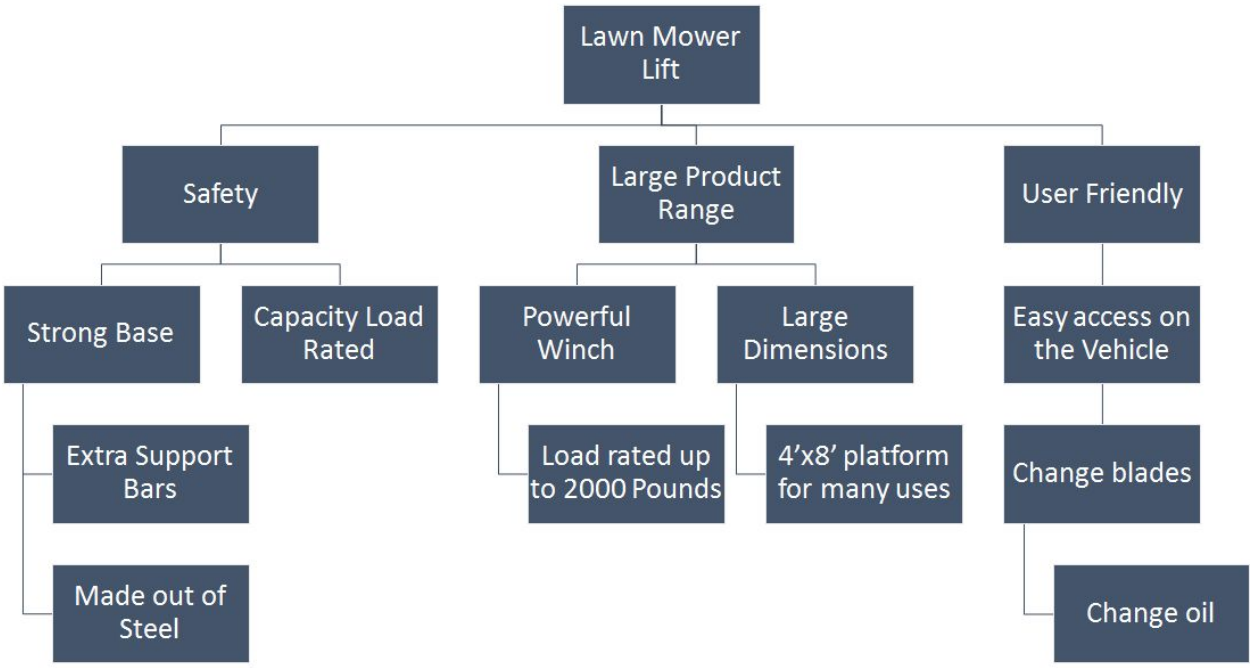


Figure 2 - Objective Tree

Free Hand Sketches of Concept Design

Our team of engineers developed many solutions of the lawn mower lift and created many of them in hand sketches. These hand sketches can be found in the appendix.

Analyzed Proposed Solutions

Using solution screening techniques, our team of engineers was able to begin to eliminate some possible solutions found through our beginning brainstorming techniques. This was done to narrow down a final solution better. We ruled out a pulley system on the lift due to concerns of the pulley not being strong enough. We neglected a wall outlet for the concerns of a mobile lift. There is not always a power source around and neglected the hand crank because of the manual labor intensity it would need to crank it. We decided for the system that the back would need to lift up too so the option of no lift is ruled out. Also, with winch would not be feasible and a normal floor jack would not be needed. We also decided that the best material for the lift would be a stronger material and decided on steel. In this stage of the design, we started to narrow down our design to just three options.

Solution 1: Our first design consisted of two ramps, one for the front tires and one for the back, they would be connected by square tubing and have 4 bottle jacks (one under each tire connected to raise the same amounts. This design used guides to ensure the ramps went up stable and straight.

Solution 2: Our second design was similar to the first, with the exception that each side would have its own rail. This made it a little easier to go to two jacks, but made it harder to get under the lawn mower which is the problem we are trying to solve.

Solution 3: Our last design, was to lift the back of the tractor up a little, and then use a winch to raise the front to desired level this would allow even more access to the bottom of the machine and is structurally safer, in that it can't fall off the rails. This is th design we are going to use. Although we are not using the first two designs, we have and may continue to steal ideas from them for improvements and modifications.

Weighted Decision Matrix

After solution screening of our morphological chart, we concluded we needed to create a weighted decision matrix for each item in the morphological chart. After evaluating all of the components, these were our results for each component.

Fastening Frame	Cost	Strength	Total
	1	2	
Weld	4	5	14
Bolts	3	4	11

Table 1: Weighted Decision Matrix (Fastening Frame)

Front Lift	Durability	Cost	Size	Total
	3	2	1	
Winch	4	3	5	23
Pulley	2	4	3	17
Come-along	3	3	2	17

Table 2: Weighted Decision Matrix (Front Lift)

Power Source (if winch)	Cost	Reliability	Mobility	Size	Total
	4	2	3	1	
Battery	3	3	5	3	36
Outlet	3	4	1	5	28
Manual	4	1	4	2	32

Table 3: Weighted Decision Matrix (Power Source)

Back Lift	Cost	Size	Durability	Functionality	Total
	3	2	3	5	
Low profile Jack	2	3	5	5	52
Floor Jack	3	3	4	5	52
No Lift	5	4	0	0	23
Winch	1	2	2	3	28

Table 4: Weighted Decision Matrix (Back Lift)

Material	Cost	Strength	Life	Total
	2	3	1	
Aluminum	2	2	5	15
Steel	3	5	3	24
Stainless	2	5	4	23
Plastic	4	0	5	13

Table 5: Weighted Decision Matrix (Material)

Embodiment Design

There are 2 main functions of our lawn mower lift; lifting the front end of the mower and raising the whole back end. Our method to lift the front end will be the winch. The winch will be mounted on the front of the lift on a steel plate. This function

will be powered by a 12 volt battery. The winch can support up to 2000 pounds. This will be a perfect device for tractors so it will be easy to lift the front end with a simple hook. The winch and battery are affordable, reliable, and durable for this type of use. The other main function will be lifting the back end platform. We decided that we would use a low profile bottle jack. This will range from as low as 6” to 14.5” and can handle up to 4000 pounds. The jack for the lift is ideal because the jack is made of steel and it is a hydraulic jack. The winch will be bolted to the frame for support and the bottle jack will have a frame that will attach it to the whole system. The whole frame and all of the supporting pipes will be attached by welds.

With the simple, individual functions of each component, the lawn mower lift will be very reliable. But if there were to be any complications to the system, there would be an easy diagnostics and repair of the system. The system is simplistic and an easy setup along with being very safe and stable. The main frame will be made out of 1005-1026 carbon steel and welded together. The platforms will be made out of common carbon steel and the front platform will be attached by bolts.

Detail Design

Calculations

Strength and Capacity of Lift

Based off of the specifications of our materials and purchased items, the yield strength of the steel tubing is 32,000 psi and the yield strength of the steel plates is 54,000 psi. We planned on using ¼-20, Grade 8 bolts which have a yield strength of

130,000 psi. For the joints that are welded, we planned on using E70XX electrode which has an estimated yield strength of 57,000 psi. The winch is rated for 2000 pounds and the bottle jack is rated for 4000 pounds (2 ton). When taking all of these values into account, the winch will be the weakest point in our design. When looking at standard lawn mowers, the average weight is around 500 pounds, with a maximum (standard) of 600 pounds. We will use 600 in our safety factor calculation.

Safety Factor

$$n = \frac{Strength}{Actual\ Load}$$

$$n = \frac{2000}{600} = 3.3$$

If we wanted to increase this value, we would just have to purchase a winch with a higher load rating. As far as the steel, joints, and bottle jack, our design is rated to hold much more than the average lawn mower. As we look into optimizing our design, material thicknesses may decrease for economical purposes, but as of right now, we want the option to be able to hold vehicles heavier than the average lawn mower.

Bill of Materials

BOM Number	Item	Quantity	Supplier	Price	Total Price	item #
1	Strongway Hydraulic High lift double ram bottle jack	1	Northern Tool	39.99	39.99	41695
2	Steel Plate	4'x3' (1)	McMaster Carr	140.30	140.30	8943K41
3	Steel Plate	3'x1' (1)	McMaster Carr	140.30	140.30	8943K41
4	Steel Plate	4'x5' (1)	McMaster Carr	140.30	140.30	8943K41
5	Steel Plate	6"x6" (1)		Use Scap from other pieces		
6	Steel Tubing	1"x1"x0.12" 6' (14)	McMaster Carr	24.14	337.96	6527K364
7	Steel Tubing	1"x1"x0.12" 3' (2)	McMaster Carr	$14.48	28.96	6527K364
8	2000 lb Marine Electric Winch	1	Harbor Freight	$79.99	79.99	61876
9	Winch Battery	1	Harbor Freight	39.99	39.99	62586
				Total:	947.79	

Table 6: Bill of Materials

Assembly drawings/part drawings

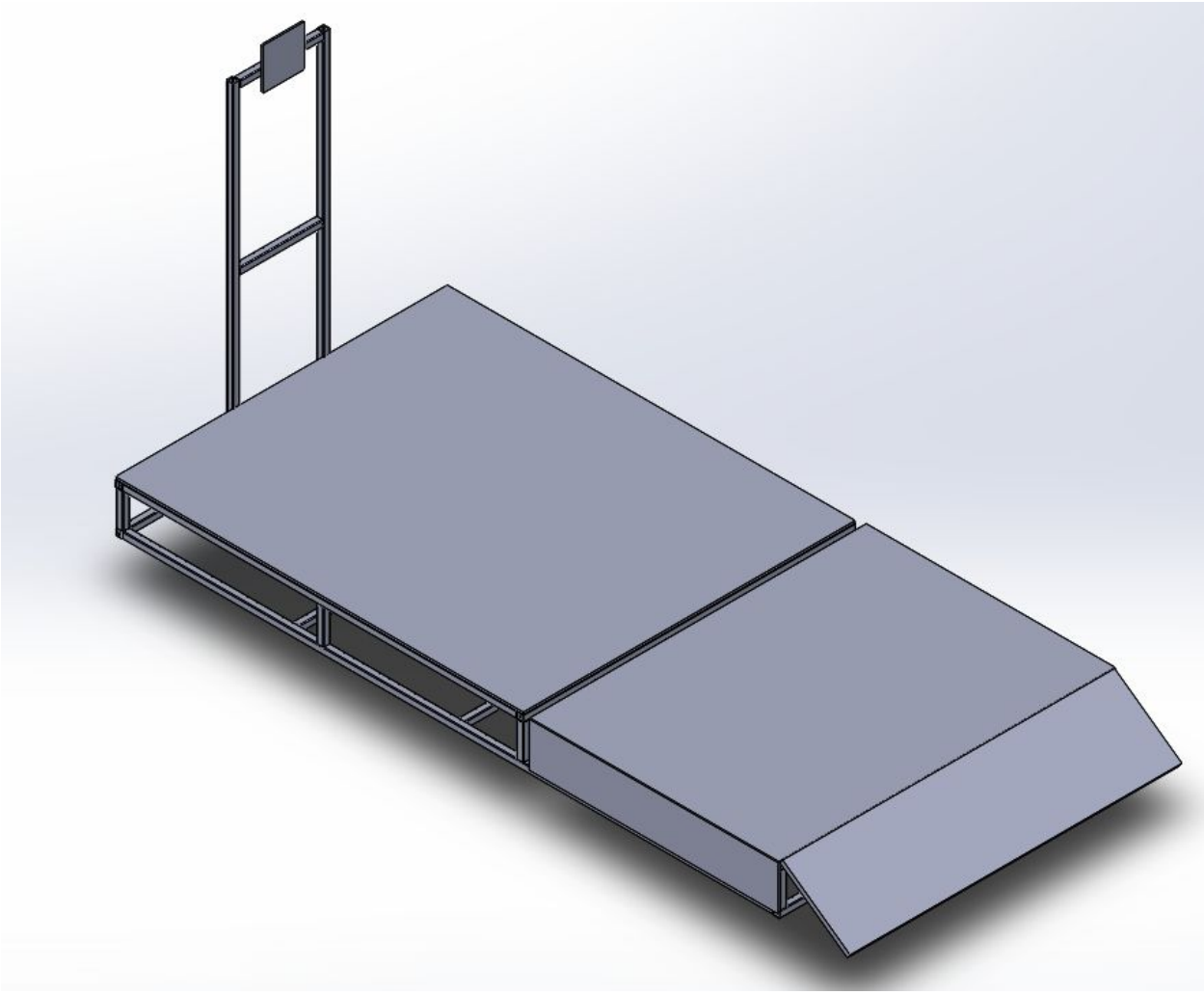


Figure 3 - Assembly Drawing (Top View)

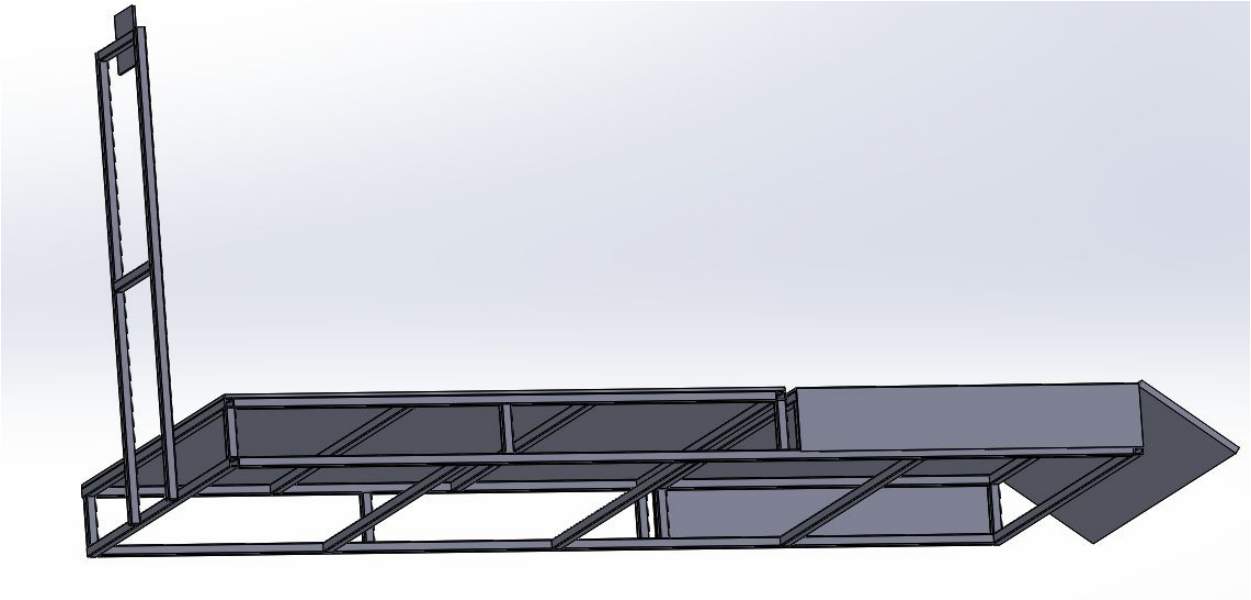


Figure 4 - Assembly Drawing (Side View)

Discussion

For our ME Design Project, our team came up with an idea to manufacture a lawn mower lift. The purpose of this design was to assist in general maintenance like replacing blades, oil changes, etc. Other designs we saw only lifted the front by about a foot. One still had to lay on the ground to do any maintenance. Ours on the other hand puts the working area at about 2 and a half feet which is the perfect level if sitting on a garage stool. While working on this project, we were able to display our engineering skills that we have learned from the classroom. By brainstorming, we came up with several solutions to our desired design. With these solutions, we ranked each one from best to worst to accumulate the top design. From our knowledge gained in the classroom, we used decision matrices and solution screening methods to focus our ideas on paper. By doing research on the subject, it helped us narrow down the little

details to construct our fully developed design. Using the methods mentioned earlier, a prototype drawing of our lawn mower lift design was generated. We genuinely believe that this product may have a chance in the market place. In our decision making of going with this final design, it was determined that this product will be easy to use, extremely reliable, and cost friendly. Hopefully, The University of Akron will be able to grant us with the money needed in able to construct the prototype product. This will help us visualize possible drawbacks/designs of our system. In conclusion, this project was very helpful in exposing us to a variety of tools to provide solutions for the customers in our future careers.

Conclusion

Looking forward, we wanted to produce a full-size model but because of financial reasons we were limited to a prototype.For simplicity reasons, we chose to have our model 3D printed rather than fabricated out of steel. Down the road, if finances allow, we may actually produce one of these lifts for personal use (since the design work is already completed). After that, there is always a possibility it taking off! Below is a picture of our 3D printed model of our riding lawn mower lift.

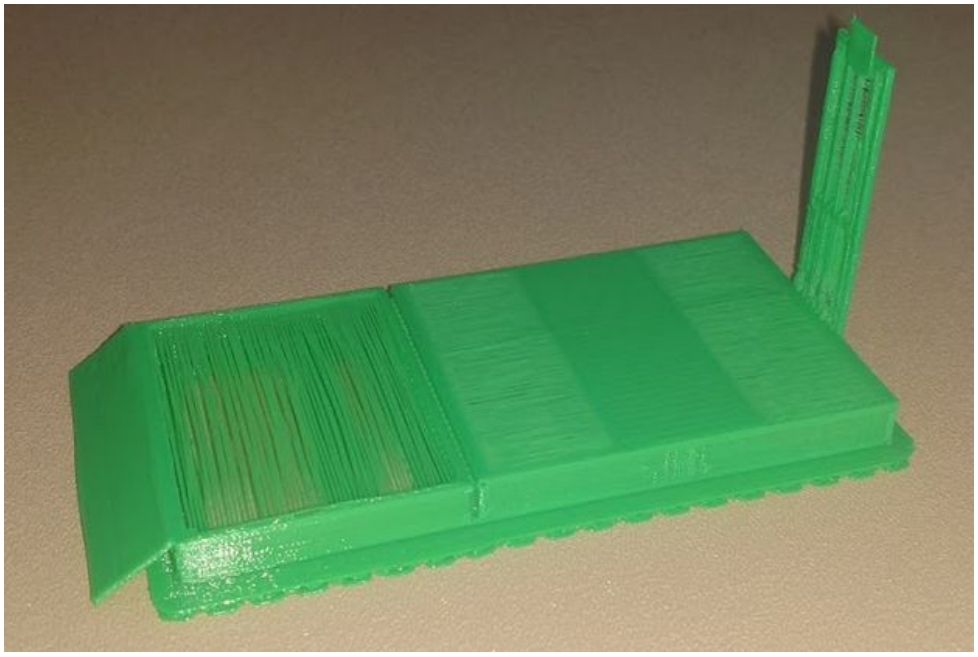


Figure 5 - Prototype (3D Printed Model)

References

"McMaster-Carr." *McMaster-Carr*. N.p., n.d. Web. 14 Dec. 2016.

Appendices

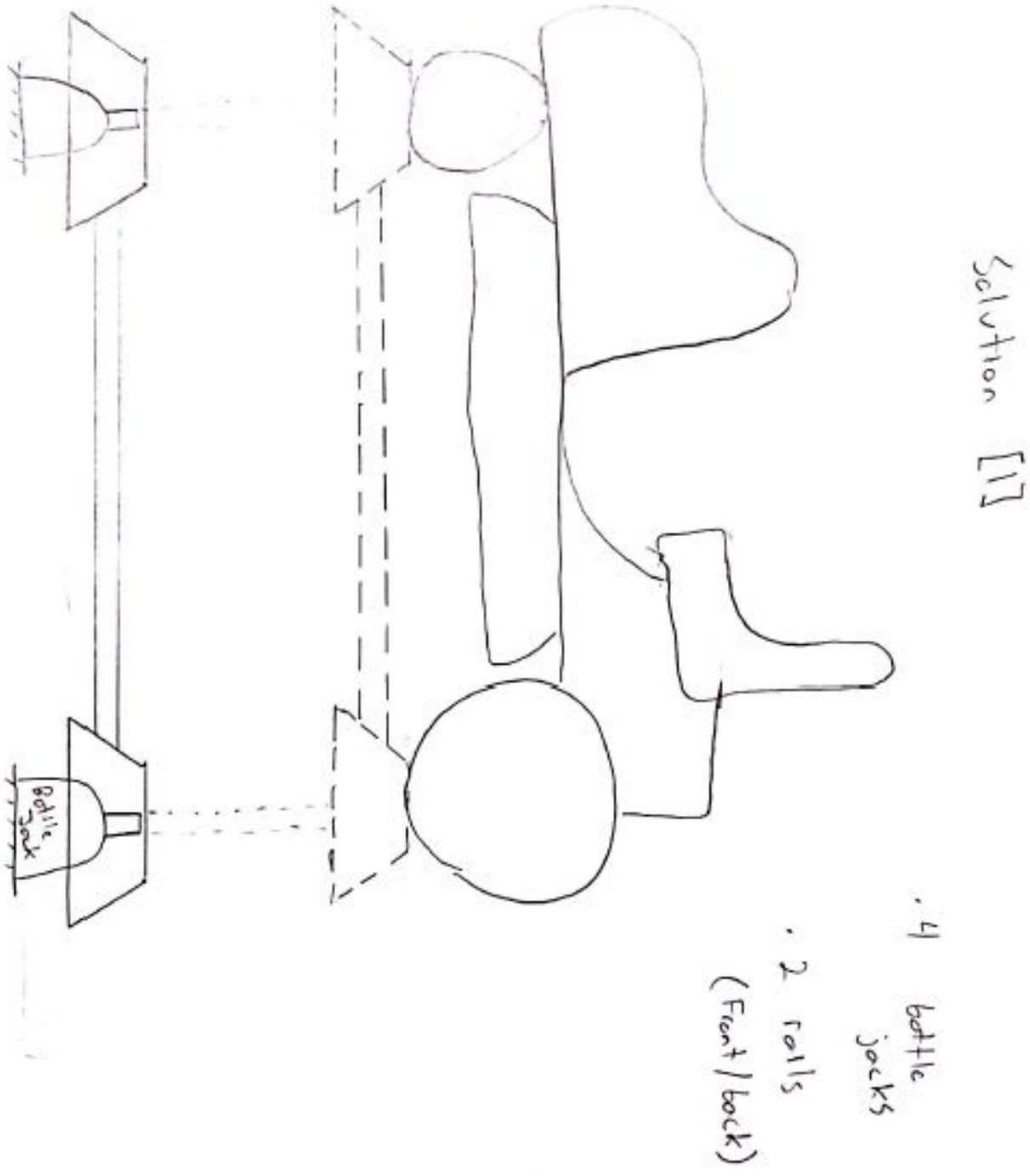
Updated Timeline:

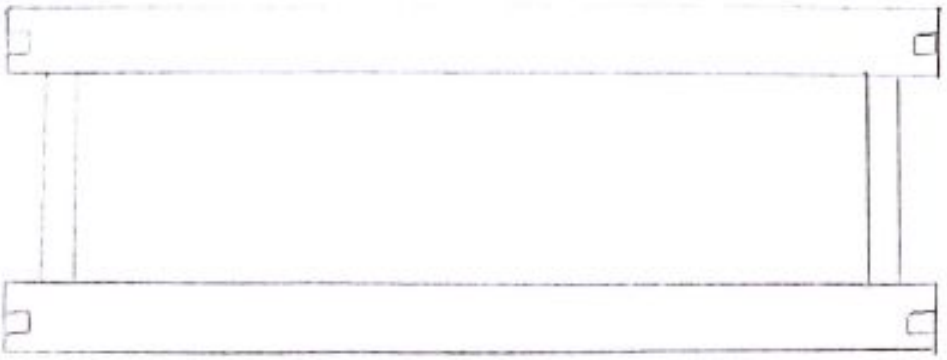
ME Senior Design Projecct		
Lawn Mower Lift		
Group Members		
Brandon Lockhart, Kody Teets, Randall Schelcher		
Timeline (Updated after mid -term and limitted finances)		
Task	**Deadline**	**Week**
Turn Proposal in	October 7th, 2016	6
Sketch Ideas	October 21sh, 2016	8
Pick a design	October 28th, 2016	9
Calculate Load Capacity and Lift Mechanisms	Thanksgiving (November 24th-27th, 2016)	13
Finish Design Work	Thanksgiving (November 24th-27th, 2016)	13
Write Bill of Materials	Thanksgiving (November 24th-27th, 2016)	13
Write Midterm Report	December 2nd, 2016	14
Finalize cost calculation	End of Christmas Break	1 (second semester
Discuss with Dr. Wang finances	January 23rd, 2017	2 (second semester)
Continue Report	February-April	3-14 (second Semester
Scale Model	Spring Break (March 27th - April 2nd, 2017)	11 (Second Sesmester)
Communicate to have prototype 3D printed	April 7th, 2017	12 (Second Semester)
Pick up prototype	April 14th, 2017	13 (Second Semester)
Senior Design Day	April 24th, 2017	14 (Second Semester)
Finish Final Report	April 26th, 2017	14 (Second Semester)

Tractor Specifications:

brand	model	weight (lb)	wheel base (in)	length center to center (in)	front tire width (in)	rear tire width (in)
JONH DEERE	1023E	1345	57.1		8.5	12
CRAFTSMAN	20374	530	31		6	8
CRAFTSMAN	29000	340	30	64	5	6.5
CUB CADET	XT1 ST54	520	47	68	6.5	9.5

Sketches:





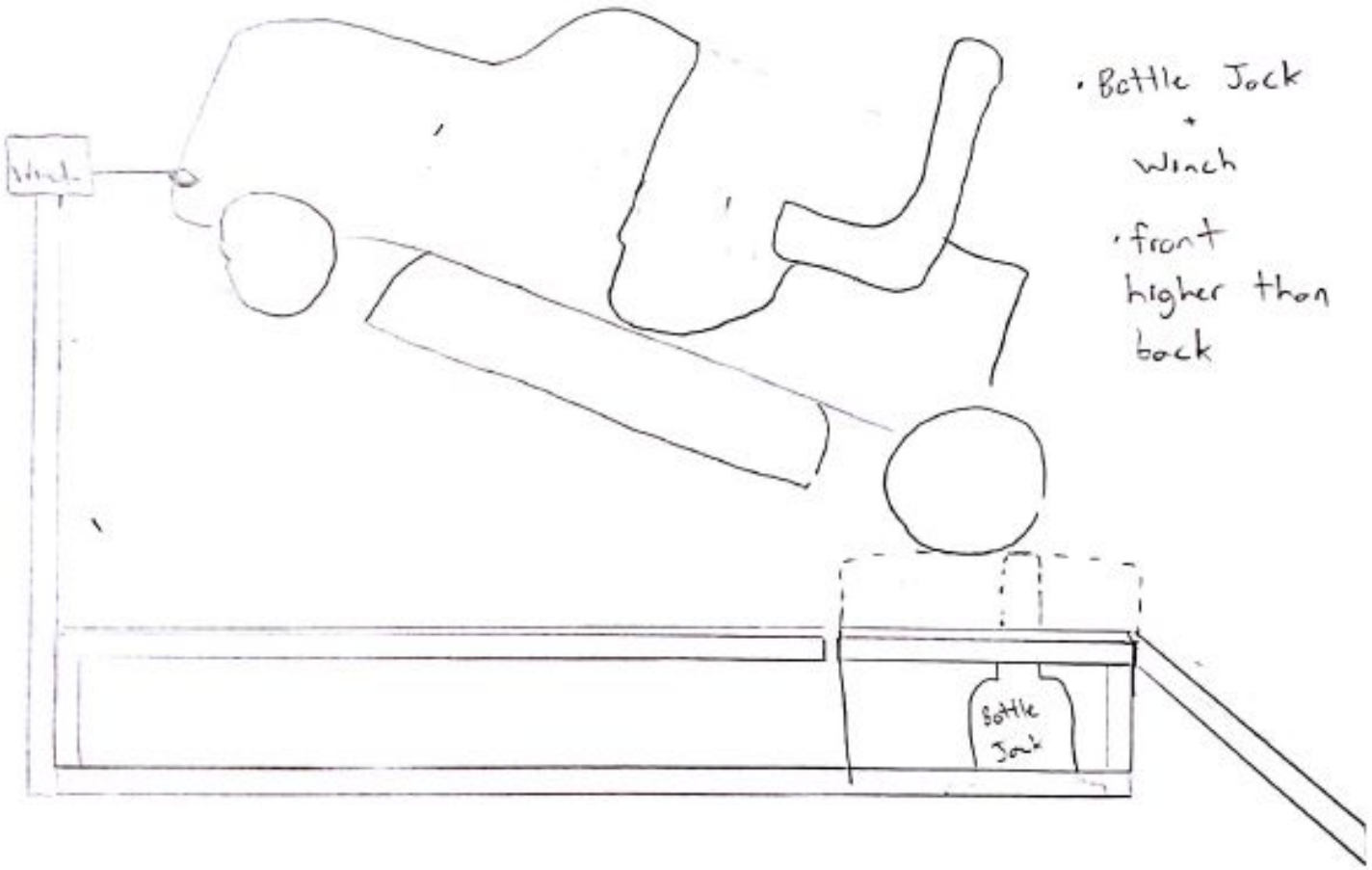
top view

Solution [2]

- 2 bottle jacks
- 2 rails (side)

side view

Solution [3]



- Bottle Jack + Winch
- front higher than back