Center Stand Lift for Sport Bikes

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by

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ABSTRACT

The current methods of lifting and supporting sport bikes for home maintenance or storage are limited in options. Most require two devices to suspend the motorcycle off both wheels. There are very limited options for a single stand supporting an entire sport bike on its own. The reason for this project was to design a center stand lift for sport bikes this is versatile enough to work on the majority of sport bikes with little modification to the stand, and no modification to the bike.

The key feature that were focused on were ease of use, many riders find current models hard to maneuver and at times dangerous to operate. The average weight of a sport bike is around 440 pounds making safety another major focus, and although it was ranked lower on the customer survey cost is a large factor, many sport bike enthusiast will buy second hand items to save what they can.

This design proved to be versatile and the hook and safety locks provide a level of security that is far above current options. This concept used common side materials to lower costs, with future modifications to improve manufacturing time can prove to be a realistic alternative to all current lift alternatives.

INTRODUCTION:

PROBLEM STATEMENT:

Working on a sport bike requires suspending it off the ground, and unlike most other motorcycles sport bikes have plastic fairings that cover most of the bike, preventing access to any typical lift areas such as the exhaust. To account for this owners use a front and a rear stand to support each wheel independently. This requires purchasing multiple stands and attachments. These stands are often hard to use, can be unsafe and are bulky to transport. There is a less common method of lifting a sport bike, by way of a center stand lift. Center stand lifts typically only support one wheel at a time, or are overpriced and limited to one model of sport bike per stand. I propose to design a more versatile center stand lift for sport bikes.

BACKGROUND:

The current, most common method of supporting a sport bike off the ground is by the use of a front and rear stand, each lifting one wheel a set distance off the ground. While the sport bike is suspended there are limited options to reposition the motorcycle without lowering it to the ground and resetting it up at another location. This lifting method is used more often because of the inexpensive nature of the parts and wide availability.

The less common method is a center stand lift that uses the hole in the swing arm pivot joint as a lifting point. This allows the bike to be lifted with one device but only one wheel at a time, also preventing the suspended bike from being moved around.

The purpose of this project is to design an inexpensive center stand lift that will lift both wheels off the ground using the frame. This device allows for more clearance while working on a sport bike, allowing for maneuverability while bike is suspended.

RESEARCH:

REDLINE CENTER STAND

The Redline Center stand in Figure 1 (1) below is a common center stand lift using the swing arm pivot hole to lift the rear of the bike for periodic maintenance such as changing rear tire, adjusting chain slack, changing oil. This device is also used for seasonal storage to prevent damage to tires known as flat spots due to sitting in one position for an extended amount of time.

This lift uses a basic lever method of raising the front or rear wheel using the base of the device as a fulcrum seen below in Figure 2 (2). Once the sport bike is lifted it cannot be moved unless it is lowered and uses the motorcycle's wheels for movement.

Figure 1 Redline Center stand

Figure 2 Redline Center Stand on Motorcycle

BURSIG PADDOCK STAND

The Bursig Paddock stand below in Figure 3 (3) lifts the sport bike from two points on the frame. Typically the points used to lift are the swing arm pivot point and a recessed motor mount location on the frame. This method allows the stand to lift both front and rear wheels at the same time giving more access to the motorcycle for maintenance and repair options.

This stand comes without casters shown, they are an optional upgrade, and without it the device is limited in mobility. The mounting bracket used with this lift is bike-specific; each additional bracket is another charge. This increases the cost and lowers the versatility of the unit.

Figure 3 Bursig Paddock Stand

FRONT AND REAR STANDS

The most common means of lifting a sport bike is the use of front and rear stands. Examples of each are shown in figure 4 (4). These stands are produced by many manufacturers. The rear lift generally is the first one purchased to perform periodic maintenance, such as chain cleaning and tightening, removing the rear wheel and changing oil.

The rear stand lifts the swing arm with the use of swing arm spools that attach to threaded holes on the swing arm around the rear axle, and are supported by hooks or U shaped attachments to the lift. This set up provides better support and is adjustable for different models. The alternate method is paddles lifting from the bottom of the swing arm in place of hooks and spools; this is not as safe due to the likelihood of slipping forward or backward on the swing arm, or slipping off completely.

The front stand has two general options for lifting the front of a sport bike. Using swivels that sit on the bottom of the forks, this still uses the suspension to support the motorcycle but allows for removing the front wheel and brakes. This method has drawbacks due to no locking mechanism and the likelihood of slipping off the stand. The preferred method is lifting from the lower triple tree using a pin. Lifting from this point also allows for removing the suspension for maintenance and repair.

Figure 4 Front and Rear stands

Every stand listed above has benefits which were singled out to be combined into this design. The next section will discuss the survey and how it was used to single out the most important features to customers.

SURVEY

A survey was generated to determine what features current users were satisfied with in the lifting device they were using, also what functions they desired in a lift see appendix B for detailed survey and results. The majority of these features were derived from interviews of amateur motorcycle racers, and enthusiasts. Motorcycle mechanics Brian Mullins of Mullins Cycle Works (5) was interviewed about features that worked well like convenience in only having to use one stand, and easier to access each wheel, and features that would be desired. Responses on a local motorcycle forum to the question "What would you change on this Center stand lift" filled in more detail (6). Tables below lists the customer responses to the survey question

Surveymonkey.com was used to build and conduct the survey (7). Twenty-seven people were surveyed with an average experience with riding sport bikes and using lift devices 7.5 years. Of the people surveyed a majority were general enthusiasts with 4 professional mechanics/shop owners, 1 professional racer, 3 amateur racers, and 6 others who do his or her own maintenance and mechanic work. Refer to appendix B for more information.

1. Features most desirable for a center stand lift. 1- Not important, 5- Most Important.

Table 1 Question 1 Importance

Feature	Average Rating
Reliability	4.7
One person operation	4.6
Safety	4.6
Durability	4.6
Ease of Use	4.4
Maneuverability	3.7
Price	3.7
Versatile	3.5
Size of storage	3.1
Ease of storage	3.0

2. Features in your current lifting device. 1-Unsatisfied, 5-Very Satisfied.

Table 2 Question 2 Importance

Feature	Average Rating
Reliability	4.2
Price	4.1
Durability	4.0
Safety	3.9
One person Operation	3.8
Ease of Use	3.7
Maneuverability	3.7
Ease of storage	3.5
Size of storage	3.4
Versatile	3.2

3. How much would you expect this device to retail?

Table 3 Question 3 Importance

Price	Average
$200-$250	40.7%
$250-$300	33.3%
$150-$200	18.5%
$300-$350	3.7%
$350-$400	3.7%

Using the quality function deployment to input the survey results, and compare them to current satisfaction, adjusting for amount of improvement and the total overall improvement determined the most important features by present listed in table 4 below. Detailed information listed in appendix C

Table 4 Customer importance

Feature	Average Rating
One person Operation	12.3%
Safety	12.0%
Durability	12.0%
Reliability	11.7%
Ease of Use	11.6%
Maneuverability	9.3%
Versatile	8.9%
Price	7.9%
Size of storage	7.4%
Ease of storage	6.9%

The next section will disuse the product features and methods for measuring each.

PRODUCT FEATURES

The interviews and research were used to derive the product features used in the survey. Each feature was given different methods to quantifiably determine if it had been met. Below is the organized list of features, importance rating from the quality function deployment, and the method to determine if the feature was adequately met. Refer to appendix C for more information.

1. One person operation 12.3%
    a. Observation: ability for one person to hold up bike while putting device into place and using it to lift bike.
2. Safety 12.0%
    a. Locking mechanism for holding bike on stand
    b. Locking mechanism for lift to prevent accidental lowering.
    c. Wheel locks for casters
    d. Guards for moving parts

3. Durability 12.0%
    a. Design factor with loading conditions in expected use
    b. Rust-resistant material/coating selection
4. Reliability 11.7%
    a. Reliability of the attachment measured by component life and proper design criteria specified in spec sheets:
        i. caster spec sheet
        ii. lifting mechanism spec sheet for each part (Design)
        iii. locks spec sheet
5. Ease of use 11.6%
    a. Does not need to be setup for each use
    b. Does not need other tools for function.
    c. Under 50lbs of force needed to lift motorcycle
6. Maneuverability 9.3%
    a. 360 degree casters
7. Versatile 8.9%
    a. Holding assembly with multiple pin locations
8. Price 7.9%
    a. Under $300 retail
    b. Use common parts for build
9. Size of storage 7.4%
    a. Reduces footprint for storage by 50%
    b. Reduces size from approximately 2 ft. x 2 ft. x 3 ft. to .5 ft. x .5 ft. x 3 ft.
10. Ease of storage 6.9%
    a. Folds up to fit in reduced space
    b. Self-latching feet for storage.

ENGINEERING CHARACTERISTICS

Engineering characteristics were chosen to best represent each of the customer requirements in a physical or measurable way. Quality function deployment or QFD was used to associate each characteristic with a set number scale and measured against the overall amounts. See appendix C for more information.

Based on the amount each characteristic is cross-referenced against the customer requirements determines the importance below in Table 5 is each characteristic and the relative importance associated with it.

Table 5 Engineering Characteristics

Characteristic	Importance
Material	17.2%
Gearing	15.9%
Locks	14.1%
Weight	10.6%
Metal Finish/Color	9.5%
Standard Components	9.4%
Size	8.6%
Clearance Geometry	7.9%
Pin locations	6.7%

The next section will discuss the design and build schedule and proposed budget.

DESIGN

CONCEPT SKETCH

There were three different concepts drawn up for the center stand lift, the first concept in Figure 5 used a scissor style mechanism uses a worm gear to raise the lift and motorcycle together. The system used two extending arms to attach to each side of the frame. This concept was ruled out due to the speed that a scissor style lift can operate. This style would also have to use two scissor lifts to provide equal support increasing the cost and force needed to operate.

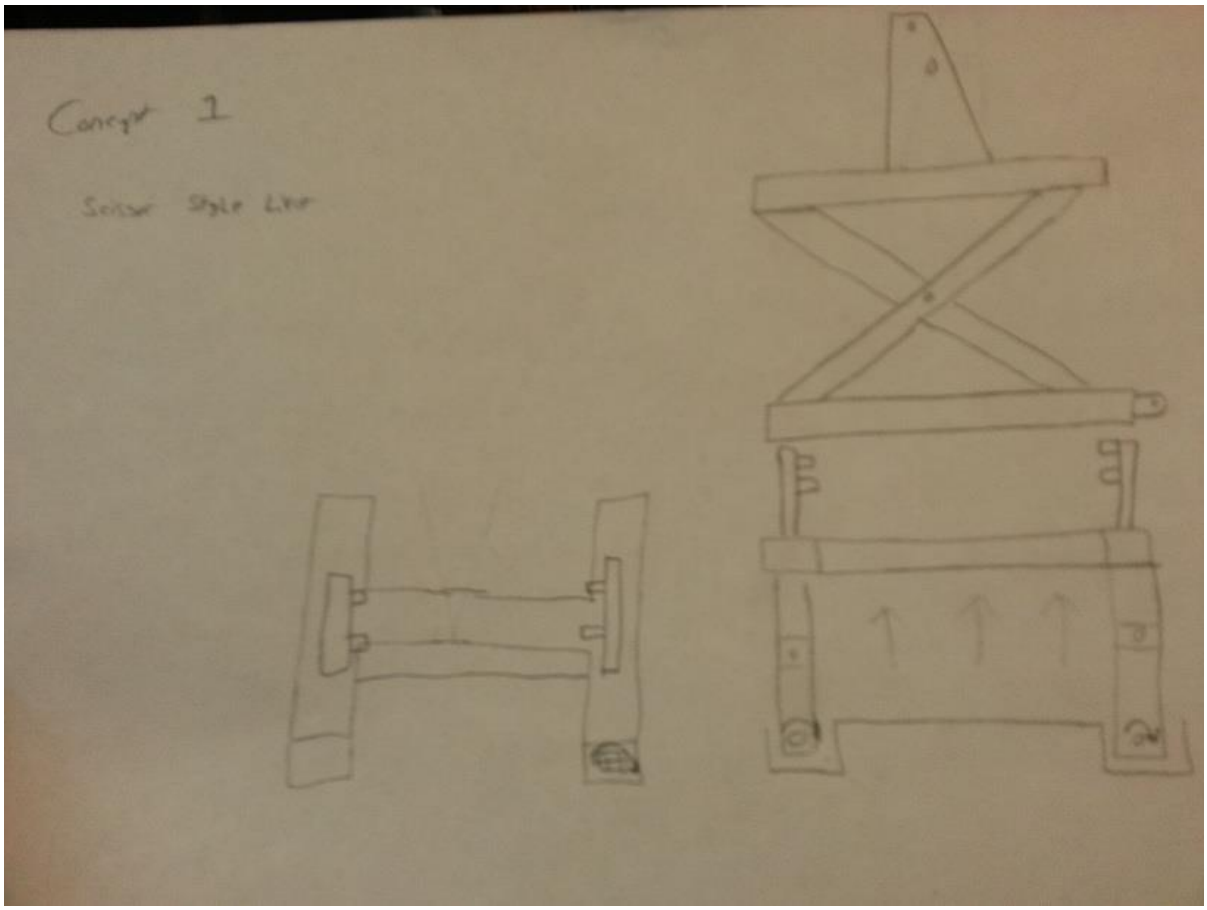

Figure 5 Sissor lift

The second concept design shown in Figure 6 below supported the sport bike from the swing arm pivot and the bottom of the exhaust using a rack and pinion gear to provide the lift. This concept was ruled out upon further research on lower fairing design. To support the sport bike from the exhaust many models would have to have the lower faring removed prior to lifting. Supporting from the exhaust would require a locking or hook mechanism to hold the sport bike from flipping backwards with minor force. This would be dangerous just after hard use due to exhaust temperatures reaching 700 degrees Fahrenheit or more.

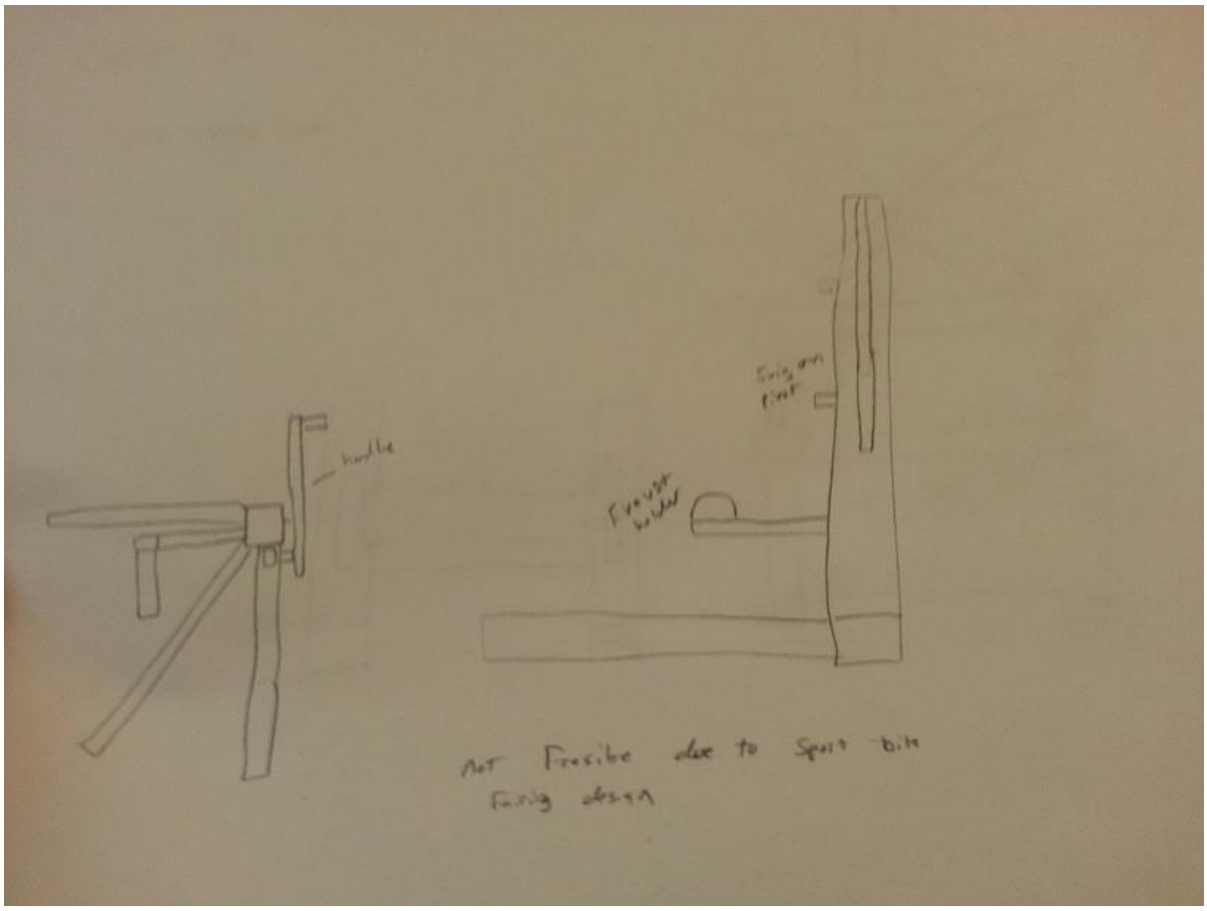

Figure 6 Header lift

The final concept that was chosen is shown in Figure 7 below. This design allowed for the most versatility for different styles of motorcycles. This concept uses a rack and pinion gear to lift the motorcycle with sliding and removable pins to adjust to each style of motorcycle. Using two pins that sit inside the frame and swing arm pivot prevent the sport bike from rotating on the lift. The rack and pinion gear to lift allows for more height then current production models using a lever and set fifteen centimeter lift. This added height better allows for the suspension to decompress and more convenient placement while performing routine maintenance.

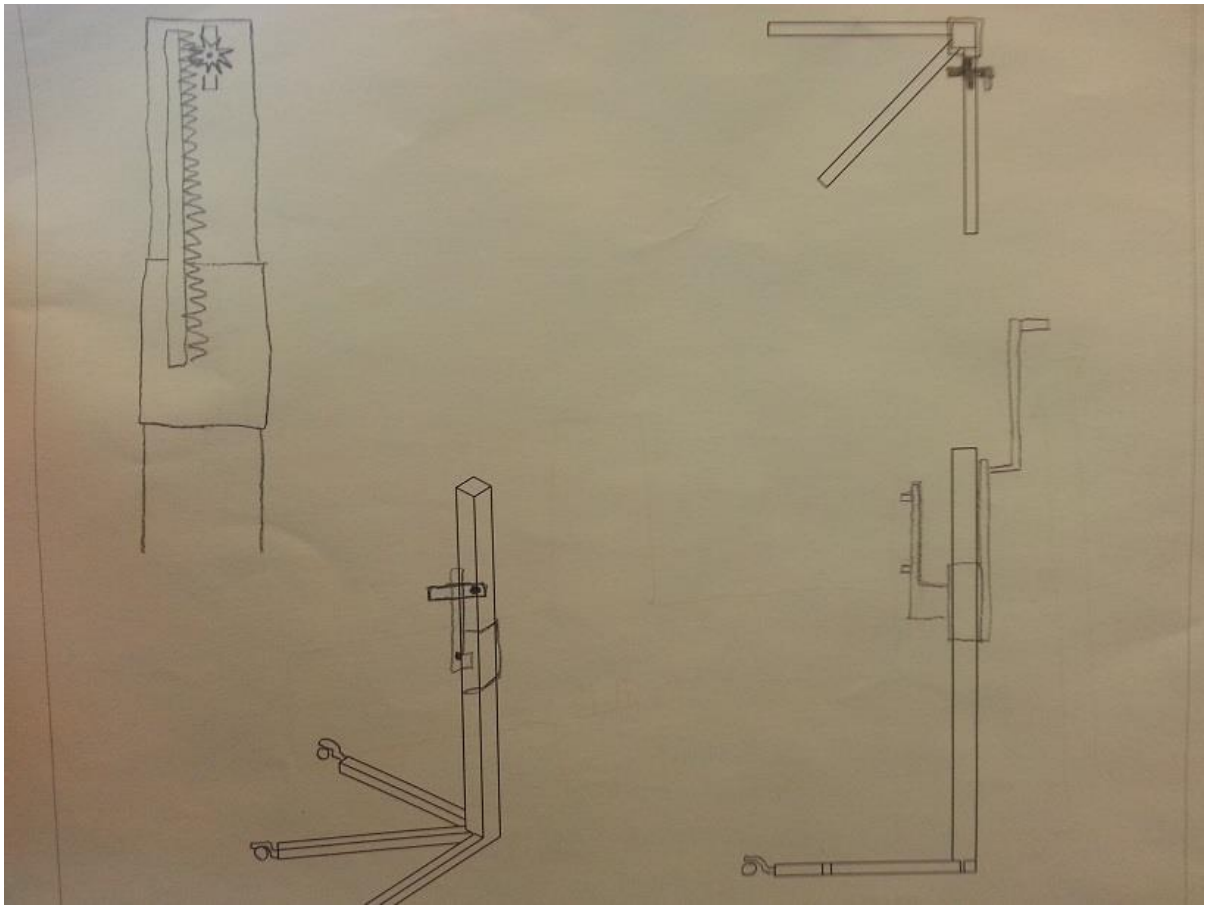

Figure 7 Rack and pinion

CALCULATIONS

When determining the calculations an initial weight had to be determined. After researching many of the possible sport bikes that would work for this center stand lift. The 2013 FZ1 weighs 487 lbs. without any accessories according to Yamaha. The helped determine a base weight of 500lbs for the design. Design factor was the next step, using the Pugsley, A.G. Formula a safety factor of 2.54 was determined. For more information please see appendix E.

Determining the angle of force on the pins at the motor mount and swing arm will give the force in the x and y directions needed to determine the moment and shear stresses as well as the combined force on the lift rack and column. The model sport bike is the 2007 Yamaha R6, the length from the swing arm to the motor mount is five inches in the y and two inches in the x.

$$\text{Motor Mount Angel} = \tan^{-1}\frac{Opposite}{Adjacent} \quad 21.8° = \tan^{-1}\frac{2}{5}$$

$$Swing\ Arm\ Angle = \tan^{-1}\frac{Opposite}{Adjacent} \quad 68.2° = \tan^{-1}\frac{5}{2}$$

After the angle is found multiplying that by the force of the sport bike design weight including the safety factor:

$$Force\ in\ y = \sin(Swing\ Arm\ Angle) * Force \quad 1179.18lbs \downarrow = \sin(68.2) * 1270lbs$$
$$Force\ in\ x = \cos(Swing\ Arm\ Angle) * Force \quad 471.64lbs \rightarrow = \cos(68.2) * 1270lbs$$
$$Swing\ Arm\ Moment = Force * Distance \quad 943.28inlb\ Clockwise = 471.64lbs * 2in$$

The force on the lift bracket and column is a combined stress, using the equations from Applied strength and of Materials(3), the area, section modulus and moment of inertia listed in this section are used to determine all calculations with common shapes.

Square tubing
a=outside length b=inside length

Area (in^2)	a^2-b^2	$1.75in^2 = 2in^2 - 1.5in^2$
I (in^4)	$\frac{a^4-b^4}{12}$	$0.9115in^4\ \frac{2in^4-1.5in^4}{12}$
Z (in^3)	$\frac{a^4-b^4}{6*a}$	$0.9115in^3\ \frac{2in^4-1.5in^4}{6*2in}$
Round bar	$\pi * r^2$	$0.0491in^2 = \pi *.125^2$

The design uses a square tubing at a column, to determine if the column is a short or long the first step is finding the Slenderness Ratio and comparing it to the

Fixed-free columns $L_e = KL = 2.10 * L \quad L_e = 75.6in$
Radius of gyration $r = .289\sqrt{a^2 + b^2} \qquad .7225in = .289\sqrt{2in^2 + 1.5in^2}$
Slenderness ratio $s_r = \frac{l_e}{r} \qquad 104.64 = \frac{75.6in}{.7225in}$
Transition Slenderness Ratio $C_c = \sqrt{\frac{2\pi^2 E}{s_y}} \quad 111.55 = \sqrt{\frac{2*\pi^2*(29*10^6 psi)}{46000psi}}$

Since the slenderness ratio is less than the Transition Slenderness ratio the equation needed to determine the critical load is J.B. Johnson Formula for short columns taken from Applied strength and of Materials(3),

$$P_{cr} = As_y\left[1 - \frac{s_y\left(\frac{L_e}{r}\right)^2}{4\pi^2 E}\right]$$

$$45086.9psi = 1.75in * 46000psi\left[1 - \frac{46000psi * (104.637in/0.7225in)^2}{4 * \pi^2 * (29 * 10^6 psi)}\right]$$

Combined stress calculated is lower than the yield strength of the column using the critical load from the previous equation 45086.9psi. The holding bracket is made of 1018 cold rolled steel with yield strength of 56000psi

on column $\sigma_c = \frac{Force}{Area} + \frac{Moment}{Section\ Modulus}$ $1708.68\ psi = \frac{1179.18lbs}{1.75in^2} + \frac{943.28\ in\ lbs}{.9115\ in^3}$

on holder 17606.8psi

The shear on the pins holding the sport bike on the motor mount and swing arm are treated as double pin, the force is at a set angle, this was used to assume direct shear on pins. The minimum pin size that can be used is .25in diameter, all pins are made out of 1018 cold rolled steel with yield strength of 56000psi

Shear on pin (double pin) $\sigma_s = \frac{f}{a}$ $12932.8psi = \frac{1270}{.0491\ in^2 * 2}$

Shear on holder 2527.7psi

All parts of this design are welded together, to account for the strength of the weld stresses. The equations used were gathered from Roymech.com.

Weld shear stress Holder combined stress Double sided holder

$J = \frac{d*w^3 + w*d^3}{12}$ $.2402in^4 = \frac{.25in*(2.25in)^3 + (.25in)^3*2.25in}{12}$

$\sigma_s = \frac{f}{J*2}$ $36643.4psi = \frac{17606.8}{.4804}$

Pin (double pin) $\sigma_s = \frac{f}{(1.414hr\pi)*2}$ $4574.3psi = \frac{1270}{.2776}$

Angle $\sigma_s = \frac{f}{t_t * l_w}$ $1609.07psi = \frac{\frac{1708.68psi}{.5in^2}*\cos(45)}{.5in^2 * 3\ supports}$

To calculate the force on each leg using the combined force on the column, distributed equally among the total area of the legs. This is used to determine the bending stress on each individual support. The supports are made from A513 tubular steel with yield strength of 46000psi

Force assume distributed load

$f = \frac{\sigma_c * \sin(45)}{a}$ $29.43lbs = \frac{1706.68psi * \sin(45)}{41in^2}$

Leg 17in $\sigma_b = \frac{f*L}{z}$ $4503.89psi = \frac{29.43lbs*17in}{.1111in^3}$

Leg 12in 3179.22psi

The lifting device uses a rack and pinion gear. The gear size was determined to provide enough height change per revolution to lower the revolutions needed to raise the sport bike off both wheels. Assuming the conditions of grade 1 tool steel with yield strength of 155000psi minimum.

W=1270lbs kv=1.1 Pd=1.75in ko=1.4 (table 9.3 dme book)

F=.5in ks=1 J=.39 (table 9-17 DME book) kb=1.5

Pressure angle=20°

$\sigma_g = \frac{w*Pd}{F*J} * k_v * k_o * k_s * k_b \; 26328.1psi = \frac{1270*1.75}{.5*.39} * 1.1 * 1.4 * 1 * 1.5$

The gear will be attached to a shaft, the force on the shaft is torsional shear. The torque transmitted to the shaft from the gear is used to determine the shear on the shaft. The shaft is made from 1018 cold rolled steel with a yield strength of 56000psi

Torque from gear = 1270*.875=1111.25 in lbs.

Polar moment of inertial = $j = \frac{\pi * D^4}{32}$ $.00614 = \frac{\pi * .5in^4}{32}$

Shear stress from torque $\tau = \frac{torque * radius}{J}$ $45246.3 = \frac{1111.25 * .25}{.00614}$

Set screws are used to hold both pins in place while the device, using the moment from the first equation and assuming 15in lbs. of torque applied was used to find the minimum size needed for each screw.

$$Diameter = \frac{Torque}{Coef * Load} \quad 0.106in = \frac{15inlb}{0.6 * \frac{471.64}{2}}$$

All calculations were verified using SolidWorks finite element analysis and to determine other stresses not accounted for in the hand calculations. See Appendix H for more details.

FABRICATION

Fabrication used the solid works drawings and build as close to specifications as possible, there were minor modifications done to adjust for the differences between drawn parts and physical parts. Methods used during fabrication are listed below.

- Metal cutting band saw
- Drill press
- Belt Grinder
- Tungsten inert gas welding
- Metal inert gas welding
- Dremel
- Sandblaster

The Column was the first part assembled. The three base tubes were welded together and finished to provide a level platform to attach the main column with the angle used as braces for support of the weight and redirection of the force. Figure 8 below is the completed base section.

Figure 8 Column

Assembling the carriage involved more precision cutting and welding, each piece had to be aligned so to not interfere with the sliding pins and align to the columns rack gear. Using the square tubing at a base building the holding bracket was completed first. Figure 9 below shows the first stage of the carriage completion.

Figure 9 Pin holder assembly

Building the lifting sections was the next step, the gear side of the carriage had to retain the strength of the square tubing but account for the missing section for the Rack gear on the column shown below in Figure 10. Using precut pieces a bridge was formed high enough to allow movement, but not be in the way.

Figure 10 Lifting bracket

Each of the extended legs was cut to size and the attachments that held the wheels were manufactured. The holes for the casters were threaded to allow for angle adjustments in case the base was not level seen below in Figure 11

Figure 11 Leg assembly

TESTING

Initial testing revealed three major flaws. First the handle for the crank was getting interference with the rear pegs of the motorcycle. The handle interface was lengthened to prevent this from happening again. The second problem was with the support pins, there was not enough material for the pins to properly pinch onto the lifting points of the motorcycle, and a hook bracket was designed to extend behind the frame of the motorcycle forcing all weight onto the pins in a vertical direction. The final problem encountered was metal burs and shavings causing the carriage and column to gouge into each other, this was addressed with powder coating all pieces and using grease to lower the friction at the interaction points.

After the initial testing and problems were addressed strength testing was done, given the limited resources available testing of each pin was the best option with the available gauges. Using a Weigh-Tronix digital strain gauge each pin was tested to more than half of the maximum force allowed. Figure 12 below is the record of the upper pin tested and figure 13 is the lower pin tested.

Figure 12 Upper pin test

Figure 13 Lower pin test

Video documentation illustrated the device meeting other design objectives one person operation, collapsible, and easy to use, also including overloading with shock forces. Upon completion of the test the design was proven to work and met or exceeded all product features.

SCHEDULE AND BUDGET

The total time for this design project is twenty-seven weeks, including three weeks during winter break. The total design and testing takes place between the sixth and twentieth weeks. Expected completions dates for phases agreed upon are listed in Table 6 below.

Table 6 Schedule

	Dec 2 - 8	Dec 9 - 15	Dec 30 - Jan 5	Mar 3 - 9	Mar 17 - 23
Design base assembly	6/5				
design lift assembly		13/15			
Order Components			5/2-14		
Fabrication				7/16	
Testing					21/30

The project was consistently behind the projected time table by a small amount due to outside influences. The final product was completed on time. Fabrication took double the time allotted due to the limited hours available in the work shop due to school and work conflicts. For more detail refer to appendix F

BUDGET

Table 7 Budget for prototype

Area	Projected	Actual
Material for base	$100	40.85
Material for Lift	$50	26.98
Gears	$40	47.79
Handle	$55	11.54
Latches	$25	6.08
Casters	$20	24.62
Total	$290	157.86*

The budget listed is for the prototype design, not retail expectations. This end figure does not include powder coating costs. Powder coating was done by a friend for free and was excluded from the final cost.

CONCLUSION

The common method of lifting and supporting a modern sport bike has inherent drawbacks including the force needed to operate the device, lack of safety of each device. Of each model makes up for lowered cost, the build quality and functionality are also diminished. The concept designed here addresses all of these problems and more. Testing verified the strength and safety of the concept, there are further long term tests that need to be done to determine durability. While fabricating each piece of the center stand possible changes were observed that could improve manufacturing and ease of use. This design will need one or more revision to make the device easier to manufacture and increase the designs profitability.

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APPENDIX A RESEARCH

Redline Center stand

http://www.redlinestands.com/catalog/ 9/7/12

Key benefits
- Lifts from swing arm pivot hole allowing front and rear suspension work
- Great for changing rear tires, tightening chains, and changing oil
- Includes 12 adaptor pins with CNC cut wooden pin holder
- Jack can be used to lift front of bike by supporting exhaust header
- Stand is adjustable in width to fit all sport bikes
- Price $249

Problems
- Only lifts one side of the bike at a time.
- Once Motorcycle is on the stand it has to be taken down to move.
- Set up is complicated

Bursig Paddock Stand

http://www.bursigusa.com/shop 9/7/12

Key Features
- Lifts entire bike at once.
- Attached wheels allow for mobility after raised
- Rubber padded feet for protection when wheels are not in place.
- Price $665 (with wheels)

Problems
- Is not easily transportable
- Hinge lift mechanism razes bike to set height.
- Mounting bracket is model specific.
- Price

Front and Rear stands

http://www.pit-bull.com
9/7/12

Key Features
• Portability.
• Versatile.
• Allows access to all parts of bike.
• Uses multiple lift methods (Pin, Spool, rubber shelves).
• Price $50-$150 each.

Problems
• Needs two stands to lift bike.
• Stands are known to slip off for all but pin and spool styles.
• Awkward to use alone.
• Not all models fit same pin

Brian Mullins
Mullins Cycle Works (Owner)
WERA racer #626
Emailed response to interview.

Mullins center stand lift
9/8/12

Likes: The fact that the bike is completely elevated and on wheels...you can roll it around wherever. Makes for really quick oil changes, tire changes, fork repairs etc etc etc They fold up so you can tuck them away easily. It's a great tool to have.
Changes: Price! They're frickin expensive. Versatility....they fit a couple bikes but aren't readily interchangeable due to the mounting points. I would need a garage full of adapters in order to service all of my customers bikes with them.
I would buy one if they were cheaper.

Clays Forum posts 2012

Forum Responses
All are direct quotes from forum.

Part of senior design is finding customers, and what they would want in a product.
so what would you want in this product? how would you like it to change if you could?
[URL="http://www.bursigusa.com/shop"]Center stand lift[/URL]
Thanks

SlowAnthony I would love to have that. I would want it to be able to lift the bike from BOTH sides - Not just dedicated to one side...(maybe it does but I didn't see it).

GrapeApe Make the pin go through the bike, longer so it was more universal fit so you don't have to buy a gsxr plate and a kawi plate for each diff bike, make an adjustable height and placement kit to fit more bikes. and possibly make the legs fold or a 2 pc design so it could easily hang on a wall of trailer or garage when not in use.

GrapeApe If you could get this down to the $250 price point it would be more attainable for the layperson.

Aweasel larger diameter urethane casters...I doubt that rolls easily on asphalt or concrete. spacers so stand is offset from bike further, would have to beef up the adjacent bar and brace it, also would need longer legs

OhioYJ I'd like to see one up close, I don't like there not being ant sort of safety (Some way to lock it on to the stand). Also it's lifting from a point on the frame (of the bike), that isn't necessarily meant to carry the entire load of the bike? Not that I think it would hurt it, but something else to throw out there for the sake of the argument.

PRESIDENT I have seen similar products like this. It's not bad for the bikes. I LOVE the idea!!! Wheels should be included and the price seems fair.

ej257 I think an option of raising the bike even higher would be attractive, although, that may require more counterweight or more bracing, just saying, it'd be nice to not have to crawl around on the ground to change oil, and this is a lot cheaper than a pneumatic/hydraulic lift.

bassJAM I think it would be somewhat easy to make this work not only as a lift, but a stabilizer also. Make that "lifting" part move up and down very freely, so that you could fit it into the bike and let the bike stand perfectly upright while still having the full weight on the bike's wheels. The idea is that it could be handy for setting suspension without an extra helper around to hold your bike upright.

mapolley07 I like the idea. maybe it could be modified to rotate the bike say upside down and lock it into position like an engine stand or car rotisserie. Of course all fluids would have to be drained first, but flipping the bike upside down could be useful at times, or being able to use this thing to lay a bike on its side to work on clutches stators, etc.

Lift the bike up, then tip it sideways or rotate it end over end, or both. would definitely help getting into tight spots or for fabbing up custom bits like brackets and such

MattKat Different height adjustments, ability to switch sides, better casters.

mapolley07 A more practical concern would be find a way to lift the bike without blocking/utilizing motor mounts so that the motor can be pulled with the bike suspended. But regardless, having a stand like this for pulling swing arms and forks would be great

APPENDIX B - SURVEY

1. Features most disable for a center stand lift. 1- Not important, 5-Most Important.

Create Chart | Download

	1	2	3	4	5	Rating Average	Response Count
Safety	0.0% (0)	0.0% (0)	7.4% (2)	25.9% (7)	**66.7% (18)**	4.59	27
Price	0.0% (0)	3.7% (1)	**48.1% (13)**	18.5% (5)	29.6% (8)	3.74	27
Ease of Use	0.0% (0)	7.4% (2)	0.0% (0)	40.7% (11)	**51.9% (14)**	4.37	27
One Person Operation	0.0% (0)	3.7% (1)	0.0% (0)	33.3% (9)	**63.0% (17)**	4.56	27
Reliability	0.0% (0)	0.0% (0)	0.0% (0)	30.8% (8)	**69.2% (18)**	4.69	26
Durability	0.0% (0)	0.0% (0)	0.0% (0)	38.5% (10)	**61.5% (16)**	4.62	26
Maneuverability	4.0% (1)	0.0% (0)	**44.0% (11)**	28.0% (7)	24.0% (6)	3.68	25
Ease of Storage	7.7% (2)	15.4% (4)	**53.8% (14)**	7.7% (2)	15.4% (4)	3.08	26
Size of Storage	7.4% (2)	22.2% (6)	**33.3% (9)**	22.2% (6)	14.8% (4)	3.15	27
Versatile	7.7% (2)	3.8% (1)	**38.5% (10)**	30.8% (8)	19.2% (5)	3.50	26
					answered question		**27**
					skipped question		**0**

2. Features in your current lifting device. 1-Unsatisfied, 5-Very Satisfied. Create Chart Download

	1	2	3	4	5	Rating Average	Response Count
Safety	0.0% (0)	11.1% (3)	22.2% (6)	**37.0% (10)**	29.6% (8)	3.85	27
Price	0.0% (0)	0.0% (0)	29.6% (8)	29.6% (8)	**40.7% (11)**	4.11	27
Ease of Use	3.7% (1)	11.1% (3)	18.5% (5)	**40.7% (11)**	25.9% (7)	3.74	27
One Person Operation	3.7% (1)	3.7% (1)	**37.0% (10)**	22.2% (6)	33.3% (9)	3.78	27
Reliability	0.0% (0)	7.7% (2)	11.5% (3)	30.8% (8)	**50.0% (13)**	4.23	26
Durability	0.0% (0)	11.5% (3)	23.1% (6)	19.2% (5)	**46.2% (12)**	4.00	26
Maneuverability	3.8% (1)	11.5% (3)	**30.8% (8)**	23.1% (6)	**30.8% (8)**	3.65	26
Ease of Storage	7.7% (2)	7.7% (2)	**30.8% (8)**	**30.8% (8)**	23.1% (6)	3.54	26
Size of Storage	7.7% (2)	15.4% (4)	**30.8% (8)**	23.1% (6)	23.1% (6)	3.38	26
Versatile	15.4% (4)	7.7% (2)	**38.5% (10)**	15.4% (4)	23.1% (6)	3.23	26
					answered question		**27**
					skipped question		**0**

3. How much would you expect this device to retail? Create Chart Download

	Response Percent	Response Count
$150-$200	18.5%	5
$200-$250	**40.7%**	**11**
$250-$300	33.3%	9
$300-$350	3.7%	1
$350-$400	3.7%	1
	answered question	**27**
	skipped question	**0**

APPENDIX C – QFD

John Clays Center Stand Lift Sport Bike 9 = Strong 3 = Moderate 1 = Weak	Size	Standard Components	Weight	Material	Locks	Gearing	Pin locations	Clearances Geometry	Metal Finish/Color	Customer importance	Current Satisfaction	Planned Satisfaction	Improvement ratio	Modified Importance	Relative weight	Relative weight %
Safety	3	3		9	9	9			3	4.6	3.9	4.4	1.1	5.2	0.120	12.0%
Price		9		9					9	3.7	4.1	3.8	0.9	3.4	0.079	7.9%
Ease of Use			3		9	9	3	3		4.4	3.7	4.2	1.1	5.0	0.116	11.6%
One person Operation			3	3		9	3	3		4.6	3.8	4.4	1.2	5.3	0.123	12.3%
Reliability		9		3	3					4.7	4.2	4.5	1.1	5.0	0.117	11.7%
Durability				9		3			9	4.6	4.0	4.5	1.1	5.2	0.120	12.0%
Maneuverability	3		9	3	3			3		3.7	3.7	4.0	1.1	4.0	0.093	9.3%
Ease of storage	9		9		3					3.0	3.5	3.5	1.0	3.0	0.069	6.9%
Size of storage	9		3		3					3.1	3.4	3.5	1.0	3.2	0.074	7.4%
Versatile							9	9		3.5	3.2	3.5	1.1	3.8	0.089	8.9%
Abs. importance	1.93	2.13	2.40	3.87	3.18	3.59	1.52	1.79	2.15	22.6				43.2	1.0	1.0
Rel. importance	0.09	0.09	0.11	0.17	0.14	0.16	0.07	0.08	0.10	1.0						

APPENDIX D – PRODUCT OBJECTIVES

1. Safety 12.0%
    a. Locking mechanism for holding bike on stand
    b. Locking mechanism for lift to prevent accidental lowering.
    c. Wheel locks for casters
    d. Guards for moving parts

2. Price 7.9%
    a. Under $300 retail
    b. Use common parts for build

3. Ease of use 11.6%
    a. Does not need to be setup for each use
    b. Does not need other tools for function.
    c. Under 50lbs of force needed to lift motorcycle

4. One person operation 12.3%
    a. Observation: ability for one person to hold up bike while putting device into place and using it to lift bike.

5. Reliability 11.7%
    a. Reliability of the attachment measured by component life and proper design criteria specified in spec sheets:
        i. caster spec sheet
        ii. lifting mechanism spec sheet for each part (Design)
        iii. locks spec sheet

6. Durability 12.0%
    a. Design factor with loading conditions in expected use
    b. Rust-resistant material/coating selection

7. Maneuverability 9.3%
    a. 360 degree casters

8. Ease of storage 6.9%
    a. Folds up to fit in reduced space
    b. Self-latching feet for storage.

9. Size of storage 7.4%
    a. Reduces footprint for storage by 50%
    b. Reduces size from approximately 2 ft. x 2 ft. x 3 ft. to .5 ft. x .5 ft. x 3 ft.

10. Versatile 8.9%
    a. Holding assembly with multiple pin locations

APENDIX E DESIGN FACTOR

Pugsley, A.G.

He recommends determining the coefficient of safety as a product of two coefficients.

SF = SF1 * SF2

where:

- SF1 is a function of parameters A, B, C from the first table
- SF2 is a function of parameters D, E from the second table

Meaning of parameters:

A. Quality of material, level of processing, maintenance, service inspections

B. Control over possible overloading

C. Accuracy of analysis, knowledge of experimental data of experience with similar parts

D. Threat to people when a failure of the part occurs

E. Financial impact when a failure of the part occurs

Parameter A	Parameter C	Parameter B			
		B=1	B=2	B=3	B=4
A=1	C=1	1.10	1.30	1.50	1.70
	C=2	1.20	1.45	1.70	1.95
	C=3	1.30	1.60	1.90	2.20
	C=4	1.40	1.75	2.10	2.45
A=2	C=1	1.30	1.55	1.80	2.05
	C=2	1.45	1.75	2.05	2.35
	C=3	1.60	1.95	2.30	2.65
	C=4	1.75	2.15	2.55	2.95
A=3	C=1	1.50	1.80	2.10	2.40
	C=2	1.70	2.05	2.40	2.75
	C=3	1.90	2.30	2.70	3.10
	C=4	2.10	2.55	3.00	3.45
A=4	C=1	1.70	2.15	2.40	2.75
	C=2	1.95	2.35	2.75	3.15
	C=3	2.20	2.65	3.10	3.55
	C=4	2.45	2.95	3.45	3.95

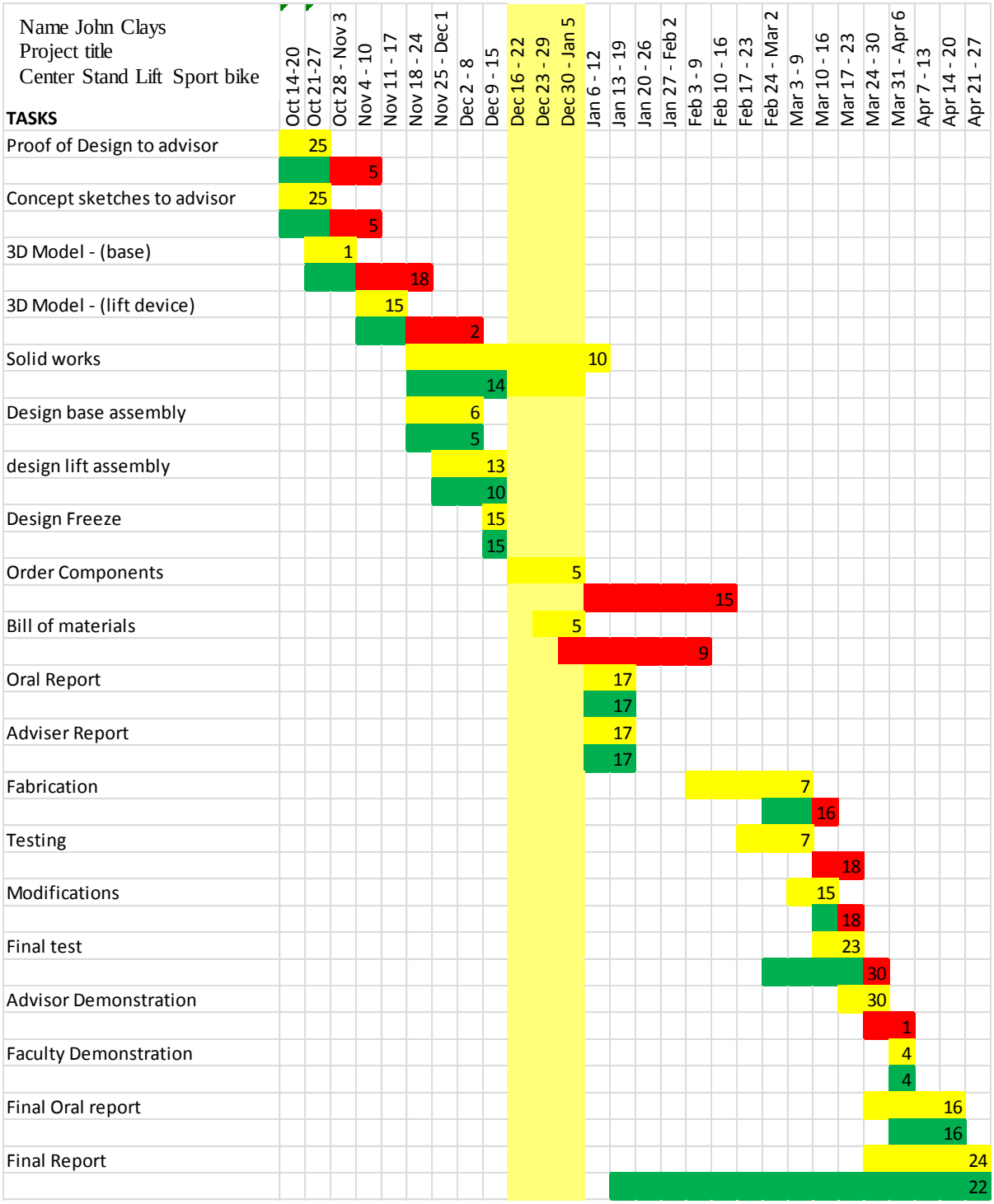
Where the evaluation means: 1=Very good; 2=Good; 3=Sufficient; 4=Bad

Parameter D	Parameter E		
	E=1	E=2	E=3
D=1	1.0	1.0	1.2
D=2	1.2	1.3	1.4
D=3	1.4	1.5	1.6

Where the evaluation means: 1=Minimum; 2=Mean; 3=Very serious

http://www.mitcalc.com/doc/help/en/c_safety.htm

APPENDIX F – SCHEDULE



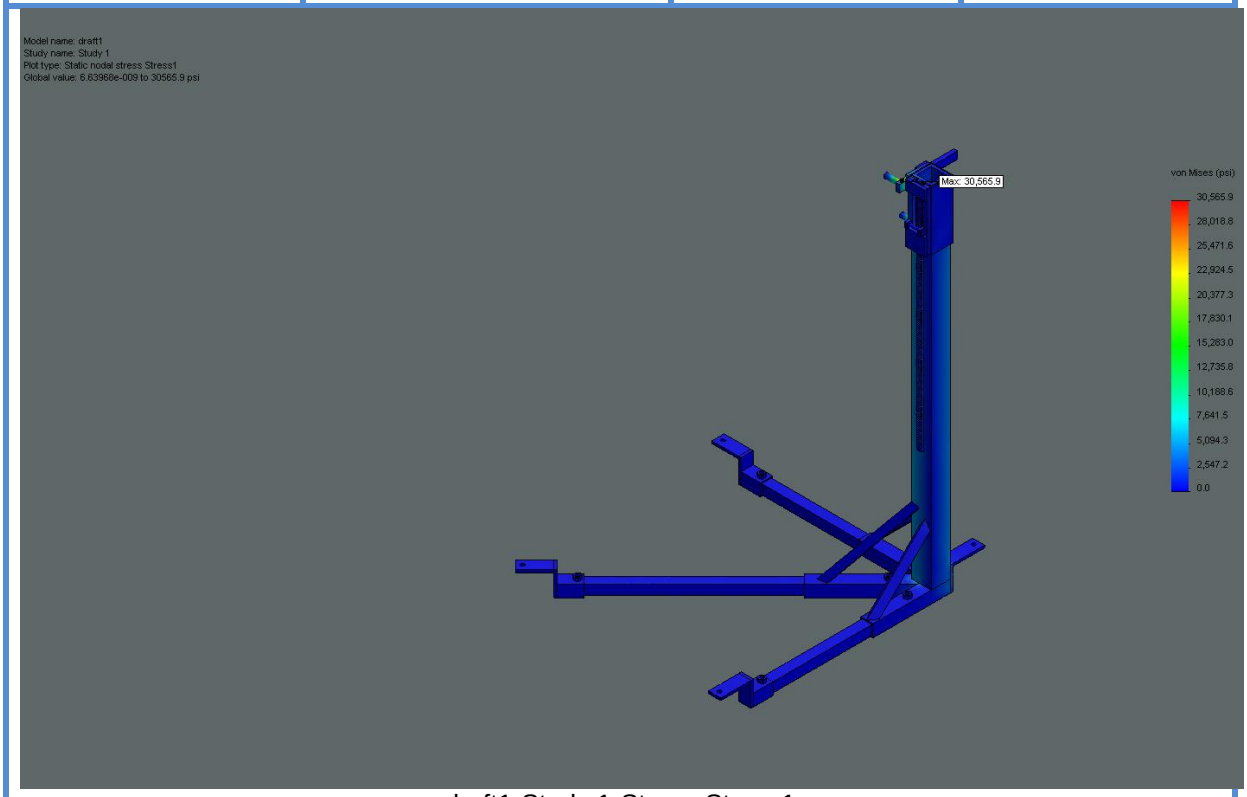
APPENDIX G – BUDGET

Budget for Center Stand Lift for Sport bike

Area	Projected	Actual
Material for base	$100	40.85
Material for Lift	$50	26.98
Gears	$40	47.79
Handle	$55	11.54
Latches	$25	6.08
Casters	$20	24.62
Total	$290	157.86*

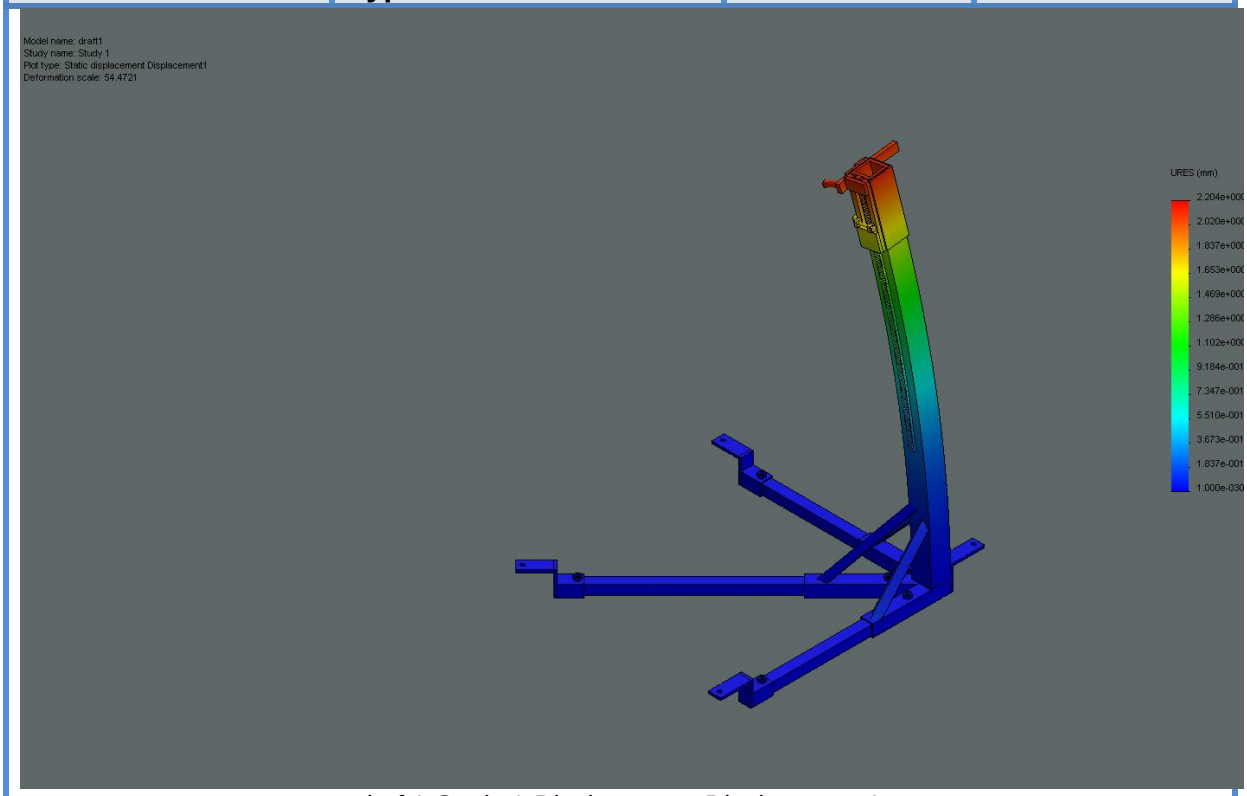
APENDIX H FEA STUDY RESULTS

Name	Type	Min	Max
Stress1	VON: von Mises Stress	6.63968e-009 psi Node: 30490	30565.9 psi Node: 13539



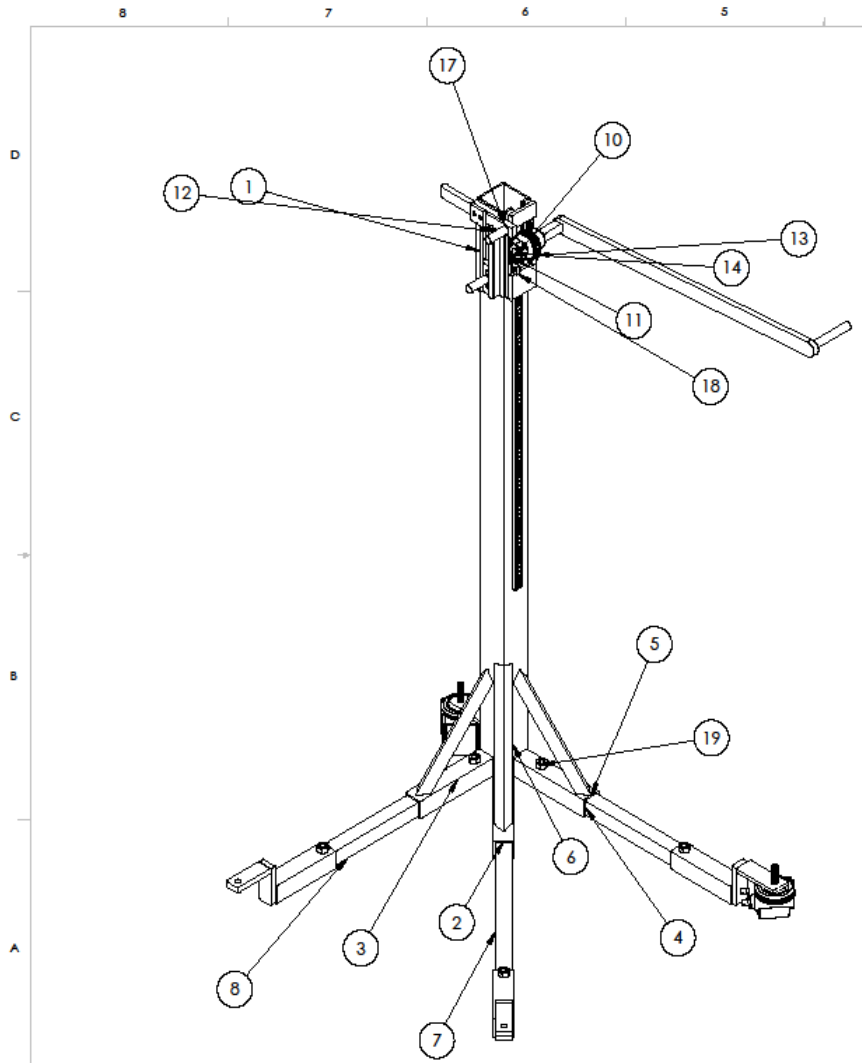
draft1-Study 1-Stress-Stress1

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0 mm Node: 1257	2.20408 mm Node: 13370

Name	Type	Min	Max
 draft1-Study 1-Displacement-Displacement1			

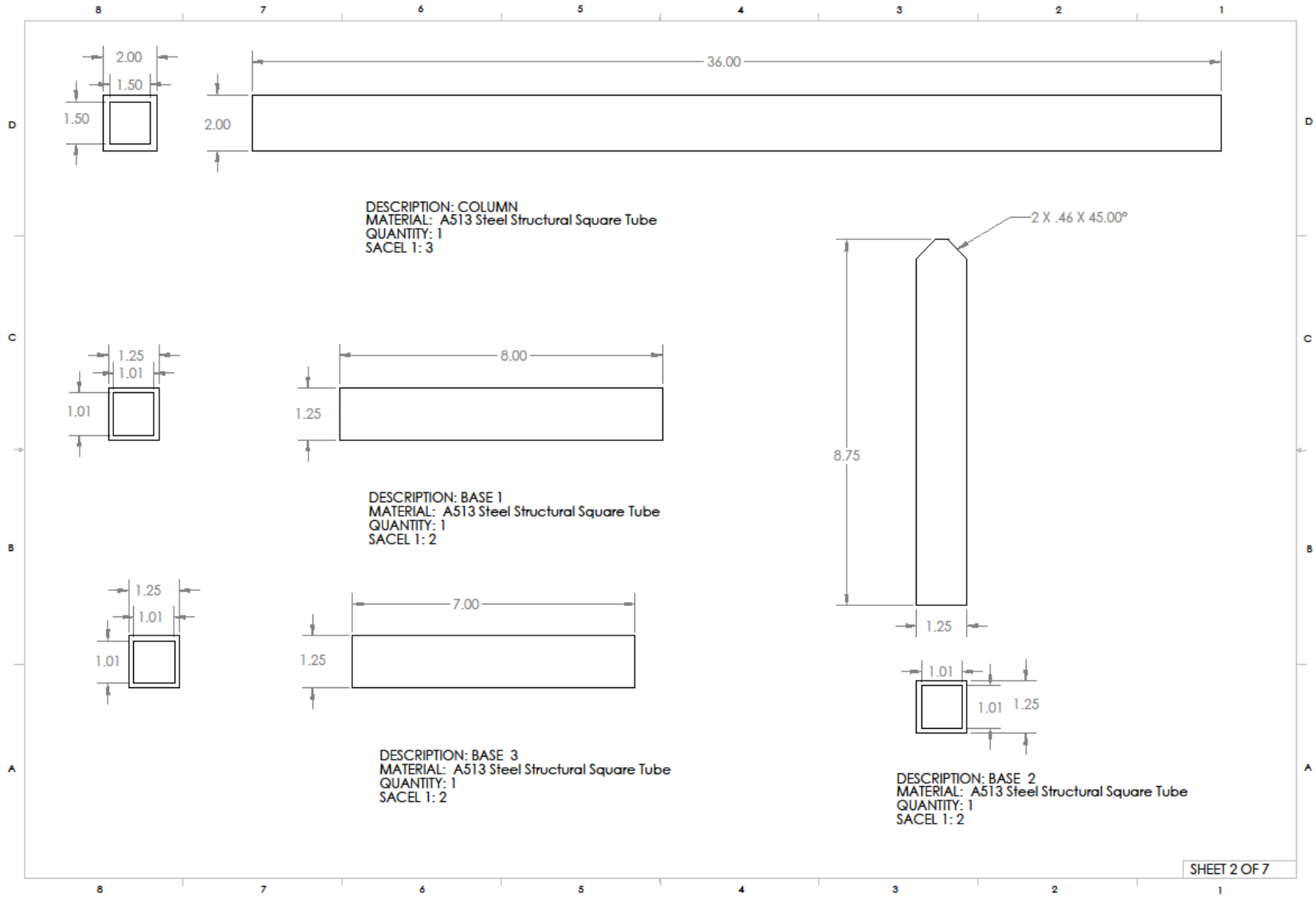
Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	2.40204e-016 Element: 15234	0.000831858 Element: 6504

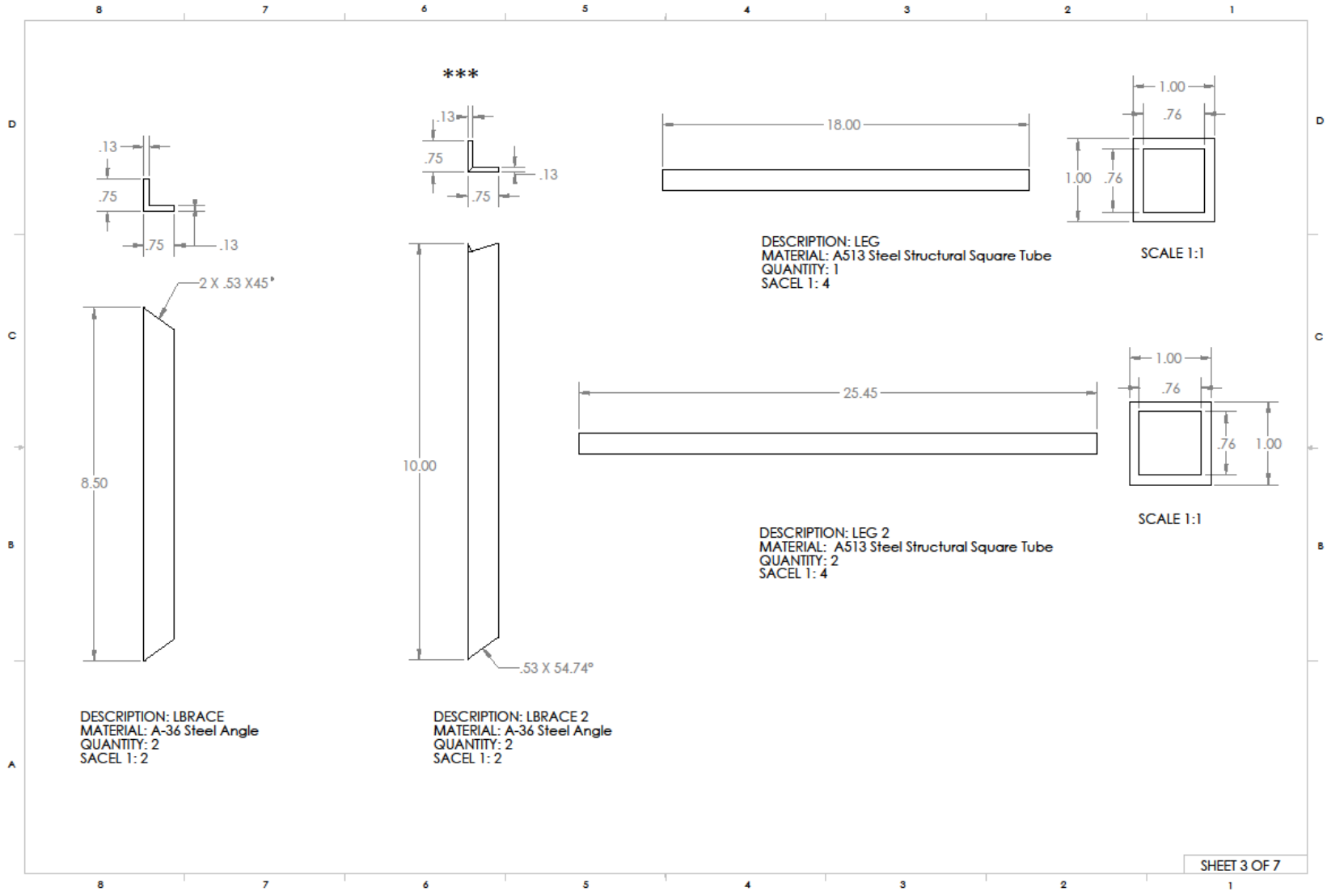
APENDIX I DRAWINGS

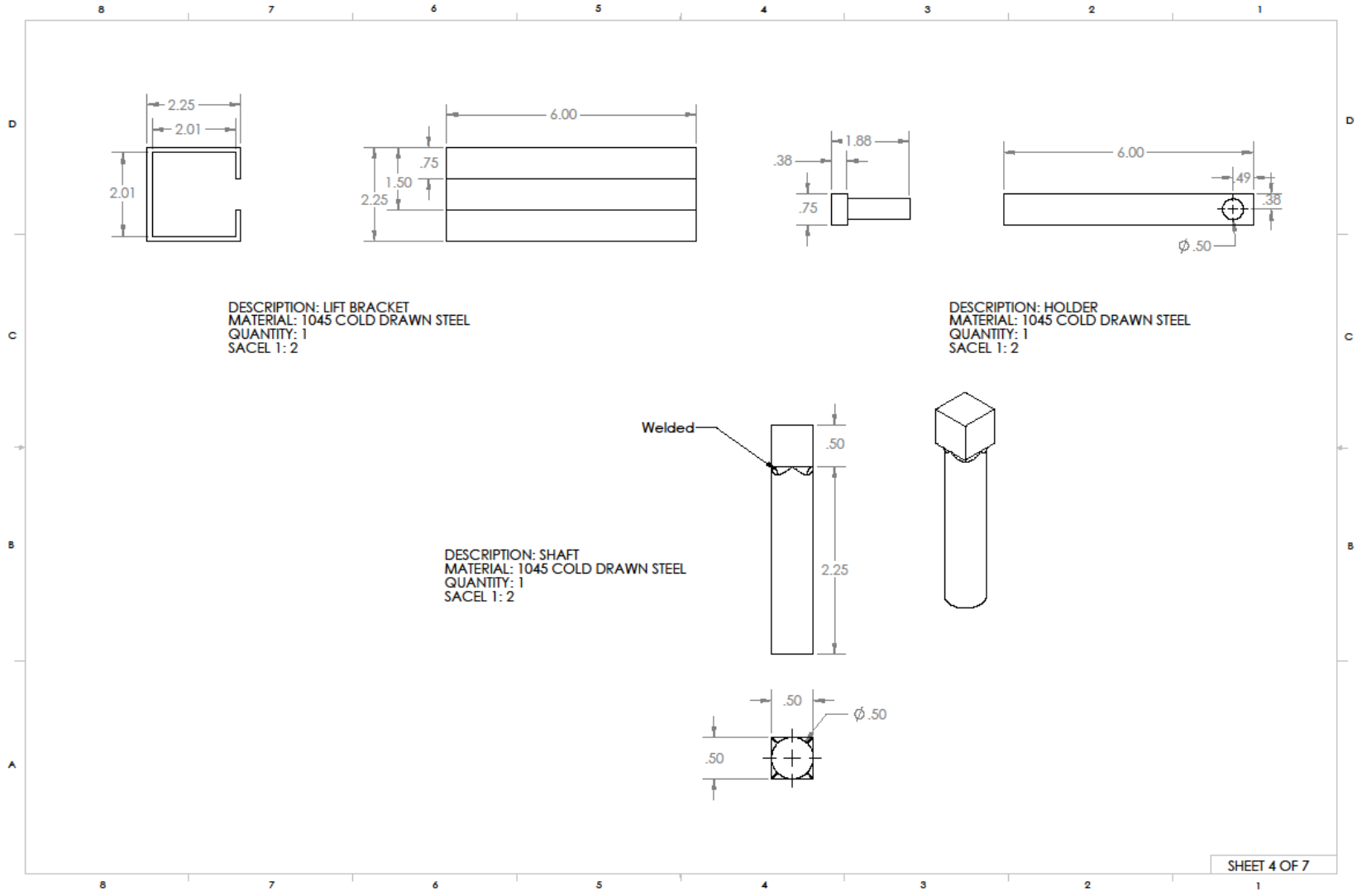


	1		bottomcover	31
	1		topcover	30
	1		HBOLT 0.25-20x2x0.75-N	29
	1		hzcover	28
	1		rightvps	27
	1		leftvpcs	26
	2		leftvptm	25
	2		hzrail	24
	1		wheelslock	23
	2		wheels	22
	1		rearwheel	21
	1		pinholder	20
B	6		B18.2.4.1M - Hex nut, Style 1, M10 x 1.5, with 16mm WAF --D-N	19
M	2		lockbace	18
M	2		Spacer	17
M	2		SPACER	16
M	1		handle	15
M	1		shaft	14
B	1		draftspur	13
M	1		holder	12
B	2		3813T2	11
B	1	draftrack	Inch - Rack-spur - rectangular 20DP 20PA 0.5FW .25PH 24L--SAll	10
M	1		liftbracket	9
M	2		leg	8
M	1		leg2	7
M	1		lbrace2	6
M	2		Lbrace	5
M	1		base1	4
M	1		base3	3
M	1		base2	2
M	1		column	1
MAKE (M)/BUY (B)	QTY.	DESCRIPTION	PART NUMBER	ITEM NO.

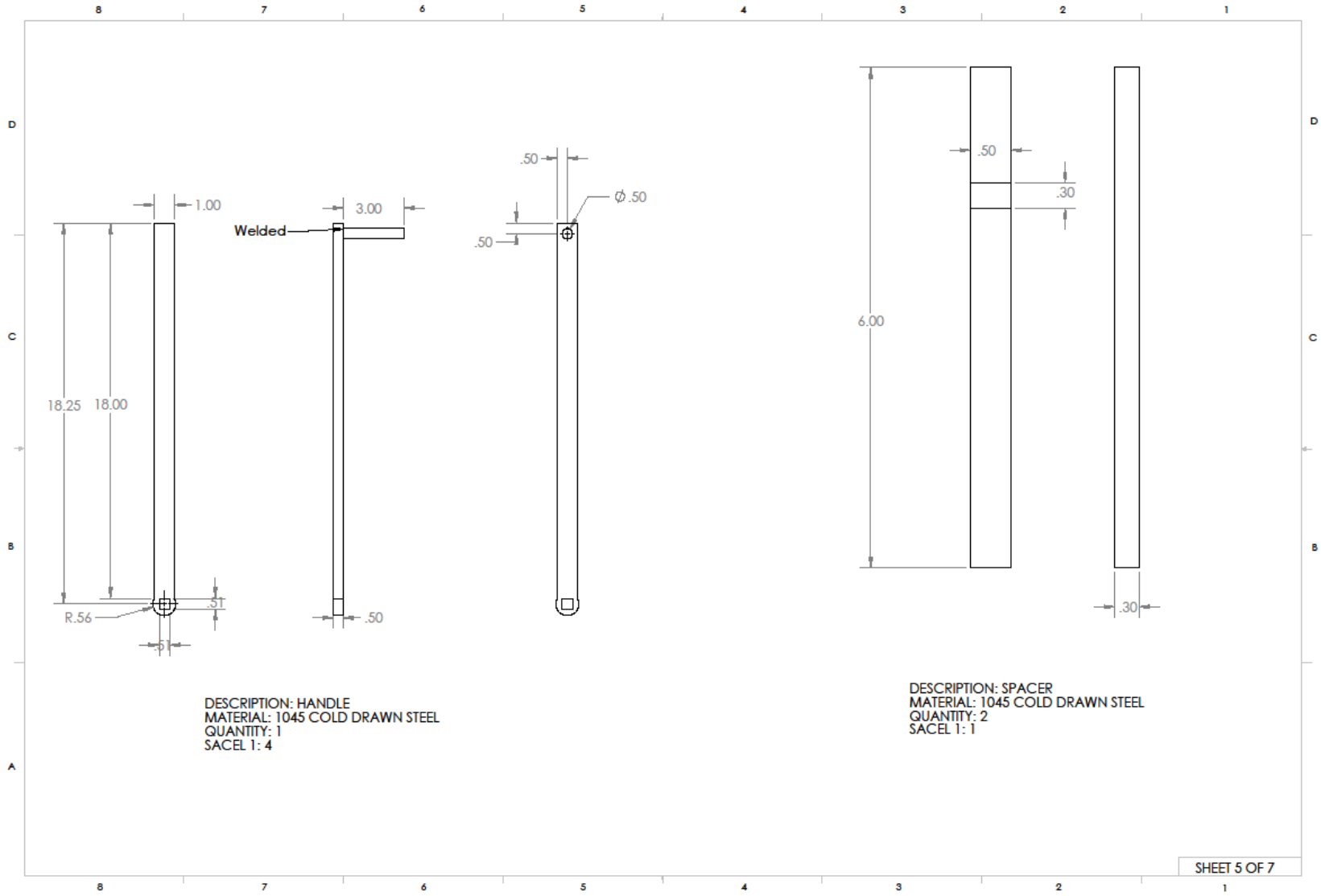
SHEET 1 OF 7


2.00
1.50
1.50
2.00
36.00
DESCRIPTION: COLUMN
MATERIAL: A513 Steel Structural Square Tube
QUANTITY: 1
SACEL 1: 3
1.25
1.01
1.01
8.00
1.25
DESCRIPTION: BASE 1
MATERIAL: A513 Steel Structural Square Tube
QUANTITY: 1
SACEL 1: 2
1.25
1.01
1.01
7.00
1.25
DESCRIPTION: BASE 3
MATERIAL: A513 Steel Structural Square Tube
QUANTITY: 1
SACEL 1: 2
2 X .46 X 45.00°
8.75
1.25
1.01
1.01
1.25
DESCRIPTION: BASE 2
MATERIAL: A513 Steel Structural Square Tube
QUANTITY: 1
SACEL 1: 2
SHEET 2 OF 7

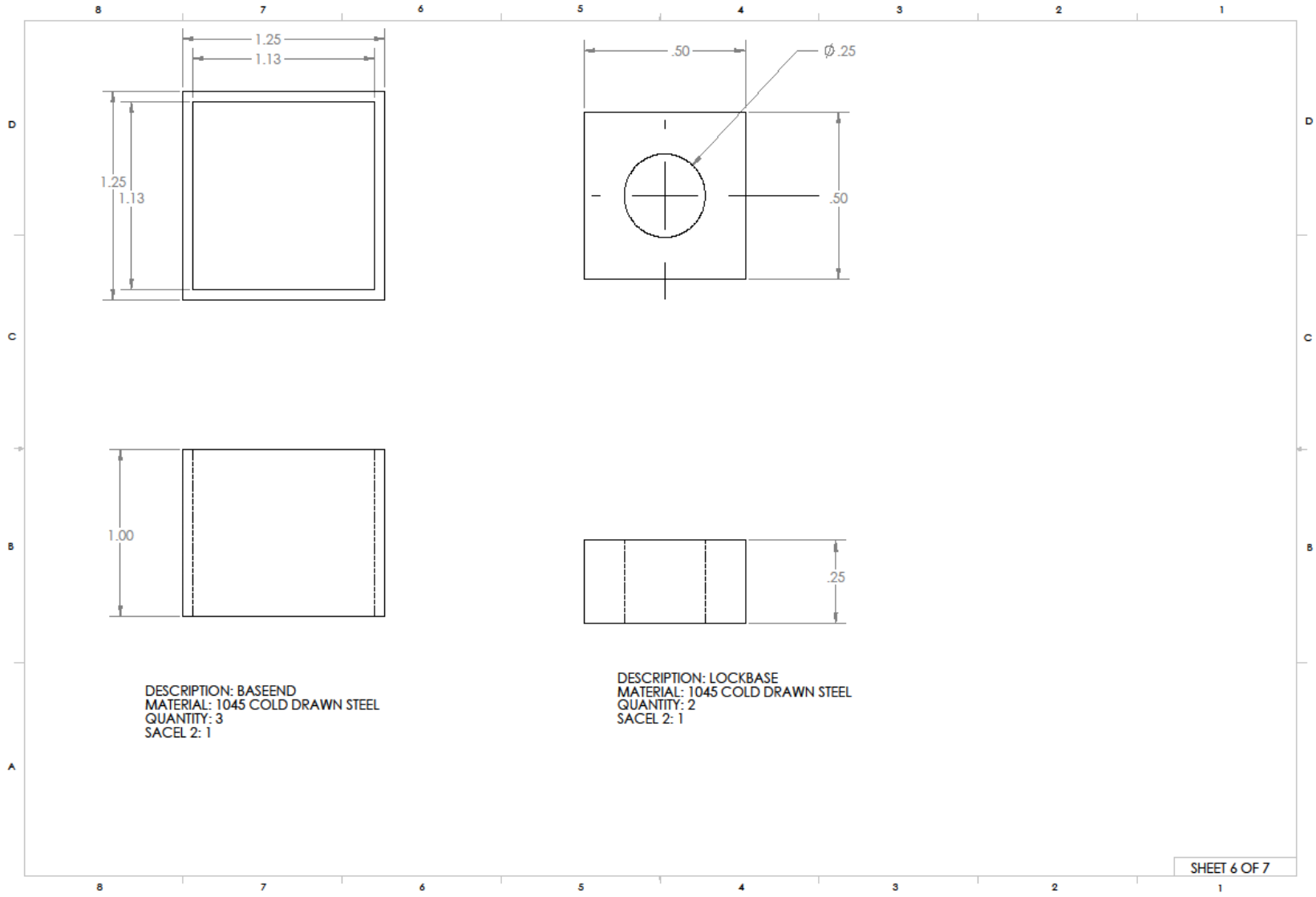

***
.13
.75
.75
.13
2 X .53 X45°
8.50
DESCRIPTION: LBRACE
MATERIAL: A-36 Steel Angle
QUANTITY: 2
SACEL 1: 2
.13
.75
.75
.13
10.00
.53 X 54.74°
DESCRIPTION: LBRACE 2
MATERIAL: A-36 Steel Angle
QUANTITY: 2
SACEL 1: 2
18.00
1.00
.76
1.00
.76
DESCRIPTION: LEG
MATERIAL: A513 Steel Structural Square Tube
QUANTITY: 1
SACEL 1: 4
SCALE 1:1
25.45
1.00
.76
.76
1.00
DESCRIPTION: LEG 2
MATERIAL: A513 Steel Structural Square Tube
QUANTITY: 2
SACEL 1: 4
SCALE 1:1
SHEET 3 OF 7

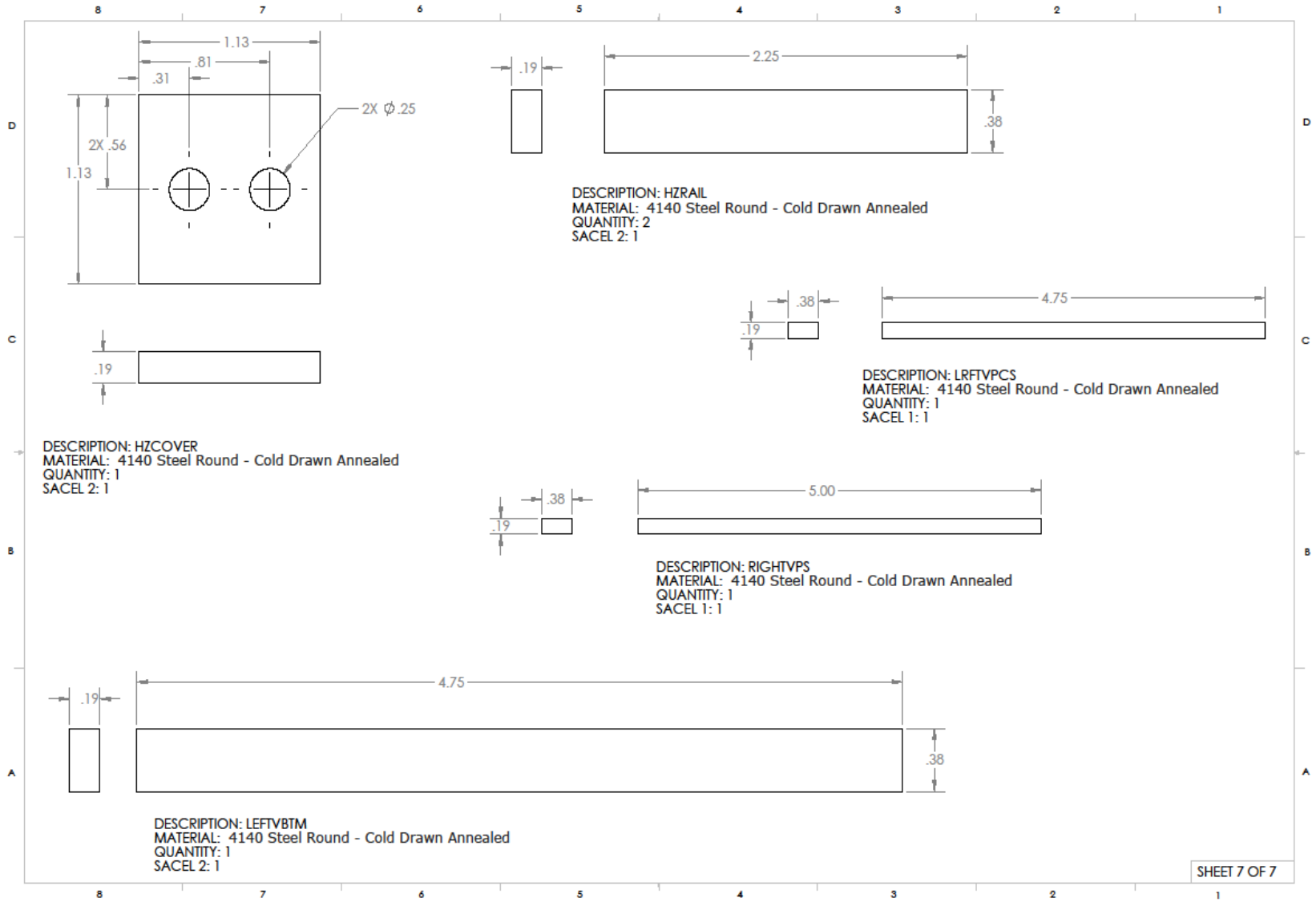

2.25
2.01
2.01
6.00
.75
1.50
2.25
1.88
.38
.75
6.00
.49
.38
Ø .50
DESCRIPTION: LIFT BRACKET
MATERIAL: 1045 COLD DRAWN STEEL
QUANTITY: 1
SACEL 1: 2
DESCRIPTION: HOLDER
MATERIAL: 1045 COLD DRAWN STEEL
QUANTITY: 1
SACEL 1: 2
Welded
.50
2.25
DESCRIPTION: SHAFT
MATERIAL: 1045 COLD DRAWN STEEL
QUANTITY: 1
SACEL 1: 2
.50
Ø .50
.50
SHEET 4 OF 7

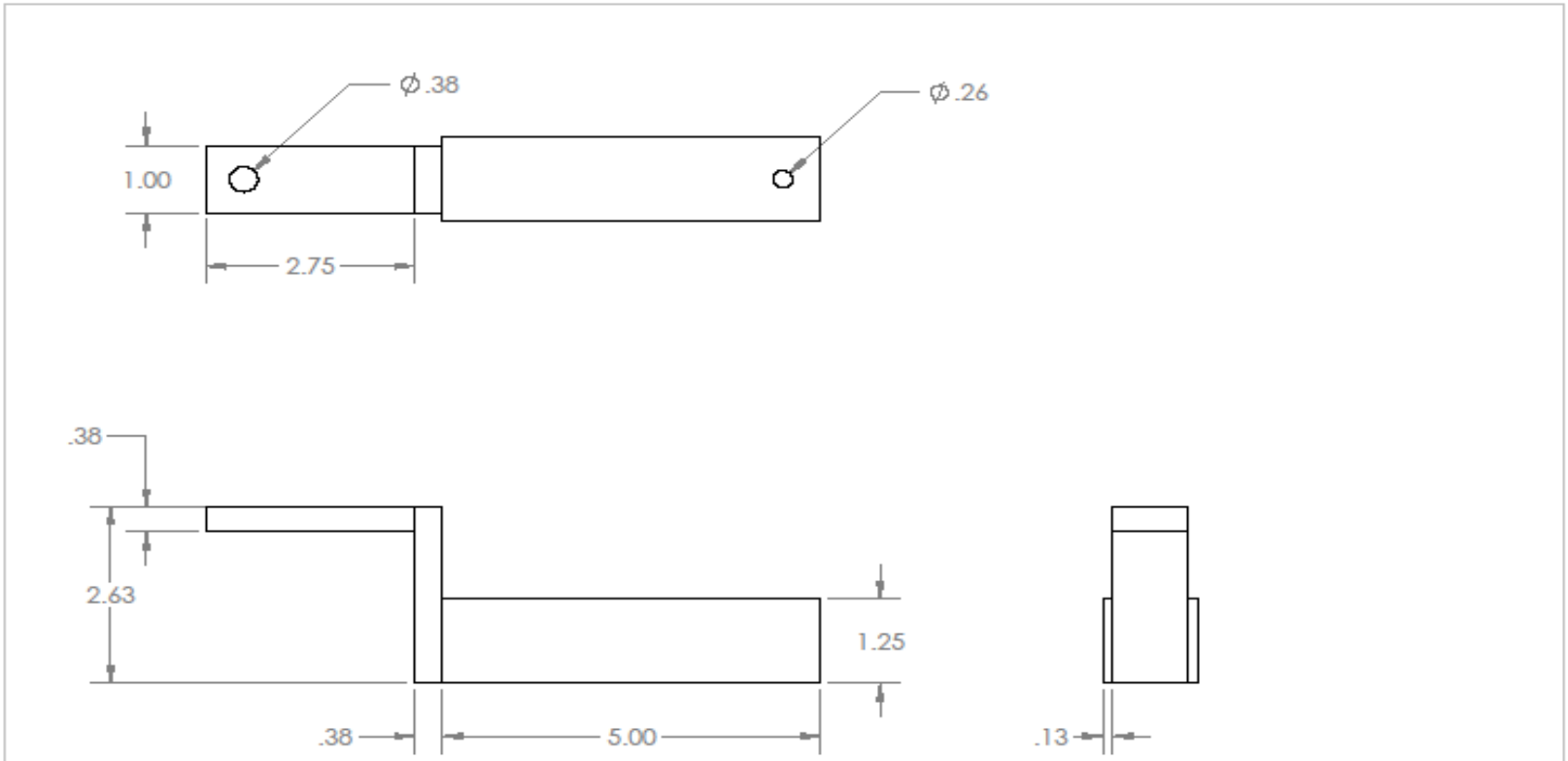
Appendix I4


1.00
3.00
Welded
.50
Ø.50
.50
18.25
18.00
R.56
.51
.51
.50
DESCRIPTION: HANDLE
MATERIAL: 1045 COLD DRAWN STEEL
QUANTITY: 1
SACEL 1: 4
.50
.30
6.00
.30
DESCRIPTION: SPACER
MATERIAL: 1045 COLD DRAWN STEEL
QUANTITY: 2
SACEL 1: 1
SHEET 5 OF 7

Appendix I5


1.25
1.13
1.25
1.13
1.00
.50
Ø.25
.50
.25
DESCRIPTION: BASEEND
MATERIAL: 1045 COLD DRAWN STEEL
QUANTITY: 3
SACEL 2: 1
DESCRIPTION: LOCKBASE
MATERIAL: 1045 COLD DRAWN STEEL
QUANTITY: 2
SACEL 2: 1
SHEET 6 OF 7


1.13
.81
.31
2X Ø.25
2X .56
1.13
.19
DESCRIPTION: HZCOVER
MATERIAL: 4140 Steel Round - Cold Drawn Annealed
QUANTITY: 1
SACEL 2: 1
.19
2.25
.38
DESCRIPTION: HZRAIL
MATERIAL: 4140 Steel Round - Cold Drawn Annealed
QUANTITY: 2
SACEL 2: 1
.38
.19
4.75
DESCRIPTION: LRFTVPCS
MATERIAL: 4140 Steel Round - Cold Drawn Annealed
QUANTITY: 1
SACEL 1: 1
.38
.19
5.00
DESCRIPTION: RIGHTVPS
MATERIAL: 4140 Steel Round - Cold Drawn Annealed
QUANTITY: 1
SACEL 1: 1
.19
4.75
.38
DESCRIPTION: LEFTVBTM
MATERIAL: 4140 Steel Round - Cold Drawn Annealed
QUANTITY: 1
SACEL 2: 1
SHEET 7 OF 7



		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN		
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL	COMMENTS:		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

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TITLE:

SIZE	DWG. NO.	REV
A	wheels	
SCALE: 1:5	WEIGHT:	SHEET 1 OF 1

5 4 3 2 1