Hobie Cat Kayak

Group Members

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Advisors and Clients

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- <u>Client</u>
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    CEO Patriot Products
- <u>Project Sponsor</u>
  - The Ability Center of Toledo
  - National Science Foundation

What is the Hobie Cat Kayak?

The Hobie Cat Kayak is a non-traditional kayak powered by the Mirage Drive System.

- Foot powered propulsion system.
- More efficient than conventional paddles.
- Modeled from tuna fins and penguin flippers.
  - Foil Design

Project Description

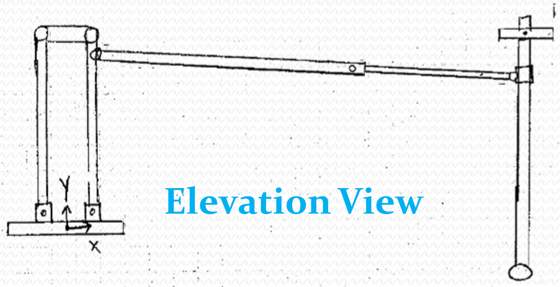
- Currently the kayak is not adaptable to individuals with limited or no use of their legs. Our focus is to transfer the user's arm motion to the Mirage Drive System.
- There are no products such as this on the market today.
- Our design centers around ease of use, simplicity, and keeping all functionality of the current Hobie Cat Kayak.
- Removal and installation of the device shall be as easy as for the Mirage Drive System.

Methodology

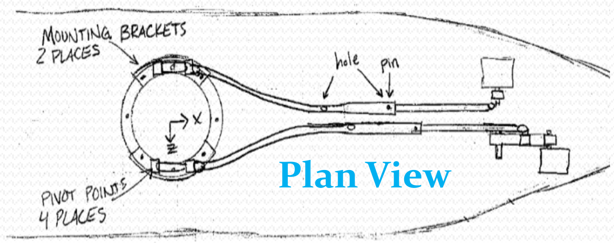
- Design Guidelines
  - Operated by arms while in a sitting position.
  - Device will be located between inner thighs.
  - Corrosion resistant.
  - Light weight.
  - Adjustable grip height and connecting rod length.
- Original Concepts
  - Two push pull rocker arms
  - Hand crank
  - Direct cables

Designs

1

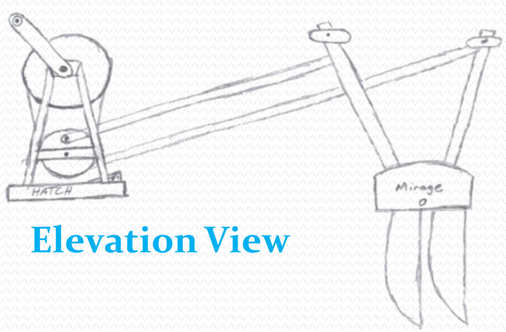


Elevation View

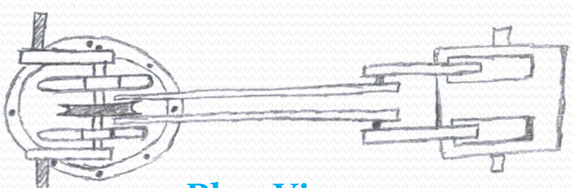


Plan View

2

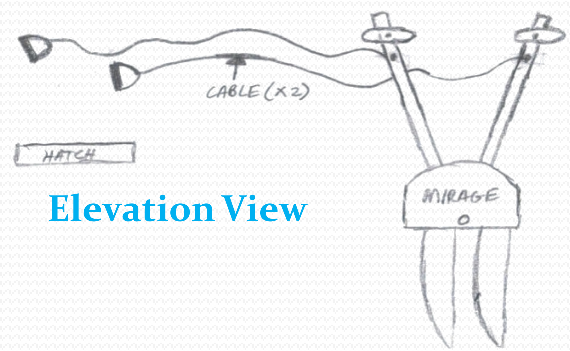


Elevation View

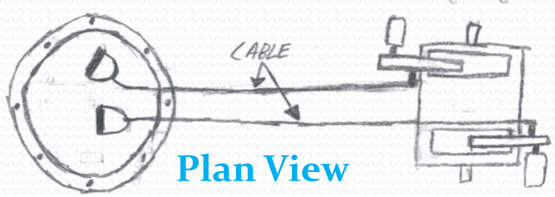


Plan View

3



Elevation View



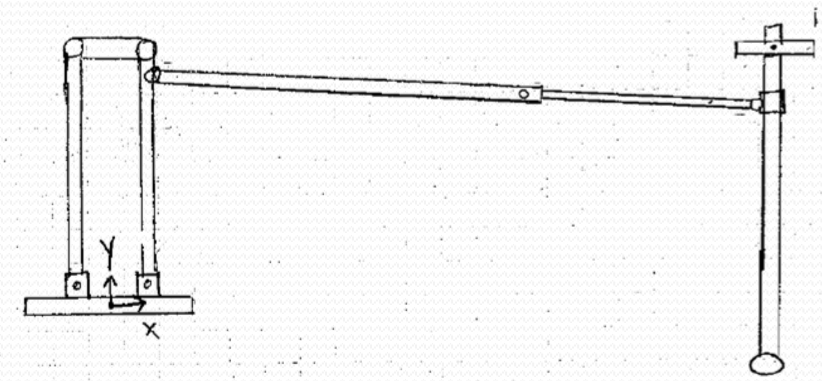
Plan View

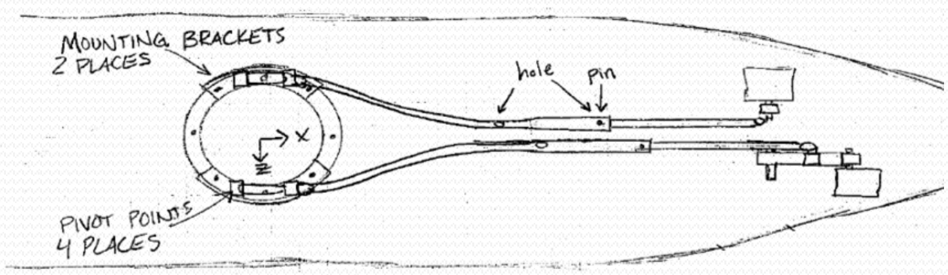
Initial House of Quality

	Importance	Rocker	Crank	Cable
Safety	5	4	4	5
Light Weight	4	4	3	5
Cost	3	4	3	5
Original Function	2	5	3	5
Ease of Use	4	5	3	3
Adaptable	5	5	4	1
Durable	5	4	3	4
Score		123	94	107

Selected Design

- Design 1
  - Allows for upper body to remain square with device, no rotation of spine required
  - Allows for use of hatch.
  - Allows for simultaneous use of rudder while in operation.
  - Lowers center of gravity, mounted closer to kayak hull.

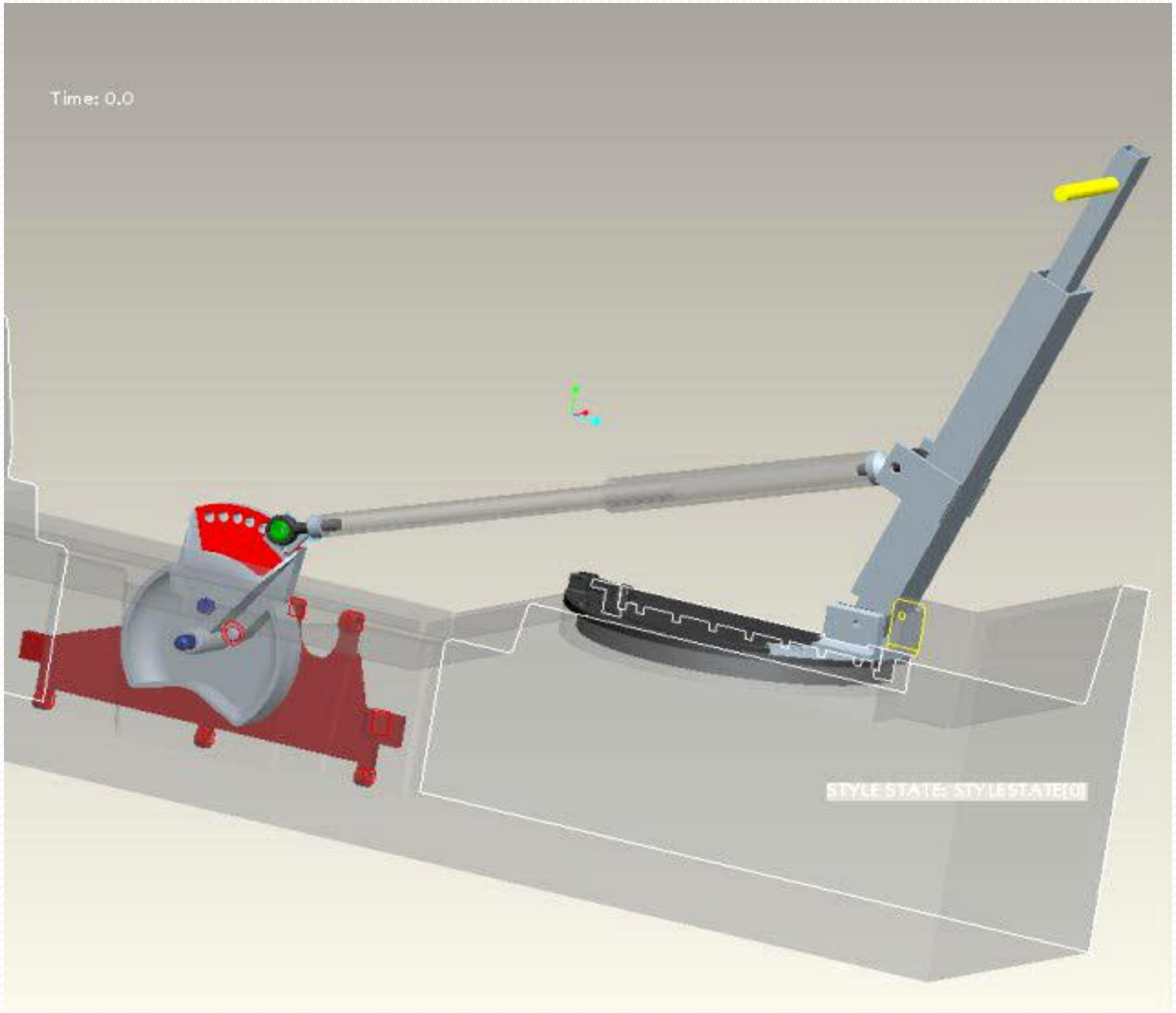




Customer Design Requirements

- Telescoping connecting rods.
- Telescoping rocker arms.
- Quick release mounts to Mirage Drive System and kayak hatch.
- Made from aluminum.
  - Mirage Drive supplier uses this currently on their product.
- Interchangeable handles for rocker arms to adapt to different users abilities.

Simulation Model



Second House of Quality

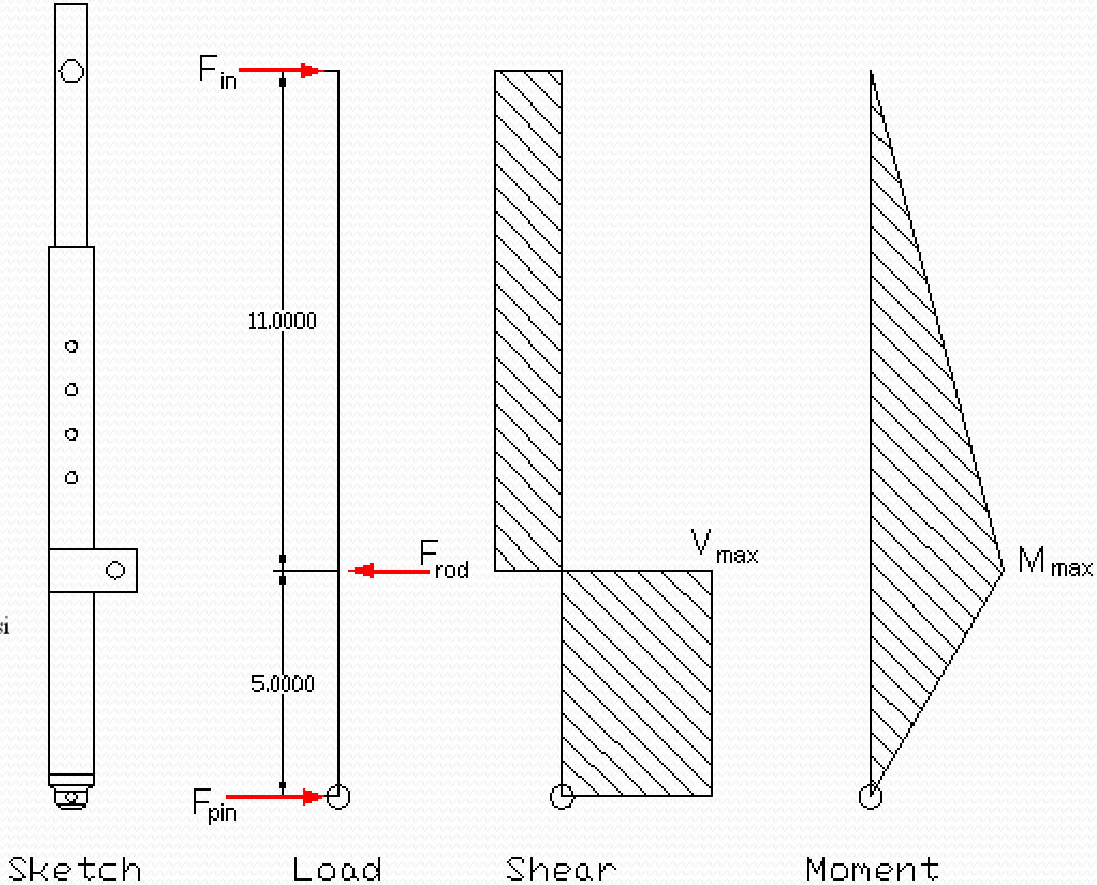
	Importance	Aluminum	Stainless Steel	Steel	High Strength Plastic
Safety	5	5	5	5	5
Light Weight	4	4	3	3	5
Cost	3	4	3	5	3
Weldability	3	4	5	5	0
Manufacturer's Use	5	5	0	0	5
Corrosion Resistant	5	4	4	2	5
Strength	5	4	4	5	3
Score		130	101	102	119

Zach Walker

Rocker Arm Calculations

Rocker Arm Stress

Cross sectional Area	$A_A := (1.5in)^2 - (1.25in)^2$
Moment of Inertia	$I_A := \frac{(1.5in)^4}{12} - \frac{(1.25in)^4}{12}$
Max Shear Force	$V_{maxA} := F_{pin} = 330 \cdot lbf$
Max Moment	$M_{maxA} := V_{maxA} \cdot 5in$
Shear Stress	$\tau_A := \frac{V_{maxA}}{A_A} = 480 \cdot psi$
Bending Stress	$\sigma_{bA} := \frac{(M_{maxA} \cdot .75in)}{I_A} = 5665.57 \cdot psi$
Combined Stress	$\sigma'_A := \sqrt{3\tau_A^2 + \sigma_{bA}^2} = 5726.25 \cdot psi$
Factor of Safety	$n_A := \frac{Sy_{alum}}{\sigma'_A} = 7.86$



Rocker Arm Bracket

Bearing Stress in Bracket at Pin

Projected Area $A_{proj} := D_{pin3} \cdot t_{plate} = 0.07 \cdot in^2$

Bearing Stress $\sigma_{brg} := \frac{0.5F_{rod}}{A_{proj}} = 3413.33 \cdot psi$

Factor of Safety $n_{brg} := \frac{Sy_{alum}}{\sigma_{brg}} = 13.18$

Bearing Stress in Bracket at Bolt

Projected Area $A_{proj} := D_{pin1} \cdot t_{plate} = 0.05 \cdot in^2$

Bearing Stress $\sigma_{brg} := \frac{F_{eq}}{A_{proj}} = 8746.78 \cdot psi$

Factor of Safety $n_{brg} := \frac{Sy_{alum}}{\sigma_{brg}} = 5.14$

Bolts Connecting Bracket to Rocker Arm

Bolt Area $A_{bolt} := \frac{\pi}{4} \cdot D_{pin1}^{\ 2}$

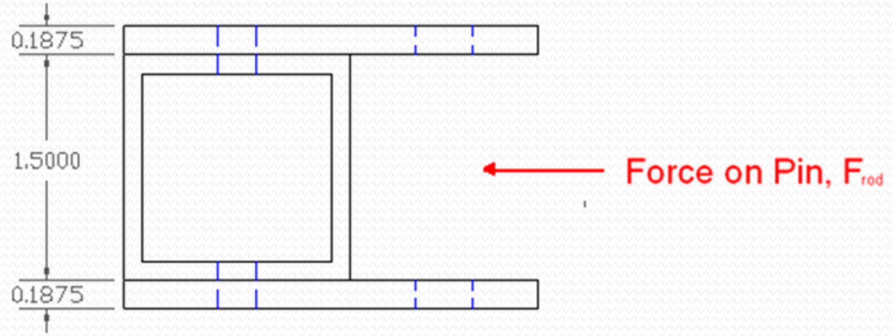
Normal Force $F' := \frac{F_{rod}}{2}$ $F'_x := F' \cdot \cos(\alpha)$ $F'_y := F' \cdot \sin(\alpha)$

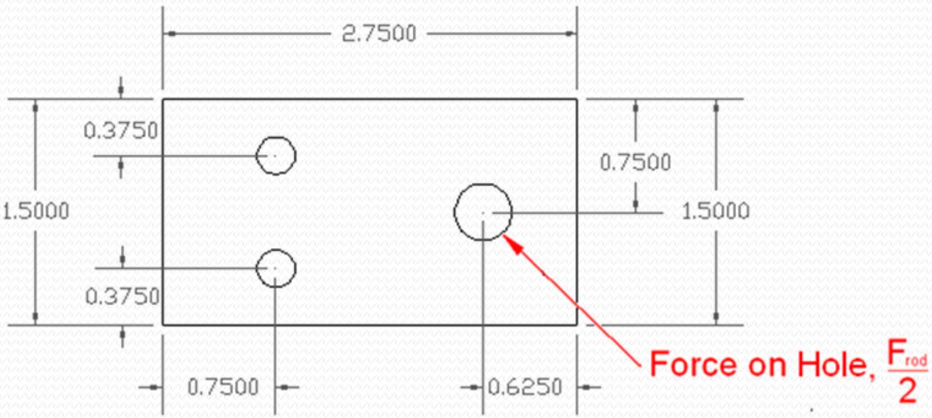
Force Due to Moment $F'' := \frac{1}{2} \cdot \frac{(F'_y \cdot 1.375in)}{.375in}$

Equivalent Force $F_{eq} := \sqrt{F'_y{}^2 + (F'' + F'_x)^2}$

Shear Stress $\tau_{bolt} := \frac{F_{eq}}{A_{bolt}} = 8352.56 \cdot psi$

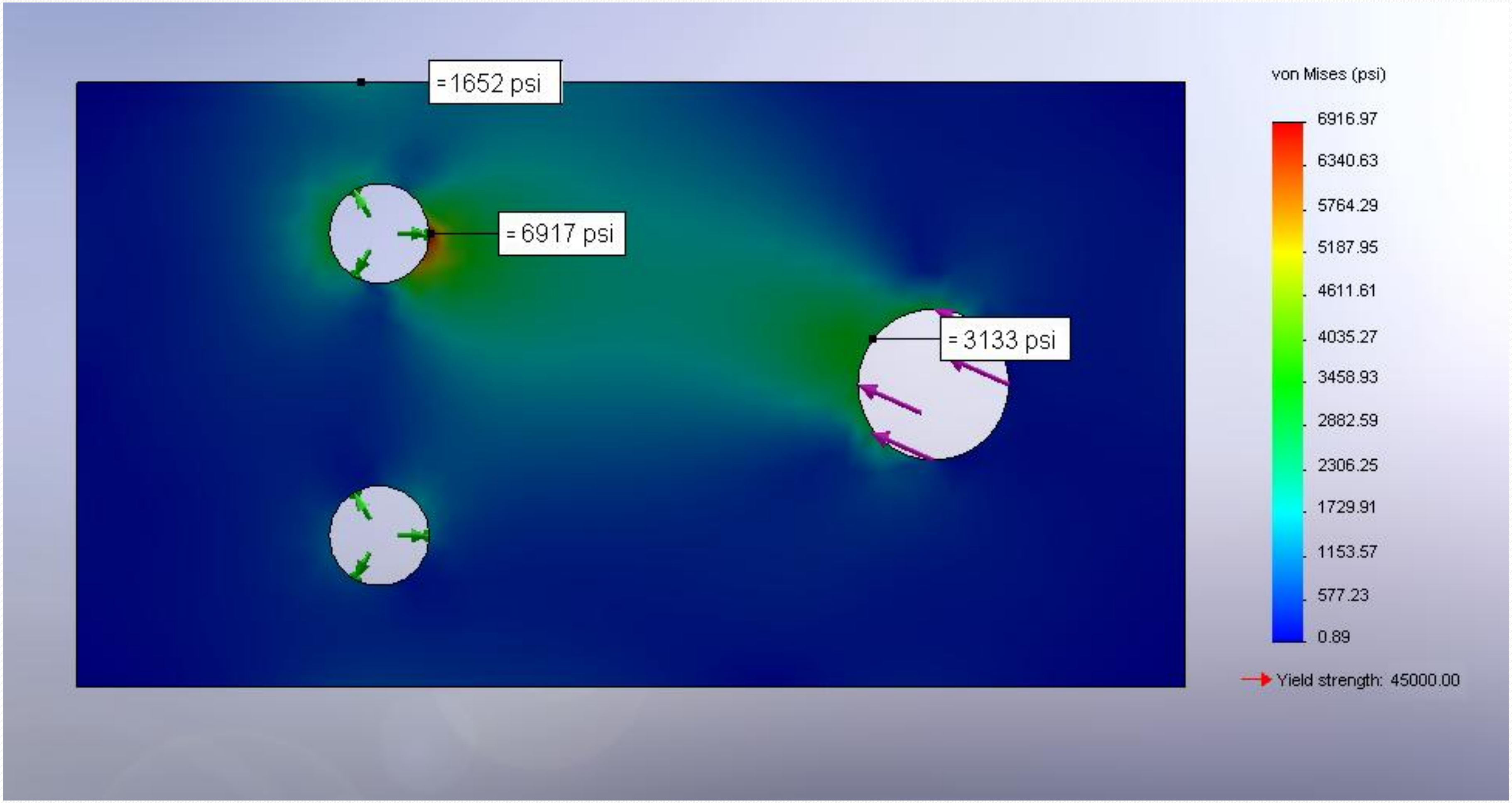
Factor of Safety $n_{bolt} := \frac{Ssy_{gr1}}{\tau_{bolt}} = 6.36$





Zach Walker

FEA on Rocker Arm Bracket

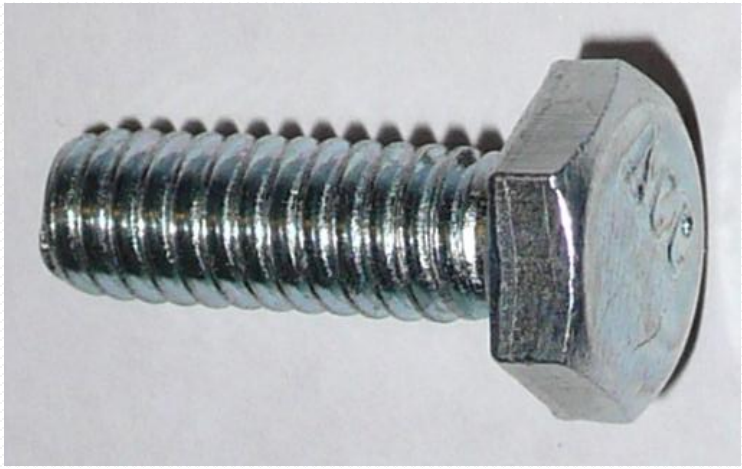


Zach Walker

Mirage Bolt and Pin Calculations

1/4" Bolts Connecting Bracket to Mirage Drive

Area	$A_{bolt} := \frac{\pi}{4} \cdot D_{pin1}^{\;2}$
Angle of Force	$\theta := 45deg$
Normal Force	$F' := \frac{F_{rod}}{2}$
Force Due to Moment	$F'' := \frac{1}{2} \cdot \frac{\left(F_{rod} \cdot \cos(\theta) \cdot 1in\right)}{.375in}$
Equivalent Force	$F_{eq} := \sqrt{F'_x{}^2 + \left(F'' + F'_y\right)^2}$
Shear Stress	$\tau_{bolt} := \frac{F_{eq}}{A_{bolt}} = 13139.437 \cdot psi$
Factor of Safety	$n_{bolt} := \frac{Ssy_{gr1}}{\tau_{bolt}} = 4.04$



3/8" Quick Release Pin

Area	$A_{pin} := \frac{\pi}{4} \cdot D_{pin3}^{\;2}$
Shear Stress	$\tau_{pin} := \frac{F_{rod}}{A_{pin}} = 4345.99 \cdot psi$
Factor of Safety	$n_{pin} := \frac{Ssy_{ss}}{\tau_{pin}} = 5.31$

Zach Walker

Connecting Rod Calculations

Connecting Rod Stress

Cross sectional Area $A_D := \frac{\pi}{4}\left[(1in)^2 - (.5in)^2\right]$

Moment of Inertia $I_D := \frac{\pi}{64}\cdot\left[(1in)^4 - (.5in)^4\right]$

Axial Stress $\sigma_D := \frac{F_{rod}}{A_D} = 814.87\cdot psi$

Factor of Safety $n_D := \frac{Sy_{alum}}{\sigma_D} = 55.22$

Critical Load for Buckling $P_{crD} := \frac{\pi^2\cdot E_{alum}\cdot I_D}{(20in)^2} = 11809\cdot lbf$

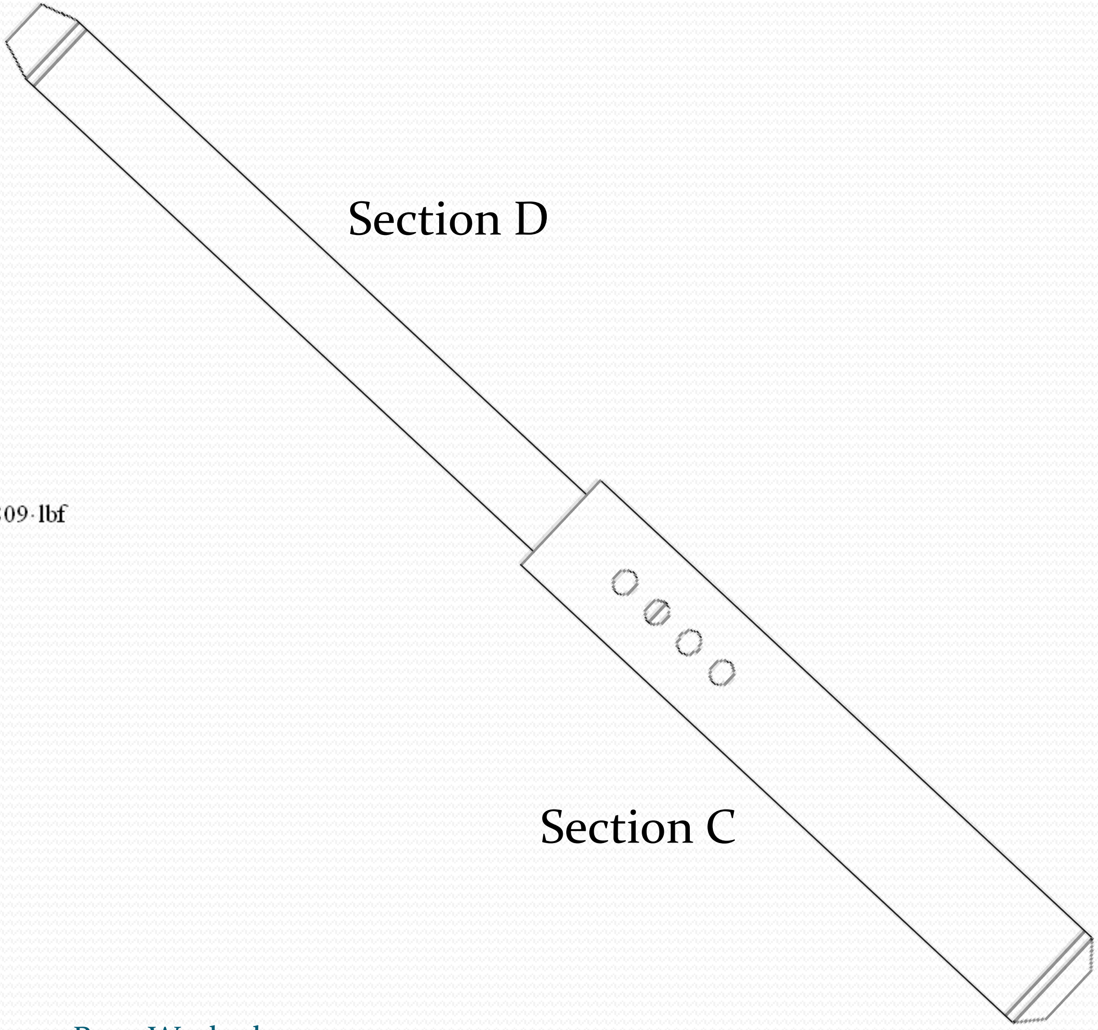
Factor of Safety $n_{crD} := \frac{P_{crD}}{F_{rod}} = 24.6$

Bearing Failure at Quick Release Pin

Projected Area $A_{CD} := D_{pin3}\cdot(1.3in - .5in)$

Bearing Stress $\sigma_{CD} := \frac{F_{rod}}{A_{CD}} = 1600\cdot psi$

Factor of Safety $n_{CD} := \frac{Sy_{alum}}{\sigma_{CD}} = 28.12$



Ryan Wackerly

Mirage Bracket Calculations

Stress in Bracket at Critical Point

Force on Bracket $F := F_{rod}$

Normal Stress $\sigma_n := \frac{F \cdot \sin(\theta)}{1.5in \cdot .1875in} = 1.21 \times 10^3 \cdot psi$

Shear Stress $\tau := \frac{F \cdot \cos(\theta)}{1.5in \cdot .1875in} = 1206.796 \cdot psi$

Bending Moment $M := F \cdot \cos(\theta)(1in)$

Bending Stress $\sigma_b := \frac{(M \cdot y)}{I} = 6604.2 \cdot psi$

Combined Stress at the Critical Point $\sigma' := \sqrt{3\tau^2 + (\sigma_n + \sigma_b)^2} = 8085.8 \cdot psi$

Factor of Safety $n_{brkt} := \frac{Sy_{alum}}{\sigma'} = 5.57$

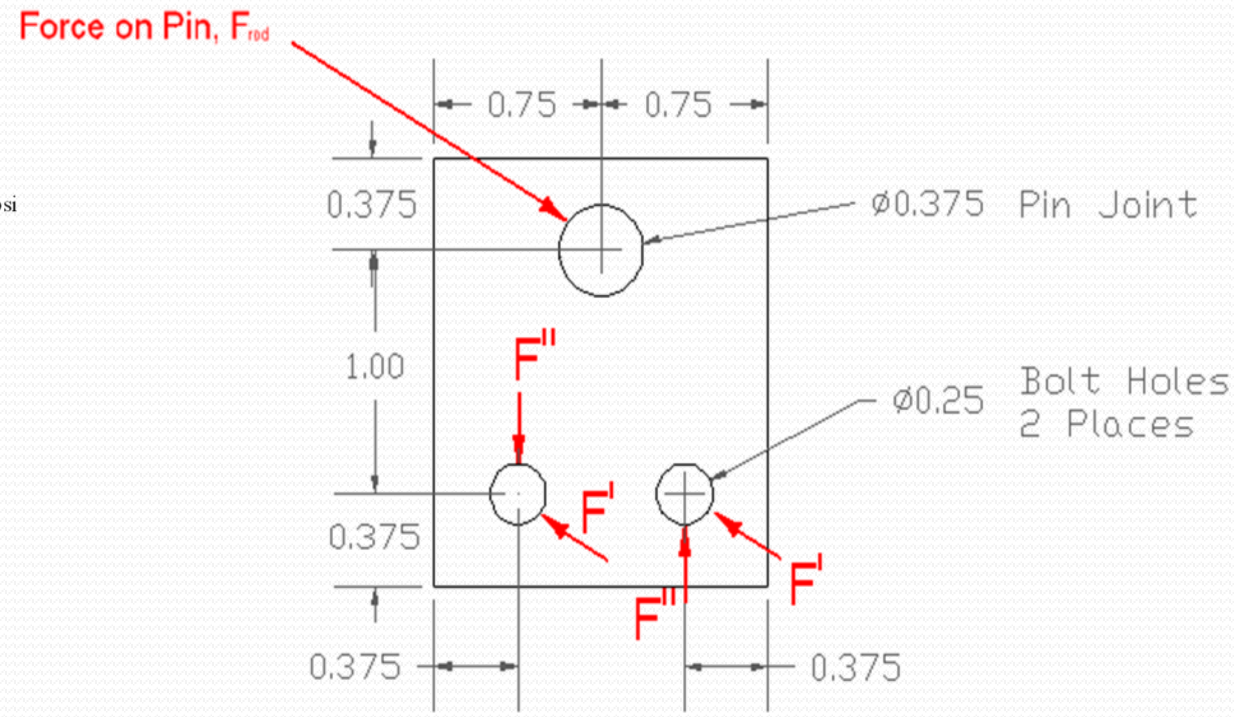
Bearing Stress in Bracket at Bolt Hole

Thickness $t_{plate} := \frac{3}{16} \cdot in$

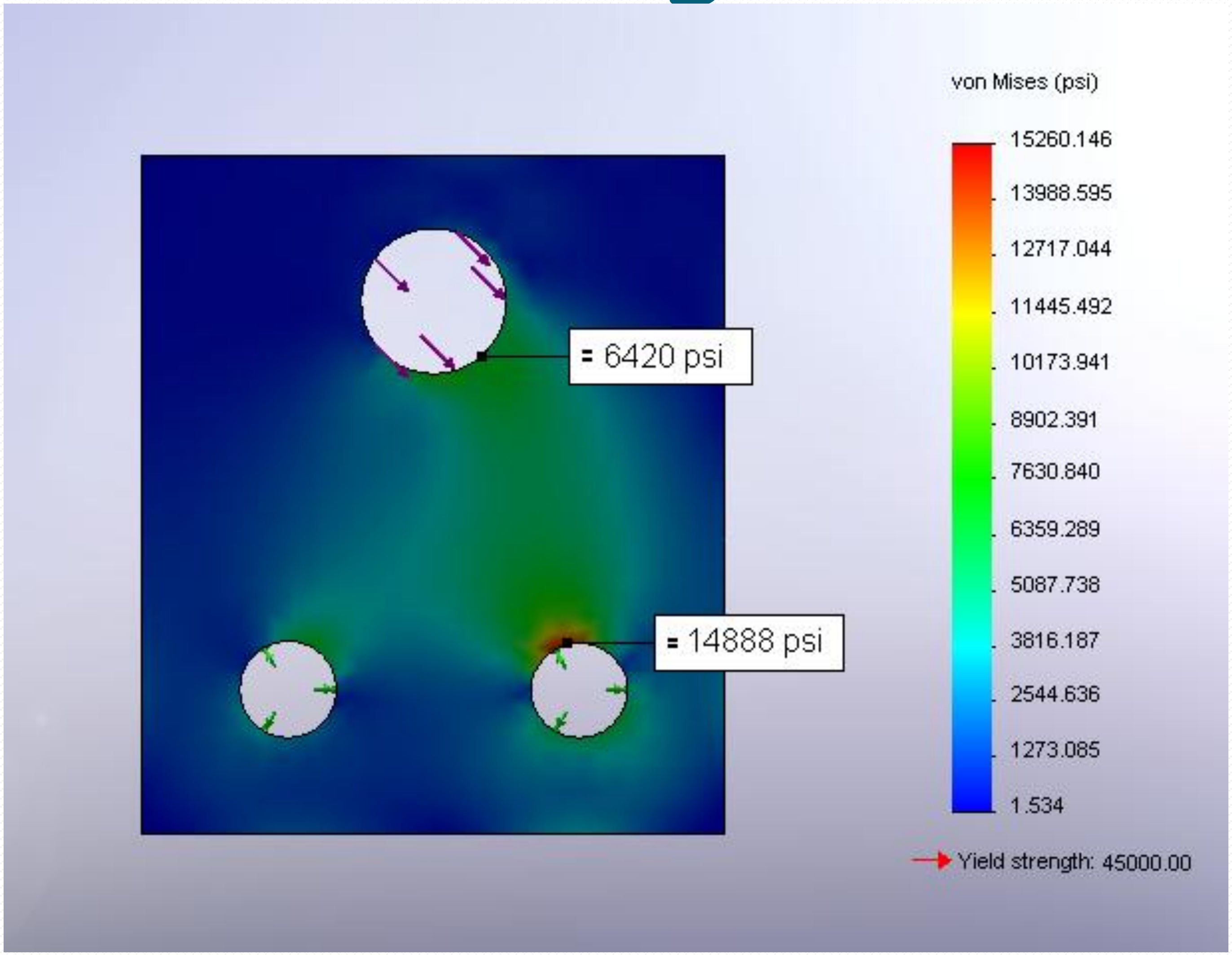
Projected Area $A_{proj} := D_{pin1} \cdot t_{plate} = 0.05 \cdot in^2$

Bearing Stress $\sigma_{brg} := \frac{F_{eq}}{A_{proj}} = 13759.59 \cdot psi$

Factor of Safety $n_{brg} := \frac{Sy_{alum}}{\sigma_{brg}} = 3.27$



FEA on Mirage Bracket



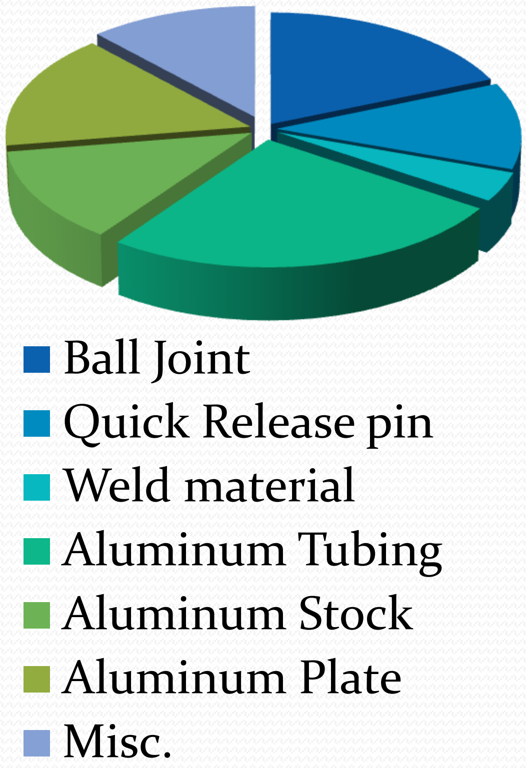
Work Plan & Project Deliverables

	January			February				March					April				May
	12	19	26	2	9	16	23	2	9	16	23	30	6	13	20	27	4
Establish Group																	
Assign Roles																	
Meet with Client																	
Meet with Client Advisors																	
Meet with Faculty Advisors																	
Brainstorming Sessions																	
Establish Multiple Designs																	
Design Selection																	
Proposal Presentation/Report																	
Design Modeling																	
Order Materials																	
Assemble/Test																	
Midterm Presentation/Report																	
Finished Product																	
Final Presentation/Report																	
Design Expo																	
NSF CD and Abstract																	
Evaluations/Final Paperwork																	

Ryan Wackerly

Budget

Aluminum Tubing	$87
Aluminum Plate	$53
Aluminum Stock	$43
Quick Release Pin	$40
ER 5356 Aluminum Welding Rods	$13
Ball Joint Ends	$63
Miscellaneous Items	$35
Travel	$182
Machining Costs	$65/hr
Total Cost of Project	$516



Questions

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