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JME 4110 Mechanical Car Jack

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Joint Engineering Program

University of Missouri–St. Louis ▪ Washington University in St. Louis

ELEVATE YOUR FUTURE.
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The Mechanical Compact Car Lift is a product in which you will be able to lift all four wheels of your vehicle off of the ground. This product will be motorized, so minimal work will be needed to operate the lift. The product can be used on various vehicles, ranging from a ½ ton truck to a smart for-to.

JME 4110
Mechanical Engineering
Design Project

Mechanical Car Lift

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1 INTRODUCTION

1.1 VALUE PROPOSITION / PROJECT SUGGESTION

Car jacks are a needed tool when beginning to work on a vehicle. One can complete basic maintenance on their personal vehicle at home with the helpful use from a car jack. The typical scissor design of the car jack has been around since cars have. A new design of the car jack makes completing basic maintenance at home a breeze.

1.2 LIST OF TEAM MEMBERS

Brett Brooks
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2 BACKGROUND INFORMATION STUDY

2.1 DESGIN BRIEF

Design a portable car lifting system that will lift all four wheels of a vehicle off the ground a few inches for tire rotations. Our design of the car jack will be implementing an electric motor that will operate the lead screw of the scissor jack. The jack will need to be safe, portable, and operated by a single user. The jack should be able to lift anything from a ½ ton truck to a smart for-to. The jack will need to be designed to be safe, user friendly, and operate in a timely manner. To save time, a manufactured jack will be purchased and modified to accomplish this.

2.2 BACKGROUND SUMMARY

Research for some preexisting designs yielded a ton of results. Several companies are using the typical scissor jack, most commonly seen in the emergency pack of a car, with an electric motor attached to operate the lead screw. This design uses the car battery as a source of power for the jack. Below are some photos of existing designs.

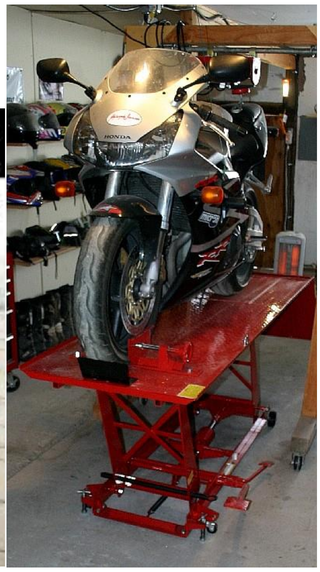


Figure 1. **Figure 2.** **Figure 3.**

Figure 1: https://i.ytimg.com/vi/9ikuBYQLYrw/maxresdefault.jpg

The image shows a typical scissor jack that has been modified. Where a typical scissor jack is powered by a rotational torque from a user, this design is using the rotational torque from a motor to lift the car.

Figure 2: https://www.walmart.com/ip/WALFRONT-5Ton-12V-DC-Automotive-Car-Electric-Hydraulic-Floor-Jack-Lift-Garage-and-Emergency-Equipment-Electric-Jack-Car-Electric-Jack/914154486?wmlspartner=wlpa&selectedSellerId=15913&adid=22222222222259161622&wmlspartner=wmtlabs&wl0=e&wl1=o&wl2=c&wl3=75041753952457&wl4=pla-4578641317536065&wl5=&wl6=&wl7=&%20wl10=Walmart&wl12=914154486_10000016648&wl14=motorized%20car%20jack&veh=sem

Image 2 shows something like a bottle jack. In this case the jack is also operated by an electric motor to lift the car. The bottle jack like design allows this jack to be compact.

Figure 3:

https://www.bing.com/images/search?view=detailV2&ccid=VX%2fXUsIU&id=B627162F0F304268534ADC7AB0746D7DC84DA19F&thid=OIP.VX_XUsIUkMmEO3tavO2H7AAAAA&mediaurl=http%3a%2f%2fwww.motorcyclejazz.com%2fimages%2fHFL_2.jpg&exph=727&expw=400&q=harbor+freight+motorcycle+lift&simid=608006285268944259&selectedIndex=14&ajaxhist=0

Image 3 shows a motorcycle lift. This design is something that could be manipulated to lift a car. Shortening the pad (where the motorcycle sits) to fit between the wheels of a car and increasing the lifting power would help us achieve our goal of lifting a car.

Issues to consider

Some issues that may arise with this project that need to be considered. One of these issues is that the jack must hold a certain amount of weight and be stable. This is a concern to safety, and the jack must be stable because the car could fall off the jack. The following document demonstrates safety concerns regarding vehicle lifts: https://www.autolift.org/wp-content/uploads/2014/12/Lift-Inspection-Guide.pdf . Another issue with having a strong and stable jack is that they are typically bulky, heavy and take up a decent amount of space. The main concern with our project is going to be space and weight, this product will be operated by one user. Floor jacks are operated by one user as well, however floor jacks are heavy and have wheels.

3 CONCEPT DESIGN AND SPECIFICATION

3.1 USER NEEDS AND METRICS

3.1.1 Record of the user needs interview

Table 1 – User Needs Interview

Project: Mechanical Car Jack **Interviewer:** Craig Geismann

Question	Customer Statement	Interpreted Need	Importance
What variety of vehicles does the jack need to lift?	Anything from a ½ ton truck to a smart car.	Can to lift 4000lbs max and fit different wheel bases	5
Is there a time constraint for assembling the product?	A few minutes is appropriate.	Can be assemebled in less than 2 minutes.	3
What size envelope does the jack need to fit?	Inside a garage.	Jack can fit inside a garage	5
What are acceptable forms of power for the lift?	Electric would be best but human power is acceptable.	Jack is powered by electricity	5
What are the time constraints for lifting the vehicle 3 inches?	Maximum of 5 minutes.	Jack will lift in less than 5 minutes	3

What is an acceptable weight for the lift itself?	One person can move it.	Jack will accommodate movement for one person	4
What safety features are required?	Ratcheting, and safety pins for locking height	Jack will provide locking mechanicsm for height	3
What price could you see a product like this go for?	$200 or less	Jack will be purchasable for around $200.	3
What types of terrain does the jack need to operate on?	Concrete floors.	Jack will operate on concrete floors.	4

Table 2 – Initial Needs for Mechanical Car Jack

Need Number	**Need**	**Importance**
1	Jack can serve a variety of vehicles	5
2	Jack takes little time for assembly	3
3	Jack can fit inside a garage	5
4	Jack is powered by electricity	5
5	Jack will lift in less than 5 minutes	3
6	Jack can be moved by one user	4
7	Jack has safety features	3
8	Jack can be sold for reasonable price	3
9	Jack can operate on several terrains	4

3.1.2 List of identified metrics

Table 3 – Identified metrics

Metric Number	Associated Needs	Metric	Units	Min Value	Max Value
1	1,8	Adjustable Length	Feet	1	6
2	1,8	Adjustable Width	Feet	1	3
3	1,5	Weight Capacity	Tons	0	3
4	2	Assembly Time	Seconds	30	120
5	1,3	Storage Size	Cu. Ft.	10	2000
6	4	Alternate Forms Of Power	Binary	0	1
7	1,5	Lifting Time	Minutes	1	5
8	1,3,6,8	Weight Of Lift	Pounds	50	600
9	7,8	Safety Features	Integer	0	5
10	8	Market Price	Dollars	200	600
11	4,9	Different Terrains	Integer	0	3

3.1.3 Table/list of quantified needs equations

Table 4 – Quantified Needs Matrix

Concept #1		Metric													
		Adjustability of Length of lift	Adjustablility of Width of lift	Weight capacity	Assembly time	Storeage Size	Alternate Forms Of Power	Lifting Time	Weight of Lift	Safety Features	Market price	Different types of terrains	Need Happiness	Importance Weight (all entries should add up to 1)	Total Happiness Value
Need#	Need	1	2	3	4	5	6	7	8	9	10	11			
1	Lift serves a variety of vehicles	0.3	0.3	0.3		0.03		0.03	0.03				0.99	0.1875	0.185625
2	Lift takes little time for assembly				1								1	0.0625	0.0625
3	Lift fits in garage					0.75			0.2			0.05	0.95	0.1875	0.178125
4	Lift is powered by electric						1						1	0.0625	0.0625
5	Lift time is minimized			0.25				0.75					1	0.09375	0.09375
6	Lift can be moved by one person								1				1	0.15625	0.15625
7	Lift has safety features									1			1	0.15625	0.15625
8	Lift can be sold for a resonable price	0.025	0.025						0.1	0.05	0.7		0.9	0.0625	0.05625
9	Lift can operate on several terrains											1	1	0.03125	0.03125
Units		Feet	Feet	Tons	Seconds	Cu. Ft.	Binary	Minutes	Pounds	Intiger	Dollars	Intiger	Total Happiness		0.9825
Best Value		6	3	3	30	10	1	1	50	5	200	3			
Worst Value		1	1	0	120	2000	0	5	600	0	600	0			
Actual Value		6	3	3	30	10	1	1	50	5	200	3			
Normalized Metric Happiness		1.00	1.00	1.00	1.00	1.00	1.00	1.000	1.00	1.00	1.00	1.00			

3.2 CONCEPT DRAWINGS

Figure 4 - Concept #1:

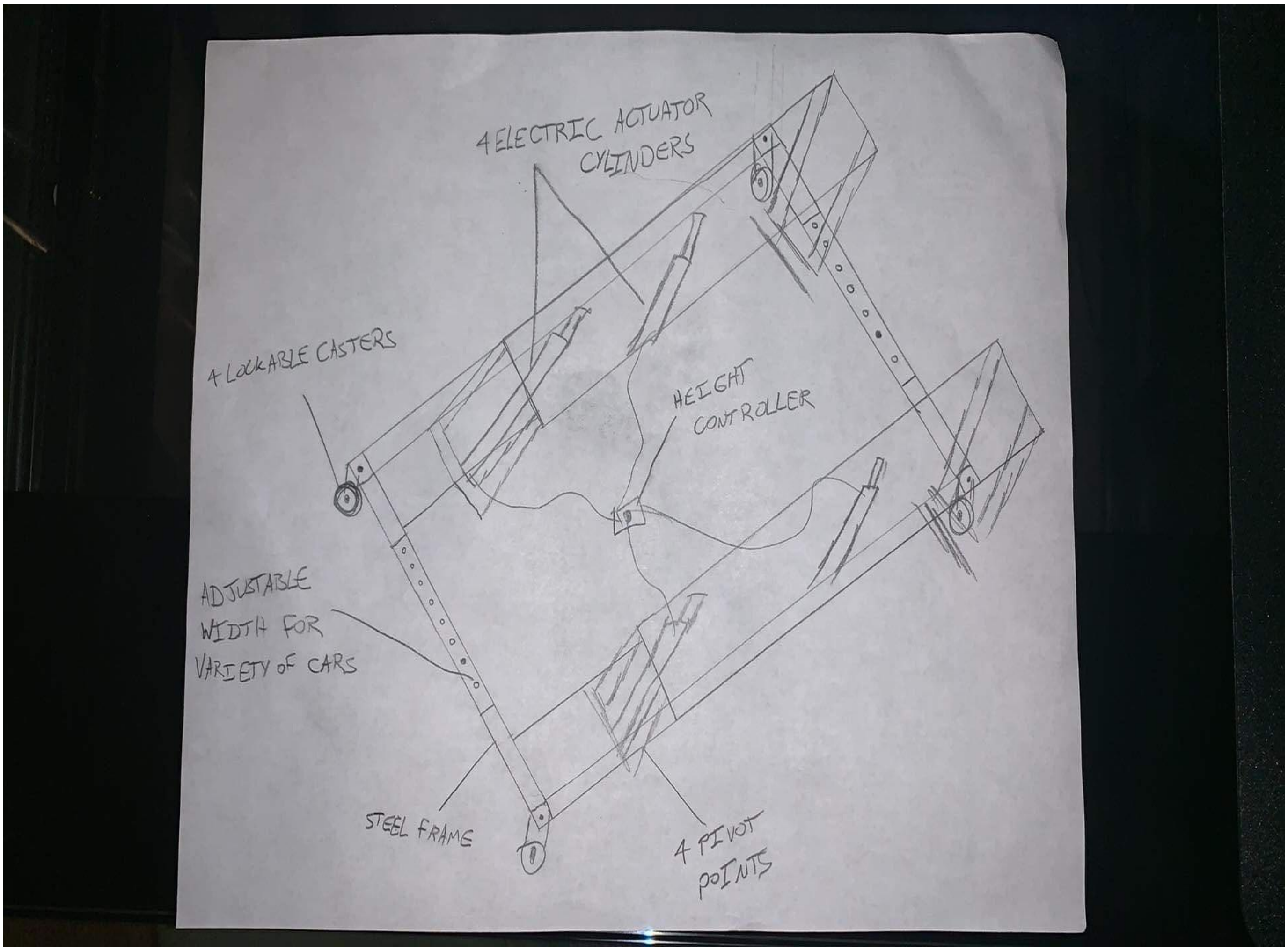


Figure 5 - Concept #2:

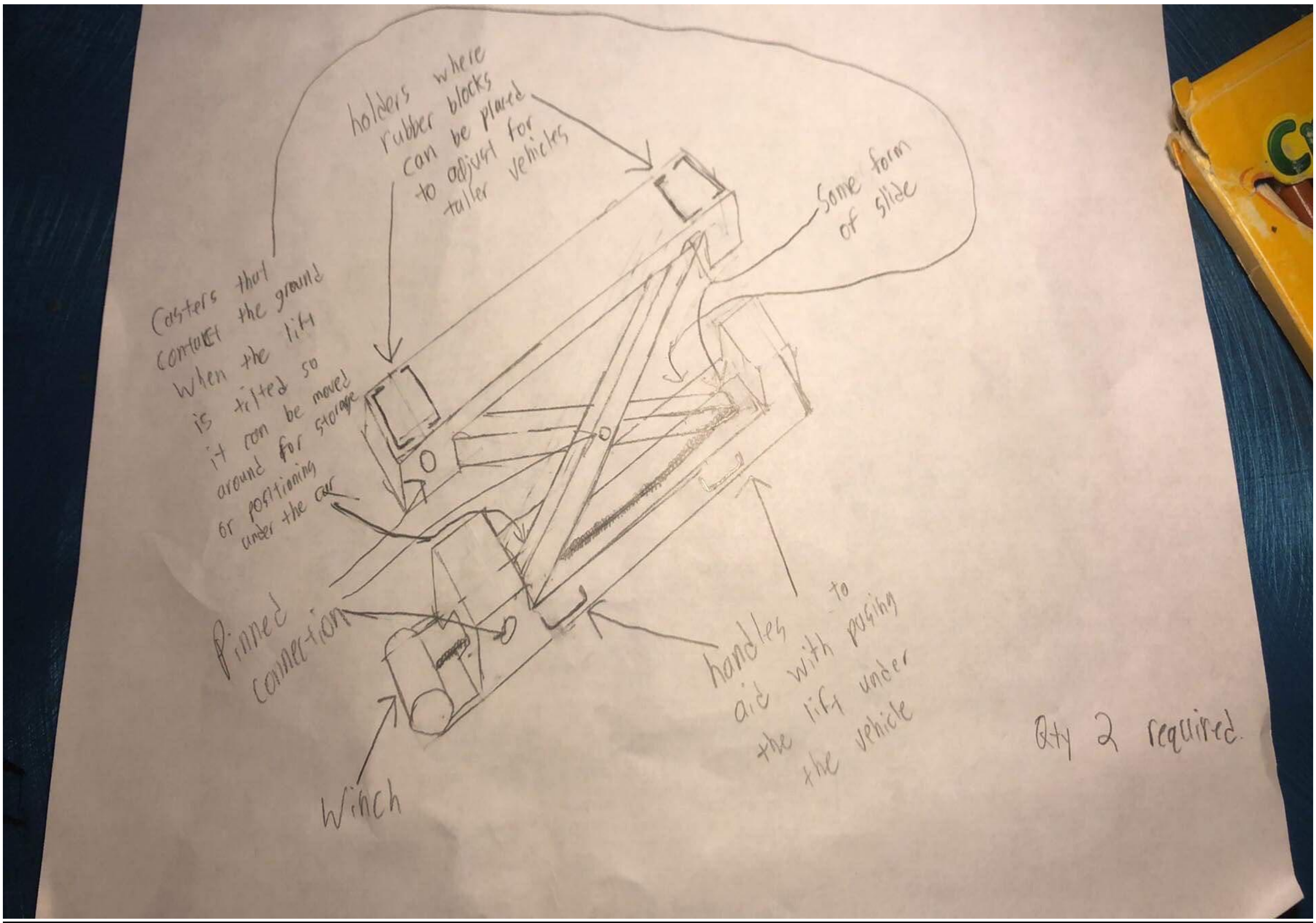


Figure 6 - Concept #3:

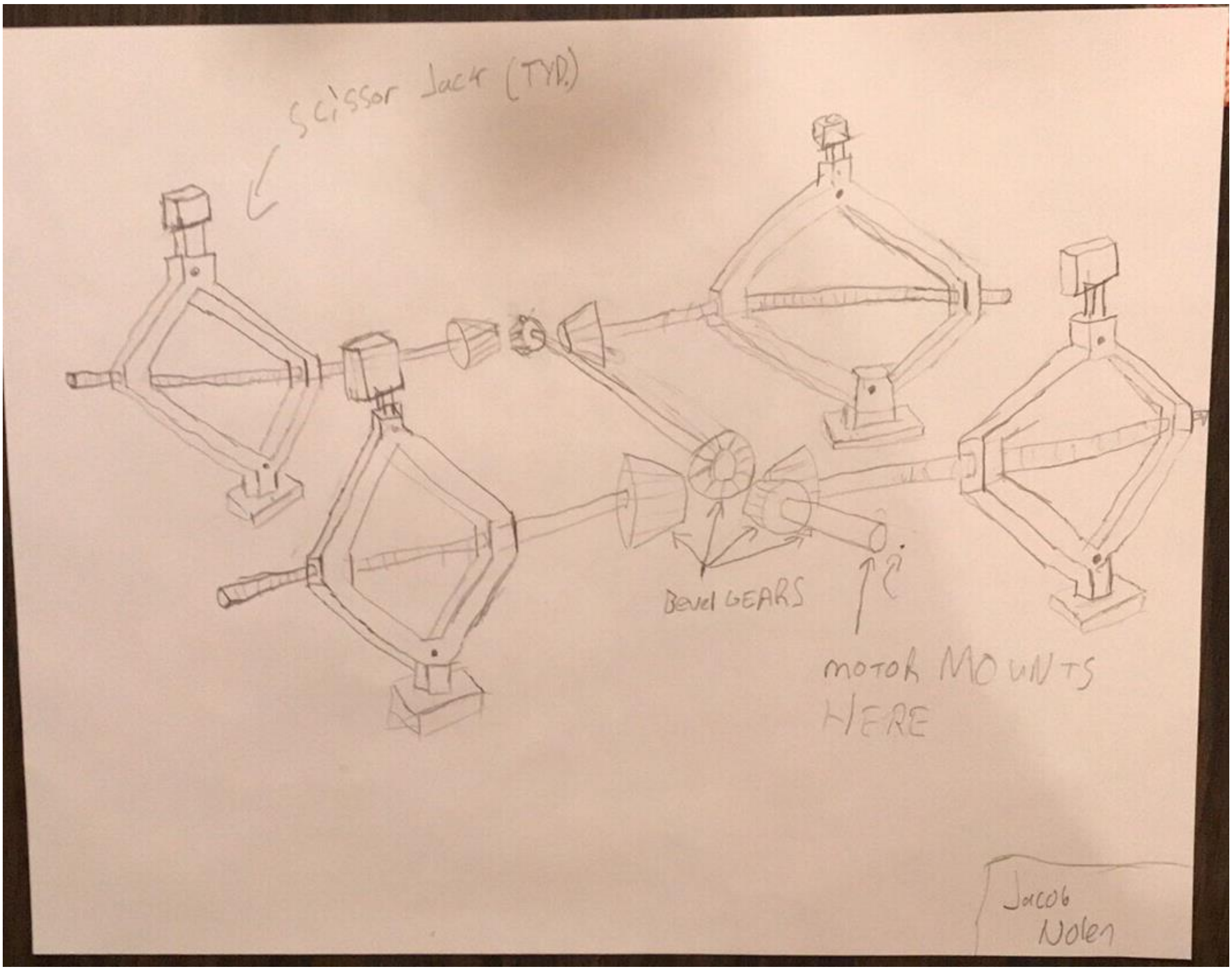
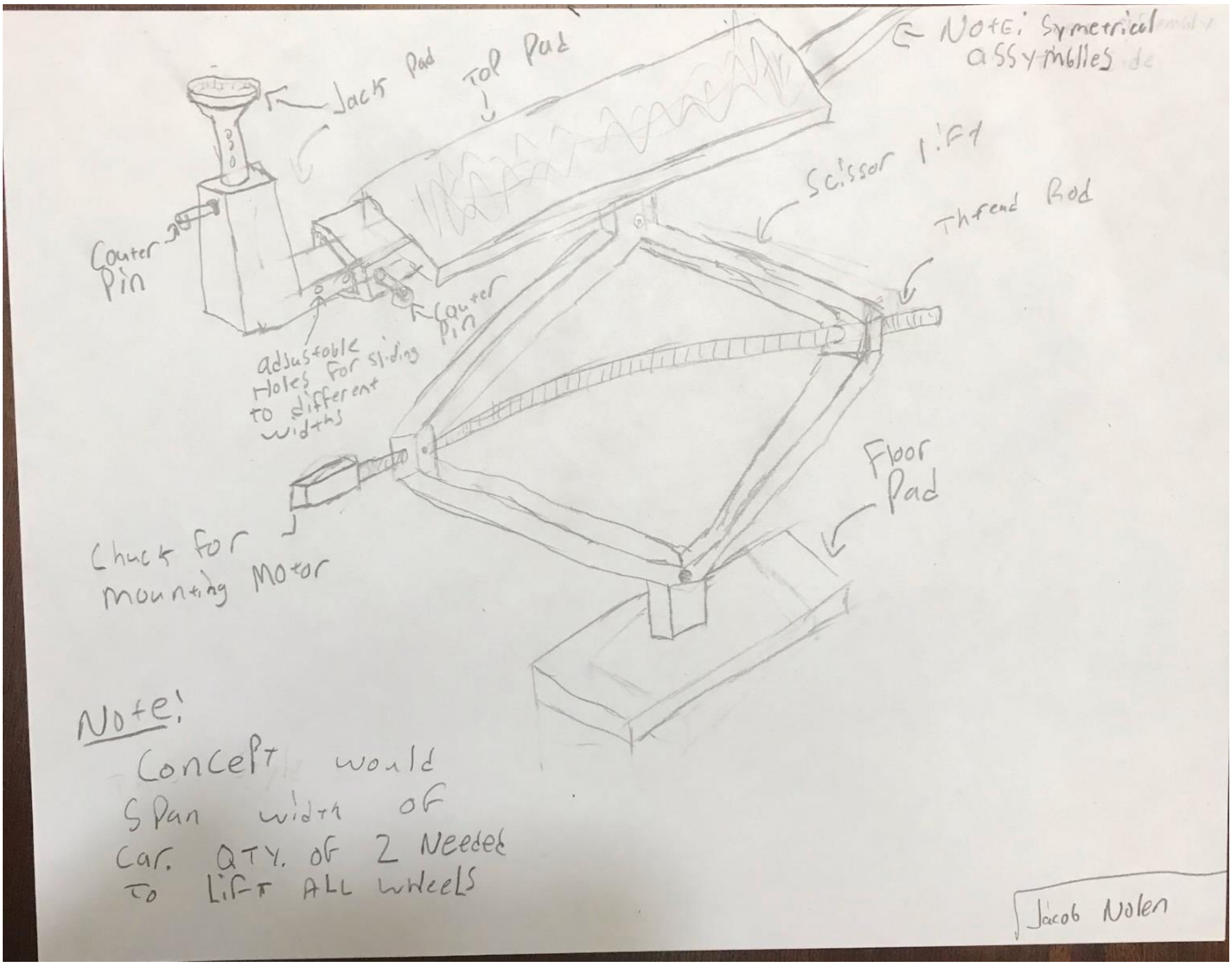


Figure 7 - Concept #4:



3.3 A CONCEPT SELECTION PROCESS.

3.3.1 Concept scoring

Table 5 - Concept #1:

Concept #1		Metric													
		Adjustablity of Length of lift	Adjustablility of Width of lift	Weight capacity	Assembly time	Storeage Size	Alternate Forms Of Power	Lifting Time	Weight of Lift	Safety Features	Market price	Different types of terrains	Need Happiness	Importance Weight (all entries should add up to 1)	Total Happiness Value
Need#	Need	1	2	3	4	5	6	7	8	9	10	11			
1	Lift serves a variety of vehicles	0.3	0.3	0.3		0.03		0.03	0.03				0.819296	0.1875	0.153618
2	Lift takes little time for assembly				1								0.2	0.0625	0.0125
3	Lift fits in garage					0.75			0.2			0.05	0.87614	0.1875	0.164276
4	Lift is powered by electric						1						1	0.0625	0.0625
5	Lift time is minimized			0.25				0.75					0.822917	0.09375	0.077148
6	Lift can be moved by one person								1				0.8182	0.15625	0.127844
7	Lift has safety features									1			0.6	0.15625	0.09375
8	Lift can be sold for a resonable price	0.025	0.025						0.1	0.05	0.7		0.24432	0.0625	0.01527
9	Lift can operate on several terrains											1	0.333333	0.03125	0.010417
Units		Feet	Feet	Tons	Seconds	Cu. Ft.	Binary	Minutes	Pounds	Intiger	Dollars	Intiger	Total Happiness		0.717323
Best Value		6	3	3	30	10	1	1	50	5	200	3		1	
Worst Value		1	1	0	120	2000	0	5	600	0	600	0			
Actual Value		4	3	2	100	20	1	1.5	150	3	550	1			
Normalized Metric Happiness		0.80	1.00	0.67	0.20	0.95	1.00	0.875	0.82	0.60	0.13	0.33			

Table 6 - Concept #2:

Concept 2		Metric													
		Adjustablity of Length of lift	Adjustablility of Width of lift	Weight capacity	Assembly time	Storeage Size	Alternate Forms Of Power	Lifting Time	Weight of Lift	Safety Features	Market price	Different types of terrains	Need Happiness	Importance Weight (all entries should add up to 1)	Total Happiness Value
Need#	Need	1	2	3	4	5	6	7	8	9	10	11			
1	Lift serves a variety of vehicles	0.3	0.3	0.3		0.03		0.03	0.03				0.972435	0.1875	0.182332
2	Lift takes little time for assembly				1								0.5	0.0625	0.03125
3	Lift fits in garage					0.75			0.2			0.05	0.83275	0.1875	0.156141
4	Lift is powered by electric						1						1	0.0625	0.0625
5	Lift time is minimized			0.25				0.75					0.953125	0.09375	0.089355
6	Lift can be moved by one person								1				0.5	0.15625	0.078125
7	Lift has safety features									1			0.6	0.15625	0.09375
8	Lift can be sold for a resonable price	0.025	0.025						0.1	0.05	0.7		0.305	0.0625	0.019063
9	Lift can operate on several terrains											1	0.666	0.03125	0.020813
Units		Feet	Feet	Tons	Secconds	Cu. Ft.	Binary	Minutes	Pounds	Intiger	Dollars	Intiger	Total Happiness		0.733328
Best Value		6	3	3	30	10	1	1	50	5	200	3		1	
Worst Value		1	1	0	120	100	0	5	600	0	600	0			
Actual Value		6	3	3	45	12	1	1.25	325	3	500	2			
Normalized Metric Happiness		1	1	1	0.5	0.977	1	0.9375	0.5	0.6	0.25	0.666			

Table 7 - Concept #3:

Concept 3		Metric													
		Adjustablity of Length of lift	Adjustablility of Width of lift	Weight capacity	Assembly time	Storeage Size	Alternate Forms Of Power	Lifting Time	Weight of Lift	Safety Features	Market price	Different types of terrains	Need Happiness	Importance Weight (all entries should add up to 1)	Total Happiness Value
Need#	Need	1	2	3	4	5	6	7	8	9	10	11			
1	Lift serves a variety of vehicles	0.3	0.3	0.3		0.03		0.03	0.03				0.787185	0.1875	0.147597
2	Lift takes little time for assembly				1								0.66	0.0625	0.04125
3	Lift fits in garage					0.75			0.2			0.05	0.7734	0.1875	0.145013
4	Lift is powered by electric						1						1	0.0625	0.0625
5	Lift time is minimized			0.25				0.75					0.80625	0.09375	0.075586
6	Lift can be moved by one person								1				0.4545	0.15625	0.071016
7	Lift has safety features									1			0.6	0.15625	0.09375
8	Lift can be sold for a resonable price	0.025	0.025						0.1	0.05	0.7		0.55795	0.0625	0.034872
9	Lift can operate on several terrains											1	0.666	0.03125	0.020813
Units		Feet	Feet	Tons	Secconds	Cu. Ft.	Binary	Minutes	Pounds	Intiger	Dollars	Intiger	Total Happiness		0.692396
Best Value		6	3	3	30	10	1	1	50	5	200	3		1	
Worst Value		1	1	0	120	2000	0	5	600	0	600	0			
Actual Value		5	3	2	60	20	1	1.5	300	3	350	2			
Normalized Metric Happiness		0.8	1	0.6	0.66	0.91	1	0.875	0.4545	0.6	0.625	0.666			

Table 8 - Concept #4:

Concept 4		Metric													
		Adjustablity of Length of lift	Adjustablility of Width of lift	Weight capacity	Assembly time	Storeage Size	Alternate Forms Of Power	Lifting Time	Weight of Lift	Safety Features	Market price	Different types of terrains	Need Happiness	Importance Weight (all entries should add up to 1)	Total Happiness Value
Need#	Need	1	2	3	4	5	6	7	8	9	10	11			
1	Lift serves a variety of vehicles	0.3	0.3	0.3		0.03		0.03	0.03				0.897642	0.1875	0.168308
2	Lift takes little time for assembly				1								0.222	0.0625	0.013875
3	Lift fits in garage					0.75			0.2			0.05	0.80978	0.1875	0.151834
4	Lift is powered by electric						1						1	0.0625	0.0625
5	Lift time is minimized			0.25				0.75					0.53125	0.09375	0.049805
6	Lift can be moved by one person								1				0.6364	0.15625	0.099438
7	Lift has safety features									1			0.4	0.15625	0.0625
8	Lift can be sold for a resonable price	0.025	0.025						0.1	0.05	0.7		0.47864	0.0625	0.029915
9	Lift can operate on several terrains											1	0.3333	0.03125	0.010416
Units		Feet	Feet	Tons	Secconds	Cu. Ft.	Binary	Minutes	Pounds	Intiger	Dollars	Intiger	Total Happiness		0.648589
Best Value		6	3	3	30	10	2	1	50	5	200	3		1	
Worst Value		1	1	0	120	2000	0	5	600	0	600	0			
Actual Value		5	3	3	100	20	1	3.5	250	2	400	1			
Normalized Metric Happiness		0.8	1	1	0.222	0.91	1	0.375	0.6364	0.4	0.5	0.3333			

3.3.2 Preliminary analysis of each concept's physical feasibility

Concept #1:

This concept is particularly feasible because 90% of this concept already exists and it only requires slight modifications to off the shelf parts. This design basically builds two motorcycle style lifts and attaches them via an adjustable steel frame. The steel frame can be adjusted by simply releasing a pin and either pulling the lifts apart or pushing them together to adjust the width. A pin can then be put into the proper hole in the frame to lock the width in place. This also makes the lift easy to store as it can be taken apart into two halves and rotated upright to place against a wall, taking up minimal space when stored. The lift will also be on collapsible casters that allow the lift to be rolled around with ease or collapsed allowing the lift to sit sturdily on the floor. The lift will require two specialty parts. I would like to replace the widely used hydraulic actuators with electric ones to allow for greater reliability and controllability. These electric actuators will require a controller to control the height and speed of the lift. This controller can be wireless to be sure the operator can be a safe distance from the lift while operating.

Concept #2:

The concept behind this design is to take basic principles of a drive on vehicle rack and modify it down such that it can slide under the car as well as be easily removable. The design will be small enough so that it can be slid under the side of a car between the two tires and aligned with the vehicle's pinch welds or frame as they are common lifting points. This design will require two identical units in order to be able to slide one under each side of the vehicle. This design features pins and rollers or slides that will allow the scissor design to move only vertically while lifting. This is seen as a benefit over other designs which move the car horizontally as well as vertically as they lift in an angular fashion. The next feature of this design is a winch that will provide the lifting force via drawing the arms of the scissors closer together and creating lift. This feature could also be easily swapped for a hydraulic or pneumatic actuator if those mechanisms are deemed more appropriate.

Concept #3:

This concept is based off the scissor jack. The scissor jack to be used would be ones like that out of a car's emergency kit along with the spare tire. This concept uses four of these scissor jacks, placed at every jack point of the car. The only part needing fabrication would be the shafts connecting all four jacks. This part is realistic to build, it would take 7 beveled gears and some sort of metal stock. The beveled gears would be welded onto a rod in the configuration shown. This configuration resembles that of a differential. The screw of each jack would then be welded to each rod with a bevel gear on it. The power of the electric motor could also be increased, depending on the gears. The difficult part about this build would be having the adjustability for the length and width.

Concept #4:

This concept also uses the same mechanism as a scissor jack. The scissor jack would be mounted on a larger floor pad for stability. The top plate would then be modified to allow two arms. The arms would be adjustable lengths to accommodate the different widths of vehicles. The arms would have a jack pad integrated in them to make a safe jack spot for the vehicle. The screw would then have a chuck for an electric motor to attach to for lifting and lowering. The fabrication needed for this design would be the top plate. This would be a difficult design to integrate onto a scissor jack. A concern with this design is the weight capacity. Usually a scissor jack is used to lift one corner of the vehicle up. This would lift both side of the vehicle up, so some strengthening of the jack would be needed.

3.3.3 Final summary statement

The winner of the concepts would be the concept with the highest happiness, this would be concept # 2 with a 73% happiness. The reason why this design had a higher score is because the adjustability was the highest, it would also provide the closest dollar amount to the market price. It also yielded the lowest lifting time. This concept is one to be considered when going forward with design. The others had lower scores due to the adjustability, our product needs to serve a variety of vehicles.

3.4 PROPOSED PERFORMANCE MEASURES FOR THE DESIGN

The goal of our project is to design a jack that will work on several different types of vehicles. With the selection of concept #4, we would be able to use this design on several vehicle types. Our team figured that the needs we came up with for our design were sufficient, however some revisions were needed. The issue our team would run into is finding a winch that would fit into our budget. The need for market price would have to expand for this design. Most jacks come with safety features integrated in the design, any other implications of safety features would be minimal. This changed the need of safety features to implicated safety features.

3.5 REVISION OF SPECIFICATIONS AFTER CONCEPT SELECTION

Table 9 – Revised Needs For Mechanical Car Jack

Need Number	**Need**	**Importance**
1	Jack can serve a variety of vehicles	5
2	Jack takes little time for assembly	3
3	Jack can fit inside a garage	5
4	Jack is powered by electricity	5
5	Jack will lift in less than 5 minutes	3
6	Jack can be moved by one user	4
7	Jack has additional safety features	3
8	Jack can be sold for reasonable price	3
9	Jack can operate on several terrains	4

Table 10 – Revised Identified Metrics

Metric Number	Associated Needs	Metric	Units	Min Value	Max Value
1	1,8	Adjustable Length	Feet	1	6
2	1,8	Adjustable Width	Feet	1	3
3	1,5	Weight Capacity	Tons	0	3
4	2	Assembly Time	Seconds	30	120
5	1,3	Storage Size	Cu. Ft.	10	2000
6	4	Alternate Forms Of Power	Binary	0	1
7	1,5	Lifting Time	Minutes	1	5
8	1,3,6,8	Weight Of Lift	Pounds	50	600
9	7,8	Safety Features	Integer	0	2
10	8	Market Price	Dollars	200	800
11	4,9	Different Terrains	Integer	0	3

Table 11- Revised Concept #2 Scoring

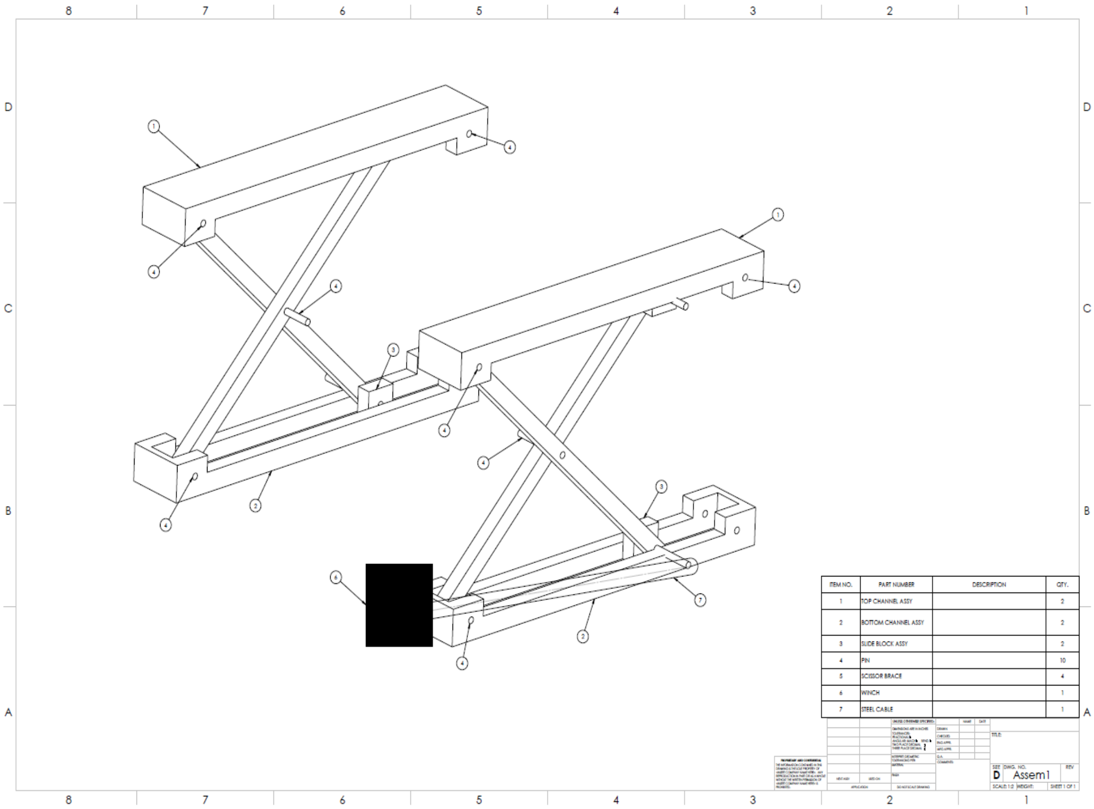
Concept 2		Metric													
		Adjustablity of Length of lift	Adjustabillity of Width of lift	Weight capacity	Assembly time	Storeage Size	Alternate Forms Of Power	Lifting Time	Weight of Lift	Safety Features	Market price	Different types of terrains	Need Happiness	Importance Weight (all entries should add up to 1)	Total Happiness Value
Need#	Need	1	2	3	4	5	6	7	8	9	10	11			
1	Lift serves a variety of vehicles	0.3	0.3	0.3		0.03		0.03	0.03				0.972435	0.1875	0.182332
2	Lift takes little time for assembly				1								0.5	0.0625	0.03125
3	Lift fits in garage					0.75			0.2			0.05	0.83275	0.1875	0.156141
4	Lift is powered by electric						1						1	0.0625	0.0625
5	Lift time is minimized			0.25				0.75					0.953125	0.09375	0.089355
6	Lift can be moved by one person								1				0.5	0.15625	0.078125
7	Lift has safety features									1			0.5	0.15625	0.078125
8	Lift can be sold for a resonable price	0.025	0.025						0.1	0.05	0.7		0.41662	0.0625	0.026039
9	Lift can operate on several terrains											1	0.666	0.03125	0.020813
Units		Feet	Feet	Tons	Secconds	Cu. Ft.	Binary	Minutes	Pounds	Intiger	Dollars	Intiger	Total Happiness		0.724679
Best Value		6	3	3	30	10	1	1	50	2	200	3			
Worst Value		1	1	0	120	100	0	5	600	0	800	0			
Actual Value		6	3	3	45	12	1	1.25	325	1	550	2			
Normalized Metric Happiness		1	1	1	0.5	0.977	1	0.9375	0.5	0.5	0.4166	0.666			

4 EMBODIMENT AND FABRICATION PLAN

4.1 EMBODIMENT/ASSEMBLY DRAWING

Attached below is the initial embodiment plan. This drawing includes two scissor style lifts, attached to the lift would be a winch. The winch would pull the sliding arm, actuating the jack to the up position. The two lifts would then be attached by means of welding metal stock to the bottom plate. The distance between these two would adjustable by having holes drilled in the metal stock and coulter pins inserted.

Figure 8 - Initial Embodiment Assembly



4.2 PARTS LIST

Table 12 – Initial Bill Of Materials

Bill Of Materials				
Sourced from (link)	**Part Number**	**Description**	**Qty**	**Price**
Home Depot (https://w\	306535567	1000lbs Scissor Jack	4	$292.32
Amazon (https://www.a	MY1025	24V Electric Motor	4	$138.00
Amazon (https://www.a	7729K13	Motor Controller	1	$56.00
			Total	$486.32

4.3 DRAFT DETAIL DRAWINGS FOR EACH MANUFACTURED PART

Figure 9 – Lift Assembly

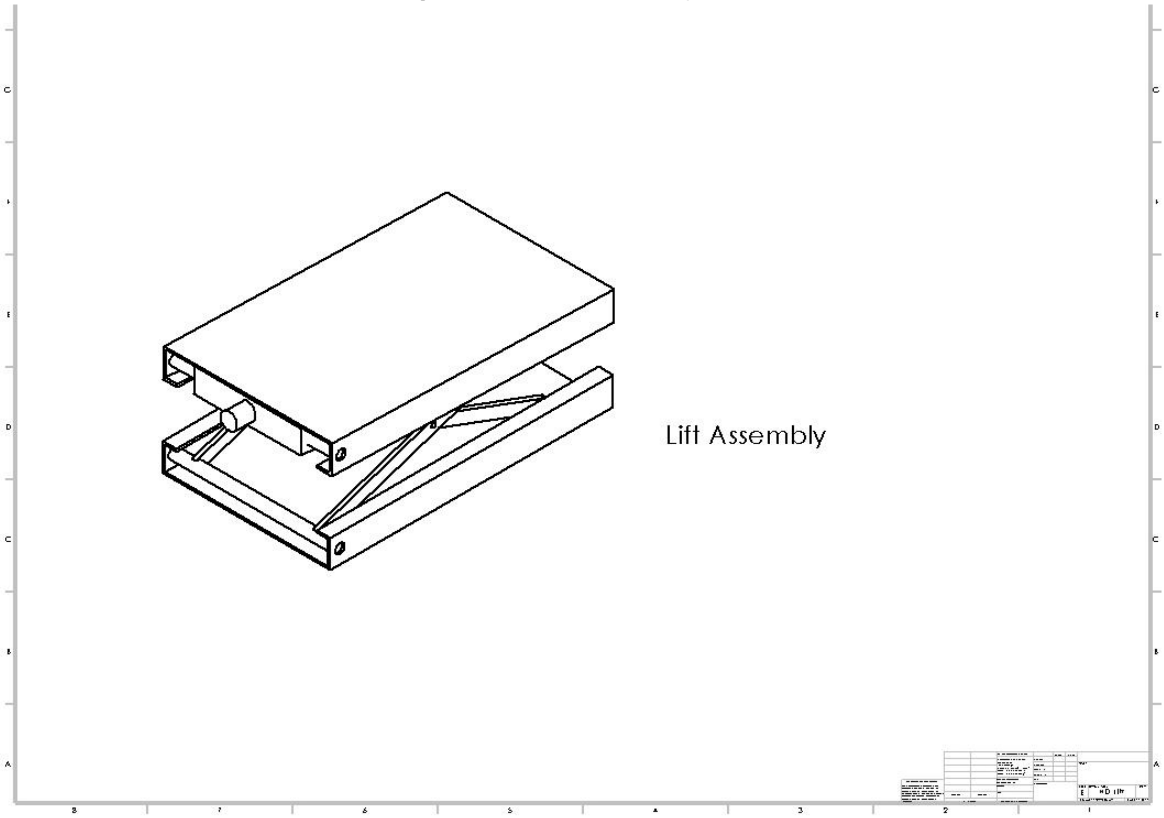


Figure 10 – Motor

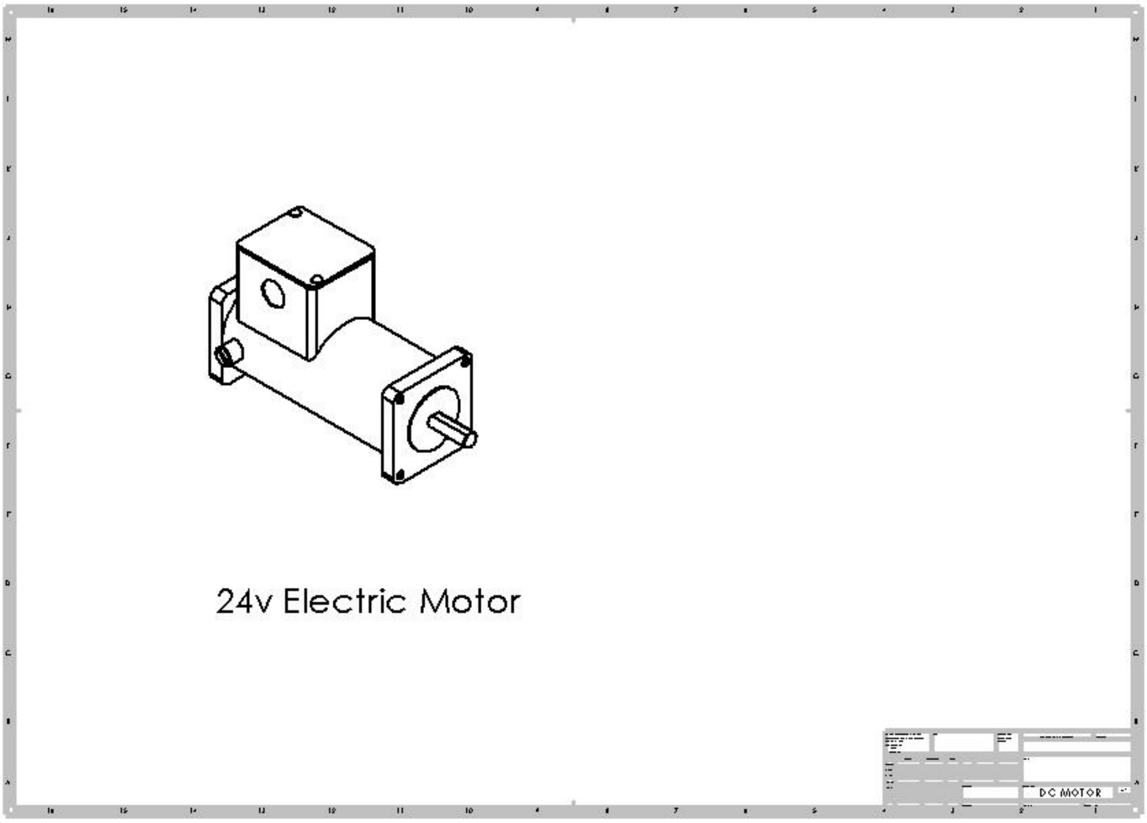


Figure 11 – Motor Mount

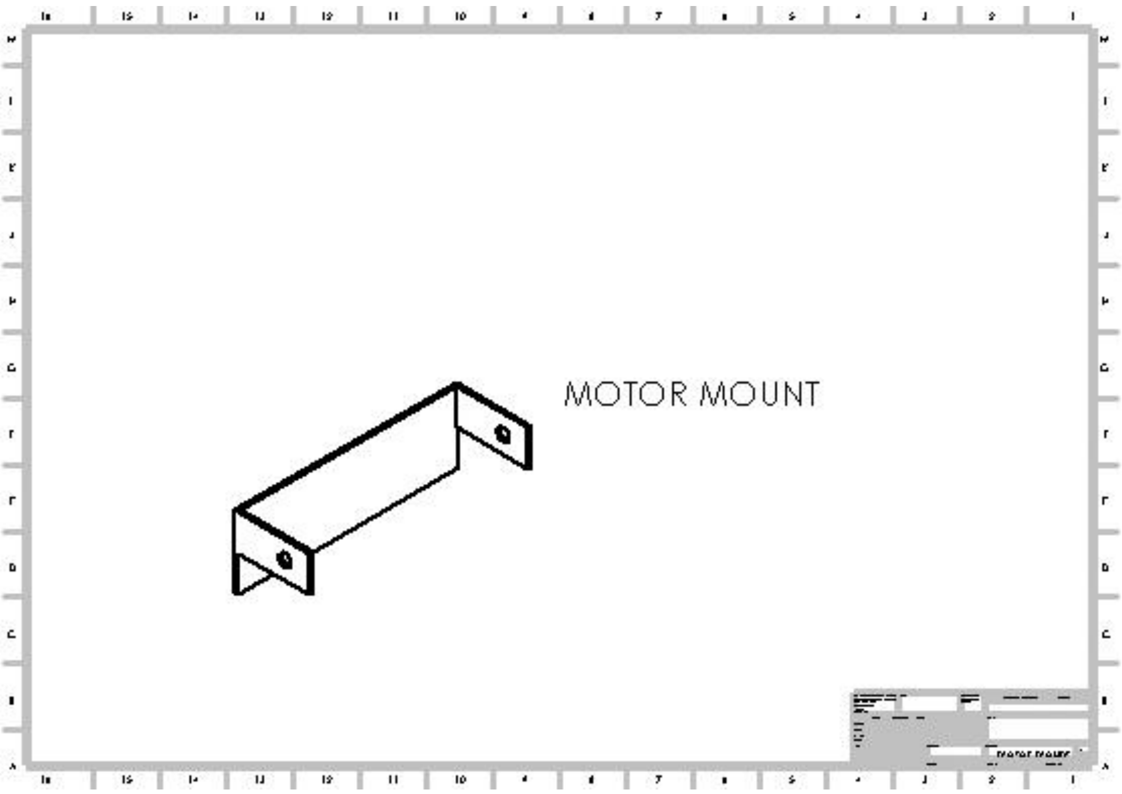


Figure 12 – Single Lift Assembly Initial

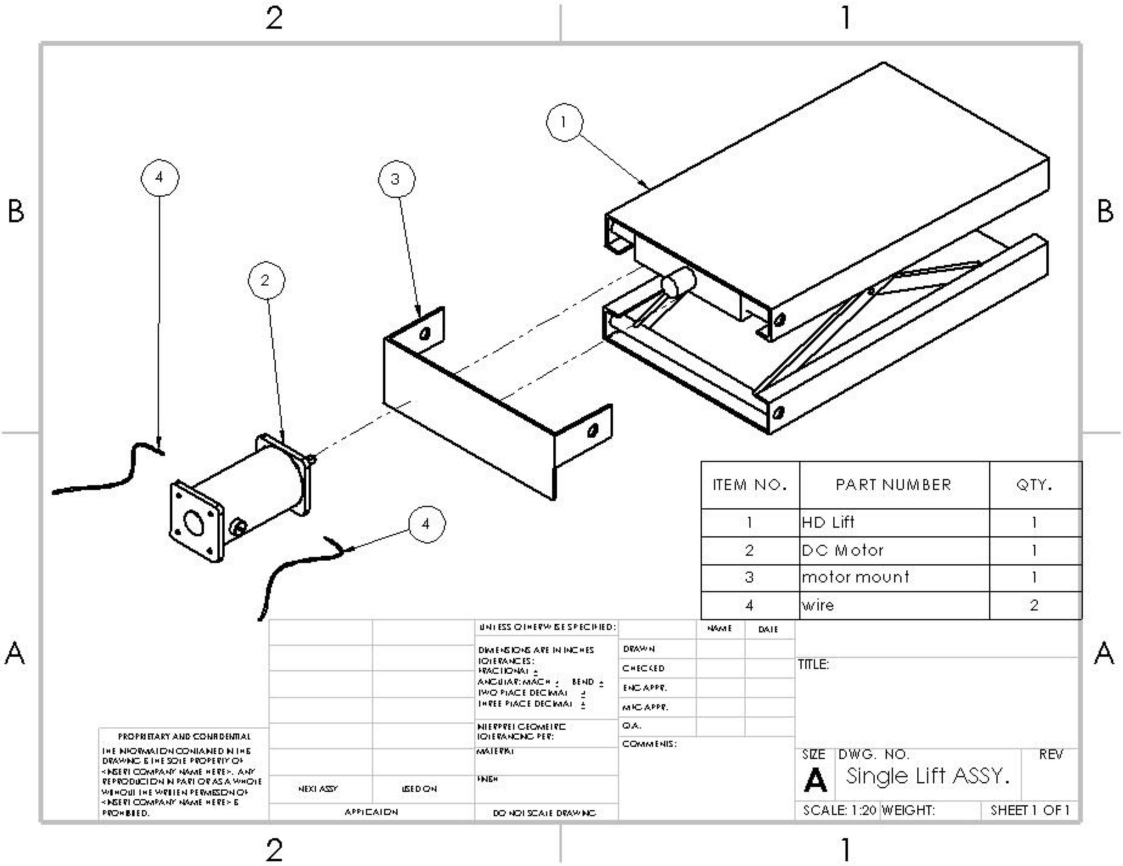
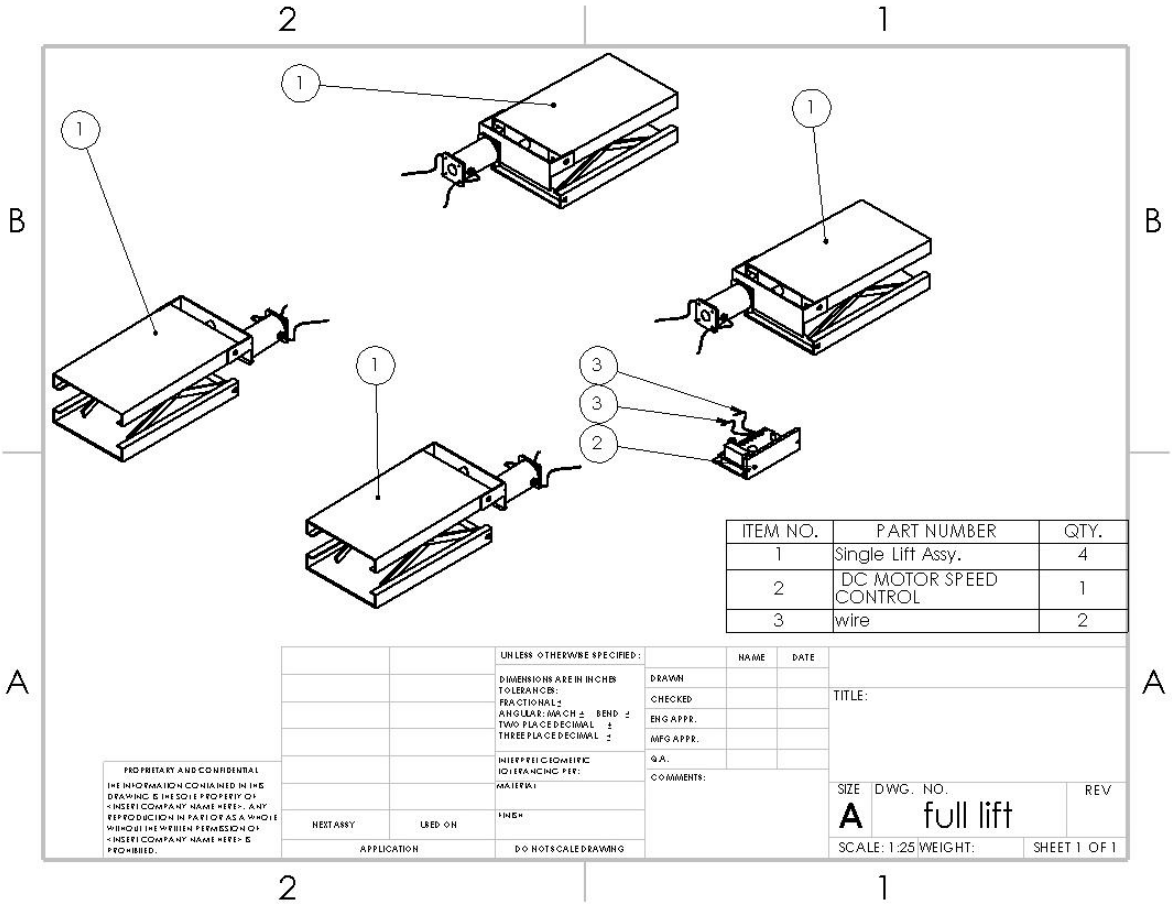


Figure 13 – Full Lift Assembly Initial



4.4 DESCRIPTION OF THE DESIGN RATIONALE

Scissor Lift:

This is a Scissor Lift Assembly capable of lifting 1000lbs. The assembly comes with a mechanism that allows the user to lift the car via an electric wench or crank by hand.
Four of these Scissor Lift Assemblies will be used to lift the car, one in each corner. We chose this particular Scissor Jack Assembly because it was the cheapest and it fit our lifting capacity requirements. Also, this lift was already set up to have a motor attached which saved us on fabrication costs.

Price: $73.08 each

Electric Motor:

The size of the electric motor still has yet to be determined, the torque rating for the screw actuation on the scissor lift will need to be determined. Once this is found then the motor can be sized accordingly. In the assembly, each Scissor Lift Assembly will require one motor. We chose this motor because of price and also because it will power the screw mechanism on the jack. The motor is DC, so it can be powered via battery which may be convenient in some situations. The motor will also be easily mountable to the Scissor Lift Assemblies.

Price: $34.50 each.

Electric Motor Controller:

Control the speed of low-voltage permanent-magnet DC motors. These controls accept DC input voltage and supply a variable DC output voltage. Set a minimum and maximum speed and adjust the current limit on these controls. Operate controls manually or remotely with an electrical signal. We chose this controller, so that it will give us control over all motors simultaneously.

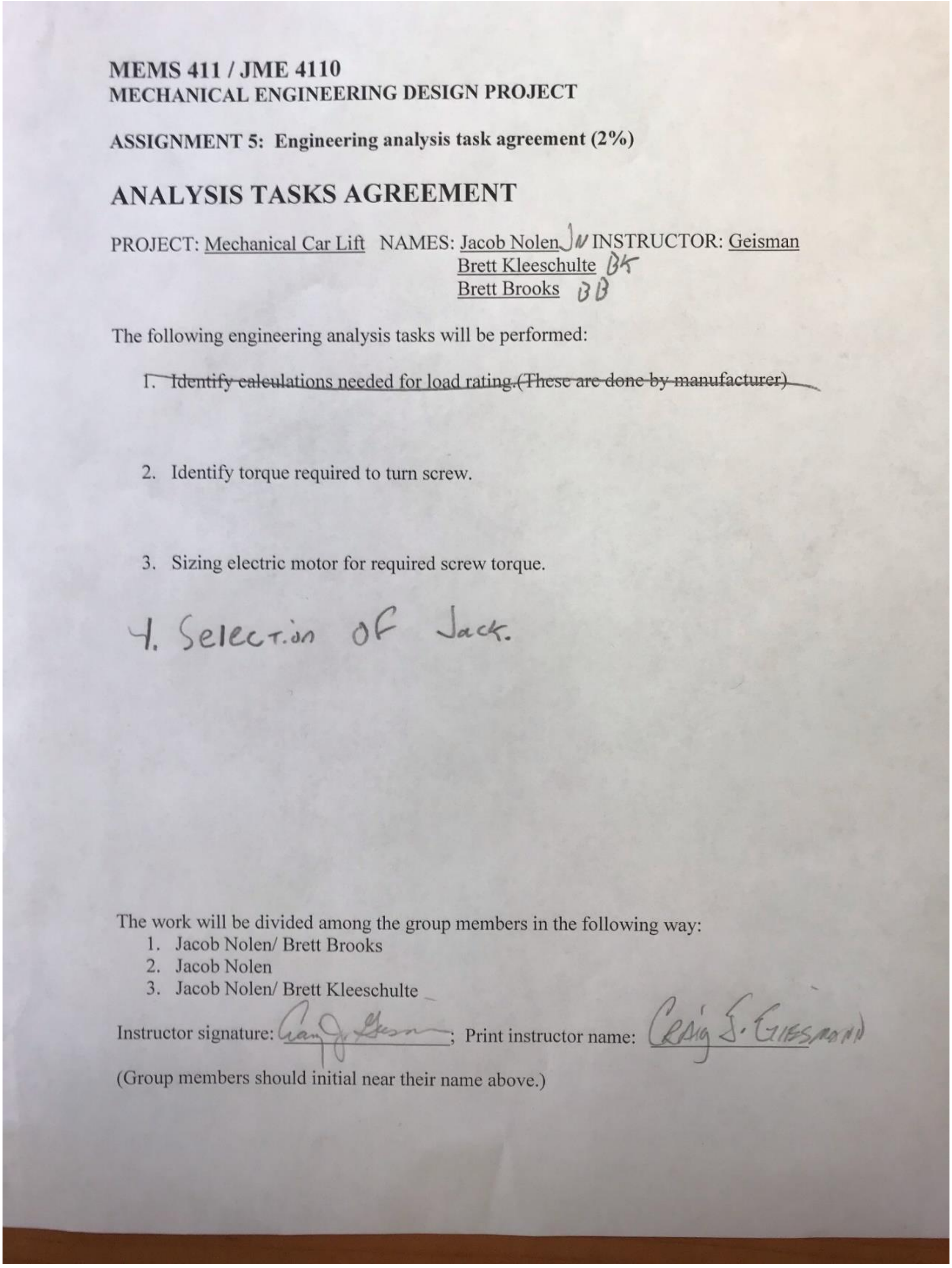
Price: $56.00 each

5 ENGINEERING ANALYSIS

5.1 ENGINEERING ANALYSIS PROPOSAL

5.1.1 Signed engineering analysis contract

Figure 14 - Signed Analysis Tasks Agreement



MEMS 411 / JME 4110
MECHANICAL ENGINEERING DESIGN PROJECT

ASSIGNMENT 5: Engineering analysis task agreement (2%)

ANALYSIS TASKS AGREEMENT

PROJECT: Mechanical Car Lift NAMES: Jacob Nolen JN INSTRUCTOR: Geisman
Brett Kleeschulte BK
Brett Brooks BB

The following engineering analysis tasks will be performed:

1. ~~Identify calculations needed for load rating.(These are done by manufacturer)~~

2. Identify torque required to turn screw.

3. Sizing electric motor for required screw torque.

4. Selection of Jack.

The work will be divided among the group members in the following way:
1. Jacob Nolen/ Brett Brooks
2. Jacob Nolen
3. Jacob Nolen/ Brett Kleeschulte

Instructor signature: ____________; Print instructor name: Craig S. Giessmann

(Group members should initial near their name above.)

Revised Engineering Analysis Agreement

MEMS 411 / JME 4110

MECHANICAL ENGINEERING DESIGN PROJECT

ASSIGNMENT 5: Engineering analysis task agreement (2%)

PROJECT: Mechanical Car Lift NAMES: Brett Brooks INSTRUCTOR: Geisman

Brett Kleeschulte

Jacob Nolen

The following engineering analysis tasks will be performed:

1) Selection of Jack

2) Identify torque required to turn the screw

3) Sizing electric motor required to turn screw

The work will be divided among the group members in the following way:

1) Jacob Nolen/ Brett Brooks
2) Jacob Nolen
3) Jacob Nolen/ Brett Kleeschulte

Instructor signature: _________________; Print instructor name: ________________

(Group members should initial near their name above.)

5.2 ENGINEERING ANALYSIS RESULTS

5.2.1 Motivation

Selection of Jack

Selecting a jack is important for our design. Our design requires that the jack used to lift the vehicle will need to hold the weight of a ½ ton truck. A ½ ton truck weights about 4000lbs. The jack selected will need to hold a ¼ of the weight because our design uses four jacks collaboratively. If a correct jack is not chosen, our design will fall through along with the vehicle.

Torque Required to Turn Screw

Finding the torque required to turn the screw that actuates the jack up and down is critical for our design. We will use the torque found to size an electric motor to power the jack. If this calculation is done wrong we may end up with an undersized motor that will over torque, or we may end up with an oversized motor that could possibly strip the lead screw of the jack.

Sizing Electric Motor

Sizing an electric motor is just as important as selecting the right jack. If the electric motor is not sized correctly, it may destroy itself or the jack. The motor could also spin the lead screw too fast and cause the jack to lift unsafely.

5.2.2 Summary statement of analysis done

Selection of Jack

The jack used to lift the vehicle will need to be selected to hold the weight of a ½ ton truck. A ½ ton truck weights about 4000lbs. Our design will incorporate four scissor jacks, all powered by a motor that is integral to the jack. Under this assumption we can assign a rated load required for the jack. The rated load would need to be at least 1000lbs. Our jack would also need to keep a lower profile for use on a variety of vehicles. The range for the profile would need to be between 3”-8”. Our jack would also need to lift a range of 6”-12” if this is not accomplished, wood blocking would need to be implemented to shim the jack up toward the lift point.

Torque Required to Turn Lead Screw

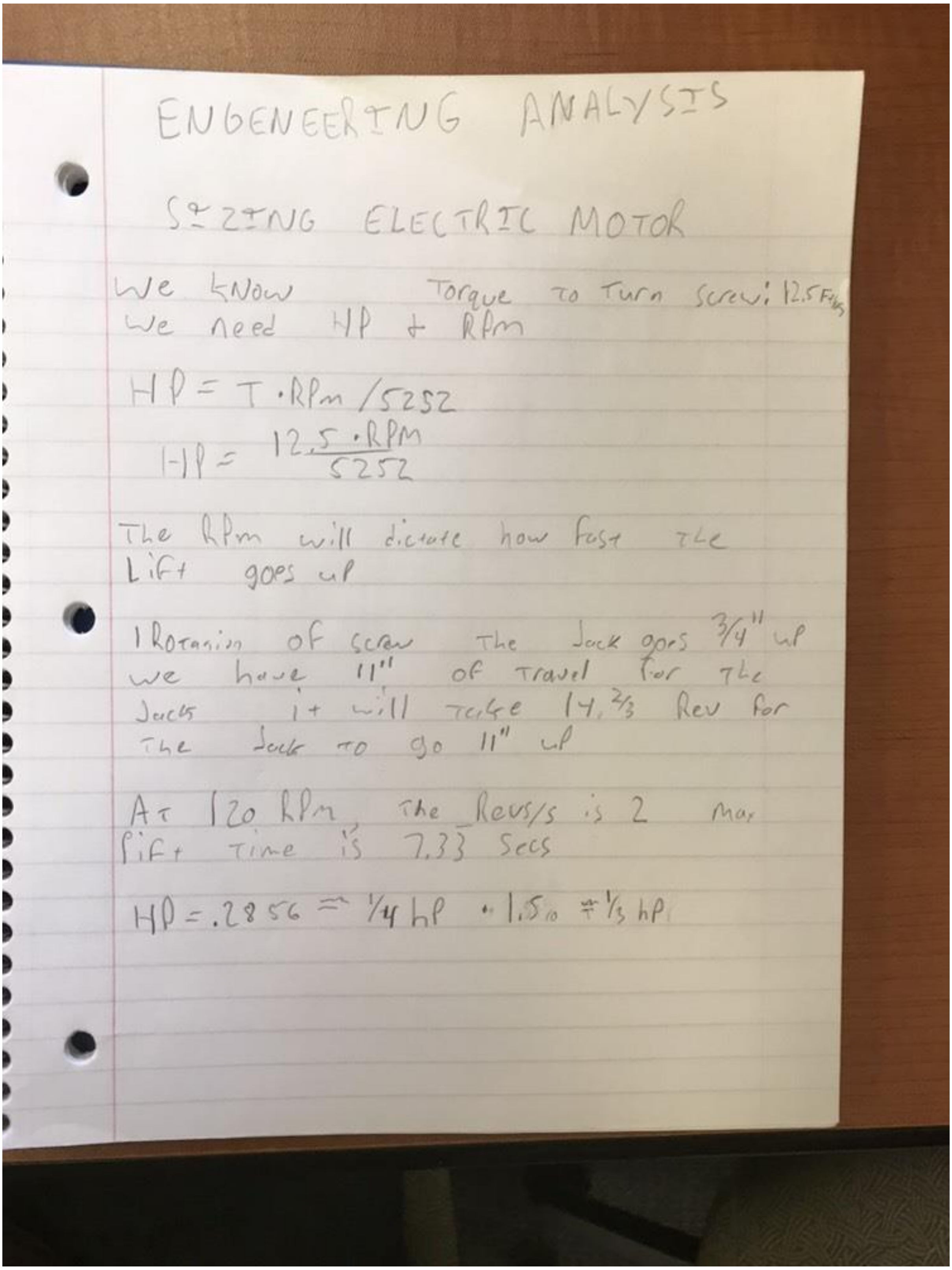
To find the torque required to turn the lead screw, we used a torque wrench with a 7/8” socket. The method for finding the torque is identified in the methodology.

Sizing Electric Motor

Once the torque was found we needed two things for selecting the correct motor, Horsepower and RPM. The equation used is: $HP = \frac{Torque*RPM}{5252}$. The RPM value is the revolutions per minute at which the hp was measured, electric motors provide constant torque at all rpms. We also needed to know how fast we wanted the lift to go. The lift has a travel of 11” and goes up ¾” per 1 revolution of screw. It would take 14 ⅔ revolutions of the screw to reach the highest travel. So, at 120 RPM the jack would lift in 7.333 seconds, at 240 RPM the jack would lift in 3.66 seconds. The rpm will need to stay low, in order to ensure safety of users.

Note that in the analysis done, the values are assumed. Also note that the calculations were done for one jack assembly, our design calls for use of four of the jack assemblies, therefore providing enough power to lift a ½ ton truck.

Figure 15 - Engineering Analysis Sizing Electric Motor



ENGENEERING ANALYSIS

SIZING ELECTRIC MOTOR

We know Torque to Turn screw: 12.5 Ft lbs
We need HP + RPM

$HP = T \cdot RPM / 5252$

$HP = \frac{12.5 \cdot RPM}{5252}$

The RPM will dictate how fast the Lift goes up

1 Rotation of screw the Jack goes 3/4" up
we have 11" of Travel for the Jack it will Take 14.2/3 Rev for The Jack to go 11" up

At 120 RPM, The Revs/s is 2 max lift Time is 7.33 Secs

HP = .2856 ≈ 1/4 hP · 1.5 ≈ 1/3 hP

5.2.3 Methodology

Selecting the Jack

The method by which we selected the jack was to ensure that the one we found matched the criteria laid out above. We did a web search of a screw powered jack and found one that was rated for 1100lbs, 3" tall when collapsed, and lifted 14".

Identifying Torque Required to Turn Screw

Finding the torque required to turn the screw was fairly simple. The testing was completed as follows using the torque wrench:

1. Load the lift to maximum capacity of 1100lbs.
2. Operate the lift with a torque wrench until wheel is 1" off ground.
3. Adjust torque wrench setting while wheel is off the ground until required torque is found.

Sizing the Electric Motor

To select the electric motor, the following equation will be used: $TQ = \frac{HP*5252}{RPM}$ where the Torque is in Ft. Lbs. This equation can be used because electric motors deliver constant torque at any rpm. An example motor at 1000 RPM yielding 1 hp would give a torque of 5.25 ft. lbs. The torque value would have to be equal or greater than 20 Ft. lbs. unlike the example.

5.2.4 Results

Selecting the Jack

We were able to find a jack that fit all of these parameters set in place by us. This means that we had reasonable restrictions for selecting a jack.

Identifying Torque Required to Turn Screw

What we found was that the torque it takes to turn the screw is 12.5 ft. lbs. This is a reasonable number as the screw shouldn't take much torque to turn because it is typically human powered.

Sizing Electric Motor

The motors will be selected based on the equation used in the methodology section. We were able to find an electric motor to use. The motor can be found here: https://www.amazon.com/Carolina-Tarps-Motor-Truck-1-5hp/dp/B07PDJ7SJD/ref=sr_1_2?keywords=carolina+tarps&qid=1565556648&s=hi&sr=1-2

The motor is one that could be found on a dump truck for rolling the tarp up. The motor would produce a torque of 30 ft. lbs. at 80 rpm. There is also a wiring kit to wire a switch for reversible actuation. We were not able to go with this option due to time constraints with ordering. We were able to use a winch motor for actuation of the jack the winch can be found here:

https://www.northerntool.com/shop/tools/product_200631835_200631835?cm_mmc=Google-pla&utm_source=Google_PLA&utm_medium=Winches%20%3E%20AC%20Powered%20Winches&utm_campaign=Keeper&utm_content=44627&gclid=EAIaIQobChMIob7F2dn74wIVDtvACh1XHgKyEAQYASABEgLldfD_BwE

The motor uses a 1hp motor with a 262:1 gear reduction that would provide us with enough torque and rpm to lift the jack.

5.2.5 Significance

The results from the analysis done did affect our design. When sizing the motor needed, we needed to find a motor that would supply enough torque at a low enough rpm. This was very difficult to find in our price range. Our team put in several calls to local electric motor vendors around the Saint Louis area, but the companies were not able to find one in our price range. This caused us to use a winch motor which required more modification to get the design to work.

6 RISK ASSESSMENT

6.1 RISK IDENTIFICATION

Cost

People wanting to do basic maintenance at home are trying to cut cost out of owning a car

Reliability

People using this jack are going to want several uses out of it so they can start saving money

User Safety

Lifting a vehicle can be a deadly process, especially if the user has to get under the vehicle

Vehicular Safety

Vehicles can be damaged by wrongful use of a jack

6.2 RISK ANALYSIS

Cost

Keeping the cost of the jack down can be done by finding parts that will integrate well with one another.

Reliability

Using parts that are correctly sized can help keep the jack working for a longer time. An example could be using an oversized motor could damage the lead screw on the jack.

User Safety

Utilization of safety features already in place by the jack is important. Keeping the parts the way they were will help reduce the risk of injury. One example would be allowing the user to operate the jack from a safe distance.

Vehicular Safety

Just like user safety, keeping the safety features of the jack the way they were is important. If a jack needed a hole drilled in it, this could risk the loading weight the jack can handle

6.3 RISK PRIORITIZATION

Keeping the user safe is the most important risk in the project. Vehicles weight upwards of 2000 pounds this is enough weight to cause serious harm or even fatal injuries for a user. User safety takes precedence over the other risks. Next in line is vehicular safety, cars and trucks are expensive. A vehicle falling off the jack can yield a costly bill at an automotive shop. Keeping the jack reliable is third in our list. Someone who is looking to purchase this jack will want to be able to use it several times for regular maintenance items, saving costs. The user will not want to purchase a new jack every few months. Last is cost, keeping the cost of the jack low is important. The customer will not want to pay $500-$600 on a jack when they can just take their car to the mechanic and get maintenance items done for $200.

7 CODES AND STANDARDS

7.1 IDENTIFICATION

ASME B30.1- Standard for Jacks, Industrial Rollers, Air Casters, and Hydraulic Gantries

Chapter 1-1 applies to mechanical jacks

UL 1004-1 Standard for Rotating Electrical Machines - General Requirements

7.2 JUSTIFICATION

ASME B30.1 is relevant to our project. In chapter 1-0 section 1-0.1 identifies the scope of Volume B30.1. The scope of the volume is identified as "…applying to the construction, operation, inspection, testing, and maintenance of mechanical ratchet jacks, hand- or power- operated mechanical screw jacks…". This scope of the volume applies to the mechanical screw operated jack our team is designing. The chapter that applies to our project is chapter 1-1 Mechanical Jacks. This standard was chosen because this is an industry standard code to follow. A quick web search for a floor jack from a retailers website identifies that the jack does or does not conform to the ASME standards.

The UL 1004-1 Standard for Rotating Electrical Machines is relevant to our project because our design will use an electric motor to power the screw actuation on the jack.

7.3 DESIGN CONSTRAINTS

7.3.1 Safety

1. The control parts of the jack should be designed to minimize exposure of operator injury while providing operation and adjustment
2. The jack should be designed so that the stress in the structural components doesn't exceed 50% of the yield strength of the material at the rated load.
3. When synchronized lifting, all jacks should be the same manufacturer and model.

7.3.2 Quality

1. Replacement parts shall meet or exceed the original equipment specs.

7.3.3 Ergonomic

1. Carrying handles should be designed to hold 200% of the jacks weight

7.3.4 Ecological

1. The jack should be designed to operate the rated load at temperatures it will be used in

7.3.5 Life cycle

1. Repairs, alterations, and modifications shall be specified by the manufacturer or qualified person
2. The jack should be designed to handle proof loading
    a. Proof loading is the process in which a newly designed mechanical jack undergoes dynamic testing of different parts above the design load.

7.3.6 Legal

1. Jacks shall provide a means for labeling the manufacturer, rated load of load point, and auxiliary point, if applicable, the model number, jack handle length and force required.

7.4 SIGNIFICANCE

These constraints won't affect our design by much. The motor will have to be sized to the appropriate torque. The jack will be purchased from a manufacturer. The jack will confirm to the ASME standards as listed above. Most of the constraints listed above have already been met by the manufacturer for the jack to be offered for retail. The constraints that will affect us the most are the ones that state specifications to be met when modifying jacks, and constraints on synchronized lifting. The synchronized lifting requires that when lifting.

8 WORKING PROTOTYPE

8.1 PROTOTYPE PHOTOS

Figure 16 – Working Protoype Assembly

Figure 17 – Working Prototype Assembly

8.2 WORKING PROTOTYPE VIDEO

HTTPS://YOUTU.BE/KV9TL-ZO9IC

HTTPS://YOUTU.BE/8SPOMH5C46S

8.3 PROTOTYPE COMPONENTS

Figure 18 - Jack

Jack

The function of the jack is to provide the source of lifting for the vehicle. This jack is a scissor lift jack that is operated by a screw shaft.

Figure 19 – Winch Motor

Winch Motor

In order for the jack to be operated without work being required from the operator a power source must be fitted to the jack. This came in the form of a winch motor. The motor has its own controller such that it can be operated with one hand.

Figure 20 - Baseplate

Baseplate

The baseplate creates a solid connection between the jack and the motor. It has spacers and a mounting plate for the motor welded to it such that the screw on the jack and shaft of the motor are always aligned.

Figure 21 – Motor Shaft Adapter

Motor Shaft Adapter

In order for the output shaft of the motor to connect to the input of the jack an adapter was created. The adapter is simply a 7/8" socket welded onto the part of the winch that slips onto the output shaft of the winch motor.

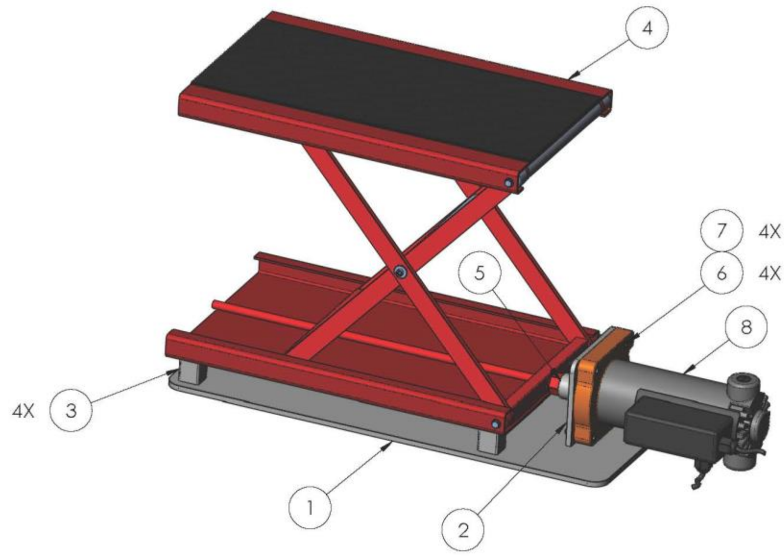
9 DESIGN DOCUMENTATION

9.1 FINAL DRAWINGS AND DOCUMENTATION

9.1.1 Engineering Drawings

See Appendix C for the individual CAD models.

Figure 22 - Car Lift Assembly



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	PART 1	BOTTOM PLATE	1
2	PART 2	MOTOR MOUNTING PLATE	1
3	PART 3	SPACER	4
4	5001.5044	MOTORCYCLE JACK	1
5	7-8 SOCKET	7/8 6PT 1/2 DRIVE SOCKET	1
6	91290A332	M6X1.0 Socket Head Cap Screw	4
7	94645A205	M6X1.0 Nylon-Insert Locknut	4
8	KAC1500	WINCH MOTOR	1

TITLE: CAR LIFT ASSY DRAWING

SIZE A | DWG. NO. 1-2 | REV A

SCALE: 1:10 | SHEET 1 OF 5

Figure 23 – Exploded Car Lift Assembly

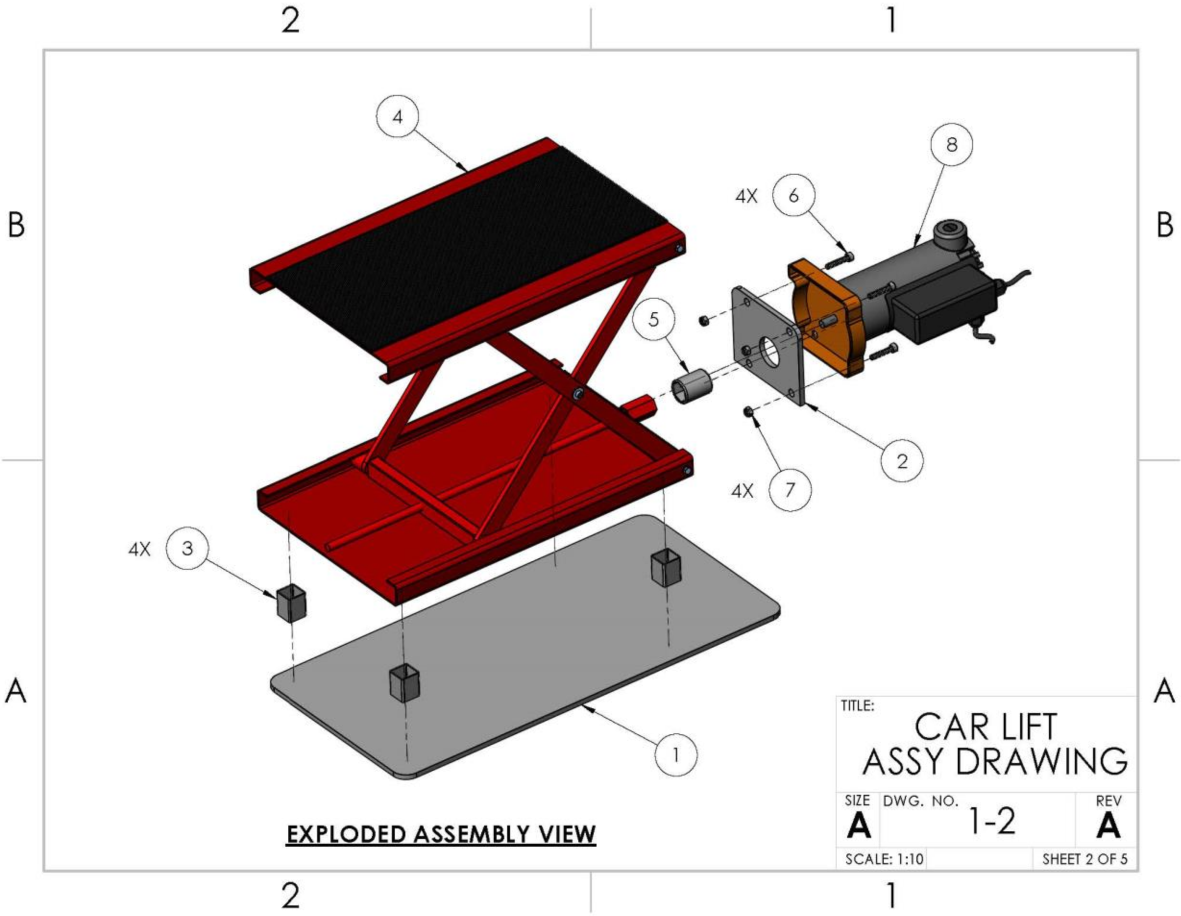


Figure 24 – Bottom Plate

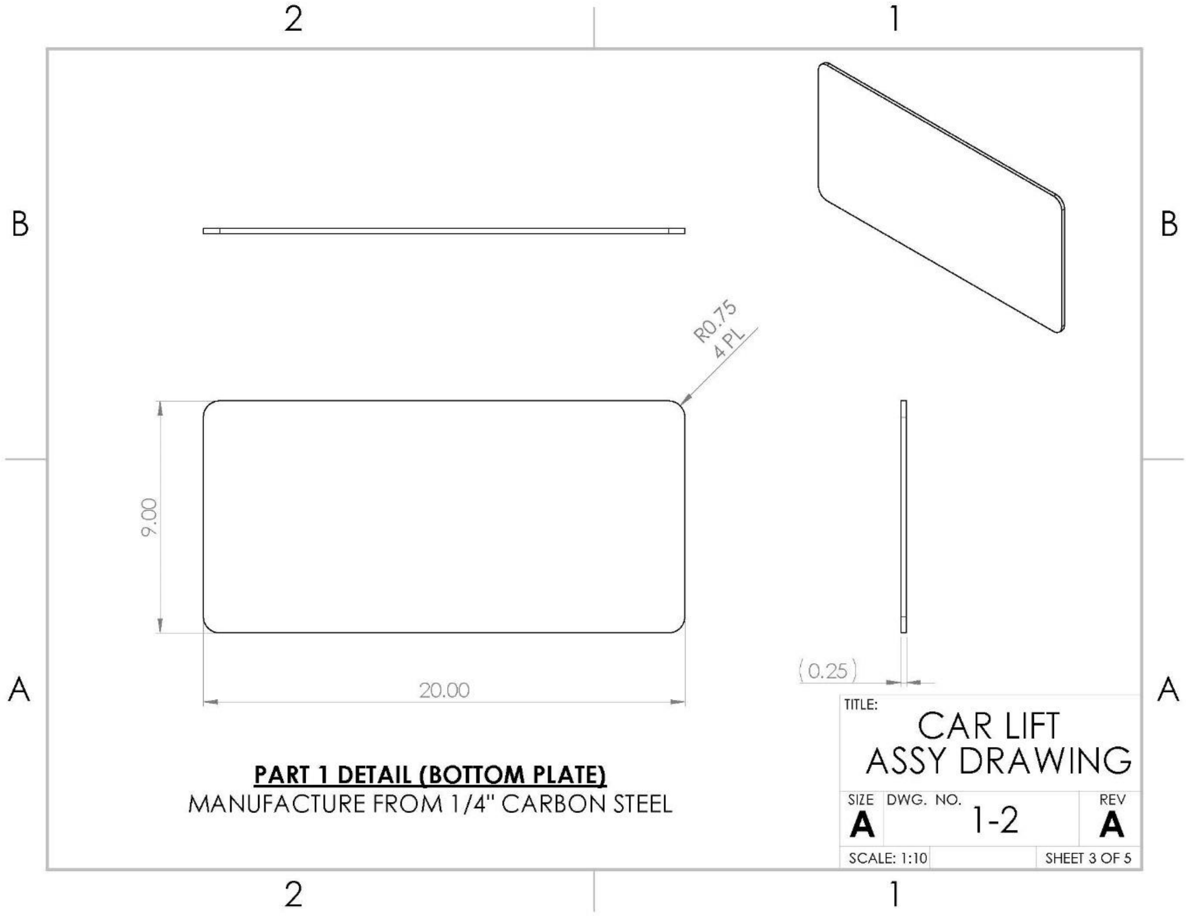


Figure 25 – Motor Mounting Plate

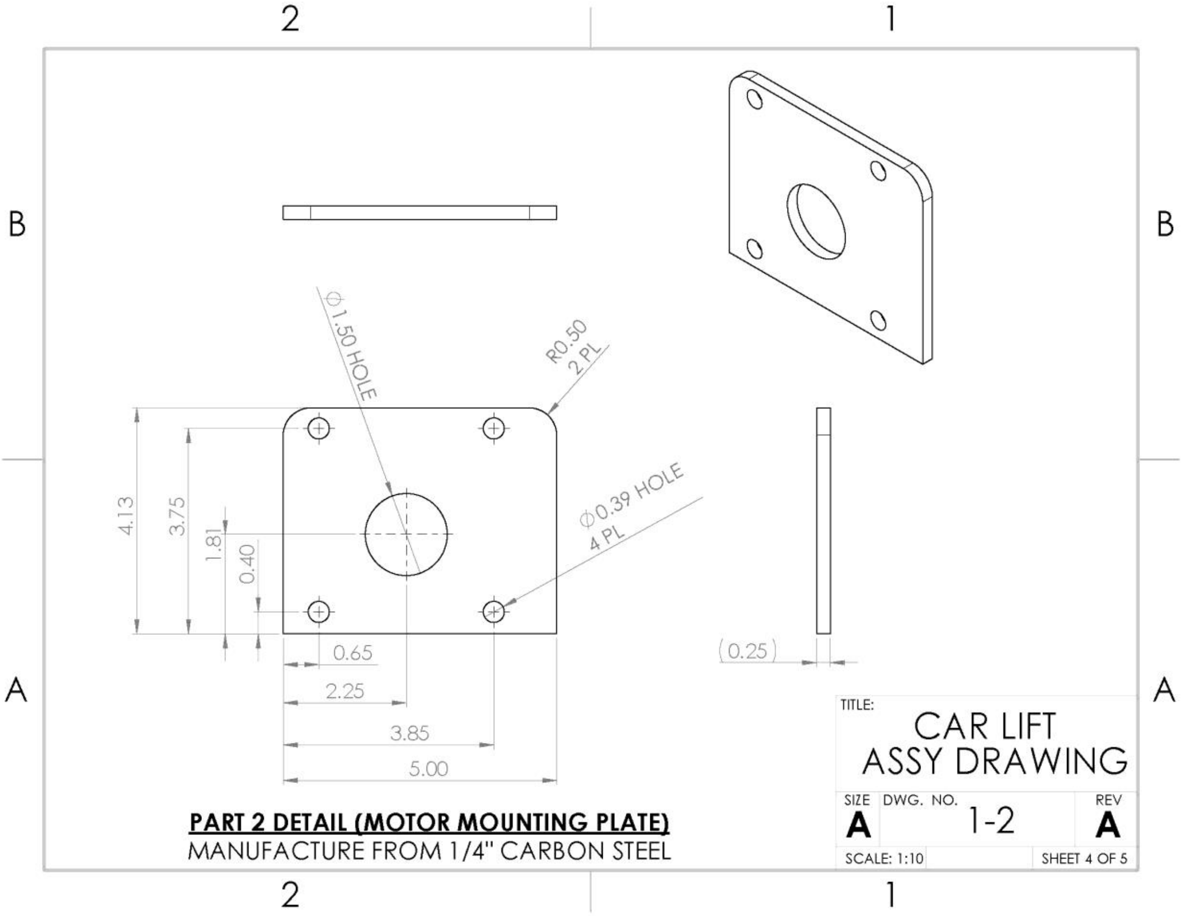
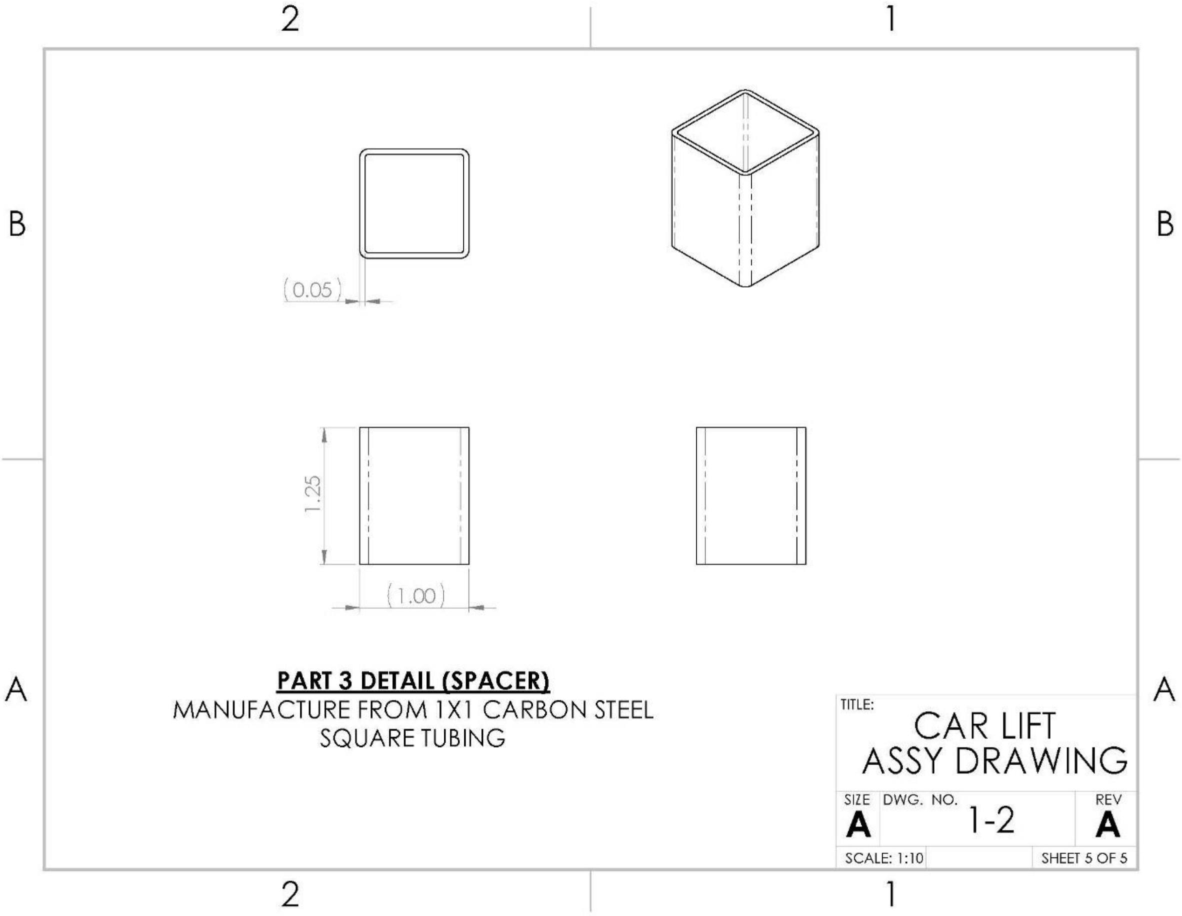


Figure 26 – Spacer



9.1.2 Sourcing instructions

Links:

1. https://www.homedepot.com/p/Everbilt-1-4-in-x-4-in-x-12-in-Plain-Steel-Plate-800497/204325592
2. https://www.homedepot.com/p/Everbilt-1-4-in-x-4-in-x-12-in-Plain-Steel-Plate-800497/204325592
3. https://www.homedepot.com/p/Everbilt-48-in-x-1-in-x-1-16-in-Steel-Square-Tube-801117/204225781
4. https://www.homedepot.com/p/Extreme-Max-1000-lbs-Wide-Motorcycle-Scissors-Jack-5001-5044/306535567
5. https://www.homedepot.com/p/TEKTON-1-2-in-Drive-7-8-in-6-Point-Shallow-Socket-14281/206110526
6. https://www.mcmaster.com/91290a332
7. https://www.mcmaster.com/94645a205
8. https://www.amazon.com/Keeper-KAC1500-Electric-Winch-Remote/dp/B00PX0VM7M

Table 13 – Bill Of Materials

Bill Of Materials								
Item #	Part #	Part	Description	Link	Source	Qty	Price/ea	Total
1	1	BOTTOM PLATE	1/4" Steel Stock	https://www.homedep	Salvage	1	Salvaged	$ -
2	2	MOTOR MOUNTING PLATE	1/4" Steel Stock	https://www.homedep	Salvage	1	Salvaged	$ -
3	887480011173	Square Tubing 4' 1"x1"	1"x1" Square Tube	https://www.homedep	Home Depot	1	Salvaged	$ -
4	5001.5044	MOTORCYCLE JACK	Jack	https://www.homedep	Home Depot	1	$ 74.95	$ 75.95
5	371003246165	7/8 6PT 1/2 DRIVE SOCKET	Socket (Motor)	https://www.homedep	Home Depot	1	$ 2.78	$ 2.78
6	91290A332	M6X1.0 SOCKET HEAD CAP SCREW	Screw (Motor)	https://www.mcmast	McMaster Carr	4	$ 0.66	$ 2.64
7	94645A205	M6X1.0 NYLON-INSERT LOCKNUT	Nut (Motor)	https://www.mcmaste	McMaster Carr	4	$ 0.27	$ 1.08
8	KAC1500	WINCH MOTOR	Motor	https://www.amazon.	Keeper	1	$ 346.58	$ 346.58
							Total	$ 429.03

Item Numbers:

1. The bottom plate is used to mount the jack. This is just ¼" steel plate and can be found just about anywhere. Local hardware stores should have this
2. The mounting plate can be found by using the scrap pieces of the bottom plate
3. The square tubing can also be found at local hardware stores. This is used to shim the jack up so that the shafts of the jack and motor line up.
4. The motorcycle jack can be found on homedepot's website. This is used as the lifting mechanism for the design. Any jack that has the same weight capacity and lift mechanism as this can be used.
5. The socket was used to attach the winch motor to the lead screw of the jack. This can be found at local hardware stores as well.
6. The screw was used to mount the motor to the motor mounting plate. This can be found at local hardware stores as well. The same dimensions are required.
7. The nut was used to secure the motor to the mounting plate. This can be found at local hardware stores. The threads must match that of the screw.
8. The winch motor can be found on amazon. This is produced by a company called "Keeper". This was used to power the jack. Any winch that had reversible controls and a load capacity of 1500lbs could be used.

9.2 FINAL PRESENTATION

Link to the video presentation:

https://www.youtube.com/watch?v=P-NTie-11zU

10 TEARDOWN

Jacob Nolen JN
Brett Brooks BB
Brett Kleeshulte BK

Instructor comments on completion of teardown/cleanup tasks:
Sweep Jolley Floor

Instructor signature: [signature]; Print instructor name: JAKIELA
Date: 8/12/19

(Group members should initial near their name above.)

11 APPENDIX A - PARTS LIST

Table 14 - Parts List

Parts List					
Part #	Description	Material	Qty	Price	Total
1	BOTTOM PLATE	STEEL	1	SALVAGED	$ -
2	MOTOR MOUNTING PLATE	STEEL	1	SALVAGED	$ -
3	SPACER	STEEL	4	SALVAGED	$ -
5001.5044	MOTORCYCLE JACK	-	1	$ 74.95	$ 75.95
7-8 SOCKET	7/8 6PT 1/2 DRIVE SOCKET	-	1	$ 2.78	$ 2.78
91290A332	M6X1.0 SOCKET HEAD CAP SCREW	-	4	$ 0.66	$ 2.64
94645A205	M6X1.0 NYLON-INSERT LOCKNUT	-	4	$ 0.27	$ 1.08
KAC1500	WINCH MOTOR	-	1	$ 346.58	$ 346.58

12 APPENDIX B - BILL OF MATERIALS

Table 15 - Final Bill of Materials

Bill Of Materials								
Item #	Part #	Part	Description	Link	Source	Qty	Price/ea	Total
1	1	BOTTOM PLATE	1/4" Steel Stock	https://	Salvage	1	Salvaged	$ -
2	2	MOTOR MOUNTING PLATE	1/4" Steel Stock	https://	Salvage	1	Salvaged	$ -
3	887480011173	Square Tubing 4' 1"x1"	1"x1" Square Tube	https://	Home Depot	1	Salvaged	$ -
4	5001.5044	MOTORCYCLE JACK	Jack	https://	Home Depot	1	$ 74.95	$ 75.95
5	371003246165	7/8 6PT 1/2 DRIVE SOCKET	Socket (Motor)	https://	Home Depot	1	$ 2.78	$ 2.78
6	91290A332	M6X1.0 SOCKET HEAD CAP SCREW	Screw (Motor)	https:/	McMaster Carr	4	$ 0.66	$ 2.64
7	94645A205	M6X1.0 NYLON-INSERT LOCKNUT	Nut (Motor)	https://	McMaster Carr	4	$ 0.27	$ 1.08
8	KAC1500	WINCH MOTOR	Motor	https:/	Keeper	1	$ 346.58	$ 346.58
							Total	$ 429.03

13 APPENDIX C – COMPLETE LIST OF ENGINEERING DRAWINGS

Go to link for CAD files:

https://drive.google.com/drive/folders/1cd_dsGxw0FEXGBNFInFUkv_GAsf8pJtc?usp=sharing

14 ANNOTATED BIBLIOGRAPHY

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