Thank you Tiffany, Jacob, and Nick!

You've each brought more joy to my life than I ever thought possible,

I love you each you very, very much!

Tiffany, thank you for always being at my side and becoming

my educational role model, may our boys carry on your diligence.

Jacob, today was you're last day of Preschool, Congratulations! June 2, 2005

Nick, this is your last free summer, you get to go to Preschool next year!

Also, thank you Mom & Dad for the Zero Down, Zero Payment for Life!
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Informative Abstract

For a typical shadetree mechanic or anyone else who like to work on cars at their home, a frustrating problem has developed over the recent years due to the increasing number of unibody constructed vehicles that have become so very popular with many automobile manufacturers. The problem is the limited amount of strong jack points in which this construction incorporates into its design. This especially reigns true if one would like to use a jack in combination with a jack stand. In order to lift and support a vehicle with jack stands, 2 jack points under the vehicle must be used at all time with traditional methods.

The developed product, the Horseshoe Jack eliminates the need for 2 jack points when using a jack in combination with jack stands. The Horseshoe jack incorporates an open ended, horseshoe shape pocket that allows a jack stand to slide into it when the Horseshoe Jack is in the raised position, all while utilizing just one jack point.

Additional benefits of the Horseshoe Jack include reducing the time to lift and support a vehicle with jack stands to just 20 seconds, increasing stability while raising a vehicle resulting in a safer process, and the Horseshoe Jack’s simplistic modifications can be applied to many traditional hydraulic floor jacks.
Introduction

For the typical "shadetree mechanic", hydraulic floor jacks and jack stands are extremely helpful, but as today's automobile chassis continually change, using a hydraulic floor jack in combination with jack stands requires more advanced planning by the mechanic than it has in the past.

Limitations of Traditional Hydraulic Floor Jack

The current process of using a hydraulic floor jack in combination with a jack stand requires two jack points under the vehicle, one point to raise the vehicle with the jack and the other point to allow the vehicle to rest on the jack stand. The most predominant type of construction for passenger cars today is unibody, meaning “the construction technique uses the external skin of an object to support some or most of the load of the structure” [1]. Though an excellent design, it lacks user friendliness for a do-it-yourselfer because it typically includes only four manufacturer approved jack points per vehicle, one near each wheel. For those who have access to only one hydraulic floor jack, problems quickly arise if they want to lift the vehicle at one point and support it with a jack stand near that same point. In order to complete this task, it becomes necessary for the mechanic to choose one approved jack point to raise the vehicle with the jack and another unapproved jack point to allow the weight of the vehicle to bear down on the jack stand. Time consuming, careful consideration by the mechanic must be exercised when choosing the unapproved lift point. If failure occurs, the vehicle could come crashing down, piercing thru the undercarriage of the vehicle with the jack stand, or even worse, crashing down on a mechanic beneath the vehicle.
Design Solution

A successful design solution requires modifications to the hydraulic floor jack’s base and saddle, specifically Sears’ hydraulic floor jack model number 12112. After these modifications have been made, the hydraulic floor jack will incorporate an open pocket, or a “horseshoe” shape if you may. This horseshoe shape will allow the hydraulic floor jack to raise a vehicle at one strong supportive point, including, but not limited to the manufacturer’s approved jack point. Once the vehicle has been raised to its proper height, the newly designed floor jack will allow a jack stand to slide into place using the same jack point. After the jack stand is in place, the hydraulic floor jack could be lowered and moved to another location of the vehicle if desired.
Pictured below is a typical hydraulic floor jack, though parts will change shape and size in the new Horseshoe Jack described in this report, they will serve the same purposes.

Hydraulic Floor Jack

Picture provided by Allproducts.com [2].

Text and arrows added by Author, Tom Losekamp
Design Objectives

 Modifications required to convert the Sears jack into the Horseshoe Jack included removing the jack saddle, two tie rods within the jack saddle (not visible in photo), two non-swivel wheels, tie rod between the two non-swivel wheels, and a portion of the jack base. These components were replaced with an all new design and upon completion had to fulfill the following objectives:

- While using the Horseshoe Jack in combination with a jack stand only one jack point could be used for lifting and supporting the vehicle.
- 25% reduction of time to lift and support the vehicle with the Horseshoe Jack and jack stands when compared to Sears #12112.
- Two points of contact between the vehicle and the Horseshoe Jack’s saddle must increase the stability of the vehicle while raised.
- Based on a production of 700,000 units per year, cost to design and build the Horseshoe Jack could only increase as much as 10% over Sears’ jack #12112.
- The Horseshoe Jack must remain versatile; it must be able to raise a passenger car at a minimum of four points and an SUV at a minimum of ten points.
- Weight increase of the Horseshoe Jack must not exceed 25% of the Sears jack.
- The length of the Horseshoe Jack must not increase more than four inches along the Z-axis and the length along the X and Y-axis must remain the same when compared to Sears’ jack #12112.
- The Horseshoe Jack must be able to raise at least 2 ¼ tons.
Researching Existing Problems

Creating a better product than what is already on the market requires listening to the consumer. Various methods, such as written and verbal surveys can aid in determining what customers want from the end product. Not only does the customer survey data provide a good feel of what the customer wants or demands, it also serves as a valuable tool in developing a Quality Function Deployment (QFD) House of Quality. This is a structured methodology and mathematical tool that is used to identify and quantify customer requirements and translate them into key critical parameters [3]. In hopes of identifying the need for the Horseshoe Jack, an initial survey was solicited via email and in person to more than 30 friends and fellow co-workers to get an idea of what experiences they encounter during the vehicle jacking process. The full survey can be view in Appendix C-1. These survey responses confirmed what was already expected, the traditional hydraulic floor jack could benefit from a redesign. This was especially the case for ten respondents who own passenger cars, such as a sedan or sports car.

Limited Jack Points

The reason the Horseshoe Jack benefits passenger car owners are because of different chassis designs. As mentioned before, unibody construction for vehicles are very popular in today automotive market, but not necessarily with today’s trucks and SUV’s. Trucks and SUV’s are commonly built on two rectangular structural steel tubing rails as exhibited by the following Ford F-150 truck chassis photograph [4]. These two rails sit parallel to one another, spanning the length of the vehicle. Not only do these rails provide strength, durability, & rigidity that trucks and SUV’s need, they also serves as a
trusted jack point should the vehicle need to be raised by a hydraulic floor jack. Its spanning length allows for many different jacking locations for the user which is very convenient, however this is not the case with unibody constructed vehicles. Unibody constructed vehicles differ as can be seen with the photograph of the 2005 Ford Mustang cab design [5]. Unibodies incorporate their strength in many different areas of the entire frame eliminating the need for the two structural rectangular tubes, unfortunately this reduces the number of places a person can raise the vehicle with a jack. It is the automobiles manufacturer’s responsibility to place sturdy, supportive jack points on the vehicles, but as mention previously, there are typically only four of them, one located near each wheel.

2005 Ford F-150 Truck Chassis
Oversized Jack Saddle

With just four jack points, it becomes very frustrating if the user needs to support their vehicle with jack stands. Survey results located in Appendix C-2 conclude that 62% of passenger car owners experienced difficulty just finding the manufacturer’s approved jack points to use when raising up there vehicle, 75% of sport car owners felt the same way. Once the owner has found the jack points, still more problems present themselves, 100% of those the passenger cars and sports car owners quickly realized that the jack saddle was oversized when fitted up to the jack point. Jack points have many different shapes and size, but the jack point area of contact only averages about four inches in length by a half inch wide, Appendix D-2. The most common design for passenger vehicles joins two to three pieces of thin steel together and positions them in such a manner to create a very strong lift point for the vehicle. This design serves its purpose well in regards to conforming to the manufacturer’s service vehicle jack
provided with the vehicle, but does not fair well with respect to wide saddle designs typically found on hydraulic floor jacks.

This is a typical jack point for a passenger car. Notice the reinforced steel surrounded by only thin sheet metal.

Oversized jack saddle of a traditional jack.

The diameter of the traditional floor jack is not able to make 2 points of contact with the reinforced steel. If raised this way, the undercarriage sheet metal of the vehicle
will be damaged. In order to prevent this from happening, the saddle must be moved to left or right (with respect to picture) to ensure a contact point occurs between the jack saddle and the reinforced steel. During product testing of Sears’ jack, a problem occurred during a similar lifting method. You will see more on this in the appendix with regards to the increased stability design objectives. To briefly explain, as about 2000 lbs rested on just one edge of the saddle, the load proved to be too great, the weld between the jack saddle and its supporting sleeve broke, causing a scare, but no damage to the vehicle or operator. The photos show the damage that occurred.

Poor welding was the cause of failure. The saddle slides into the sleeve.

**Jack Stand Placement Uncertainty**

Additional survey results exposed more potential concerns owners had when using a traditional hydraulic floor jack in combinations with jack stands. After the owner
raises the vehicle up at the manufacturers approved jack point, another point of the
vehicle must be chosen for the jack stand. 83% of passenger car owners surveyed
considered it difficult finding another point for the jack stand, Appendix C-2. It becomes
much more complicated than simply just looking under the vehicle for a point, the point
must be strong enough to support the vehicle’s weight bearing down upon it. Consider
for example, if a suspension component is chosen as the resting point for the jack stand,
one must know if the component is strong enough not to fracture, shear, compress, or
completely break in half, it also must be assessed as to how the suspension component
will react as the jack releases its load upon the jack stand. As a vehicle is raised by its
official jack point, the shocks extend, but if the jack stand sits under that shock or any
component attached to the shock, once the weight is distributed, the shock then
compresses again, creating an opportunity for the jack stand to be tilted to one direction
or another and causing it to fall over. This will surely damage the vehicle, the jack, the
jack stand, the operator, or any combination of the four. The difficulty of finding a
trustworthy second jack point is a valid concern, 75% of the sports car owners did not
feel confident with their second jack point choice, Appendix C-2. This statistic should be
taken very seriously, an estimated 4,822 persons were injured in vehicle jack related
accidents between November 1, 1994 and October 31, 1995, of these 3,567 injuries were
caused by a jack or vehicle slipping or falling over [6].
Design Alternatives

After the initial survey of identifying the problem with the traditional hydraulic floor jack, the same surveyed individuals were also asked to give their thoughts on three different designs to assist in what design prototype would be best. “Design 3” from the survey was the overwhelming choice of the individuals; this concept was applied to the Horseshoe Jack.

On the survey, this design described the need for modifying the saddle, base, & lift arm of a traditional jack to fit around the jack stand. The primary advantage was conveyed as a single point lift and support for the vehicle.
Product Design

Success of this product relied heavily on mechanical design aptitude, but also design stress analysis of the modified components. All design calculations are available in Appendix B-1.

The Base

In order to make this concept function properly, much attention was paid to the dimensions of the base. To devise the perfect fit, base dimensions of commercially available jack stands had to be obtained. After researching different manufacturers, the data available on Appendix D-1 revealed that there are essentially two categories of jack stands, 3 ton capacity and 6 ton capacity. Since Sears jack #12112 is rated at a capacity of 2 ¼ tons, there was no sense in designing the jack to accommodate a 6 ton jack stand. The dimension that is most critical to the design is the length of the jack stand’s Z-axis. The Horseshoe jack has been designed to allow a jack stand to be slid into place as long as the Z-axis dimension is less than 7 inches and the X-axis is less than 8 inches. Sears jack stand model number 121120 was readily available and its dimensions are similar to 3 ton jack stands, so this was used during product testing and demonstrations.

The design of the Horseshoe Jack eliminated the tie rods between the two non-swivel wheels of the Sears jack; this in turn greatly reduced structural integrity of the base. The side members of the Sears jack were only ¼ " steel plates on edge cut to size. On edge, the steel plates will resist bending when a force is applied directly above or below the plate, but if the force is offset, the steel plate will easily bend with relatively small applied force. The function of the tie rods were to keep the force directly above the
side members, but with these removed, the side members would have a natural tendency to spread away from one another, offsetting the force, allowing a twisting action to occur in the plate. Two methods could have been used to resist twisting, first is to increase the thickness of the plate steel, or the other was to use structural steel tubing. Calculations revealed that to reduce twisting to $1^\circ$ or less, the steel would have to be 1" thick. One inch thick steel would have been much too heavy and wasteful in terms of excessive material and cost. The better solution was utilized is integrating square structural tubing. As stated in Robert Mott’s Applied Strength of Material textbook [7] structural tubing resist twisting due to torsional stress much better than a flat plate [7]. The Horseshoe jack was built with 1018 cold rolled steel 2" square structural, this combination of material and shape reduced the amount of twist to just $0.42^\circ$ angle of twist in this side member at its furthest point. With a safety factor of 3, design stress will be 19,302 PSI, with this requirement, 1018 cold rolled steel (CRS) with an ultimate tensile strength of 80,000 PSI is more than sufficient [8].

Even though square tubing resist bending, it was still necessary to calculate the actually bending stress the tube would experience. With the pivoting arm of the jack, the load is dispersed at many different angles, to account for this, calculations were solved when the arm of the jack is loaded with the arm parallel to the ground and also when the jack is raised to its highest position. Again, with a safety factor of 3, when parallel to the ground, the maximum bending stress on the tube was 22,930 PSI and 37,696 when the arm is raised to its highest position. These values are still within the ultimate strength limits of 1018 CRS.
The Saddle

To assure the Horseshoe jack design maximizes its full potential, it is desired that the jack be able to conform to as many vehicles as possible. The spreadsheet presented in Appendix D-2 is from a large sample of vehicles, if the frame was not used, with the exception of the BMW 525 and Mercedes Benz C320, each vehicles use the joined steel design or chassis for its jack point. Please note, when referring back to the photograph of the traditional equipment, axis were established. The specified dimensions in the spreadsheet are listed as (z-axis) x (x-axis) in inches, the Y-axis is not specified. Determining the average z-axis length of four inches aided in developing the new saddle for the Horseshoe Jack.

The saddle and saddle support of the Sears Jack also relied on tie rods to provide structural integrity within the product. A robust design was implemented to compensate for the missing tie rods. One may consider the final saddle design to be over engineered, but in this case, the positives outweigh the negatives. The saddle was design in a horseshoe shape, in theory there should only be direct compression in the negative y direction, if for some reason the force would be slightly offset; it would want to spread the shape out. With the redesign, there is more than enough cross sectional area in the corners to resist this spreading effect. Another benefit of the oversized saddle is that it ensures more surface contact between the saddle and the jack point.

In real world applications, the maximum compressive stress is only 692 PSI when the saddle experiences the known limit of 2 ¼ tons is applied. After adding in a safety factor of 8 with recommendation of Applied Strengths of Material textbook [7] or any a ductile material that would be subject to a repeated load, the maximum load the saddle
could hold before failing would be 44,531 lbs. Calculations were performed with the thought of using 1020 annealed steel, but after discussion with Mark Richter of Richter's Designing & Fabrication, 1045 CRS was available and used. This serves as an addition safety factor considering the ultimate strength of 1045 CRS is 91,000 PSI, higher than 1018 CRS. Either material choice would have been more than sufficient.

**Pins and Bolts**

The Horseshoe Jack required various fasteners of various diameters, to ensure these fasteners wouldn't fail during operation, I devised two tables to display shear stresses. The following equation is utilized to calculate the maximum shear stress on a pin with one member acting on it (single shear) [7]. A force of 2250 lbs was used in all calculations, though this is more force than each pin would experience in the application. The maximum force in which the Horseshoe jack is design to lift and support is 4500 lbs, this force will always be divided by two because the load will be distributed between 2 members, but this can be distributed even further for the pins and bolts, since there will be multiple pins joints in both members.
\[ A_s = \frac{\pi D^2}{4} \]

\[ \tau = \frac{F}{A_s} \]

As = Area of Shear (in^2)

D = Diameter of Pin/Bolt (in)

\( \tau \) = Shear Stress (PSI)

F = Force (lbs)

<table>
<thead>
<tr>
<th>Pin/Bolt Diameter (in)</th>
<th>Area of Shear (in^2)</th>
<th>Max Stress w/ 2250 lbs (PSI)</th>
<th>Max Stress w/ Safety Factor of 3 (PSI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>0.049</td>
<td>45860</td>
<td>137580</td>
</tr>
<tr>
<td>0.375</td>
<td>0.110</td>
<td>20382</td>
<td>61146</td>
</tr>
<tr>
<td>0.5</td>
<td>0.196</td>
<td>11465</td>
<td>34395</td>
</tr>
<tr>
<td>0.625</td>
<td>0.307</td>
<td>7338</td>
<td>22013</td>
</tr>
<tr>
<td>0.75</td>
<td>0.442</td>
<td>5096</td>
<td>15287</td>
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<tr>
<td>0.875</td>
<td>0.601</td>
<td>3744</td>
<td>11231</td>
</tr>
<tr>
<td>1</td>
<td>0.785</td>
<td>2866</td>
<td>8599</td>
</tr>
</tbody>
</table>
The following equation is utilized to calculate the maximum shear stress on a pin with two members acting on it (double shear) [7].

$$A_s = 2 \left( \frac{\pi D^2}{4} \right)$$

$$\tau = \frac{F}{A_s}$$

As= Area of Shear (in^2)
D= Diameter of Pin/Bolt (in)
\(\tau\)= Shear Stress (PSI)
F= Force (lbs)

<table>
<thead>
<tr>
<th>Pin/Bolt Diameter (in)</th>
<th>Area of Shear (in^2)</th>
<th>Max Stress w/ 2250 lbs (PSI)</th>
<th>Max Stress w/ Safety Factor of 3 (PSI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
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<td>68790</td>
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<tr>
<td>0.375</td>
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<td>17197</td>
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<tr>
<td>0.625</td>
<td>0.613</td>
<td>3669</td>
<td>11006</td>
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<tr>
<td>0.75</td>
<td>0.883</td>
<td>2548</td>
<td>7643</td>
</tr>
<tr>
<td>0.875</td>
<td>1.202</td>
<td>1872</td>
<td>5615</td>
</tr>
<tr>
<td>1</td>
<td>1.570</td>
<td>1433</td>
<td>4299</td>
</tr>
</tbody>
</table>
Product Testing

Each and every design objective mentioned earlier in this report had to be proven. This report section discusses each objective, the test method by which it was verified, and the results. All results were confirmed by Professor Allen Arthur and in many cases, by visual observations.

Single Point Lifting & Support

While using the Horseshoe Jack in combination with a jack stand, only one jack point could be used for lifting and supporting the vehicle.

The Horseshoe Jack was placed under a vehicle's manufacturer approved jack point. The vehicle was then raised high enough for at least one tire to be off of the ground. Once in the air, a commercially available jack stand slid into the open end of the jack. The Horseshoe Jack was then be lowered and pulled out, transferring the weight of the vehicle to the jack stand.

This method was followed and successfully completed over 100 times; participating vehicles included a Mercury Mystique, a Ford Taurus, a Ford Explorer, a Ford E-150 Econoline, and a Honda Civic.

1. Lift vehicle 2. Slide stand in place 3. Lower & withdrawal jack
Standards

The Horseshoe Jack had to conform to all applicable sections of the Society of Automotive Engineers document J1884, Vehicle Jack Requirements and Test Procedures dated May 1996.

The Horseshoe Jack adhered to the following sections of the document, all of which are located in the full document in the Appendix K-1, included 4.1.1, 4.1.2, 4.2.1, and 4.3. These sections address characteristics such as range of motion, stability, and repeated use. The hydraulic mechanism did not change, therefore endurance characteristics were not tested.

Time Reduction

The time to lift and support a vehicle with the Horseshoe Jack and a jack stand had to reduce by 25% or more when compared to Sears Jack #12112.

Each time the lifting and supporting technique was applied, the time from start to finish was recorded.

\[
\frac{\text{Time Original} - \text{Time New}}{\text{Time Original}}
\]

The Horseshoe Jack required an average of just 20 seconds to raise and support the vehicle with one jack stand. Based on this extremely quick average time, it was inferred that an individual would not be able lift and support a vehicle with a traditional jack and jack stands in just 5 seconds (25% of 20 seconds). Additional steps required for this include crawling under the vehicle, locating a safe jack point, placing the jack under the 2\textsuperscript{nd} jack point, crawling back out from under the vehicle, and lowering the jack.
Increased Stability

With two points of contact between the Horseshoe Jack saddle and the vehicle's jack point, stability of the vehicle had to increase while raised.

This test method was much more involved than the two previous objectives, please refer to Appendix G-1 for detailed test procedure. As a brief description of the test, a Ford Explorer was supported under the rear differential with a jack utilizing just one point contact between the jack and the differential. An original measurement of distance was obtained from the rear passenger side tire to the ground, weight was added to the rear of the vehicle in increments of 40 to 80 pounds. At each increment increase the distance was re-measured. The more the tire lowered, the less stable the vehicle was. Similarly, the jack was positioned under the same point, now with two points of contact. The two tests were compared and the method in which the tire dropped the least would be considered more stable.

Stability of the Horseshoe Jack increased 40.36% with respect to the Sears jack.

Versatility

The Horseshoe Jack had to remain functional when placed at many different locations on a vehicle, not just when placed under the manufacturer's approved jack point. Specifically, the Horseshoe Jack had to raise a passenger car at a minimum of four different points and an SUV at a minimum of ten different points.

Observation showed that the Horseshoe Jack performed as a traditional hydraulic floor jack would, it was able to pick up a passenger car at minimum of four points and an
SUV at a minimum of ten points. As noted in the List of Assumptions, this test could be fulfilled, if and only if, the vehicle has four and/or ten strong supportive points of which the vehicle can be lifted by. The Horseshoe Jack performed properly on the five previously mentioned vehicles.

**Weight**

The weight increase of the Horseshoe Jack had to be less than 25%.

\[
\frac{\text{Weight Original} - \text{Weight New}}{\text{Weight Original}}
\]

The original weight was 74 lbs, the new weight is 91 lbs for an increase of 23.0%.

**Size**

The length of the Horseshoe Jack could increase up to four inches along the Z-axis. The length along the X and Y-axis should be unchanged. Size measurements show that all dimensions remained the same, listed below are the maximum lengths.

<table>
<thead>
<tr>
<th></th>
<th>Sears Jack #12112</th>
<th>Horseshoe Jack</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z-axis</td>
<td>13&quot;</td>
<td>13&quot;</td>
</tr>
<tr>
<td>X-axis</td>
<td>25&quot;</td>
<td>25&quot;</td>
</tr>
<tr>
<td>Y-axis</td>
<td>6.125&quot;</td>
<td>6.125&quot;</td>
</tr>
</tbody>
</table>

**Capacity**

The Horseshoe Jack had to be able to raise at least 2 ¼ tons. The source of the tested weight was a 1997 Ford E-150 Econoline 5.4L V8 custom full size van. Exact curb weight is not available, but per specification, a non-customized 4.6L V8 E-150 weighs
4660 lbs [10]. The additional weight of the 5.4L V8 and custom equipment is estimated to be about 500 lbs, totaling 5160 lbs. The Horseshoe jack was able to lift the entire front end of the vehicle off the ground, therefore satisfying the capacity requirement.

Front end of Ford E-150 Econoline raised in air.

**Production Cost**

Based on 700,000 units per year, cost to design and build the Horseshoe Jack will increase less than 10% over Sears Jack #12112.

\[
\frac{\text{Cost Original} - \text{Cost New}}{\text{Cost Original}}
\]

Cost of Sears Jack #12112 was $120. The Horseshoe Jack will change form if put into production, because of this, many prototype parts would change form to be more like that of the Sears Jack. The only part that would change drastically is the saddle, but both saddle designs would use casting to take its shape. The labor cost would be the similar, the only difference would be the cost of the material. Bulk material cost is based on weight and priced at $1.15 per pound [11]. The difference in weight would be seven pound, equating to $8.05, making the new cost 128.05. The cost difference is only a 6.7% increase.
**Fabrication**

To reiterate from earlier, modifications required to convert the Sears jack into the Horseshoe Jack included removing the jack saddle, two tie rods within the jack saddle, two non-swivel wheels, tie rod between the two non-swivel wheels, and a portion of the jack base. This simply was performed with a metal cut off wheel. All these parts were replaced and served the same function, but took a different shape.

Parts that had to be machined and thankfully donated by Richter’s Designing and Fabrication, included the wheels, the side members, ½ inch spacers, threaded bushings, and the saddle. All other components were commercially available at hardware stores and/or McMaster-Carr Company.

Once all the components were obtained, fabrication began. The spacers were placed between the new side member and the existing side members of the Sears jack. These were fastened in place by three nuts and bolts for each side. At this time, the wheels were attached to the side members, purposefully tucked into the structural square tube with a double headed snap ring pin. The saddle was then attached to the existing pivot arm of the Sears Jack after four holes were drilled in it. This was more involved than one might think. Simple nuts and bolts can’t be used, because upon tightening them, the pivot arm would not lower upon its free will when the pressure of the hydraulic cylinder is released, therefore shoulder bolts in combination with threaded bushings had to be used. The threaded bushings were cut to a precise length and the end of the shoulder bolt then bottomed out with the bushing, this eliminated the chance of the bolts loosening, and it also created the needed play between the arm and the saddle.
Component Identification
Conclusion

The Horseshoe Jack has satisfied all its design requirements, but even more importantly, it impressed many individuals in attendance at the 2005 University of Cincinnati, Ohio College of Applied Science Tech Expo. The 2005 Tech Expo was held at the Cincinnati Convention center on May 20, 2005. The Horseshoe Jack was demonstrated more than 50 times that day to single individuals and groups alike, included four groups of judges. The Horseshoe Jack performed flawlessly. The individuals were quick to compliment the concept of the Horseshoe Jack and after seeing a demonstration, were even more impressed with the product, to the point of suggesting that the product be patented. It can be summed up by confidently saying that the Horseshoe Jack was a success!
Recommendations

The Horseshoe Jack performed flawlessly, but unexpected modifications were necessary during fabrication. One modification in particular, required the open pocket of the jack saddle had to be widened about a ¼ inch on both side. During design, careful consideration was paid to the pad width of the jack stand, but not to the collet in which the pad sits. With fasteners attached to the saddle, before being widened, the open pocket was just about the same width as the collet; as the jack was withdrawal and lowered during operation, the saddle would wedge itself around the collet. To rectify this from becoming an issue for future production, more attention should be paid to the collet and not just the jack stand pad.

Additional width milled out of saddle
Appendix

List of Assumptions/Requirements
Calculations
Survey Information
Jack Stand & Jack Point Information
Drawings
Removed Components from Sears Jack #12112
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Progress Time Chart
Final Prototype Cost
Meeting Minutes
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Bibliography
List of Assumptions/Requirements

1. Regarding single point jack and support objective, only one jack point will be deemed necessary to raise and support a vehicle when using this newly modified jack in combination with a commercially available jack stand with a base dimension of less than 7" in the Z-axis and 8" in the X-axis and a pad size of less than 1.5” x 3.5" respectively. The jack point must have a minimum width along the Z-axis of 1.5", the thickness along the X-axis is not held to either a minimum or maximum constraint. The jack point must also be able to be centered in a minimum unobstructed plane of 3.5” along the Z-axis and 5” along the X-axis.

2. Regarding time reduction objective, this test will be performed on a passenger car that has 4 official jack points incorporated into the undercarriage. The testing procedure will be performed on one make and model, which will be specified at test time.

3. Regarding versatility objective, this test will be fulfilled, if and only if, the vehicle has 4 and/or 10 strong supportive points of which the vehicle can be lifted by.

4. Regarding size objective, due to the shape of the jack, only the maximum dimensions in the X, Y, and Z-axis will be measured and recorded while comparing the new and the old designs.
Calculations

Maximum Torsional Stress and Angular Twist on Square Tubing [7]

\[ \tau_{\text{max}} = \frac{T}{Q} \]

\[ \theta = \frac{TL}{GK} \]

\[ Q = 2t(a - t)(b - t) \]

\[ K = \frac{2t(a - t)^2(b - t)^2}{a + b - 2t} \]

\[
K = \frac{2 \times .25(2 - .25)^2(2 - .25)^2}{2 + 2 - 2(2 other) in^4} = 1.33984 in^4
\]

\[
\theta = \frac{9844 \times 11.5}{11500000 \times 1.33984} = .007347 \text{ Radians}
\]

\[
.007347 \times \frac{180}{\pi} = .42^\circ \text{ Angle of Twist}
\]

\[
\tau_{\text{max}} = \frac{4.375 \times 2250}{2 \times .25(2 - .25)(2 - .25)} = 6433.99 PSI
\]

T = Torque \quad T = 9844 \text{ lb in}
Q = Polar section Modulus \quad Q = 1.53 \text{ in}^3
L = Length \quad L = 11.5 \text{ in}
G = Modulus Elasticity in Shear \quad G = 11,500,000 \text{ lb in}^2
\text{t = Wall thickness} \quad t = .25"
\text{a = Height} \quad a = 2 \text{ in}
\text{b = Width} \quad b = 2 \text{ in}
Maximum Bending Stress on Square Tubing [7]
If Arm is Parallel to Ground (Max Condition)

\[ Ma = (2250 \times 15) - (Rb \times 18) \]
0 = 33750 – Rb * 18
Rb * 18 = 33750
Rb = 1875 lbs

\[ Mb = (-2250 \times 3) + (Ra \times 18) \]
0 = -6750 + Ra * 18
-Ra * 18 = -6750
Ra = 375 lbs

\[ M_0 = 0 \]
M_{15} = 0 + (375 \times 15) = 5625 lb in
M_{18} = 5625 + (-1875 \text{ lbs} \times 3) = 0

\[ \tau_{\text{max}} = \frac{M_c}{I} \]
\[ \tau_{\text{max}} = \frac{(5625)(1)}{.766} = 7643.3 \text{ PSI} \]

M = Maximum Bending Moment
\( c = \text{Centroid} \)
I = Moment of inertia

Refer to next page for diagrams.
Maximum Bending Stress on Square Tubing [7]
If Arm raised to highest position

\[ Ma = (2250 * 7) + (-Rb * 18) \]
\[ 0 = 15750 - Rb*18 \]
\[ Rb*18 = 15750 \]
\[ Rb = 875 \text{ lbs} \]

\[ Mb = (-2250 * 11) + (Ra * 18) \]
\[ 0 = -24750 + Ra*18 \]
\[ -Ra*18 = -24750 \]
\[ Ra = 1375 \text{ lbs} \]

\[ M_0 = 0 \]
\[ M_7 = 0 + (1375 * 7) = 9625 \text{ lb in} \]
\[ M_{18} = 9625 + (-875 * 11) = 0 \text{ lb in} \]

\[ \tau_{max} = \frac{Mc}{I} \]

\[ \tau_{max} = \frac{(9625)(1)}{.766} = 12565.3 PSI \]

\( M = \text{Maximum Bending Moment} \)
\( c = \text{Centroid} \)
\( I = \text{Moment of inertia} \)

Refer to next page for diagrams.
2250 lbs

$7$

$11$

$Ra=1375$ lbs

$Rb=875$ lbs

$V_{max} = 1375$ lbs

$M_{max} = 9625$ lb-ft
Compressive Stress and allowable load on Saddle [7]

**Maximum stress with known load**

\[ \tau_{\text{max}} = \frac{F}{A} \]

\[ \tau_{\text{max}} = \frac{4500 \text{lbs}}{6.5 \text{in}} = 692 \text{PSI} \]

\[ F = 4500 \text{ lbs} \]

Area = base * height

\[ \text{Area} = (4.5 - 0.625 - 0.625) * 2 = 6.5 \text{ in}^2 \]

**Maximum allowable load including safety factor including for the following conditions:**

Material: 1020 Annealed

Ultimate Strength (Su) = 57,000 PSI

Ductile Material

Repeated Load

Safety Factor (\( \tau_d \)) = \( \frac{\text{Su}}{8} \)

\[ F = A \times \tau_d \]

\[ F = 6.25 \times 7125 \]

\[ F = 44,531 \text{ lbs} \]
Shear Stress in Pins & Bolts [7]

\[ A_s = \frac{\pi D^2}{4} \]

\[ \tau = \frac{F}{A_s} \]

\[
\begin{array}{|c|c|c|c|}
\hline
\text{Pin/Bolt Diameter (in)} & \text{Area of Shear (in}^2\text{)} & \text{Max Stress w/ 2250 lbs (PSI)} & \text{Max Stress w/ Safety Factor of 3 (PSI)} \\
\hline
0.25 & 0.049 & 45860 & 137580 \\
0.375 & 0.110 & 20382 & 61146 \\
0.5 & 0.196 & 11465 & 34395 \\
0.625 & 0.307 & 7338 & 22013 \\
0.75 & 0.442 & 5096 & 15287 \\
0.875 & 0.601 & 3744 & 11231 \\
1 & 0.785 & 2866 & 8599 \\
\hline
\end{array}
\]
The following equation is utilized to calculate the maximum shear stress on a pin with two members acting on it (double shear).

\[
A_s = 2 \left( \frac{\pi D^2}{4} \right)
\]

\[
\tau = \frac{F}{A_s}
\]

\begin{array}{|c|c|c|c|}
\hline
\text{Pin/Bolt Diameter (in)} & \text{Area of Shear (in}^2\text{)} & \text{Max Stress w/ 2250 lbs (PSI)} & \text{Max Stress w/ Safety Factor of 3 (PSI)} \\
\hline
0.25 & 0.098 & 22930 & 68790 \\
0.375 & 0.221 & 10191 & 30573 \\
0.5 & 0.393 & 5732 & 17197 \\
0.625 & 0.613 & 3669 & 11006 \\
0.75 & 0.883 & 2548 & 7643 \\
0.875 & 1.202 & 1872 & 5615 \\
1 & 1.570 & 1433 & 4299 \\
\hline
\end{array}
Customer Survey Information

First Survey Sample
Hello, my name is Tom Losekamp and I'd like to borrow just a few minutes of your time. I'm a Mechanical Engineering student at the University of Cincinnati working on my final design project. The general concept that I'm developing involves modifying a hydraulic floor jack to necessitate just one supportive point when using a jack in combination with a jack stand, meaning that you will be able to lift the vehicle at one location with the jack and also support the vehicle with a jack stand at the same point. To help with design features, I would appreciate your input with the following survey. Please leave questions blank if they are not applicable to you.

Please identify the vehicle in which you perform work on the most and please answer the following question with the chosen vehicle in mind.

- Passenger Car
- Sports Car
- Truck
- SUV
- Van
- Minivan
- Other

Have you used a hydraulic floor jack in the past with this vehicle?

If so, has it been difficult to find a stable jack point on the vehicle?

After finding the jack point, has the "saddle" (the piece on the jack that touches the vehicle frame) on the jack been wider in diameter than the jack point surface?

Have you ever used jacks stand in combination with a hydraulic floor jack on this vehicle?

If so, would you consider it easy or difficult to locate two solid jack points?

In terms of feet, what do you think the distance was between the two points you chose?
- 0 to 1
- 1 to 2
- 2 to 3
- 3 or more

Were you confident that both points were strong enough to support the weight of the vehicle?

If the type of jack I described above existed, how much would you be willing to spend on it?
- $0-$49
- $50-$100
- $101-$150
- $151-$200
- $201 or more

Please rank the following criteria in order of importance to you if you were to purchase a new hydraulic floor jack. Without repeating the numbers, please label them from 1 to 7 with 1 being the most important.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inexpensive cost</td>
<td></td>
</tr>
<tr>
<td>Easy to operation</td>
<td></td>
</tr>
<tr>
<td>Lightweight construction</td>
<td></td>
</tr>
<tr>
<td>Long-term durability</td>
<td></td>
</tr>
<tr>
<td>Easy to maneuver</td>
<td></td>
</tr>
<tr>
<td>Time saving device</td>
<td></td>
</tr>
<tr>
<td>Ability of jack saddle to conform to jack point</td>
<td></td>
</tr>
</tbody>
</table>

Thank you for your time!
## Survey Tallies

<table>
<thead>
<tr>
<th>Vehicle Choice: Passenger Car</th>
<th>Majority Tally</th>
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</thead>
<tbody>
<tr>
<td>Has person used jack with the vehicle?</td>
<td>YES YES YES YES YES YES YES YES 8-YES</td>
</tr>
<tr>
<td>Has it been difficult to find a stable jack point?</td>
<td>NO NO NO NO NO NO NO NO 8-YES</td>
</tr>
<tr>
<td>Has the saddle been oversized?</td>
<td>YES YES YES YES YES YES YES 8-YES</td>
</tr>
<tr>
<td>Has person used jack stands with vehicle?</td>
<td>NO YES YES YES YES NO NO 8-YES</td>
</tr>
<tr>
<td>Easy or Difficult to locate two jack points?</td>
<td>DIFFICULT DIFFICULT EASY DIFFICULT DIFFICULT DIFFICULT 5-DIFFICULT</td>
</tr>
<tr>
<td>Distance between two points?</td>
<td>1 TO 2 1 TO 2 3 OR MORE 3 OR MORE 3 OR MORE 3 OR MORE 3 OR MORE 3 OR MORE</td>
</tr>
<tr>
<td>Confident with jack point structure?</td>
<td>YES YES NO NO NO NO NO NO</td>
</tr>
<tr>
<td>Max Cost</td>
<td>100 160 160 160 100 100 160 118.75</td>
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<td>Easy to Maneuver</td>
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<td>Ability of saddle to conform to jack point</td>
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<td>Has it been difficult to find a stable jack point?</td>
<td>NO NO NO NO NO NO NO NO 4-YES</td>
</tr>
<tr>
<td>Has the saddle been oversized?</td>
<td>YES YES YES YES YES YES YES 4-YES</td>
</tr>
<tr>
<td>Has person used jack stands with vehicle?</td>
<td>YES YES YES YES YES YES YES 4-YES</td>
</tr>
<tr>
<td>Easy or Difficult to locate two jack points?</td>
<td>DIFFICULT DIFFICULT DIFFICULT DIFFICULT DIFFICULT DIFFICULT 4-DIFFICULT</td>
</tr>
<tr>
<td>Distance between two points?</td>
<td>2 TO 3 2 TO 3 1 TO 2 2 TO 3 3 TO 3 3 TO 3</td>
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<tr>
<td>Confident with jack point structure?</td>
<td>YES NO NO NO NO NO NO</td>
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<tr>
<td>Max Cost</td>
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<td>Ability of saddle to conform to jack point</td>
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<tr>
<td>Has it been difficult to find a stable jack point?</td>
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</tr>
<tr>
<td>Has the saddle been oversized?</td>
<td>YES YES NO NO NO</td>
</tr>
<tr>
<td>Has person used jack stands with vehicle?</td>
<td>YES YES YES YES YES YES</td>
</tr>
<tr>
<td>Easy or Difficult to locate two jack points?</td>
<td>EASY DIFFICULT EASY EASY EASY EASY</td>
</tr>
<tr>
<td>Distance between two points?</td>
<td>3 OR MORE 1 TO 2 3 OR MORE 3 OR MORE 3 OR MORE 3 OR MORE</td>
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<tr>
<td>Confident with jack point structure?</td>
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<tr>
<td>Max Cost</td>
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<tr>
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<tr>
<td>Ease of Operation</td>
<td>5 2 1 3 11</td>
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<td>Lightweight Construction</td>
<td>7 8 4 7 24</td>
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<td>Long term Durability</td>
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<tr>
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<td>Ability of saddle to conform to jack point</td>
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<table>
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<td>Has person used jack stands with vehicle?</td>
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<td>Confident with jack point structure?</td>
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<td>Ease of Operation</td>
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<td>Lightweight Construction</td>
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<td>Durability</td>
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<td>Ease of Maneuverability</td>
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</tr>
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<td>Time Savings</td>
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<td>Saddle conforms to jack point</td>
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<td>Absolute importance</td>
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<tr>
<td>Relative importance</td>
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Second Survey Sample

Thank you to all of you who completed my survey in the beginning of December. I would again like to get your feedback. Please look at the three attached design ideas, they are labeled as Design 1, Design 2 & Design 3. Please answer the following questions:

In regards to the following criteria, which design do you feel would be the:

<table>
<thead>
<tr>
<th></th>
<th>Easiest to operate?</th>
<th>1</th>
<th>2</th>
<th>3</th>
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<tbody>
<tr>
<td>1</td>
<td>Lightest weight?</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<td>2</td>
<td>Most durable?</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td>3</td>
<td>Easiest to store?</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<td>4</td>
<td>Easiest to maneuver?</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>Quickest to lift &amp; a support vehicle with jack stands?</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>Easiest to find strong jack points that will conform to the jack design?</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>Least expensive to purchase</td>
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<td>2</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
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</tbody>
</table>

Again, thank you for your time!
Design Alternatives

**DESIGN 1**

Design concept: two hydraulic bottle jacks with one rod which can raise and lower vehicle with attached vehicle handle.

Primary advantage: has the ability of lifting 2 wheels off the ground at once with 2 hydraulic lifting devices.

**DESIGN 2**

Design modified hydraulic floor jack to include extension arms.

Primary advantage: has the ability of lifting 2 wheels off the ground at once with just 1 hydraulic floor jack.

**DESIGN 3**

Design setup, lift arm, and model modified into a horseshoe effect to fit around jack stand.

Primary advantage: jack and jack stand can use the same point under the vehicle for lifting and supporting the vehicle.
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<th>Alternate Design Ideas Survey Tally</th>
<th>Majority</th>
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<tbody>
<tr>
<td></td>
<td>Tally</td>
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<tr>
<td>Easiest to operate</td>
<td>3 3 3 3 3 3 1</td>
<td>3</td>
</tr>
<tr>
<td>Lightest weight</td>
<td>3 1 1 3 3 3 1</td>
<td>Tie bw 1 and 3</td>
</tr>
<tr>
<td>Most durable</td>
<td>3 3 3 3 3 3 3</td>
<td>3</td>
</tr>
<tr>
<td>Easiest to store</td>
<td>3 3 3 3 3 3 3</td>
<td>3</td>
</tr>
<tr>
<td>Easiest to maneuver</td>
<td>3 3 3 3 3 3 3</td>
<td>3</td>
</tr>
<tr>
<td>Quickest to lift &amp; support w/ jack stands</td>
<td>3 3 3 3 3 3 3</td>
<td>3</td>
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<tr>
<td>Easiest to confirm to jack points</td>
<td>3 3 3 3 3 3 3</td>
<td>3</td>
</tr>
<tr>
<td>Least expensive</td>
<td>3 1 1 3 3 3 1</td>
<td>Tie bw 1 and 3</td>
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### Jack Stand Information

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Model Number</th>
<th>Z-Axis Dimension (inches)</th>
<th>X-Axis Dimension (inches)</th>
<th>Y-Axis Range (inches)</th>
<th>Capacity (tons)</th>
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Drawings

3-D Model of Horseshoe Jack
Saddle
Material: 1045 Cold Rolled Steel
Quantity: 1
No Heat Treatment Required

Note: All dimensions are in inches and dimensional tolerances are ±0.03 unless stated otherwise.

Part Name: Saddle
Sheet number of Sheets: 1 of 1
Design by: Tim Lempicki
Printed by: Tim Lempicki
Revision Date: 09/09/00
Side member for base
Make out of 8" x 8" square stock with 3/16 wall thickness
Quantity: 6
Material: 1018 Cold Rolled Steel
Not heat treatment required
Spacer
Material: 1018 Cold Rolled Steel
Quantity: 2
No Heat Treatment Required
Threaded Bushing
Quantity (4)
1018 Cold Rolled Steel
No Heat Treatment Required
Wheels
Material: 1018 Cold Rolled Steel
Quantity: 2
No Heat Treatment Required
Lower Cross Member
Quantity: 1
Material: 1018 Cold Rolled Steel
No Heat Treatment Required
Removed Components from Sears Jack #12112
Stability Test

Objective: To prove that 2 points of contact between a jack saddle and a vehicle’s lift point is more stable than just 1 point of contact between a jack saddle and the vehicle’s lift point.

Problem: With Sears jack #12112, the concave circular saddle is oversized for most vehicles’ official jack points, this creates a condition in which one edge of the circle is positioned under reinforced steel and the other edge is positioned under sheet metal. Not only does this cause damage to the sheet metal, it also presents an unstable condition for the vehicle while raised in the air. The Horseshoe Jack will keep 2 points in contact with the reinforced steel, solving the problems just described.

Tools: Sears jack #12112, electronic caliper, small heavy objects-items used in this test included (5) 70 lb landscaping blocks, (2) 80 lb concrete bags, and (3) 40 lb sand bags were used, 1995 Ford Explorer, heavy duty pipe wrench

Procedure: The following steps will provide a systematic way of determining which is more stable, 1 point or 2 points of contact between a jack saddle and its lift point.

1. Park 1995 Ford Explorer on level surface.
2. Apply parking brake.
3. Open truck gate.
4. Chock front wheels from the front of the vehicle.
5. Place heavy duty pipe wrench directly in center of saddle, see attached photograph for better understanding. This will serve as one point of contact between the jack and the vehicle.
6. Align pipe wrench directly under the center of rear differential.
7. Choose one place on the rear passenger tire as a reference point and raise the vehicle in the air until that point is off the ground as close to 4 inches as possible. Record reading with calipers.
8. Place 1 heavy object inside of the trunk directly over the rear passenger side axle.
9. Measure and record the new distance between the pavement and reference point on the tire.
10. Continue adding (1) addition heavy object one at a time until out of objects. Measure and record new distance between pavement and reference point for each increment.
11. Remove all weights and lower the vehicle.
12. Remove pipe wrench and align 2 edges of jack saddle under the center of the rear differential.
13. Repeat Steps 7 thru 12.
Collected Data: See attached spreadsheet.

Results:
With the information provided, we can conclude that 2 points of contact between the jack saddle and vehicle provides more stability versus one point of contact. While 640 lbs is placed above the rear passenger side axle, the overall distance that the vehicle lowers on passenger side with 1 point of contact is .625" and with 2 points of contact the vehicle lowers only .3855".

With 1 point of contact, the .625" equals 15.37% change in position from its initial 4.0660" from the pavement and with 2 points at .3855" equals 9.49% change in position from its initial 4.0595". These percentages can seem may insignificant at first glance, but when compared to one another (A & B), we can see that 2 points of contact are on average 40.36% more stable than having just one point.

The results did prove the objective; however something did appear in the results which seems peculiar. Though there were not specific numbers targeted within the data, after the 210 lbs were added, both testing procedures ΔY values jumped significantly when in comparison all other values. The only rational explanation that can be drawn from this that the front shocks still have a certain amount of counteractive static friction keeping it stiff, but at some point between 140 lbs and 210 lbs motion begins, allowing the vehicle to tilt more freely.

Interesting Additional Information:
This test had to be preformed twice due to product failure of the existing Sears jack. While testing for just one point of contact, just one edge of the saddle was lined up with the center of the rear differential. The vehicle was raised in the air and the testing began. After adding 280 lbs of weight above the axle, a sleeve in which the saddle sits, failed. Inspection showed a very poor weld was to blame. This is a very realistic application while lifting up a vehicle with just one edge under reinforced steel and the other under sheet metal. Please see attached photographs.
### Stability Test
West Chester, Ohio
Keener Park Parking Lot
4:30 p.m. Saturday 2/12/05

#### 1 Point of Contact

<table>
<thead>
<tr>
<th>Weight in Trunk (lbs)</th>
<th>Distance From Ground (inches)</th>
<th>Compounded ΔY (inches)</th>
<th>ΔY from Trunk From Height (inches)</th>
<th>Compounded Difference from Original Height</th>
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#### 2 Points of Contact

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#### Weight Percentage Difference btw (A) & (B)

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**Note:** The table above provides the data for weight and distance measurements at different points, along with the percentage differences between two points of contact. The percentages indicate the change from the original height at the trunk.
One point of contact

Vehicle raised with one point of contact

Added weight

Measuring difference between added weight
Broken sleeve because of poor weld

Temporary fix to finish experiment
Quarter 1
- Project Idea
- Time Chart
- Surveys
- Preliminary Cost Estimate
- Measurable Objectives
- QFD House of Quality
- Proof of Design
- First Draft Proposal Submission
- Proposal Rework

Product Testing on Sears Jack
- Alternate Design Ideas
- Disassemble Sears Jack
- Stability Testing
- Design & Calc for Base
  - Load
  - Material
  - Stresses
- Interim Report
- Design & Calc for saddle
  - Load
  - Material
  - Stresses
  - Drawings
- Bill of Materials
- Fabrication
- Product Testing
- Rough Draft
- Final Draft
- EXPO!!!
- Prep for Final Presentation
## Final Prototype Cost

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<td></td>
<td>$25</td>
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<tr>
<td>14</td>
<td>Fabrication Hours</td>
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<td></td>
<td>$25</td>
<td>$625</td>
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<tr>
<td>15</td>
<td>General Assembly</td>
<td>10</td>
<td></td>
<td>$25</td>
<td>$250</td>
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</tbody>
</table>

Total Before Donations: $2,402.50  
Total After Donations: $129.70
Meeting Minutes with Professor Allen Arthur

Meeting 1 - 11/23/04
Rehashed general design idea.

Discussed problem statement- need specifics as to what will be included, such as weight capacity, saddle size, safety of device and time savings.

Measurable objectives conversation-cleaned up every problem element. Considered 2 points of contact to be a side benefit.

Meeting 2 - 12/1/04
Discussed what I had researched on the jack points on many different vehicles after surveying Kings Automall 10/25/04 vehicles. Also discussed the information I had found on standard jack stand sizes for 3 ton jack stands (spreadsheet & web print outs)

Revisited Measurable Objectives.

Requested info for next meeting:
Accident rates from jacks (web print outs)
Sears jack productions
More Measurable objectives
Find standards to adhere to

Meeting 3 – 12/14/04
Revisited Measurable Objectives, Problem Statement

Discussed what has to be included in the Proof of Design Statement

Agreed that we should concentrate on footprint size, rather than volume for size increase measurable.

Agreed to adhere to SAE standard J1884.

Requested info for next meeting:
Survey questionnaire to address QFD
Redo time schedule

Meeting 4- 01/05/05
Discussed time saving test procedure. Must define the operator requirements such as, is the person mechanically inclined, are they strong enough to operate the jack, do I show them the jack points or make them search for themselves, testing will only occur with one style car, how many people will be surveyed etc.
Discussed the idea of the jack still being versatile, still able to lift a vehicle in many locations, not just the official jack point.

Discussed the measurable objectives including:

- The idea of the jack being more stable than the existing Sears model. It will have 2 points of contact. Will have a test procedure which will require more weight to make the vehicle "teeter" or change its state of balance.

- Clearance needed for jack when under the car, weight maximums, dimensions, tonnage, standards, cost, & time savings.

Information requested for next meeting:
- Proof of Design
- Revised Time Chart
- House of Quality

Meeting 5 – 01/19/05
Discussed interim report and what is needed from me.

Discussed house of quality, agreed it was done properly. The result was the horseshoe design was the best design.

Beginning stages of design were discussed, especially with regards to the base design.

Information requested for next meeting:
- Updated measurable objectives
- Determine loads
- Determine load on saddle, base, & arm
- Steel Properties

Meeting 6 – 01/31/05
Discussed measurable objectives, final touches will be made and presented at next meeting.

Discussed the best test procedure for the measurable objective of improved stability.

We have come to a stand still as to how to do load analysis on the jack.

I must come up with a list of assumptions.

Meeting 7 – 02/9/05
Discussed first attempt at stability test and design elements. Discussed where torque and/or torsion was going to play are role in the analysis.
Information requested for next meeting:
  Torque in the front lift arms
  Torsion on the side pieces of the base
  Play with the thickness of the base to overcome torque
  Fill in number for measurable objectives and complete proof of design statement
Meeting 8 – 02/16/05
Presented items as requested from meeting 7.

Conversation led to how to analyze the assembly. Must find max stress in the components.
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This SAE Recommended Practice was written by the Passenger Car Early Recommended Practices
It is intended to help ensure quality and uniformity of:
With the arrival of federally n cars and light trucks, both the build
and energy management during bumper could no longer be used
under the axle or under the body be created to accept a concentr
vehicle weight.
Conceps for jacking at the sill bumper jack that positioned the
vehicle sill. For some European vertical screw designed to lift
the sill, but functioned with a bumper jack. In most cases, how
With the development of the Practice was required to encom
1. Scope—The scope of this testing of jacks supplied as origi
1. Purpose—The purpose that can be used to ensure a

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Definitions
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additive effect of small weight
front GAWR includes the sum of
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1. The vehicle base weight
2. - All fluid weight
3. - The sum of the weight
4. - The total baggage or c
5. - The total passenger
3.2 Rear GAWR (Passa
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4.2 Endurance Requirement

4.2 Endurance Requirement

without loss of function, its cap
times from a lowered position (s) to a lowered position,
4.2.1 The jack shall be operated
position giving the heaviest jack
cycle.
4.2.2 Operating handle effort
cycles shall not exceed 47.5 Nm cycles shall not exceed 47.5 Nm
4.2.3 Stability Requirement

4.1 Using the largest diameter
raised a minimum of 50 mm from a minimum of 50 mm from
clep shall remain on the jack when clep shall remain on the jack when
cle for 30 s in the forward, rear-cle for 30 s in the forward, rear-cle for 30 s in the forward, rear
paved surface providing that: paved surface providing that: paved surface providing that:
a. The jack is placed at the ma
ing to the raised tire a. The jack is placed at the ma
ing to the raised tire a. The jack is placed at the ma
ing to the raised tire
Bibliography

7. May 28, 2005