The Excite Trike

Thrilling Adult Big-Wheel Transportation

Executive Summary

As a cutting edge transportation start-up, we at Excite Trike ran an extensive analysis of what exists in the market today for adult tricycle enthusiasts. What we found was troubling. Current products on the market do not meet the needs that we see as necessary for our customers. These necessities consist of a cup holder, a hitch and rear view mirrors. Combining these into the excite trike, lead to the most satisfying trike of your life.

Group Members:

Robert Connolly
Dominic Doxen
Ian Villaroman
Clayton Schultz

Market Analysis

To be able to sell a product a firm must know how to correctly market the product utilizing the four Ps of marketing. The four Ps of marketing are product, price, promotion and place. Product is known as a tangible good or service that is sold to a consumer in exchange for money. Price is the overall cost of the product. Price can have an overall effect on the profit margins, supply, demand, and the marketing strategy. Promotion is to differentiate ourselves from the competition. This would include social media marketing, advertising, video marketing and etc. To get our product in the right location at the right time is to engage and understand the place for our product. Place is the location where we will sell our product and the future plans to expand to additional areas of the country.

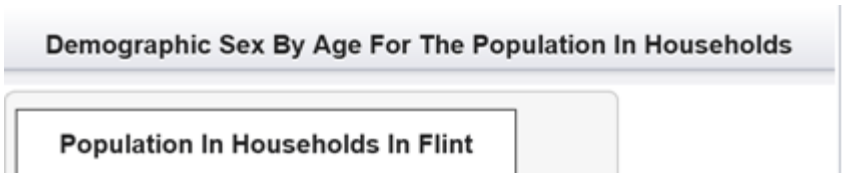
A market survey was conducted to provide information on products that are currently in production. The top three products similar to our excite trike was the Big Wheel by the Original Big Wheel company, the Pro Slider by Huffy, and the Underworld 2 Lantern Performance by the Triad company. The majority of these trikes offer fun and recreation to the user but the Pro Slider and the Underworld are strictly drift trikes. This means that there is a large loss of fun when these products are going down a steep hill versus being used on flat land. In regards to the remaining tricycle, Big Wheel, this is a children's toy that is marketed to demographic group of under 8 years of age. A more in depth analysis of the market can be found in the section labeled Appendix A.

Our product, Excite trike, is not just a drift trike but a trike that will serve as a "BMX in tricycle form." Our product will combine the ability to drift on any surface terrain but can still be utilized on flat land at speeds that depend on the output of the user. The harder you pedal the faster it will reach. The only rule is the person must be physically

capable of riding a tricycle. Also, this product is capable of pulling our friends and children with the use of our hitch.

The main need for our target market of 18-24 years of age was to bring a thrilling ride of adrenaline to those living mundane boring lives. The thrilling experience of riding our excite trike will start at the time of purchase and even through the future. Features of our product include adjustability in seat, towing features and even drifting capabilities. The features will be marketed through the use of video media advertising such as TV commercials and can be expanded into social media through the use of Youtube, Facebook, Twitter, etc. The use of advertising will allow for our firm Excite Trike to develop a brand based on fun and excitement which will gain followers who are willing to purchase the product and mention it to friends.

Our initial plan at Excite Trike is to start in the city of Flint, Michigan with a target market focused on adults (both male and female) 18 to 24 years of age.
From this location, we will expand to cities across Michigan with higher percentages of college students aged 18-24. For Flint Michigan the census was divided into male and female and we compiled all information from suburbanstats.org. Our anticipated market is the combined total of the 18-24 years of age demographic at about 10,245 people. Figures are attached below.
Data from the 2015 Flint, Michigan census



Total Population:	99,241
Male Population:	47,124

18 and 19 years:	1,551
20 years:	765
21 years:	668
22 to 24 years:	1,918

Female Population:	52,117

18 and 19 years:	1,658
20 years:	846
21 years:	732
22 to 24 years:	2,107

Compiled data for male and female aged 18-24 years of age.

	Age
Subject	**18-24 years**
Male	4,902
Female	5,343
Total	10,245

Estimated value per unit is roughly $200 per unit.

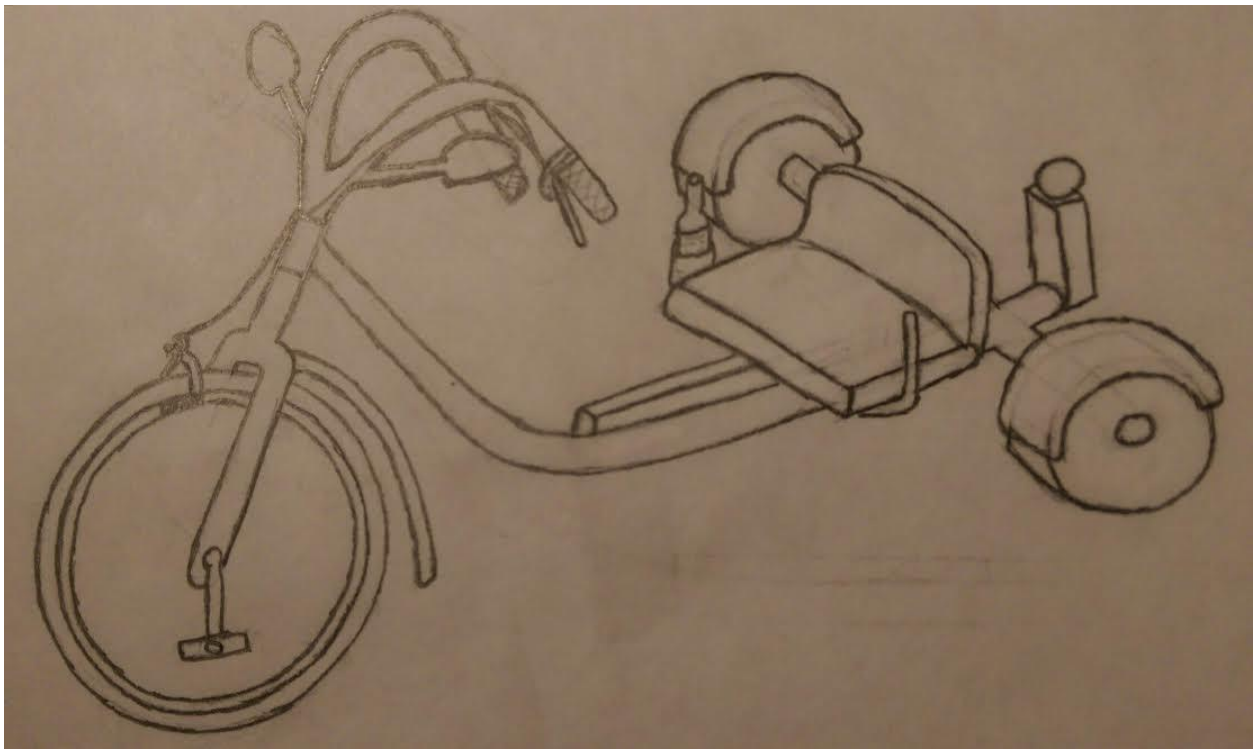
Research & Development was estimated at $40
Manufacturing/Labor was estimated at $60
Materials was estimated at $80
Delivery Costs was estimated at $20

Our anticipated usage life is built to last with the majority of materials made strictly from USA. But a general useful life for our product is mainly 4-5 years with general replacement of tires, brake pads and brake handles.

Our value proposition statement at Excite trike we will bring you a thrilling ride for all to enjoy. A ride that will bring the user adrenaline and be able to continue the experience now and in the future. A ride that will combine the traditional practicality of a tricycle on flat land but with the combine features of the drift trike. Also, our excite trike will allow you to take your friends around (probably just one).

Opportunity Identification

I. Product Concept Sketch



II. Factor of Safety

For our project, a factor of safety of 3 was determined to be necessary. The factor of safety calculation and reasoning is included below.

1) Accuracy of load knowledge…….……-2
    a) It's for an average adult, using male, as they are typically heavier
2) Accuracy of stress calculation…….…..-1
    a) We're pretty darn good at calculating stress
3) Accuracy of stress knowledge…….……..1
    a) Estimates can be obtained from material info in the book
4) Need to conserve weight or cost……...-1
    a) Not a big deal for our project. Not a major focus to conserve money
5) Seriousness of failure consequences…..……..3
    a) Pretty darn serious, people can fall off and break body parts, maybe die, we don't know
6) Quality of manufacture…….……-2
    a) We want it american made, so top notch quality and manufacturing best practices
7) Conditions of operation…….……..2
    a) We don't know if it'll be used in the dirt, in the snow, in the rain, with multiple passengers, etc.

8) Quality of inspection/ maintenance……..4
    a) People are not going to care about this thing. Drive it like they stole it.

$$\Sigma t = (-2) + (-1) + (1) + (-1) + (3) + (-2) + (2) + (4) = 4$$
$$\Sigma t = 4$$

$$Factor\ of\ safety = 1 + \frac{(10+t)^2}{100} = 1 + \frac{(10+4)^2}{100} = 2.96$$
$$Factor\ of\ safety = 2.96$$

III. Design Specifications

The following design specifications were made for Excite Trike:

Brakes

1. Have to Stop Trike and Person
2. Desired life of 5 years
3. Handle withstands clamping force

Structure

1. Support 300lb person
2. Adjustable seat to fit a 5’4” person to a 6’6” person
3. Withstand pot holes (Impulse Load)

Handlebars

1. Withstand appropriate steering force (enough to make the front wheel break traction)

Pedals

1. Withstand large output torque from a big person pedaling (need to research to find out reasonable pedaling force)

Wheels and axles

1. Able to support load of 300lb person
2. Roll flat tires
3. Lifespan of 3 years of heavy use (not including accidents)

Adjustable Seat

1. Adjustable from a 5’4” to a 6’6” person
2. Comfortable

Cupholder

1. Able to hold onto anything from a redbull can to a big gulp

Analysis Overview and Further Recommendations:

The scope of the project did not allow for the analyzation of every single part, as well as fatigue and wear analysis on most parts. As it stands right now, this tricycle should not go into production, as significant amounts of calculations and testing is still necessary. For example, wear calculations and testing should be completed on the tires and wheels. Failure testing should be completed on the frame, including torsional loads. A significant amount of testing should be completed to ensure that Excite Trike can withstand heavy impulse loads from road bumps and curbs. And most importantly, a solution still needs to be made for the cupholder to hold any size beverage from a Redbull to a Big Gulp (seriously, it's the most important one.) These are some things to further investigate beyond the scope of this project.

Design Analysis:

The table below describes who was assigned to analyze which parts.

Member Name	Part Name	Appendix
Rob Connolly	Brake Pads (Wear)	B
	Brake Handle	B
Dominic Doxen	Frame (3 Parts)	C
	Front Axle	C
	Rear Axle	C
Clayton Schultz	Handlebars	D
	Trailer Hitch	D
Ian Villaroman	Adjustable Seat	E
	Pedals	E

Below is a summary of our findings:

Part	Total Stress (psi)	Material	Factor of Safety
Frame: Bar 1 (Seat Bar)	6,512.77	2024-T3 Alum	7.67
Frame: Bar 2	12,207.76	2024-T3 Alum	4.17
Frame: Bar 3 (Front Bar)	15,952.49	2024-T3 Alum	3.13
Front Axle	41,232.14	AISI 1095	3.35
Rear Axle	12,223.099	2024-T3 Alum	4.09
Hitch	4,200	2024-T3 Alum	11.9
Handlebars	15,129	2024-T3 Alum	3.3
Hand-Brake	15,450	1020 Mld Stl	3.3
Brake Pads	213.7	Thermoplastic Polymer	5.26
Handle Bars	15,129	2024-T3 Alum	3.3
Trailer Hitch	4,200	2024-T3 Alum	11.9
Pedals	14,563.5	AISI 1095	13
Adjustable Seat	101.185	2024-T3 Alum	3

Final Recommendations

After all of the calculations were done to each part, with already designated material, our initial design was not acceptable. We wanted to create the trike all out of aluminum (2024-T3 Alum) but there were some parts that needed to be stronger than the aluminum

and that did not need to be as strong as aluminum. For example, the front axle needed to be made out of AISI 1095 steel. Also, the handbrake was made from a less strong material, 1020 Mld Steel. There could also be further changes to the parts, in regards to the materials, but then the problem with the different types of metals all combined in one trike. It is less complicated using multiple different materials compared to a single material or a select few. Also, with the parts that do not have a larger amount of total stress compared to the material, the part can be optimized to save money and lower the trike price. We recommend that there should be wear calculations completed on the wheels and tires, as well as more time spent looking at fatigue, specifically of the frame. The following excite trike can implement these previous ideas for next steps towards the future of fun!

Appendix A - Required Documents

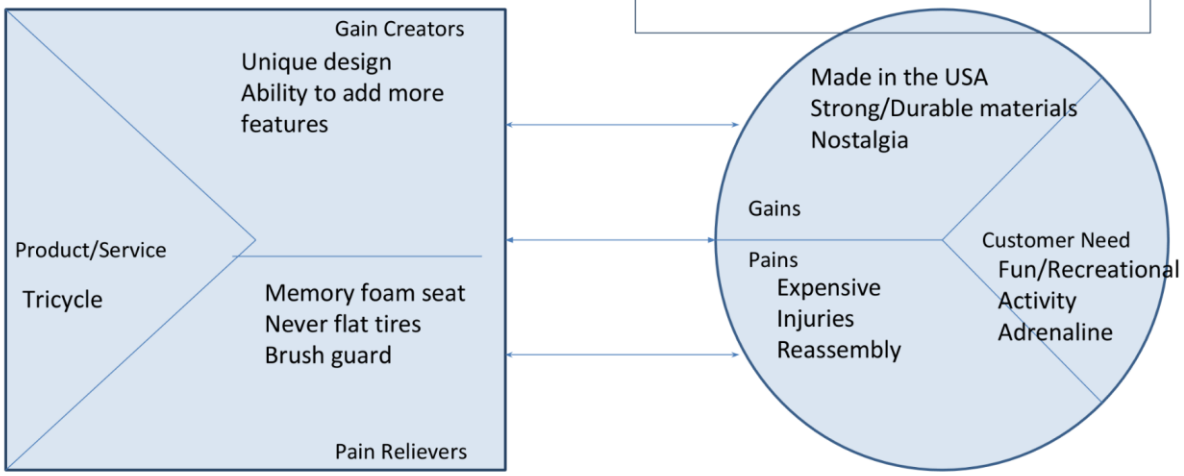
Design Failure Mode Effect Analysis

FMEA Template for AIAG and Six Sigma												MEADinfo Product
Prepared By:								FMEA No/Rev: 001/01				
Date: 11/20/16								Process/Component:			Excite Trike	
											Action Results	
Item	Function	Potential Failure Mode	Potential Effects or Failure	Svrty	Potential Causes of Failure	Ocrnc	Current Controls for Prevention/ Detection	Dtctn	RPN	Recommended Action	Responsibility and Target Completion Date	Action Taken	Svrty	Ocrnc	Dtctn	RPN
Brakes	Actuating/ modulating the Braking force	Handle Breaks	Inability to use Brakes	10	Defect in Material Over-loading	1	Visable Deformation	8	80	Design part with ductile material, and an increased factor of safety	12/09/2016					0
	Transfering the braking force	Cable Stretches	Decreased Brake effectivity	5	Regular or increased use	1	Decreased Resistance in handle	7	35	Design part with high capacity for tensile loading	12/09/2016					0
	Slowing the tricycle	Pads Wear	Decreased Brake effectivity	5	Regular or increased use	2	Visable Wear	5	50	None, customer should be able to detect and replace pads when needed	12/09/2016					0
Wheels/ Tires	Absorbing road energy, adding comfort to ride	Inflatable Tire - Deflates	Decreased ride performance	4	Changes in Ambient temperature and pressure, puncture by sharp object	5	Visable Deflation	1	20	None, customer should be able to detect and repair when needed	12/09/2016					0
	Supporting the load on the tires	Spokes Fail (Buckle)	Inability to use tricycle	8	Impact, Overloading	1	Visable Deformation	1	8	None, Customer will be able to detect and replace when needed	12/09/2016					0
Frame	Support user weight and withstand road loads	Frame Bends or Warps	Inability to use tricycle	8	Impact, Overloading	1	Visable Deformation	1	8	Material will be ductile and designed with F.O.S. to prevent occurence	12/09/2016					0
	Support user weight and withstand road loads	Front Wheel Fork Weld Failure	Inability to use tricycle	10	Impact, Overloading	1	Weld inspection in plant	5	50	Install automatic weld checks in manufacturing plant	12/09/2016					0
	Support Steering torsion and a portion of user weight	Handlebars Shear	Inability to use tricycle	10	Impact, Overloading	1	Visable Deformation	7	70	Design with relatively ductile material in order to give customer warning before failure	12/09/2016					0
Adjustable Seat	Disengage locking mechanism	Lever Breaks	Inability to adjust seat	3	Material Defect, overloading	1	Visable Deformation	10	30	None, likelyhood of failure is low, and impact is also low	12/09/2016					0
	Disengage locking mechanism	Lever deforms/get s stuck	Inability to adjust seat	3	Material wear from regular use, assembly defect	1	Assembly tested in plant	7	21	None, likelyhood of failure is low, and impact is also low	12/09/2016					0
Pedals	Transfer torque to wheels	Pedals deform	Decreased mobility	7	Material Defect, overloading	1	Visable Deformation	1	7	None, likelyhood of failure is low, and detection ability is high	12/09/2016					0
	Transfer torque to wheels	Pedals shear	Inability to use tricycle	8	Material Defect, overloading	1	None	10	80	Use of relatively ductile material in order to warn customer before failure	12/09/2016					0

Idea Canvas

Value Proposition Statement:
A thrilling ride to "Excite" all
Called the Excite Trike

Target Customer(s):
People from 14 to 100 years of age



Other competition: Motorcycles, quads, and bicycles

Market Survey

Who has a similar device?

At least three competitors/ideas

OG Big Wheel

Monster trike

Drift trike

Name of Product	**Company**	**Features**	**Price**	**Photo**
Big Wheel	Original Big Wheel	-16” Front Wheel -Weight limit= 70lbs -Pedal Powered -Plastic Frame	$40	
Pro Slider	Huffy	-Brake system -Huffy Slick tires -Durable steel handlebars -Steel frame -Aluminium Front wheel	$250	

Underworld 2 Lantern Performance	Triad	-Weight= 15 lbs -”V” disc brake design	$250	

Cost of product

$150-250

Features of (our) product

Big Wheel
Ergonomic Boss Hog Chopper Handlebars
Comfortable/ Adjustable Seat for various heights
Cup Holder
Ergonomic Aerodynamic Pedals
Body Color Fenders and Spokes
Mud Flaps
Trailer Hitch/Basket Attachment
Mirrors
Functioning Brakes (Hand-Brake)
Ratcheting pedal drive system (allows for coasting)

Customer comments of the product

Product	Good Review	Bad Review
Big Wheel	“If you're looking at the big wheel for your little one, I say go for it. Instructions should say 'patience required', but take a deep breath, do it right the first time, and then sit back and enjoy watching your kids have a blast zipping up and down the driveway.”	expect it to break, and soon, even with modest riding from a 4yo on smooth sidewalk/patio. $13 to replace. the force exerted backwards against seat while pedaling a forward stroke will easily crack the pegs away from the seat body. the seat is a single molded piece, and while the seatback and pegs individually are quite strong due to reinforcing internal corrugation, they are joined along a light gauge plate at the bottom which cracks and then "tears around" the peg as the seat back is pushed against. really poorly engineered - the point that takes the most stress has no "beef" to it at all. hard to believe it could ever make it past QA, it almost appears to be DESIGNED to fail

Pro Slider	The trike was not perfect as delivered. I had to grind some weld off the fork for the brake caliper to sit square. I had to spread the forks for the wheel assembly to fit. Finally, the head of one of the crank bolts was snapped off. (It was not fun getting the rest of the bolt out.) Would I buy it again? Absolutely! The freewheel on the pedals is awesome. This is how a big wheel should be made. My ten year old loves it.	It is fine for me but the plastic wheels are not the best and I believe I will set it up for sale and sell it for a whole new one
Underworld 2 Lantern Performance	This ROCKS! I'm 53 years young and this Drifter adds a ton of fun at the end of a long day at work. I'm impressed with the quality of the materials it is made of and the paint is just as advertised, it GLOWS in the dark. Very happy with it!	I would've loved for there to be rubber wheels instead of plastic wheels. The plastic wheels can't grip the ground when hitting the apex of corners. I'm 66 and ready to push this bad boy to the limit. I will be buying aftermarket rubber wheels to replace the plastic ones.

Recalls of the product (recall.gov)

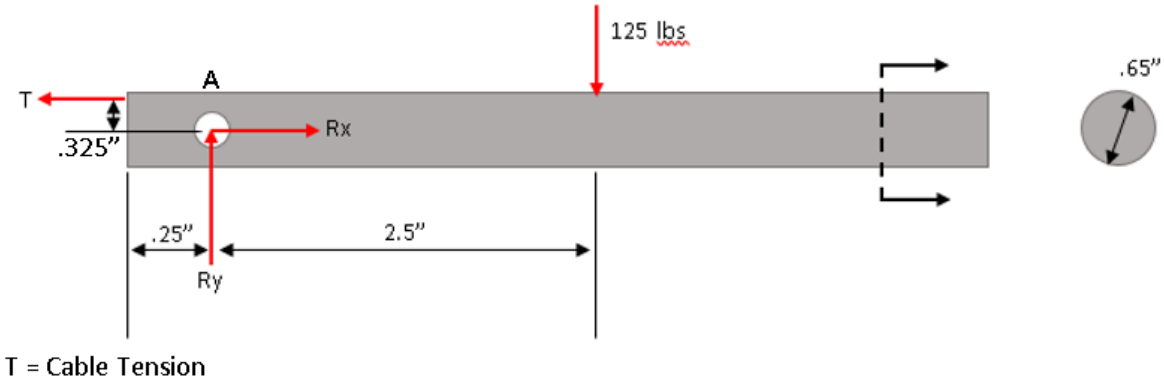
Loss Of Control (Handlebars Fail)
https://www.cpsc.gov/recalls/2013/huffy-recalls-slider-tricycles/

Back Wheel Axle Shears and Trike Falls Over https://www.cpsc.gov/recalls/2012/currie-technologies-recalls-adult-tricycles-due-to-fall-hazard/

Weld Failure on Front Fork Joint
https://www.cpsc.gov/recalls/1995/cpsc-and-radio-flyer-announce-tricycle-recall/

Appendix B - Rob Connolly Calculations

Hand-Brake



$$\Sigma F_x = R_x - T = 0$$

$$R_x = T$$

$$\Sigma F_y = R_y - 125 = 0$$

$$R_y = 125$$

$$\Sigma M = -125(2.5) + T(.325) = 0$$

$$T = 961.54\text{lbs}$$

$$\sigma_{bearing} = \frac{F_{bolt}}{d * t}$$

$$t = thickness\ of\ handle = .65$$

$$d = diameter\ of\ hole = .125$$

$$F_{bolt} = R_x = T = 961.54$$

$$\sigma_{bearing} = \frac{961.54}{(.125)(.65)} = 11.83\text{ksi}$$

$$\tau_{bolt} = \frac{F}{A} = \frac{R_x}{\pi r^2} = \frac{961.54}{\pi(.0625)^2} = 78.353ksi$$

$$S_{ult} \geq 2.96(78.353)$$

$$S_{ult} \geq 232ksi$$

$$\tau_{bolt\ hole} = \frac{F}{A} = \frac{R_y}{A - A_{hole}} = \frac{125}{(\pi(.325)^2) - (.125 * .65)} = .499ksi$$

$$\sigma_{axial} = \frac{R_x}{\left[\left(\frac{\pi D^2}{4}\right) - (d * D)\right]} = \frac{961.54}{(.332 - .081)} = 3.84ksi$$

$$D = Part\ Diameter$$

$$d = Hole\ Diameter$$

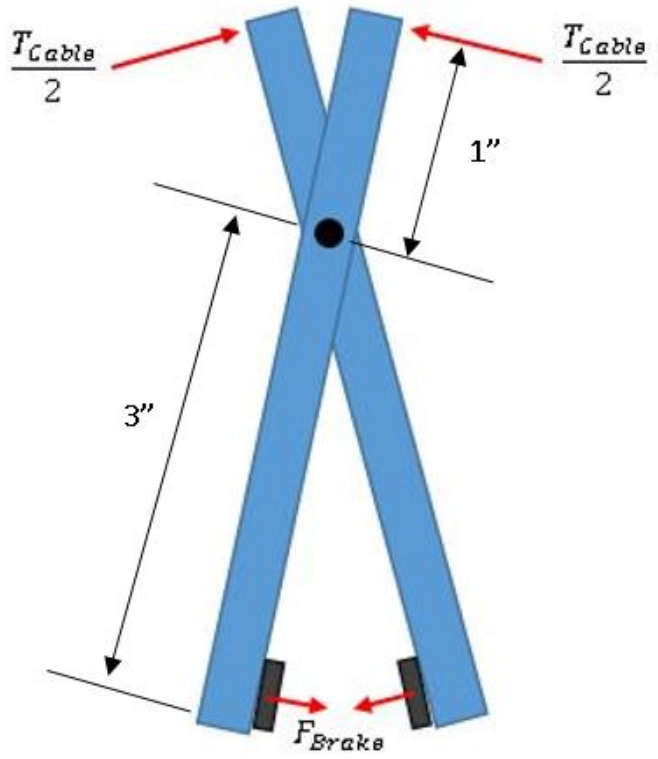
$$\sigma_{von\ Mises} = \sqrt{\frac{1}{2}[(15.43)^2 + (-15.43)^2] + 3(.499)^2} = 15.45ksi$$

$$S_{yld} \geq (2.96)15.45$$

$$S_{yld} \geq 45.732ksi$$

Material Selected: AISI 1020 Cold Drawn Mild Steel

Brake Pad

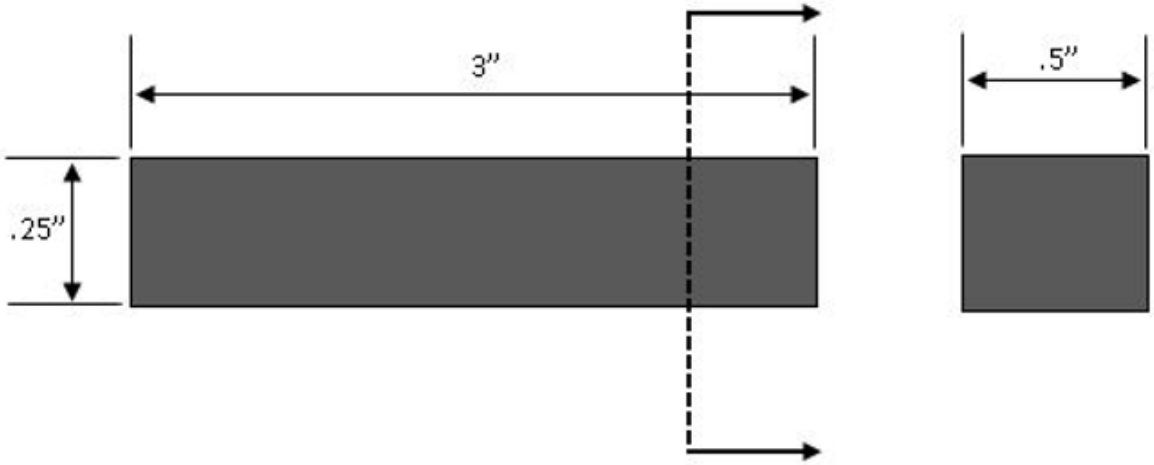


$$F = \frac{T_{cable}}{2} = \frac{961.54}{2} = 480.77$$

$$\Sigma M = 480.77(1) - F_{Brake}(3)$$

$$F_{Brake} = 160.257$$

Pad Geometry



$$P = \frac{160.257}{3(.25)} = 213.676\,psi$$

$$d_{wear} = k * P * L$$

$$d_{wear} = .375"$$

$$P = 213.676\,psi$$

$$L = Length\ of\ wear = \left[\frac{360\ in}{use} x \frac{45\ uses}{week} x \frac{52\ weeks}{year} x\ 5years\right]$$

$$=>\ .375 = k * 213.676 * \left[\frac{360\ in}{use} x \frac{45\ uses}{week} x \frac{52\ weeks}{year} x\ 5years\right]$$

$$4.167 * 10^{-10} = k$$

$$k = \frac{k_{Table}}{9S_{yld}}$$

$$4.167 * 10^{-10} = \frac{5 * 10^{-6}}{9S_{yld}}$$

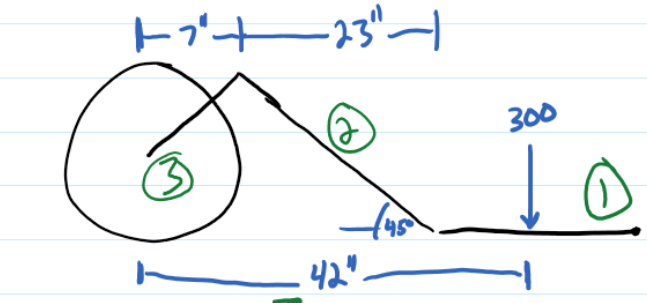
$$=> S_{yld} = \frac{5 * 10^{-6}}{9(4.167 * 10^{-10})} = 1.33\ ksi$$

Material Selected: Thermoplastic Polymer

Appendix C - Dominic Doxen Calculations

Frame Calculations

Initial Geometry Calculations



Picked by measuring 6'3" Dom

Length Bar 2

$\cos 45 = \frac{x}{23}$

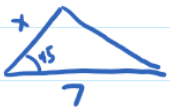
$23 \cos 45 = x$

≈ 16.25

≈ 16

length bar 1

Length Bar 3



$\cos 45 = \frac{x}{7}$

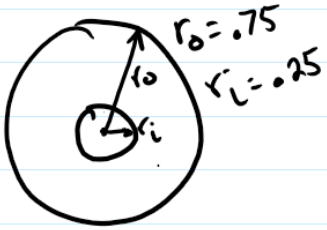
$7 \cos 45 = x$

$x = 5"$

Assumptions

Neglect Weight of Frame

Neglect Weight of Handlebars, other attached structures.

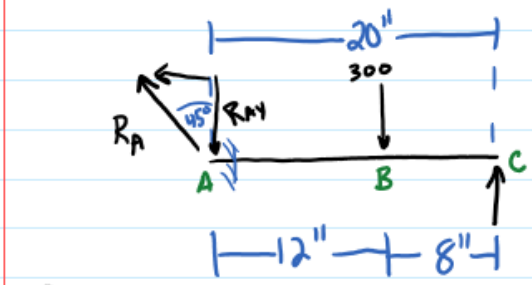


CROSS SECTION

* Aluminum Wrought 2024-T3

$S_{ult} = 70{,}000$ psi $S_{yld} = 50{,}000$ psi

Bar 1



$\Sigma F_y = 0$

$R_A - 300 + R_c = 0$

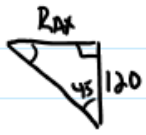
$R_A + R_c = 300$

$R_{A_y} = 1201b$

$\Sigma M_A = 0$

$-12(300) + 20(R_c) = 0$

$R_{C_y} = 1801b$



$\tan 45 = \frac{R_{AX}}{120}$

$120 \tan 45 = R_{AX}$

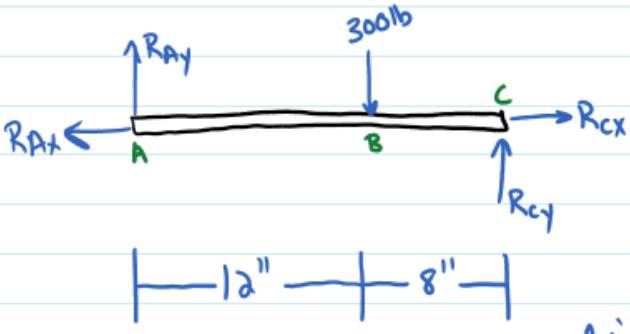
$R_{AX} = 120$

$\Sigma F_x = 0$

$-R_{AX} + R_{CX} = 0$

$120 = R_{CX}$

Failure Analysis

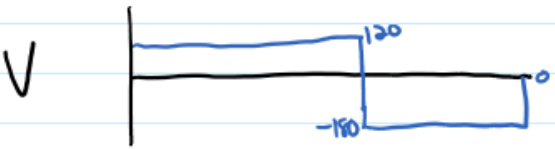


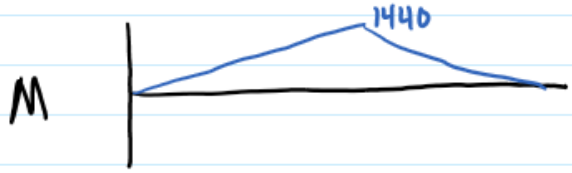
$R_{AY} = 1201b$

$R_{AX} = 1201b$

$R_{C_y} = 1801b$

$R_{CX} = 1201b$





Axial

$\sigma_{Ax_1} = \frac{F}{A} = \frac{F}{\pi(r_o - r_i)^2}$

$= \frac{120}{\pi(.75 - .25)^2} = 152.78$

Bending

$\sigma_{Bend_1} = \frac{Mc}{I} = \frac{Mc}{\frac{\pi}{4}(r_o^4 - r_i^4)}$

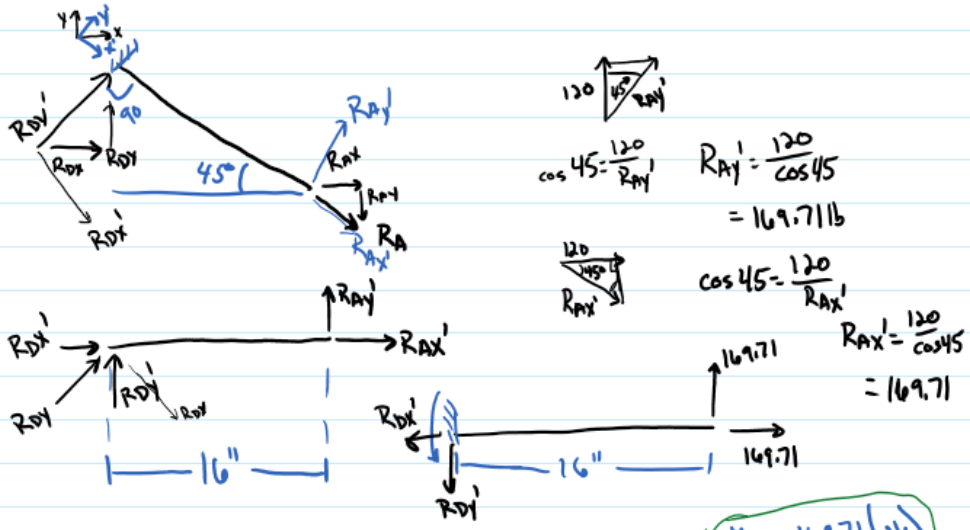
$= \frac{1440(.75)}{\frac{\pi}{4}(.75^4 - .25^4)} = 4400psi$

$\sigma_{Tot_1} = 4552.78\ psi$

$3 \times F.O.S \rightarrow 13658.34\ psi$

No Yielding Predicted

Bar 2



$M_D = 169.71(16)$
$= 2715.36$

$\Sigma F_x' = 0$

$-R_{DX}' + 169.71 = 0$

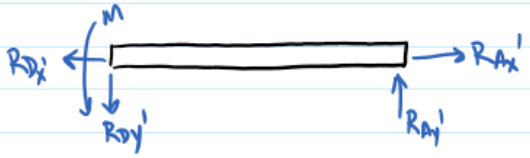
$R_{DX}' = 169.71$ lb

$\Sigma F_y' = 0$

$-R_{DY}' + 169.71 = 0$

$R_{DY}' = 169.71$ lb

Failure Analysis



$R_{AX}' = 169.71$
$R_{AY}' = 169.71$
$R_{DX}' = 169.71$
$R_{DY}' = 169.71$

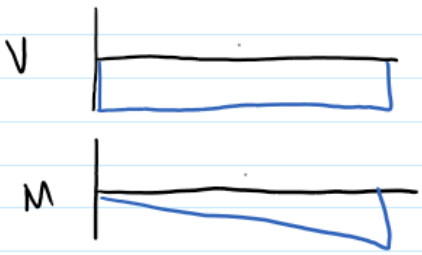
$M_D = 2715.36$

16"

Axial

$\sigma_{AX_2} = \frac{F}{\pi(r_o - r_i)^2} = \frac{169.71}{\pi(.75-.25)^2}$

$= 216.08$ psi



Bending

$\sigma_{Bend_2} = \frac{Mc}{I} = \frac{M(.75)}{\frac{\pi}{4}(.75^4 - .25^4)}$

$= \frac{2715.36(.75)}{\frac{\pi}{4}(.75^4 - .25^4)} = 8297.53$

$\sigma_{Tot_2} = 216.08 + 8297.53$

$= 8513.61$ psi

$3 \times$ F.O.S $\longrightarrow$ 25,540.83 psi No yielding Predicted

Bar 3

$\Sigma F_x' = 0$

$-R_{Dx}' + R_{Ex}' = 0$

$R_{Ex}' = R_{Dx}'$

$= 169.71$ lb

$\Sigma F_y' = 0$

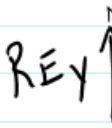
$R_{Dy}' - R_{Ey}' = 0$

$R_{Ey}' = R_{Dy}'$

$= 169.71$ lb

$M_E = 2715 + 169.71(5)$

$= 3563.55$



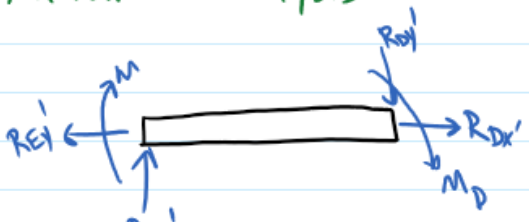
$\cos 45 = \frac{169.71}{R_{Ey}}$

$R_{Ey} = 240$

$\cos 45 = \frac{169.7}{R_{Ex}}$

$R_{Ex} = 240$

Failure Analysis



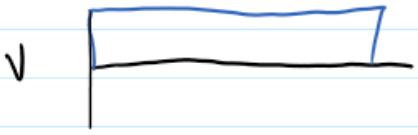
$R_{Dx}' = 169.71$

$R_{Dy}' = 169.71$

$R_{Ex}' = 169.71$

$R_{Ey}' = 169.71$

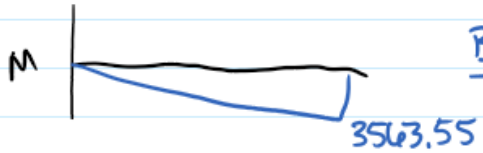
$M_D = 2715.36$



Axial

$\sigma_{Axial_3} = \frac{F}{\pi(r_o - r_i)^2} = \frac{169.71}{\pi(.75-.25)^2}$

$= 216.08$ psi



Bending

$\sigma_{Bend_3} = \frac{3563.55(.75)}{\frac{\pi}{4}(.75^4 - .25^4)}$

$= 10889.41$ psi

$\sigma_{Tot3} = 216.08 + 10889.41$

$= 11105.49$

3x F.O.S $\longrightarrow$ 33,316.47 psi No yielding Predicted

Change of Frame Cross Section to make Lighter and Decrease Cost

Change Cross Section for Lightening Purposes

$r_o = .75$

$r_i = .5625$

Bar 1

$$\sigma_{Bend} = \frac{1440(.75)}{\frac{\pi}{4}(.75^4 - .5625^4)} = 6357.56 \text{ psi}$$

$$\sigma_{axial} = \frac{120}{\pi(.75^2 - .5625^2)} = 155.21 \text{ psi}$$

$\sigma_{Tot} = 6512.77$ psi

$3 \times F.O.S = 19,538.31$

Bar 2

$$\sigma_{Bend} = \frac{2715.36(.75)}{\frac{\pi}{4}(.75^4 - .5625^4)} = 11,988.25$$

$$\sigma_{axial} = \frac{169.71}{\pi(.75^2 - .5625^2)} = 219.51$$

$\sigma_{Tot} = 12,207.76$

$3 \times F.O.S = 36,623.28$

Bar 3

$$\sigma_{Bend} = \frac{3563.55(.75)}{\pi/4\,(.75^4 - .5625^4)} = 15732.98$$

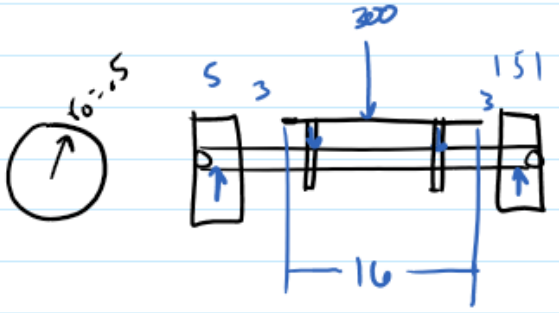
$$\sigma_{axial} = \frac{169.71}{\pi(.75^2 - .5625^2)} = 219.51$$

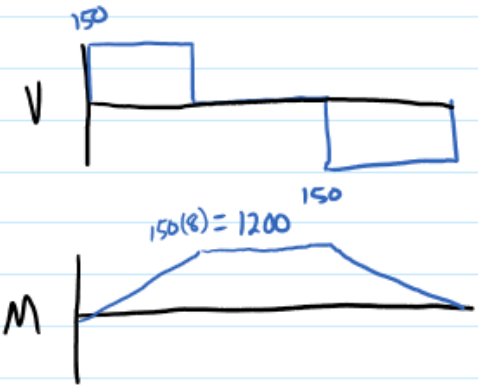
$\sigma_{Tot} = 15,952.49$

$3 \times F.O.S = 47,857.47$

Rear Axle Calculations

Rear Axle

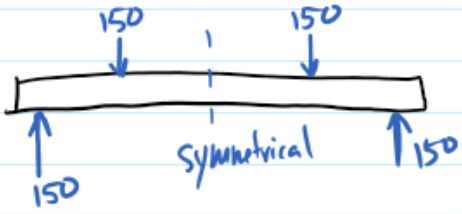




No applied torque, wheel is free spinning.

8 — 16 — 8

32"



125 125

8 — 16 — 8

$\sigma = \frac{Mc}{I} = \frac{1200(.5)}{\frac{\pi}{4}(.5)^4}$

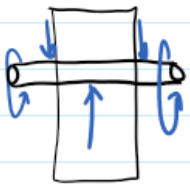
$\sigma = 12,223.099$

$3 \times F.O.S \rightarrow 36,669.298 psi$

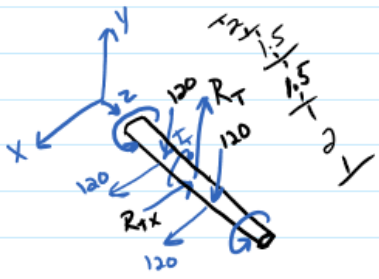
No yielding Predicted

Front Axle Calculations

Front Axle



2" + 3" + 2"



Because of Symmetry

$R_{Tx} = 240lb$

$R_{Ty} = 240lb$

$T_{pedal} = 2,022 in \cdot lb$

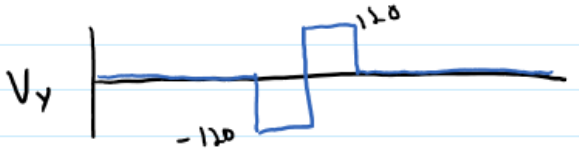
$\Sigma T = 0$

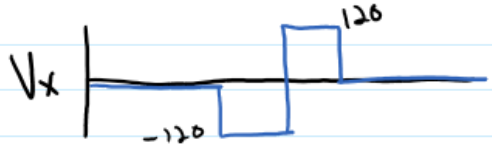
$2T_{pedal} - T_{tire} = 0$

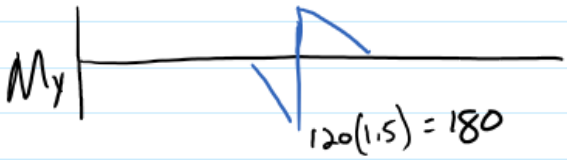
$T_{tire} = 2T_{pedal}$

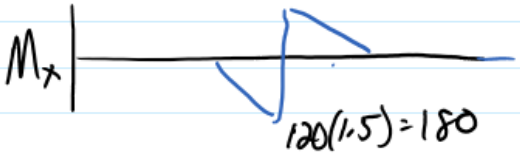
$T_{tire} = 4,044 in \cdot lb$

$\tau = \frac{Tc}{J} = \frac{2022(.5)}{\frac{\pi(.5)^4}{2}} = 20595.92$







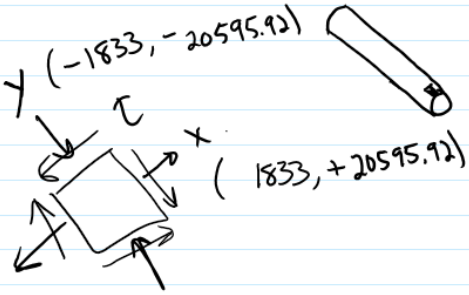


$M = \sqrt{180^2 + 180^2} = 254.56 in \cdot lb$

$\sigma = \frac{254.56(.5)}{\frac{\pi}{4}(.5)^4} = 2592.93 psi$

$\sigma_x = \frac{180(.5)}{\frac{\pi}{4}(.5)^4} = 1833.47 psi$

$\sigma_y = \frac{180(.5)}{\frac{\pi}{4}(.5)^4} = 1833.47 psi$

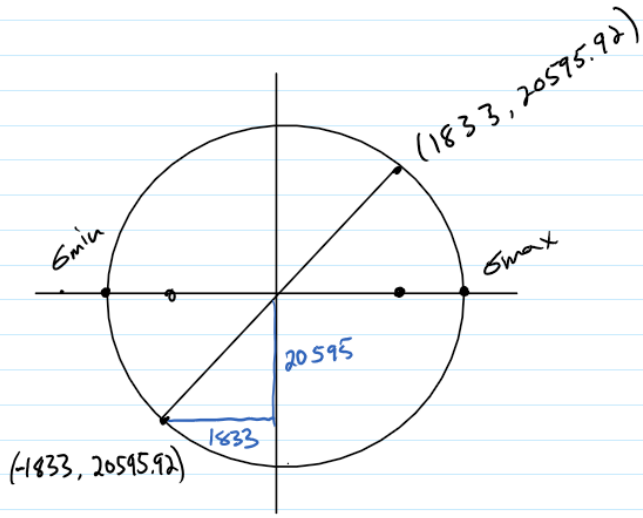


x dist to center = 1833

$\sqrt{1833^2 + 20595^2} = r$

$r = 20,676.4096 \text{ psi}$

$\sigma_{max} = 20,676.4096$



$$V.M. = \sqrt{20,676.4096^2 + 3\left(20595.92^2\right)}$$

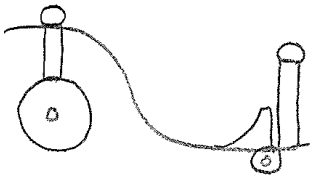
$$= 41,232.14372$$

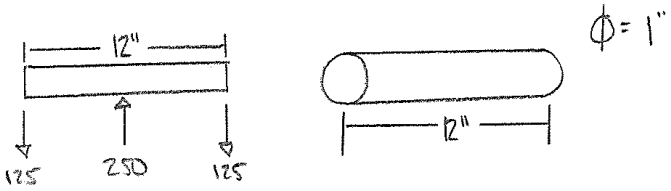
$3\times$ F.O.S $= 123,696.43$ psi

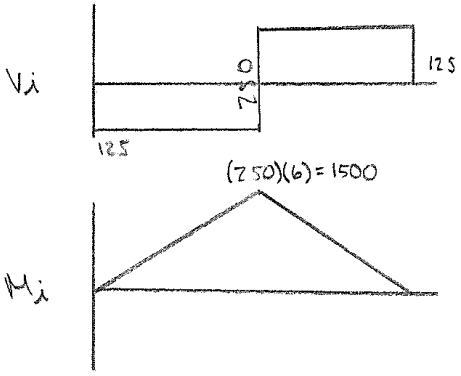
Appendix D - Clayton Schultz Calculations

Handlebar Calculations

Handlebars







$$\sigma = \frac{Mc}{I} = \frac{(1500)(.5)}{\frac{\pi(.5)^4}{4}} = 15278.9 \text{ psi}$$

$$\sigma \cdot 3 \text{ F.O.S.} = (15278.9)(3) = 45836.6 \text{ psi}$$

Aluminum Wrought

$S_{ult} = 70,000$

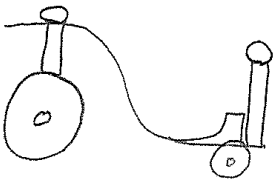
$S_{yld} = 50,000$

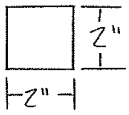
no yielding

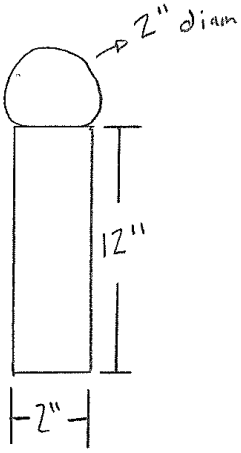
Trailer Hitch Calculations

Hitch

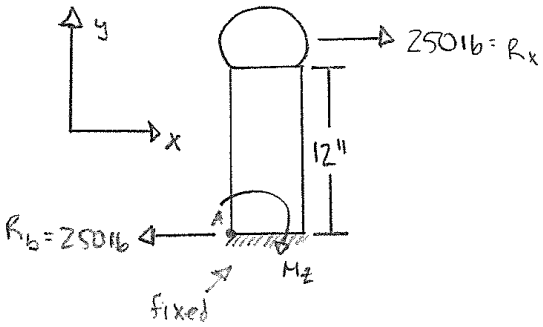
Max weight carry = 1501b

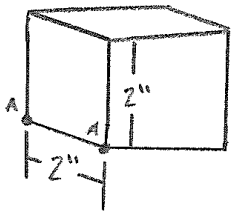






*Neglect forces from hitch on extension (contact.)

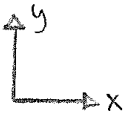


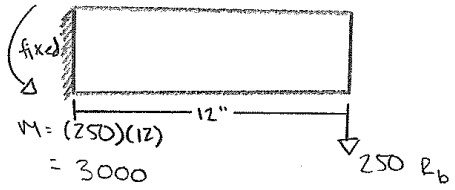


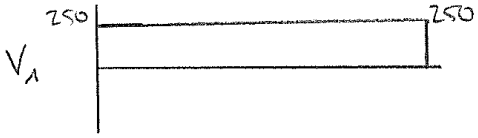
$M_z = (750\,lb)(12\,in) = 3000\,in\,lb$

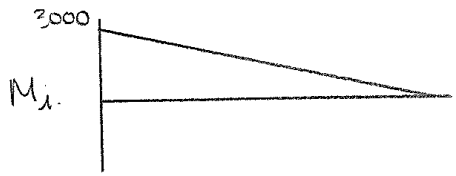
$\sigma = \frac{Mc}{I} = \frac{(3000\,in\,lb)(1\,in)}{\frac{(2\,in)(2\,in)^3}{12}} = 2,250\,psi$

$\sigma\ 3\ F.O.S = (2,250)(3) = 6,750\,psi$







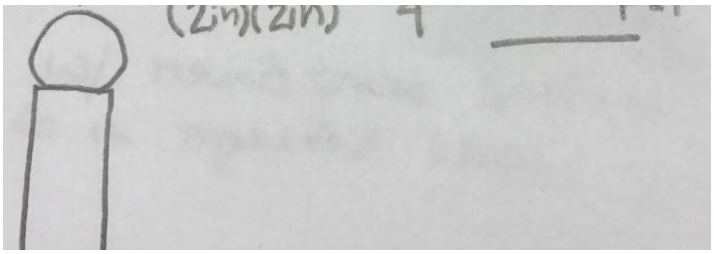


Aluminum Wrought

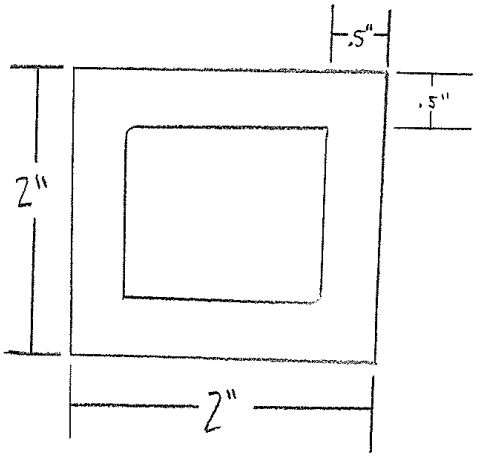
$S_{ult} = 70,000$

$S_{yld} = 50,000$

no yielding



Hollow Hitch (Optimized)



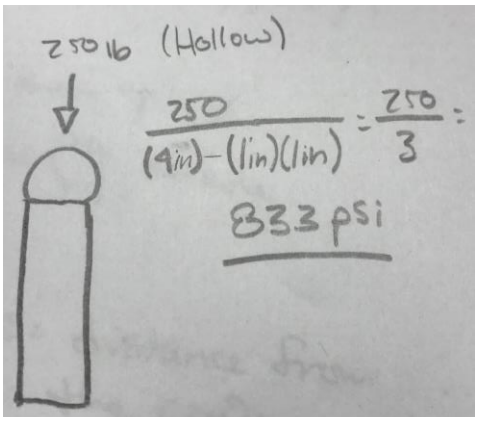
$$\sigma = \frac{Mc}{I} = \frac{(3000)(1.75)}{\frac{(2)(2^3)}{12} - \frac{(1)(1^3)}{12}} = 4200 \text{ psi}$$

$\sigma \cdot 3$ F.O.S. $= (4200)(3) = 12{,}600$ psi

Aluminum Wrought

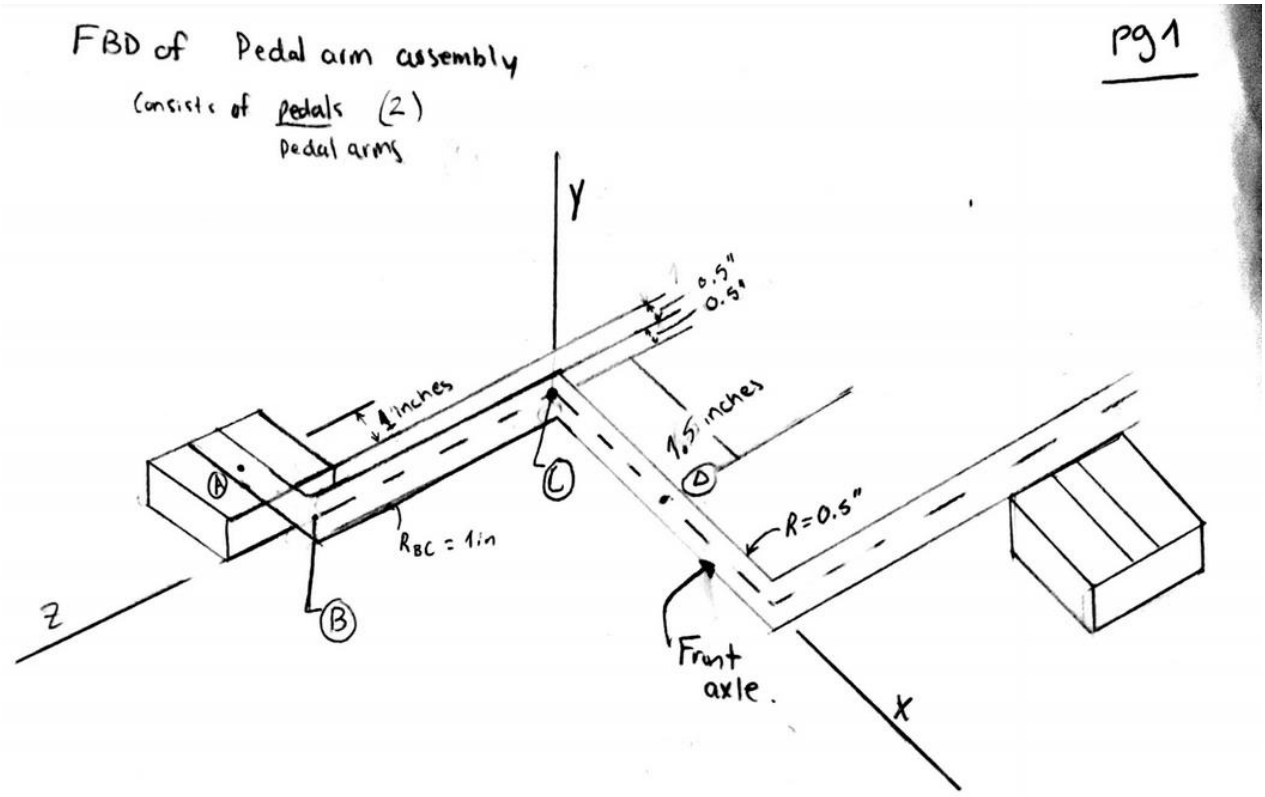
$S_{ult} = 70{,}000$

$S_{yld} = 50{,}000$


2501b (Hollow)
250
(4in)-(1in)(1in)
= 250/3 =
833 psi

Appendix E - Ian Villaroman Calculations

Pedal and arm



Pedal Specifications

Material : Steel 1095

2 inch by 2 inch

Thick : 2 inch

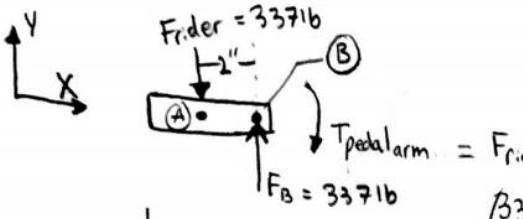
To find torque of pedal

$T_{pedal} = (F_{rider})(Distance)$

$= (337 lb)(2" + 2" + 1.5")$

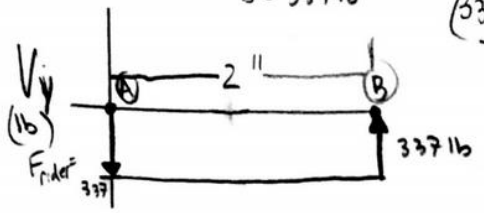
$T_{pedal} = 1853.5$ in·lb

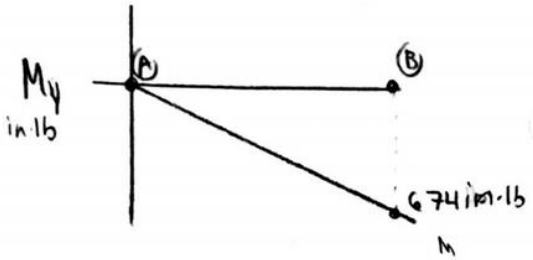
FBD of a Pedal set 1



$T_{pedal\,arm} = F_{rider} \cdot (Distance)$

$(3371b \cdot 2") \rightarrow 674\,in\cdot lb$





$\sum F_y = 0$

$\sum F_y = -F_{rider} + F_B = 0$

$F_{rider} = F_B \rightarrow F_B = 3371b$

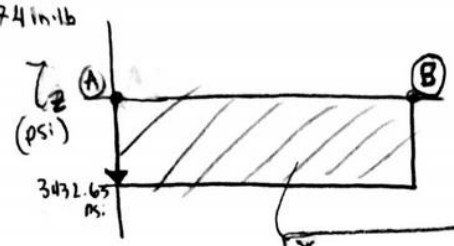
$F_{rider} = 3371b$

$r = \frac{1}{2} = 0.5$

Pg 2

$\tau_{AB} = \frac{T \cdot c}{J} = \frac{(674\,in\cdot lb) \cdot (0.5")}{\frac{\pi (0.5)^4}{2}}$

$\tau_{AB} = 3432.65\,psi$



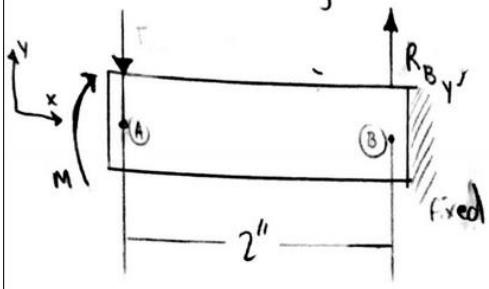
$\tau_{AB} = 3432.65\,psi$

Pedal (2) = SAME Repeated diagram.

Pedal arm assembly analysis of Pedals Set 2

Assume at B it is fixed and F_{rider} is uniform

FBD of A → B Bending



$F_{rider} = 337 lbs$

$\Sigma F_y = 0$

$\oplus\uparrow \quad \Sigma F_y = -337 lbs + R_{B_y} = 0$

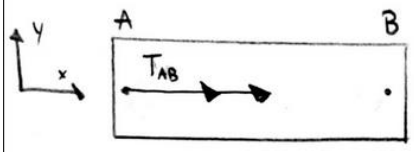
$\boxed{R_{B_y} = 337 lbs}$

$\circlearrowleft \quad \Sigma M = 0$

$M = (2 inches) \cdot (337 lbs) = 674 in\,lbs$

$M = 1011 in \cdot lbs$

FBD of A → B Twisting



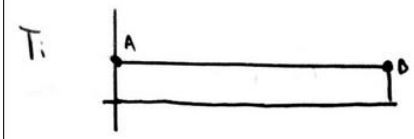
$T = (\text{Distance})(\text{Force})$

$T_{AB} = (2")(337 lb)$

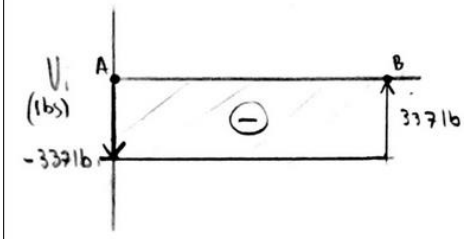
$T_{AB} = 674 in \cdot lbs$

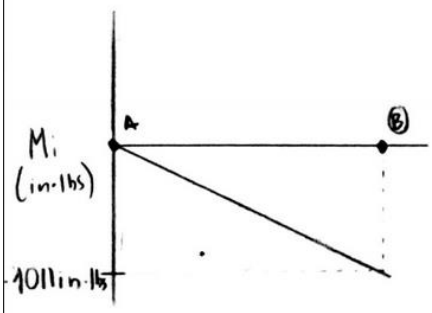
$\tau = \frac{Tc}{J} \rightarrow \frac{T \cdot c}{\frac{\pi r^4}{2}} = \frac{T_{AB} \cdot c}{\frac{\pi (r)^4}{2}}$

$\tau_{stress} = \frac{(1685 in \cdot lbs) \cdot (0.5")}{\frac{\pi \cdot (0.5")^4}{2}} \rightarrow 3432.$

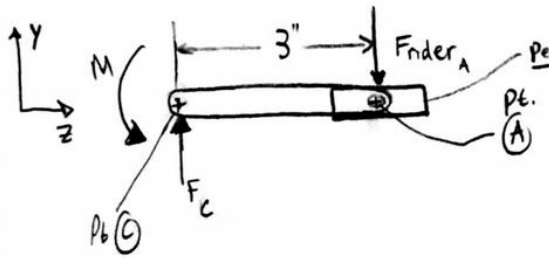


$\tau_{AB} = \frac{Tc}{J} \Rightarrow 3432.65 psi$





FBD of Pedal & Arm B-C (#1) Assume A, B, & C one piece



$\Sigma F_y = -F_{rider_A} + F_C = 0$

$F_{rider_A} = F_C$

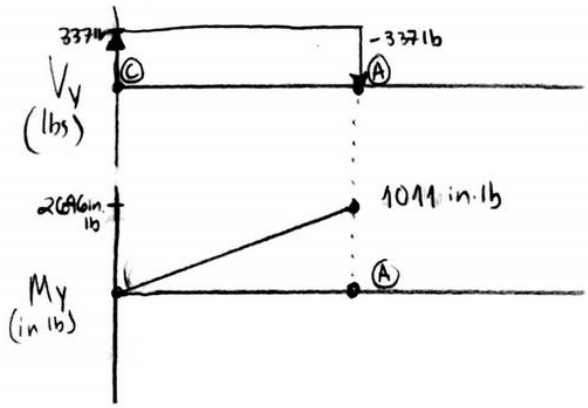
$F_C = 337lb$

$C = r$

$r = 0.5"$

$M_x = (\text{Distance})(\text{Force})$

$= (3")(337lb) \Rightarrow$ 1011 in·lb (A) Max bending moment.



M_x and M_y = 1011 in·lb ← max bending moment

$$M = \sqrt{M_x^2 + M_y^2}$$

$$= \sqrt{(1011)^2 + (1011)^2}$$

$$M = 1{,}429.77 \text{ in·lb}$$

$$\sigma = \frac{1{,}429.77 \text{ in·lb}\,(0.5)}{\frac{\pi\,(0.5)^4}{4}}$$

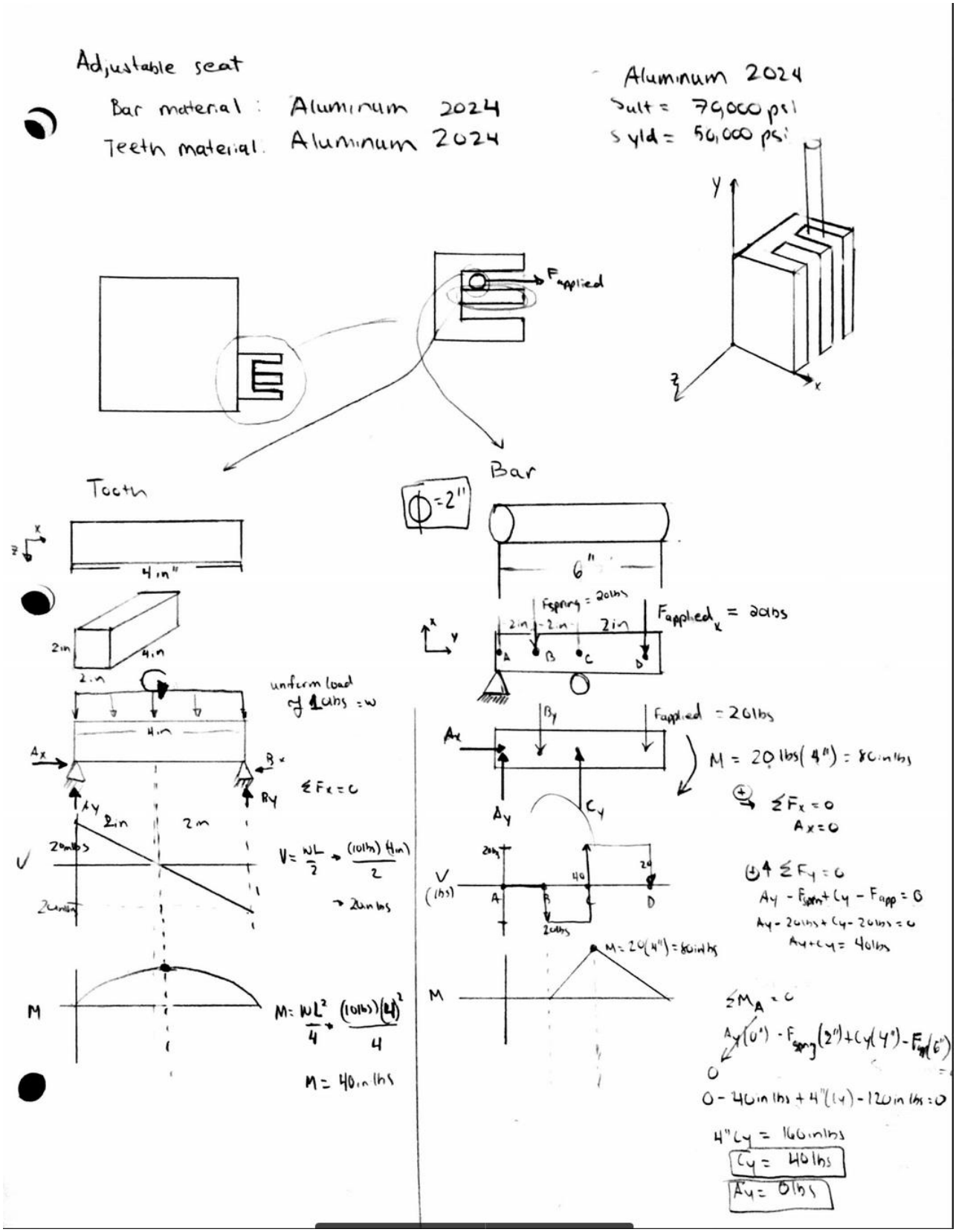
$$\sigma = 14{,}563.5 \text{ psi}$$

$$\frac{200{,}000}{14{,}563.5} = 13.73$$

$\sigma_{.3}^{FOS}$ = 43,690.6 psi No yielding predicted

(b) Note 2nd arm that accompanies pedal 2 has <u>same</u> <u>proces</u>

Adjustable seat mechanism



$I = \frac{b \cdot h^3}{12}$

Tooth 

$b = 2''$
$h = 2''$

$\sigma = \frac{Mc}{I} = \frac{(40\ in\ lbs)(1\ in)}{\frac{(2\ in)(2\ in)^3}{12}}$

$\sigma = 30\ psi$

$3 \cdot \sigma = FOS$

$3(30\ psi) = FOS$

$90\ psi = FOS$

$FOS = \frac{50,000}{90} = 555$

Material: 2024 aluminum

No yielding

$I = \frac{\pi r^4}{4}$

Bar

$\sigma = \frac{Mc}{I} \rightarrow \frac{(80\ in\ lbs)(r)}{\frac{\pi (1'')}{4}} = 101.859\ psi$ (r = 1")

$\sigma \cdot 3 = (FOS)$

$(101.859\ psi)\ 3 = (FOS)$

$305.577\ psi = FOS$

$FOS = \frac{50,000}{101.859} = 490.874$

Material: Aluminum 2024

No yielding