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## The High Rise Storage System

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**THE HIGH RISE STORAGE SYSTEM**

TEAM VOLTANK 2

Justin Harmon

ME 450/460

11/25/19

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## **ENGINEERING REPORT**

### **EXECUTIVE SUMMARY**

The High-Rise Storage System is an inventory storage solution which focuses on organization, accessibility, and space savings. Its goal is to improve operational efficiency for the employees and profitability for the owners of automotive dealerships and parts stores. The product is unique in that it is a package of a lift system and shelving designed to be used together. Entire shelf platforms can be lifted into position for access and organization of the items contained on them.

Preconstruction design analysis was performed to evaluate the strength and stability of the lift and shelves. This analysis led to changes in the original design such as using multiple materials (steel and aluminum), changing the dimensions of the base plate and frame, and adjusting the amount and location of counterweights.

Once constructed, the prototype was tested, and further modifications were made. These included installing a different type of back wheel on the lift, fixing the bearing rods in place, and aligning the motion of the bearings along the rods. The total cost of this prototype was \$1614, which included materials for testing and design iteration.

For mass manufacturing, additional changes would be made to reduce the cost and complexity of assembly. Notably, a smaller capacity winch would be used, and fasteners rather than welds would be used to attach components.

Moreover, research into potential customers suggested making the lift more compact and improving the speed of lifting.

### **INTRODUCTION OF CONCEPT/VALUE PROPOSITION**

The High-Rise Storage system is a compact storage and access system to be marketed towards the service and parts divisions at auto dealerships and auto parts stores. It creates an organizable inventory system which maximizes the amount of storage capacity for small retail spaces. The ease of accessibility of the items stored helps employees do their job faster and safer. In turn, the employer can reduce their labor costs and offer improved customer service. The product has two parts designed to produce these benefits – the shelving unit and the Lift Assistor.

The shelving unit spans the entire distance between the floor and the ceiling of a shop and therefore utilizes the entirety of vertical space which is typically wasted. This frees up horizontal floor space for merchandising and employee mobility. Unlike other shelves, this unit can store large and oddly shaped items such as sub-assembled components and drums of oil. Each of the shelf platforms rest on top of rungs rather than being fixed in place so that the entire platform can be quickly removed and replaced. Hence, the employee can lower the shelf once and doesn't have to make multiple trips up a ladder to retrieve heavy parts as with other systems. This also reduces the risk of injury to the person and damage to the part from falling off the ladder. Once lowered, each shelf can be subdivided and categorized enabling employees to serve in store customers faster.

The second part of the product, the Lift Assistor, is a human operated fork-lift system designed to remove and replace individual shelves. With minimal human effort required, the fork can lift 200 lbs. up to a 9 ft. height safely by using a self-locking winch system which provides mechanical advantage and operates through a hand crank. Additionally, the wheels on the bottom allow the lift to be moved. The complete product is shown in Figure 6 in the appendix.

## PROTOTYPE DESIGN



**Figure 1a,1b,1c. U-bolt Attachment to Fork, Pulley with Cable, Winch Bolted to Frame**

- Winch and pulley system to lift a maximum load of 200 lbs.
- Rods fixed in place at the top by dowel pins contacting top plate
- Handles for moving lift to desired location
- Angle iron x-brace for structural support of the frame



**Figure 2a,2b,2c,2d. Linear Sleeve Bearings, Pivoting Front Castors, Base plate and Counterweights, Lifting Fork**

- Linear sleeve bearings and rods to lift items between 0.5 ft and 9 ft off the ground
- Rods fixed in place at the bottom by holding block on base plate
- Casters with brakes for easy and safe maneuvering of the lift
- Counterweights and an aluminum frame for a sturdy and robust design
- Compact form factor and small fork for optimized storage space



**Figure 3a,3b. Lift System, Storage Unit**

- Complete Lift Assistor
- Shelving unit to provide efficient storage and easy access of heavy items



**Figure 4a,4b. Cantilevered rack for shelf, welded base frame**

- Cantilevered shelves for easy loading/unloading from fork
- Non-fixed shelf platform
- Welded base frame for a sturdy design
- Lift Assistor can be stored within base frame when not in use

### **CALCULATIONS AND ASSUMPTIONS**

Because the frame of the Lift Assistor was slender, instability due to tipping was a concern. The worst-case loading scenarios were analyzed to determine the location of the counterweights needed to stabilize the frame. In this analysis, the center of gravity of the lift was found using the SolidWorks model. The forces which contributed towards tipping about the front and back wheels included the weight of the lift itself, the weight resting on the fork, the force applied at the handles to move the lift, and the counterweights. These forces, shown in Figure 5, produced moments which contributed towards tipping.



**Figure 5: Forces Acting on Lift Assistor**

The first tipping scenario involved pulling the unloaded lift backwards. In this situation, no weight would be resting on the fork, and the moments would come from the weight of the Lift Assistor and the pulling force. The calculations are shown in Figure 7 in the appendix. Without a counterweight, the pulling force would produce a net counterclockwise moment about the back wheels of the lift, which would cause tipping. To eliminate this possibility, a counterweight of at least 11 pounds would need to be added 25 inches in front of the back wheels.

Next, the scenario of tipping about the front wheels of a fully loaded lift was analyzed. In this case, the maximum shelf weight of 200 pounds would be applied near the edge of the fork along with a pushing force applied at the handles. Both forces would contribute towards tipping about the front wheels. In order to eliminate this possibility, the length of the base plate was extended so that the shelf weight acted behind the front wheels. With this alteration, the moment of the shelf weight and the lift weight were large enough to counteract the tipping moment of the pushing force. These calculations are shown in Figure 8 of the appendix.

Tipping about the side wheels due to the unbalanced weight of the winch proved to be a negligible concern, although, a counterweight was placed opposite of the winch to improve stability while moving the lift.

In practice, the optimal weight distribution to prevent tipping was achieved through iteration of the SolidWorks model. Deliberate improvements included widening the wheelbase of the lift and using both steel and aluminum to alter the position of the center of gravity.

Again, due to the height of the Lift Assistor, failure of the bearing rods due to bending stress was analyzed. The weight of the rods was neglected in this analysis. Bearing sleeves, which are attached to the fork, slide along these rods and allow the fork to move vertically. Given that the fork is in static equilibrium, the moment produced by the weight on the fork is balanced by a reaction moment at the bearing sleeves. In turn, this moment is balanced by a force couple applied by the bearings on the rod as dictated by Newton's 3<sup>rd</sup> law. Specifically, the rod produces a force on the sleeve to resist motion, and the force at the upper and lower ends of the sleeve make up the couple. The associated moment and stress calculations are shown in Figure 9 of the appendix.

Ideally, the sleeve would be coincident with the rod and have contact area all around, but since there is inevitably some clearance between the rod and the sleeve, this is not realistic. More likely, the rod would contact the sleeve at small regions of the upper and lower ends of the bearings. This case was used to calculate the bending stress. Half the weight supported by the fork was applied to each rod.

The stress analysis of the rod was performed assuming a fixed free end condition. At the bottom, the rod was fixed by the tight clearance holder and at the top the rod was free as only horizontal motion was limited.

The fixed end supported a moment, which was used to find the shear and moment diagrams for the length of the rod. Based on the low magnitudes of the shear stress, we neglected the possibility of shear failure. On the contrary, the maximum bending stress of 77 ksi was greater than the yield strength of the steel at 36 ksi, and therefore, the rod diameter for the full-scale model would need to be increased to at least 1 in.

Failure due to bending of the fork was also evaluated. Treating the fork as a fixed cantilever beam, a load of 246 lbs. would be required to cause the fork to yield, which is greater than the design load of 200 lbs. The calculations for the scale model are shown in Figure 10 of the appendix. To reinforce this result, a finite element analysis was performed in SolidWorks to analyze stress due to a 50 lb. load. This analysis found a minimum factor of safety to yielding of 3.1 and is shown in Figure 11 of the appendix.

Failure of the rods due to buckling was determined to be unlikely since the vertical load on the fork is supported by the cable system rather than the rods.

The bending stresses on the shelving system were also evaluated. Each level of rungs was assumed to be cantilevered and to support a 200-lb. load. This analysis helped determine the size and materials of the rungs, as well as the dimensions of the shelves. These calculations are shown in Figure 12 of the appendix.

## **RESULTS OF TESTING / COMPARISON OF CALCULATED AND TESTED RESULTS**

While testing the mobility of the Lift Assistor by rolling it around the room, we found it difficult to move in a straight path. This was because both the front and back sets of wheels were pivoting. When an attempt was made to change the direction of the lift, one set of wheels would turn sideways rather than roll in the direction of the desired motion. Naturally, the customer would react by pushing too hard on the lift and cause it to tip. This issue was resolved by installing fixed position back wheels, which allowed the front wheels to dictate the steering direction as with a shopping cart. With this modification, the lift could be easily moved along straight and curved paths.

During testing of the winch, weights were successfully lifted upward, however, difficulties were encountered when lowering a small amount of weight. Specifically, the fork would not lower because the winch failed to release the locking mechanism holding the cable. Rather than unwind the cable, turning the hand crank of the winch just loosened the handle. After consulting the specifications, we discovered that a minimum weight of 75 lbs. was required to release the locking mechanism. Based on this information, the production lift system would use a different type of winch.

Even testing a weight greater than 75 lbs., the fork still could not be lowered consistently. This issue was associated with the interface between the rods and bearing sleeves. As explained earlier, when a weight was placed towards the end of the fork, it produced a large moment at the bearings which was balanced by a force couple. The forces of this couple were produced by the contact of the top and bottom edges of the bearings with the rods. In essence, the bearings pinched the rod and would not slide with the fork. The pinching force at the bearings was reduced by adding a second set of bearings further down along the rods, which increased the distance between the forces making up the couple. Hence, an equivalent balancing moment was produced with smaller pinching forces, and the contact area between the rods and bearings was increased, which enabled the fork to be easily lowered without getting stuck.

This pinching phenomenon also resulted in a problem for the rods, which were contained at the bottom with small clearance holes. When lifting, the bearings would pinch the rods, which would be



lifted out of the holes and through the top of the frame. This vertical motion of the rods was restrained by drilling holes through the rods and inserting dowel pins to rest against the top plate. In effect, the rods were held stationary as the contact force of the dowel pins balanced the force lifting the rods out of the holes.

The lift was also moved with and without weight both forwards and backwards to test the tendency to tip. When a person pulled the unloaded lift backwards, this pulling force nearly caused the lift to tip about the back wheels. Therefore, the counterweights would need to be placed towards the front of the lift. When the loaded lift was pushed forward, it was stable and unlikely to tip about the front wheels unless the person pushed it excessively hard. Both observations were consistent with the design calculations. Based on this, 12 lbs. and 20 lbs. of counterweights were placed in the front left and right corners of the base plate respectively. For comparison, the design calculations predicted that 11 lbs. would need to be added in front of the back wheels,

Furthermore, the Lift Assistor exceeded expectations by comfortably lifting 100 lbs. despite being designed to lift only 50 lbs. We tested a maximum of 120 lbs. and the complete results can be found in Table 1 of the appendix. The deviation between the tested and calculated lift capacities was due to the redundancy and safety allocations inherent in our design. For instance, multiple cross braces and thicker than required metal plate were used to stabilize the frame. Moreover, we used a winch that was larger than necessary. Alternatively, we could have used less material (thinner sheet metal, smaller winch, etc.) and would still have been able to lift our goal load. We would need to retest with the full-scale model to check for any changes in our designed goal load.

#### **COST OF RAW MATERIALS USED IN PROTOTYPE**

Over the course of this semester we ordered an array of materials with our primary suppliers being McMaster-Carr, Specialty Metals, and Lowe's. Some materials were unfortunately wasted or not fully utilized during the build stage of our prototype, but the amount of waste material would be drastically decreased for a mass manufactured product version. The total cost of our prototype was \$1614, and the complete bill of materials can be found in the Appendix.

#### **IMPROVEMENTS FOR MASS MANUFACTURING**

To reduce the cost and time to manufacture as well as improve the functionality, several component changes would be made to our design before mass production. For instance, a smaller horizontal pulling winch would improve lifting performance for a wide range of shelf weights and reduce the overall weight and cost of the product. Likewise, weight and cost would be reduced by replacing the bearing rods with pipes. This change was determined to be feasible due to the excess bending strength of the rods. To improve durability, the counterweights would be welded to the frame rather than glued as with the prototype.

In talking with customers during the ICORP program, several modifications for the second version of the product were motivated. For instance, fast lifting service could be offered for retail environments by allowing the cable to be detached from the winch. In essence, the cable could be manually pulled to lift the fork rather than slowly cranking the winch. Additional feedback supported the idea of a foldable Lift Assistor which could be stored on one of the shelves, and interchangeable fork types which would add value for customers with unique material storage while providing our business with a recurring revenue stream.

## **BUSINESS PLAN REPORT**

### **EXECUTIVE SUMMARY**

Automotive dealerships and parts stores will buy the High Rise Storage System because it will improve their employees' safety and productivity through faster access and better organization of inventory. In the United States, the market opportunity for this product is \$33 million.

The competitive landscape is comprised of lift and shelving systems which are sold separately and designed for warehouse environments. They lack the compactness and inventory organization opportunities of the High-Rise Storage System. With that in mind, this product will be targeted at managers who are the decision makers of the automotive franchises. We will reach them by attending automotive dealer tradeshows and promoting trial and awareness of the product.

We will leverage cheaper foreign labor to minimize manufacturing costs, with each unit being built and shipped for a total of \$567. Pricing contracts will be negotiated with customers based on a target of \$1000 per unit. Using a regional distribution and marketing strategy, we plan to capture 2% of the market by the end of the first year, which is equivalent to \$660,000 in revenue. Our total costs for the first year will be approximately \$1,150,000, and we project profitability in quarter 3 or 4 of the second year.

### **MARKET ANALYSIS**

Based on a thorough customer discovery process, we decided to pivot away from selling our product to homeowners with small garages. After 12 interviews, it became clear that homeowners don't need a lifting device for the most common tools because those tools are small. Furthermore, they don't own anything that is excessively heavy and if they do, these items are placed on the bottom shelves. Conversely, overhead items that are beyond normal reach can be easily accessed with a step ladder. Other people in this segment prefer the cheapest available option and will build something themselves even if the commercially available system offers improved safety and convenience. Another misconception in our original hypothesis was the value of indoor space savings for hobbyists. As it turned out, many hobbyists enjoy using outside space for their workshop both to minimize dust buildup and have more room to work.

As an alternative to the residential market, we found that auto parts stores and auto dealers have a compelling need for our product. This need stems from the large quantities of heavy inventory they maintain, which must be moved frequently. Some of the items include tires, oil drums, and sub-assembled parts. Often, these stores have insufficient room for a full-sized forklift to maneuver, and items must be retrieved with a ladder. Climbing up and down a ladder carrying heavy items is a dangerous and slow task which is a pain point for both employees and their employers (due to lack of productivity).

The franchise automotive dealers will be the easiest segment to penetrate, as they are independent entities and do not require vendor approval by a centralized corporate authority. The path to market for auto parts store such as AutoZone, Advance Auto, and O'Reilly Auto Parts will be more difficult as some form of universal corporate approval will be required.

The size of this market was calculated from the combination of auto dealerships and auto parts stores. In 2017, the total number of automotive dealerships with service and parts departments was 16,708. Likewise, the total number of auto parts stores between the largest three companies in this industry (AutoZone, Advance Auto, and O'Reilly Auto Parts) was 16,272. Combining these two figures, if each of these 32,980 outlets were to buy a \$1000 lift, the market opportunity would be \$33,000,000.

## *COMPETITORS*

The competition in this market arises from similar lift systems and alternate shelving designs. Regarding the lift systems, the Vestil Manufacturing Company, Wesco Company, and non-franchise hardware stores have similar variants which are focused on industrial and warehouse application and are sold online as well as in Home Depot. These products are similar in terms of cost, ranging from \$600 - \$1000, although the hydraulic lifts cost well over \$1000. While the competitive products lift more weight than our product at nearly 800 lbs., they do not lift as high as our product.

Moreover, in typical shelving systems the individual shelf levels cannot be removed as they are attached to the rungs. These competitive shelving systems also cost from \$200-\$300 which pushes the price for an alternative system (shelves and lift) above the price of our product. The interfunctionality of our lift and shelving system as a package creates a significant competitive advantage.

## *TARGET CUSTOMER*

Participation in the I-Corps customer discovery program helped us to realize the potential of selling our product to businesses rather than individuals. Specifically, we will target the decision makers of automotive dealership service departments and auto parts stores. This will be achieved by emphasizing the improved productivity of employees which is enabled by our system. A common task of these employees is to retrieve various parts, sometimes very heavy or large, throughout the day. Currently, this is done using a step ladder, which is not only unsafe, but is also inefficient if multiple trips are needed to fetch parts on the same shelf. The High-Rise Storage System will provide these employees with easier and safer access to the inventory by using the lift to remove the entire shelf. Additionally, when stocking new inventory, they will be able to better categorize the layout on each shelf which will lead to improved customer service response time and quality.

## **STRATEGY AND IMPLEMENTATION**

To gain exposure and market penetration, we will register for automotive dealer conventions, trade shows and gatherings. For instance, we might attend a gathering for Ford Dealership franchisees. At these events, we will set up a booth and perform demonstrations of our product. We will also give away free product in raffles. Similarly, we will go to trade shows for auto parts stores and set up booths. Throughout this process, we hope to sell our product, but will also gain valuable feedback about what product features are most important to the customer and what they are most likely to pay for. This will aid us in the future negotiation of contracts and iterations of the product's design. To induce trial at these events, we will give away a select number of free 10-year warranty packages with the purchase of a High-Rise Storage System. Once our brand is more established, we will sell warranty packages only on individual components. This will serve as an additional revenue stream and intentionally limit the resource requirements of our service business. As a more frequent stream of revenue, we will sell modular extensions of the shelving portion of the High-Rise Storage System that businesses can buy when they expand and need more storage space.

## **FINANCIALS AND PROJECTIONS**

### *COST OF GOODS SOLD*

The main costs associated in producing the High-Rise Storage system include procurement of the raw materials, labor for mechanical assembly, and the shipping and handling. By manufacturing in China, we will be able to leverage the cheaper labor costs relative to manufacturers in the United States. The total cost of raw materials will be \$203 per unit. In this estimation, the raw materials were sourced through vendors on Alibaba and include steel and aluminum hardware, which was priced by the ton, as well as minor hardware components such as castors. The total labor costs for mechanical fabrication and assembly were \$220 per unit. This was based on using a contracted manufacturer in China, where the labor rate is 1/3 of that in the U.S. Furthermore, this cost assumed a total manufacturing time of 1 hour from start to finish on the production line, and the employment of 24 people to handle the machining, fabrication, and assembly. The manufacturing company was also assumed to make a 30% gross profit in their operation, which was factored into the cost of our contract. The cost of shipping a 40 ft. container from China to the US is roughly \$1500, depending on the proximity of the destination port city to our facility. One of these containers will fit 36 units, so the cost to ship would be \$42 per unit. The other costs are for handling, taxes, and duties. The total of these remaining costs would be roughly \$50 per unit. Including a 10% contingency, the total cost per unit will be \$567. In future supply chain development, the shipping costs will be drastically reduced by shipping the components to the U.S. and then assembling them into the final product.

### *PROJECTED PROFITABILITY*

Based on these cost projections, we plan to sell our product for at least \$900. This will create a 50% (\$300 per unit) gross margin and be a competitive price in the marketplace, where similar products cost between \$700 - \$1200. Since we are targeting franchise businesses, we will negotiate prices based on the order size. Considering that the U.S. market opportunity for our system is \$33 million, we plan to capture \$660,000 in revenue by the end of the first year. This is based on meeting the regional demand within our state, assuming that each of the 50 states has a similar opportunity. In subsequent years, we will continue our regional expansion strategy by branching out to more populous areas of the southeast.

In the first year we plan to spend \$850,000 to manufacture 1500 units. Other startup costs will total approximately \$300,000 and will include marketing, legal, accounting, etc. Based on total first year costs of \$1,150,000, and continued penetration into our target market, we project to be profitable by the third or fourth quarter of our second year.

**APPENDIX**



**Figure 6: High Rise Storage System Prototype**

Full  
Scab

Analyze tipping about back wheels, when no weight is on fork and lift is being pulled backwards

$W_{tot} = 0$   
 $X_{cc} = 5.3''$

$W = 400\text{-lb}$

$50\text{-lb}$   
 $48''$   
 $30''$

$\sum M_{backwheels} = -(400\text{-lb})(5.3'') + (50\text{-lb})(48'')$   
 $= 280\text{ lb}\cdot\text{in} \rightarrow \text{CCW}$

net moment CCW about back wheels, so lift will tip when pulled backwards with 0-lb on fork and 50-lb pulling force

therefore, we need to add weight in front to balance

add some weight @ 25''

$50\text{-lb}$   
 $W_{add}$   
 $25''$

$\sum M = 0 = (50\text{-lb})(48'') - (400\text{-lb})(5.3'')$   
 $- W_{add}(25'')$

$W_{add} = 11.2\text{-lb}$

need to add at least 11.2 lb @ 25'' from the back wheels to stabilize

**Figure 7: Calculations for Tipping of Unloaded lift about Back wheels**

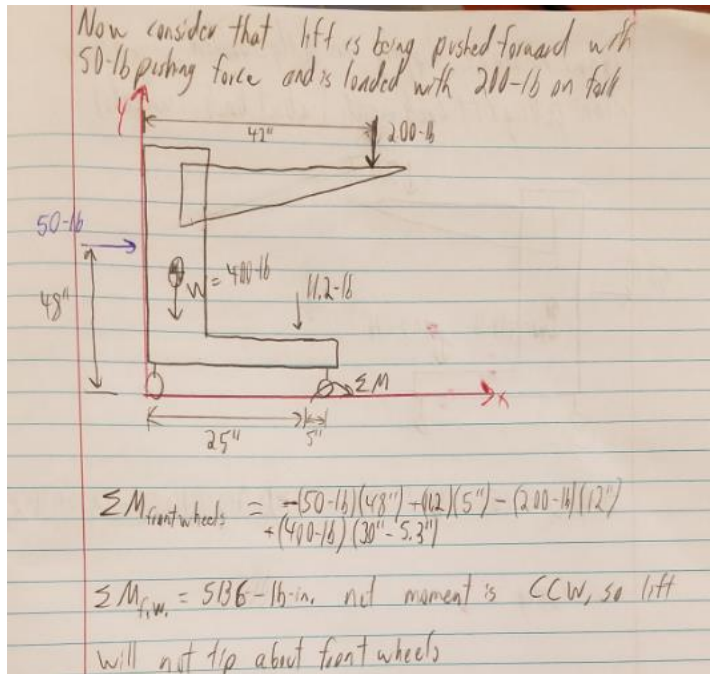
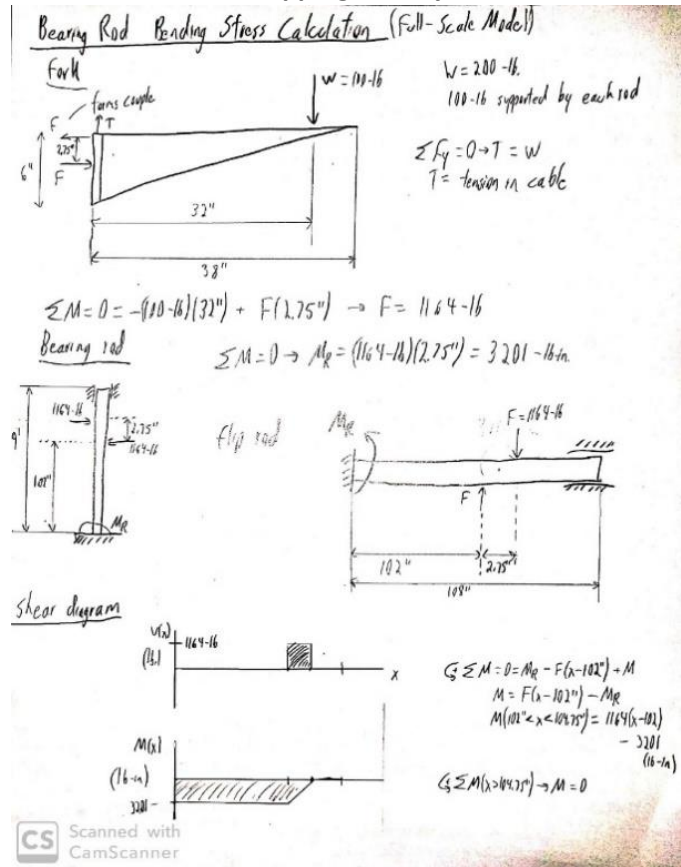


Figure 8: Calculations For Tipping of Fully-Loaded Lift About Front Wheels



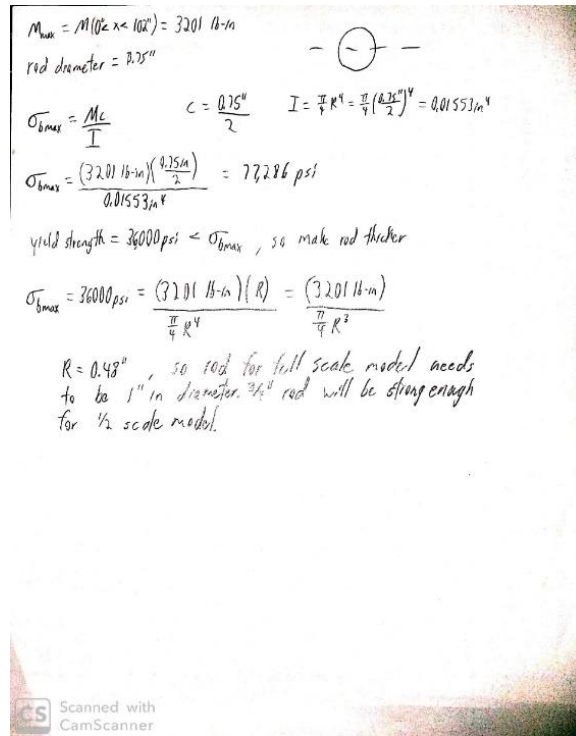
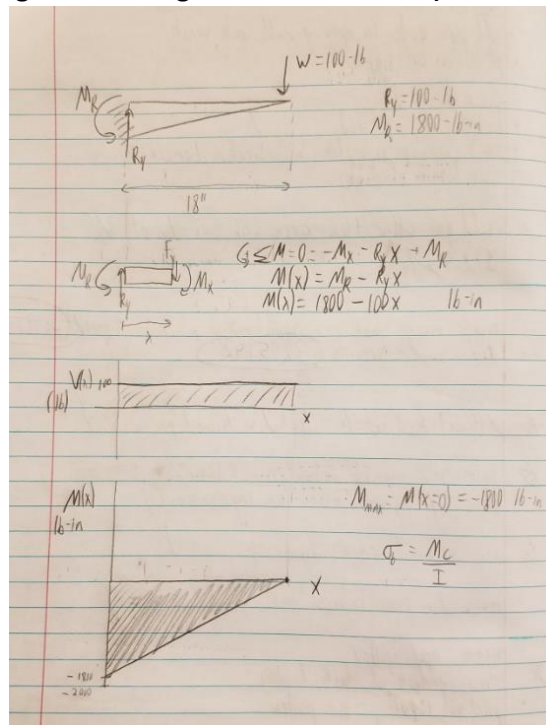


Figure 9: Bearing Rod Bending Stress Calculations (Full Scale Model)



cross section of beam

width of fork = 12"

height of fork = 3"

thickness of top flange = 0.125"

compound centroid

find  $I$  at start of force

$$C_y = \frac{\sum C_y A_i}{\sum A_i}$$

$$C_y = \frac{2[(1.9375)(0.125)(2.875)] + (0.125)(12)(2.9375)}{2(0.125)(3-0.125) + (12)(0.125)}$$

$$C_y = 2.452 \text{ m}$$

$2.9375$   
 $3 - \frac{1}{2}(0.125)$   
 $= 2.9375$

$I = I_1 + I_2 + I_3$   
 $I_1 = (2.9375 - 2.452)^2 (0.125 \cdot 12)$   
 $I_1 = 0.354 \text{ m}^4$   
 $I_2 = I_3 = (2.452 - 1.4375)^2 (0.125)(3 - 0.125) = 0.2699 \text{ m}^4$   
 $I = 1.0933 \text{ m}^4$   
 $\sigma_b(x=0) = \frac{(-1800 \text{ lb} \cdot \text{in})(-2.452 \text{ in})}{1.0933 \text{ m}^4} = 4037 \text{ psi @ bottom fiber of fork}$

$$\sigma_b(x=0) = \frac{(-1800)(0.548)}{1.0933} = 902 \text{ psi @ top fiber}$$

grade 3000 alum. used for body (5000 and 6000 can be used as well)

yield of 3000 grade aluminum (and 6000) is between 5000 and 10000 psi.

4037 psi < 5000 psi, therefore our fork should not deform in lifting 180 lbs.

Next step: at what load will our fork yield

$$\sigma_b = \sigma_y = 5000 \text{ psi} = \frac{M(x=0)(2.452 \text{ in})}{1.0933 \text{ m}^4}$$

$$M(x=0) = 2229 \text{ lb} \cdot \text{in}$$

$$M(x) = M_R - Wx^0 \quad M_R = W(18 \text{ in})$$

$$2229 \text{ lb} \cdot \text{in} = W(18 \text{ in})$$

$$W_{\text{max}} = 123 \text{ lb}$$

Figure 10: Calculation of Maximum Allowable Load on Fork Scale Model to Prevent Yielding



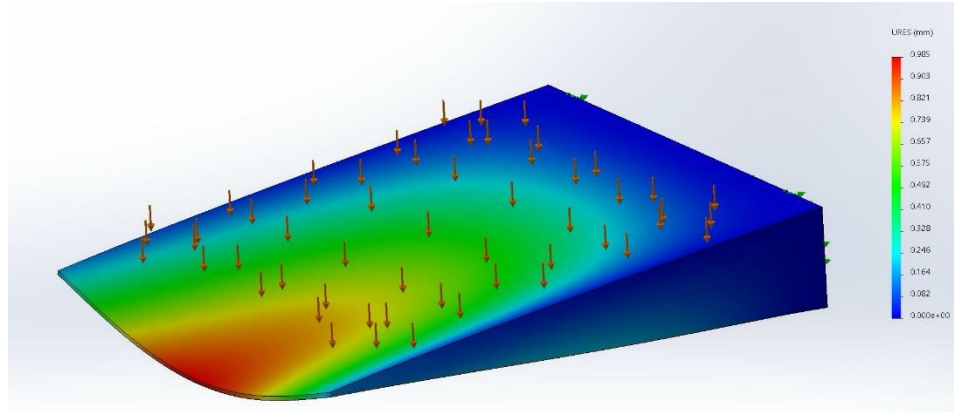


Figure 11. Deformation of the Fork

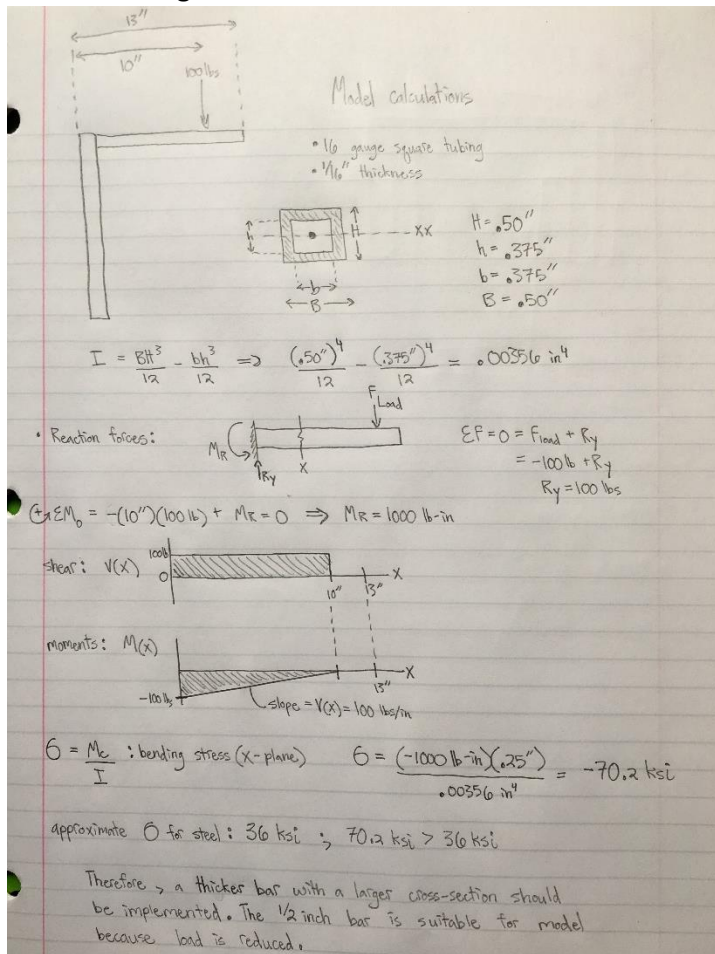


Figure 12. Cantilevered Shelf Bending Stress Calculations

Table 1. Results from Testing










Weight (lbs.)	Lift (y or n)	Lower (y or n)	Tip (y or n)	comments
50	y	y	n	maybe put more weights on front right to help balance side to side

60	y	y	n	more stable with most weight at base of fork
70	y	y	n	slight gallop when moving forward, lift could roll more smoothly, but not sure how to remedy this with pivoting castors
80	y	y	n	when unwinding winch, sometimes cable catches bolt on side, possibly move guide back
90	y	y	n	
100	y	y	n	
110	y	y	n	
120	y	y	n	worried the frame would fail, didn't want to break it

### BILL OF MATERIALS FOR PROTOTYPE

	A	B	C	D	E	F	G	H	I	J	K	L
2					Ordering Link	Phone Number	Email					
3	casters with wheel brake			4	McMaster	https://www.mcmaster.com/245952		245952	43.25	173		
4	pulley			2	McMaster	https://www.mcmaster.com/3434118		3434118	8.35	16.7		
5	wire cable	price per ft.		25	McMaster	https://www.mcmaster.com/549n12		549N12	2.25	56.25		
6	linear sleeve bearings			2	McMaster	https://www.mcmaster.com/6374k216		6374K216	106.69	213.38		
7	carriage bolts	pack of 100		1	McMaster	https://www.mcmaster.com/93604a639		93604A6	12.5	12.5		
8	hex nuts	pack of 100		1	McMaster	https://www.mcmaster.com/90376019		9037601	6.77	6.77		
9	winch			1	McMaster	https://www.mcmaster.com/235644		3196T44	145.04	145.04		
10	aluminum angle iron											0
11	3/4" X 3/4" X 1/8"	54" long cuts		4	Specialty Metals and Supply Corp.		865-609-1007	amv@specialty-metals.net		19	76	
12		0 1/8" long cuts		4	Specialty Metals and Supply Corp.		865-609-1007	amv@specialty-metals.net		5.5	22	
13		0 6" long cuts		4	Specialty Metals and Supply Corp.		865-609-1007	amv@specialty-metals.net		15	6	
14	aluminum sheet	0										0
15	1/8" X 48" X 48"	0		1	Specialty Metals and Supply Corp.		865-609-1007	amv@specialty-metals.net		42	42	
16	aluminum strip	0										0
17	1/8" X 1"	56" long cuts		2	Specialty Metals and Supply Corp.		865-609-1007	amv@specialty-metals.net		4.25	9.5	
18	steel square tube	0										0
19	12" X 12" (1/8 GUAGE)	12" long cuts		16	Specialty Metals and Supply Corp.		865-609-1007	amv@specialty-metals.net		1	16	
20	3" X 3" (1/16 GUAGE)	30" long cuts		2	Specialty Metals and Supply Corp.		865-609-1007	amv@specialty-metals.net		12.8	25.6	
21	2" X 2" (1/16 GUAGE)	60" long cuts		2	Specialty Metals and Supply Corp.		865-609-1007	amv@specialty-metals.net			0	
22	1" X 1" (1/16 GUAGE)	21" long cuts		4	Specialty Metals and Supply Corp.		865-609-1007	amv@specialty-metals.net		3.5	14	
23	steel plate	0										0
24	1/4" thickness	1/2" X 1/2" cut		1	Specialty Metals and Supply Corp.		865-609-1007	amv@specialty-metals.net		11.6	11.6	
25	2" X 3" X 6"	0		2	Specialty Metals and Supply Corp.		865-609-1007	amv@specialty-metals.net		20.5	41	
26	1" X 3" X 5"	0		2	Specialty Metals and Supply Corp.		865-609-1007	amv@specialty-metals.net		10	20	
27	pull handles	0		2	McMaster	https://www.mcmaster.com/11665a32		11665A32	16.6	33.2		
28	Linear Motion Shaft	3/4" X 60"	2	McMaster Carr	https://www.mcmaster.com/bearing-rods			606R34	56.41	112.82		
29	u-bolt	2" x 2.6875"	2	McMaster Carr	https://www.mcmaster.com/233979			233979	1.68	3.36		
30	mounted linear ball bearing	2.75" x 2.0625"	2	McMaster Carr	https://www.mcmaster.com/93383			9338T3	66.60	133.20		
31	mounted pulley for wire rope	.25" wire 3" dia	2	mcmaster carr	https://www.mcmaster.com/305939			3059T38	13.16	26.32		
32	Copper Swage Sleeves	.25" wire dia	10 pkg.	mcmaster carr	https://www.mcmaster.com/swaging-sleeves			389T73	16.14	16.14		
33												33
34	https://www.mcmaster.com/8975k237	mcmaster carr	amv@specialty-metals.net	alum Al 3/4" X 3/4" X 1/8" cuts		5.5	6					12.19
35	https://www.mcmaster.com/8996K387	mcmaster carr		8996K387								12.19
36	https://www.mcmaster.com/6259113			8359T113								35.62
37	https://www.mcmaster.com/2134n51-2134n12			2134N51								34.06
38	Linear sleeve bearing			2	McMaster-Carr	https://www.mcmaster.com/93383						26.11
39	1 pack of anti-slip tape			1	mcmaster-carr	https://www.mcmaster.com/6370036						26.11
40	bolts from lowes											6.67
41												7.26
42												60 approximate
43												
44												1613.74

## BUSINESS MODEL CANVAS

 <p><b>Key Partners</b></p> <p>supply chain partners...          manufacturer abroad          assembler domestically          raw materials suppliers          retail outlets          auto dealers          auto parts stores</p>	 <p><b>Key Activities</b></p> <p>manufacturing          assembly          shipping of raw materials          distribution          Marketing          legal team          accounting</p>	 <p><b>Value Propositions</b></p> <p>Safety of employees          time to retrieve parts          maximize storage space          organization of parts</p>	 <p><b>Customer Relationships</b></p> <p>Warranty of components</p> <p>no long term          service contract</p> <p>sell modular shelf          add-ons          (ink and printer model)</p>	 <p><b>Customer Segments</b></p> <p>auto parts stores</p> <p>automotive dealers          and service centers</p>
 <p><b>Key Resources</b></p> <p>venture capital funding          contact lists in          dealerships          cheap labor stability          website          customer service          inventory and parts          management</p>		 <p><b>Channels</b></p> <p>sell at Auto Zone,          Napa, etc.</p> <p>sell at McMaster Carr</p> <p>sell where dealers          buy things</p>		
 <p><b>Cost Structure</b></p> <p>shipping, labor, materials, advertising, R&amp;D - optimize warranty          and design improvements for durability and          ease of manufacturing</p>		 <p><b>Revenue Streams</b></p> <p>selling combined storage system          extended warranty option          selling modular shelf extensions</p>		