IAC Presentation

Rover Team 1

Pittsburg State University

COLLEGE OF TECHNOLOGY

Manufacturing/Design Project - Rover Team 1

Overview

Challenge

Design and build a human powered rover that can complete the NASA obstacle course in minimal time

Stakeholders

NASA

Benefits

We hope to create a rover that is as light as possible and durable enough to complete the course in minimal time

“The challenge will focus on designing, constructing and testing technologies for mobility devices to perform in these different environments, and it will provide valuable experiences that engage students in the technologies and concepts that will be needed in future exploration missions”

https://www.nasa.gov/roverchallenge/competition/index.html

Design Inputs

NASA Requirements

- Turning radius
- Ground clearance
- Collapsible – 5x5x5
- Width of assembled design
- Dust shield
- Seat belts
- Design/Manufacture our own wheels
- Safe to drive
- Human Powered

Our Constraints

- Overall Weight
- Center of gravity
- Support riders
- Must climb hills
- Maneuver crevasses

Frame Design

Concept

- Light weight triangular design for structural stability

Material

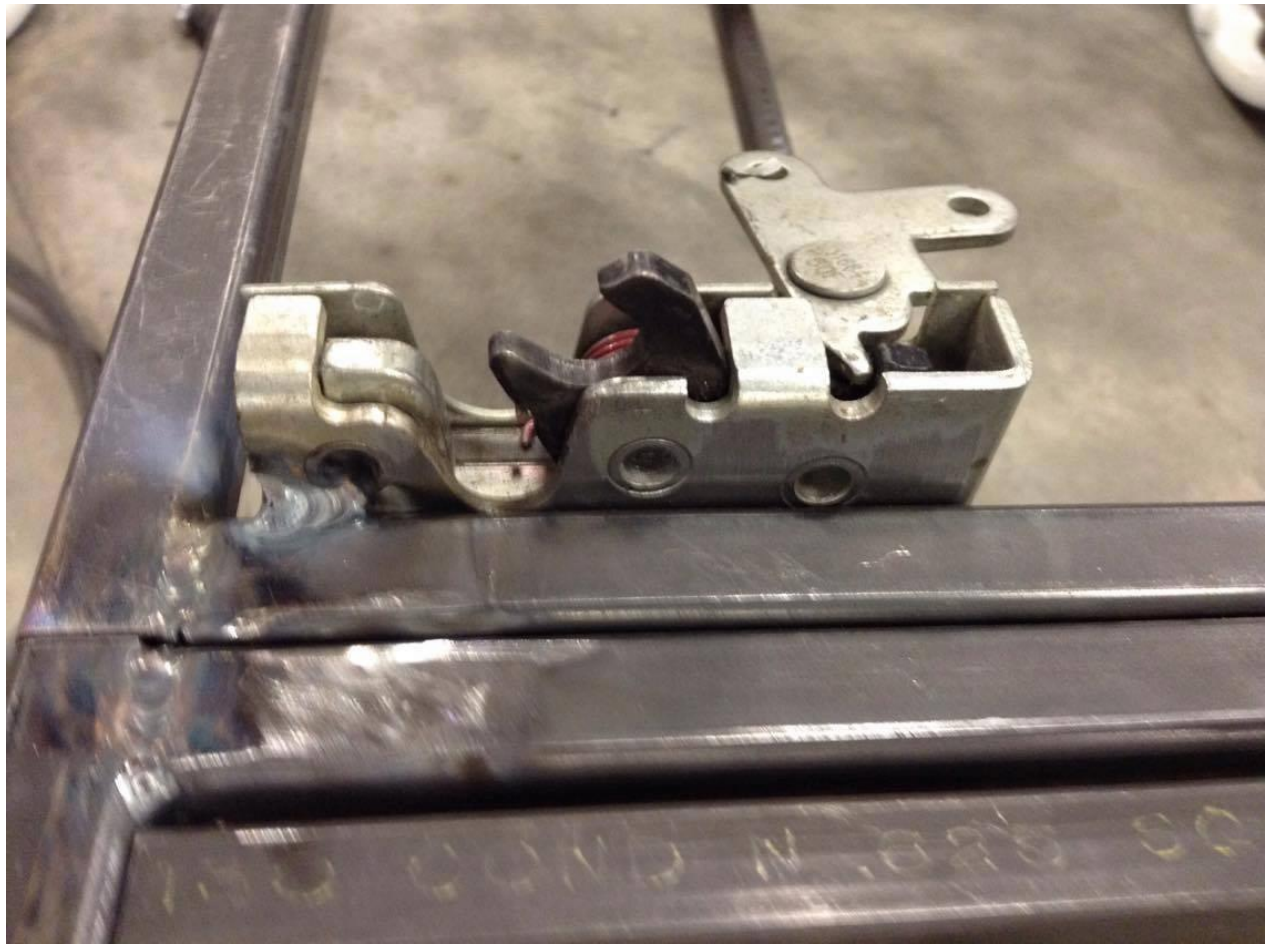
- Square-cut steel tubing
- ¾” thick

Manufacturing

- Cut tubing on band saw
- Tig welded pieces together
- Hinge: Ordered part welded on
- Quik Latches fasten frame halves

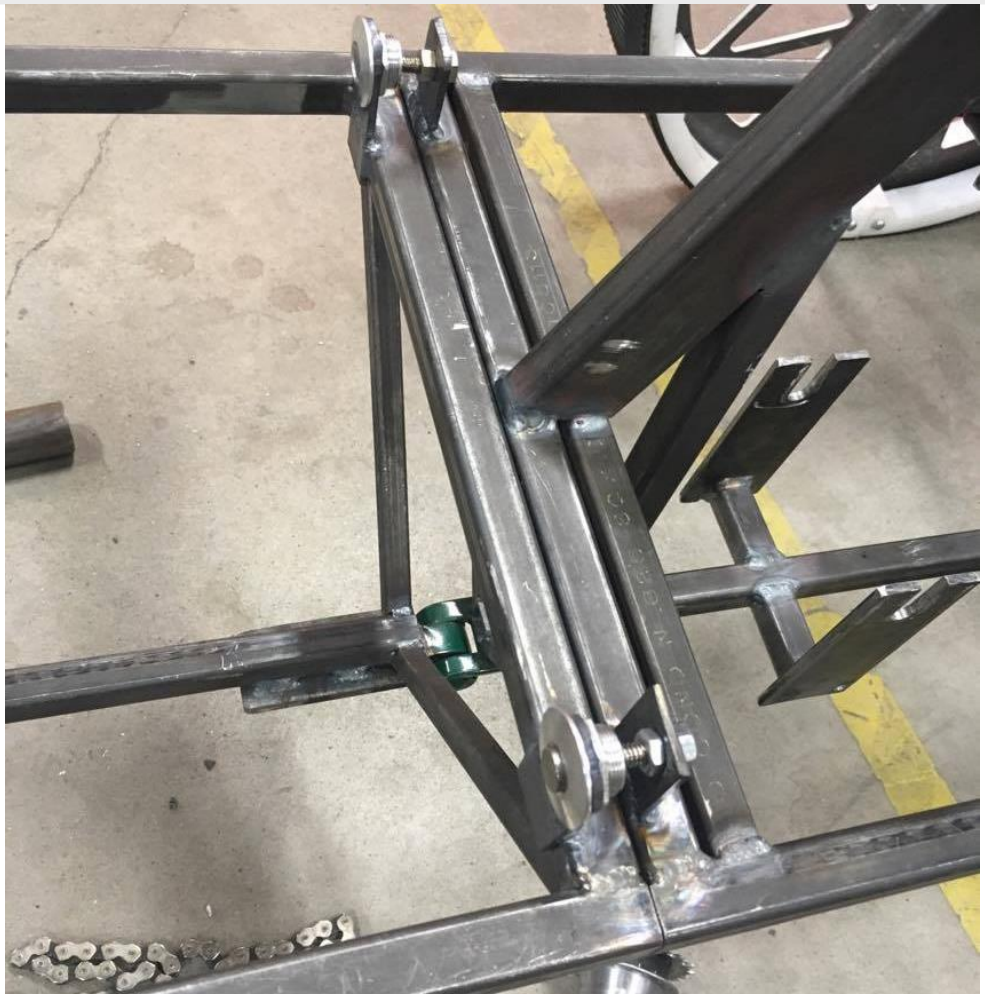
First Latch Attempt

- Tig welded to frame
- Latch did not hold the frame together



Quik Latches

- Donated latches
- Tig welded to frame
- Light weight and easy to use



Rear Suspension

Leaf Spring Design

- Light weight easy assembly
- Grade A stainless steel springs

Manufacturing

- Tig welded shackles to frame
- Cut holes in leaves for bearing housing assembly
- Used scrap aluminum for bearing housings
- Bolted assembly together

Steering & Front End Suspension

Independent Suspension

- A-Frame material: ¾” Plain Carbon Steel 0.083”
- Steering knuckle: modified from last year’s rover
- Steering controlled from front

Front End Suspension

Manufacturing front suspension components

- Used a tubing bender to get accurate angles
- Tig welded
- Heims ends for easy adjustment
- Tabs cut on water jet
- Used scrap HDPE for bushings

Wheels/Axle

Wheel Design

- 3/16” aluminum plate center
- 26in diameter
- 4in wide to go over cracks
- HDPE spacers for width
- Timing belt for tread, mechanically fastened on

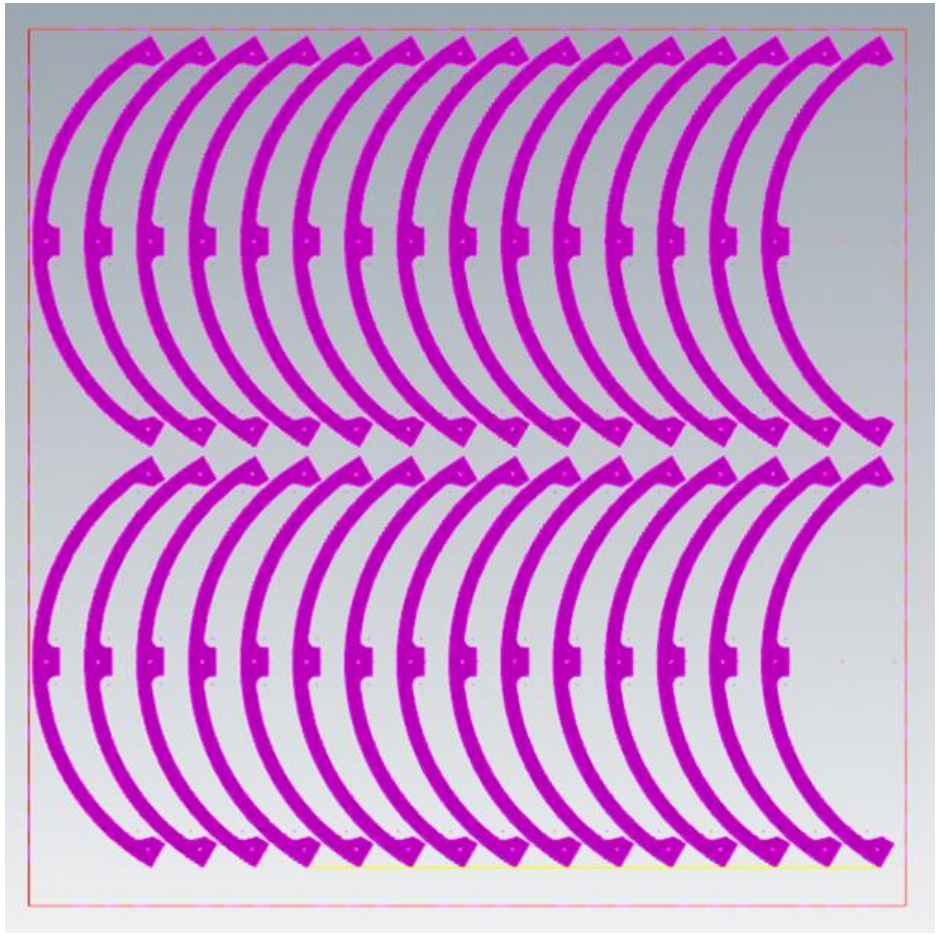
Axles

- 0.100” 4130 chromoly tubing
- ¾” and 1” diameter in the front, 1” in the rear

Wheels Design

Manufacturing

- HDPE sections cut on water jet
- Aluminum centers and hubs cut on water jet
- Holes drilled out for hub assembly



Wheels/Axle

Manufacturing

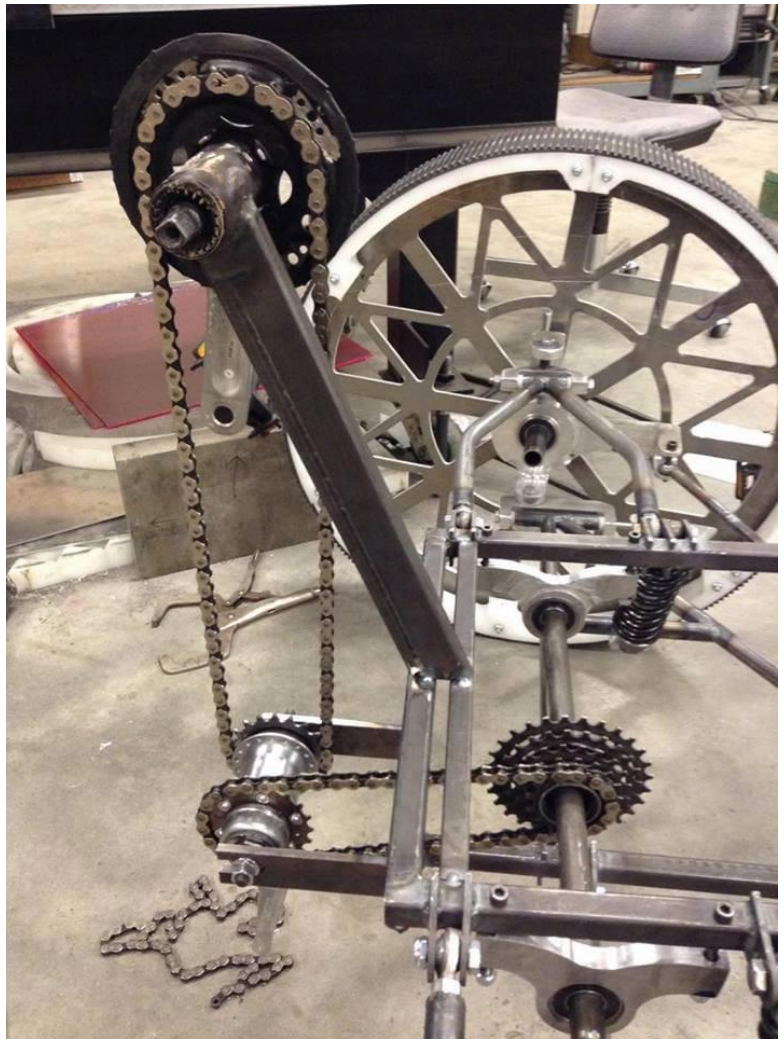
- Our hubs had less than .005” runout
- The hub was then TIG welded to the axle

Dust Shields

- Cut on Water Jet
- Yellow half of split face glued in place
- Heat element used to bend plastic to shape

Drive Train

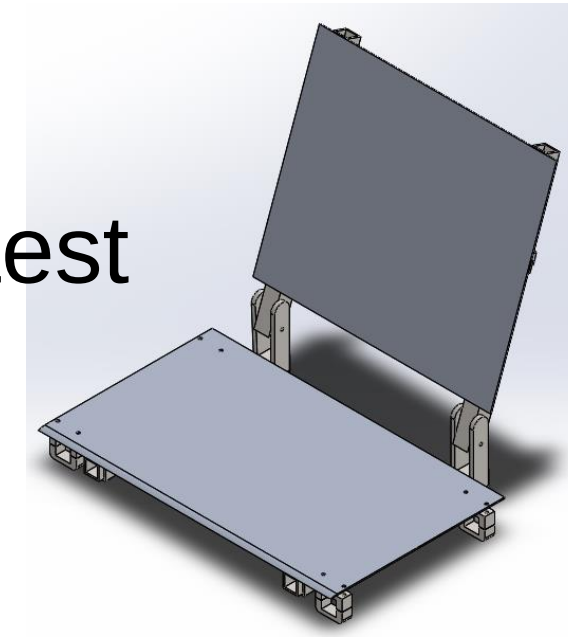
- Single speed hub
- Limited slip differential on front end
- Brakes built in to rear hub
- Low gear ratio with a low top speed
- Reused old sprockets



Seats

Non-Adjustable Design

- Clamps to the frame with aluminum clamps
- Rear seat serves as a kickstand for the 5x5x5 test
- Buckle seat belts
- Material:
  - Seat: Aluminum
  - Steel tubing for frame



Meeting Design Constraints

Overall Weight
184 Lbs

Ground Clearance
18 in

Assembled Width
54.68 in = 4.56 ft

Turn Radius
11.4 ft

Folded View

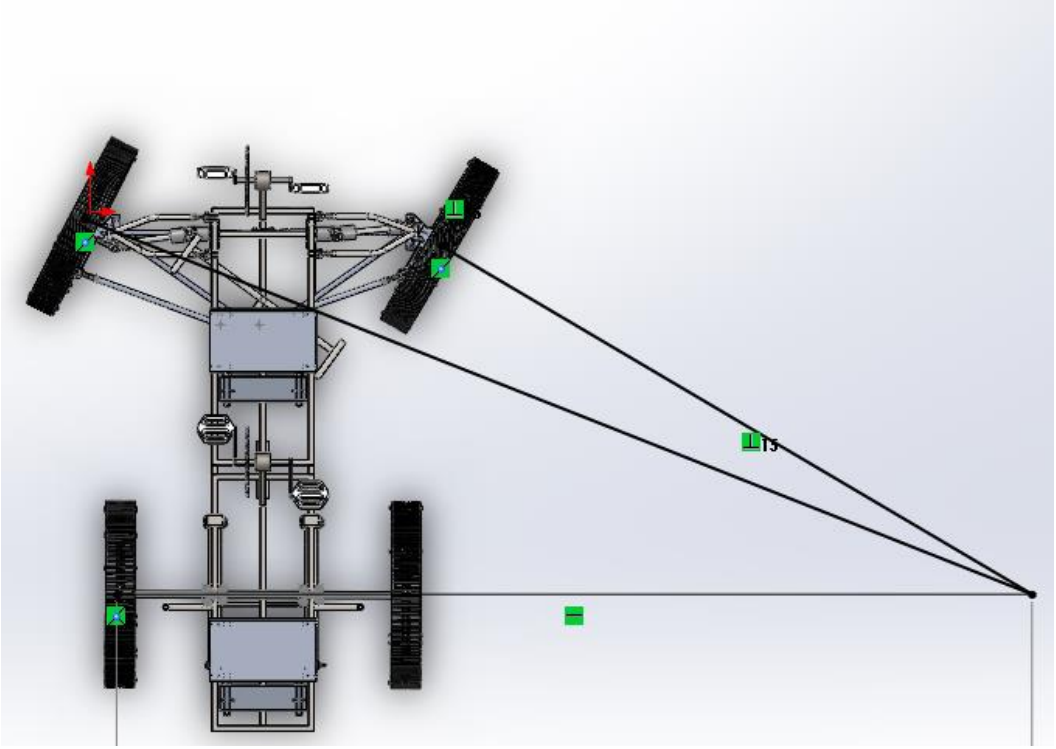
- Rover fits inside 5’x5’x5’ box
- Meets the NASA design constraint

Ground Clearance

- Meets the NASA design constraint: 17” clearance

Turn Radius

- Turn Radius Meets the NASA requirement of 15ft max
- Our actual measured turn radius was <u>11ft 4in</u>



Manufacturing Schedule

Manufacturing Schedule	To be Completed by
Wheel Components Cut Out	12/21/2016
Small Parts Cut Out	12/21/2016
Wheel Completion	1/10/2017
Frame Completion	1/17/2017
Suspension Completion	2/3/2017
Drive Train Completion	2/15/2017
Steering Completion	3/3/2017
Seat Completion	3/10/2017
Rover Testing	Week Before Spring Break

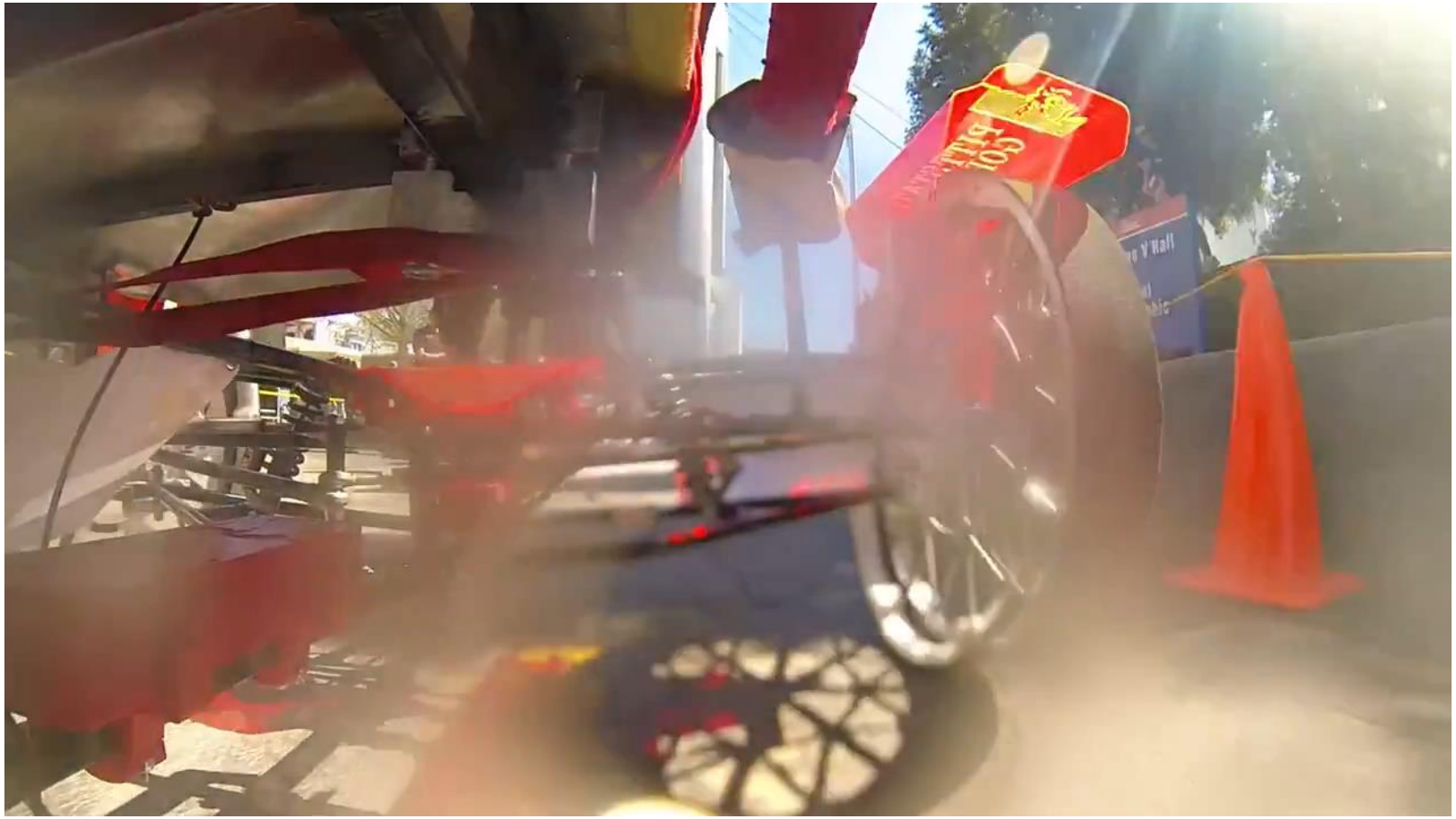
Final Budget

Materials			
3/4 square tubing .083 wall	24'	40'	$44.64
1/2 square tubing	18'	20'	$26.16
HDPE Plastic	4'x4' sheet	4'x4'	$441.10
1/4" Aluminum	4'x8' sheet	4'x10'	$336.10
1.5"x3/4" square tubing	3'	3'	Supplied
Bicycle pedals	2 sets	2 sets	Supplied
Single speed hub	2	2	$100.00
1/8" sheet	4'x4'	1'x2'	$12.26
1/4" flat strap .75" wide	2'	2'	$6.18
1" .083 wall round tubing	12'	20'	$13.20
1/4" 20 bolts	100	100	$42.84
1/4" 20 lock nuts	100	100	$6.70
3/8" 24 bolts	20	20	$12.80
3/8" 24 lock nuts	20	20	$3.09
5/8" 18 bolts	20	20	$23.56
5/8" 18 lock nuts	20	20	$13.16
Chain			Supplied
Travel			
Hotel			$800
Transportation			$500
Total			**$2,381.79**

Materials		
Metal from Washburn Farm & Home		$96.10
3/4 square tubing .083 wall	24'	
1/2 square tubing	18'	
1.5"x3/4" square tubing	3'	
1/8" sheet	1'x2'	
1/4" flat strap .75" wide	2'	
Bicycle pedals	2 sets	Supplied
Single speed hub	2	Supplied
HDPE Plastic	4'x4' sheet	$519.41
1" .083 wall round tubing	12'	Supplied
Hardware from Fastenal		Donation
1/4" 20 bolts	100	
1/4" 20 lock nuts	100	
3/8" 24 bolts	20	
3/8" 24 lock nuts	20	
5/8" 18 bolts	20	
5/8" 18 lock nuts	20	
U joints		Donation
Chain		Supplied
Travel		
Hotel		$420
Transportation		$500
Total		**$1,958.82**

Competition Obstacles

Wheel Video



Front End Suspension

Rover Challenge Results

Race 1 Time:

19:11 mins

Race 2 Time:

12:03

*5 minute faster raw time

Competition Standing:

12th Place

Failures & Lessons Learned

Only Failure:

- Rear drive train failed on first race
  - Added a support for the rear hub
  - Second Race improved time by 5 mins

Lessons Learned

- Use interchangeable gears for the butte
- Build separate breaking system

Thank You

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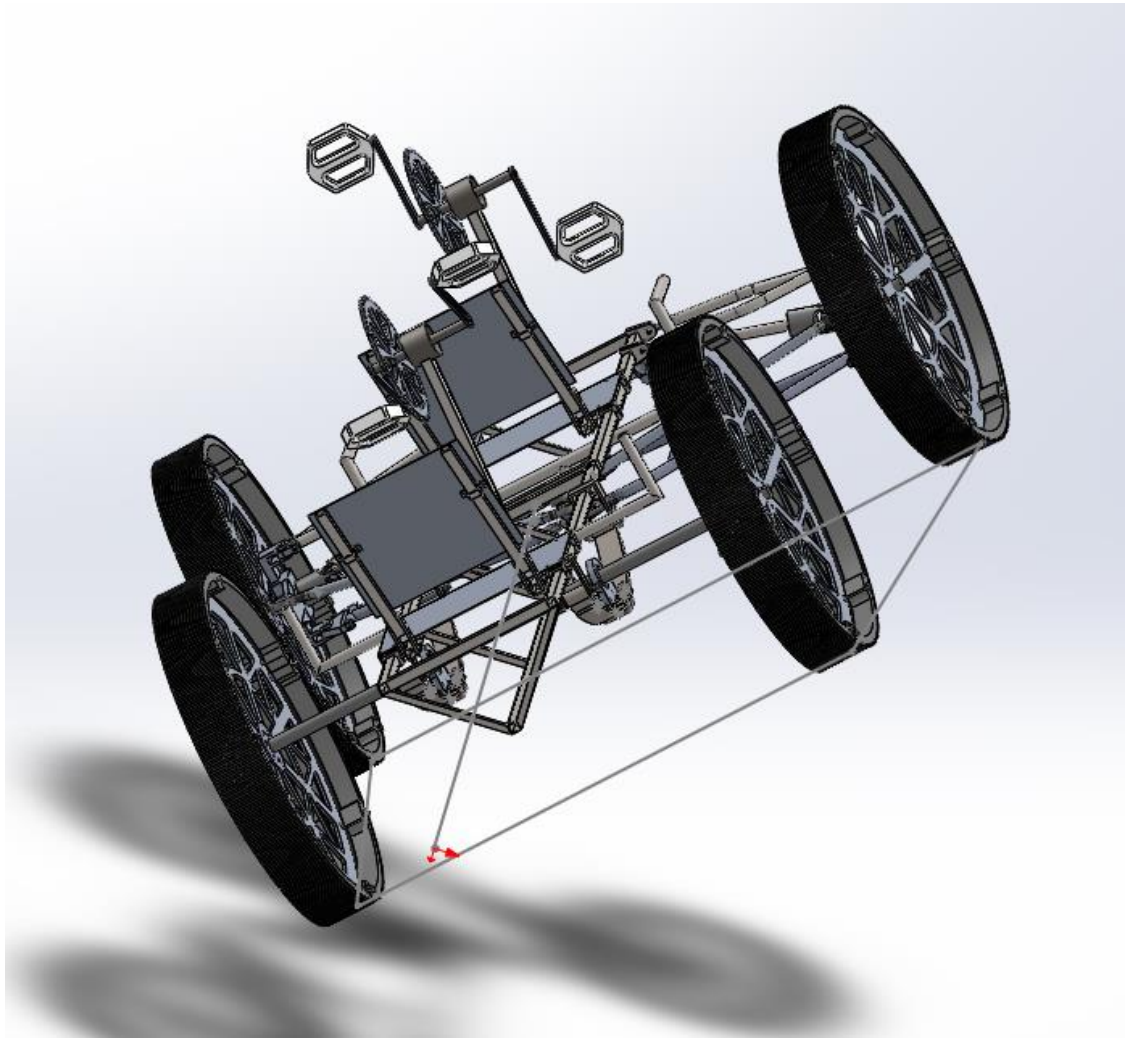
Failure Modes

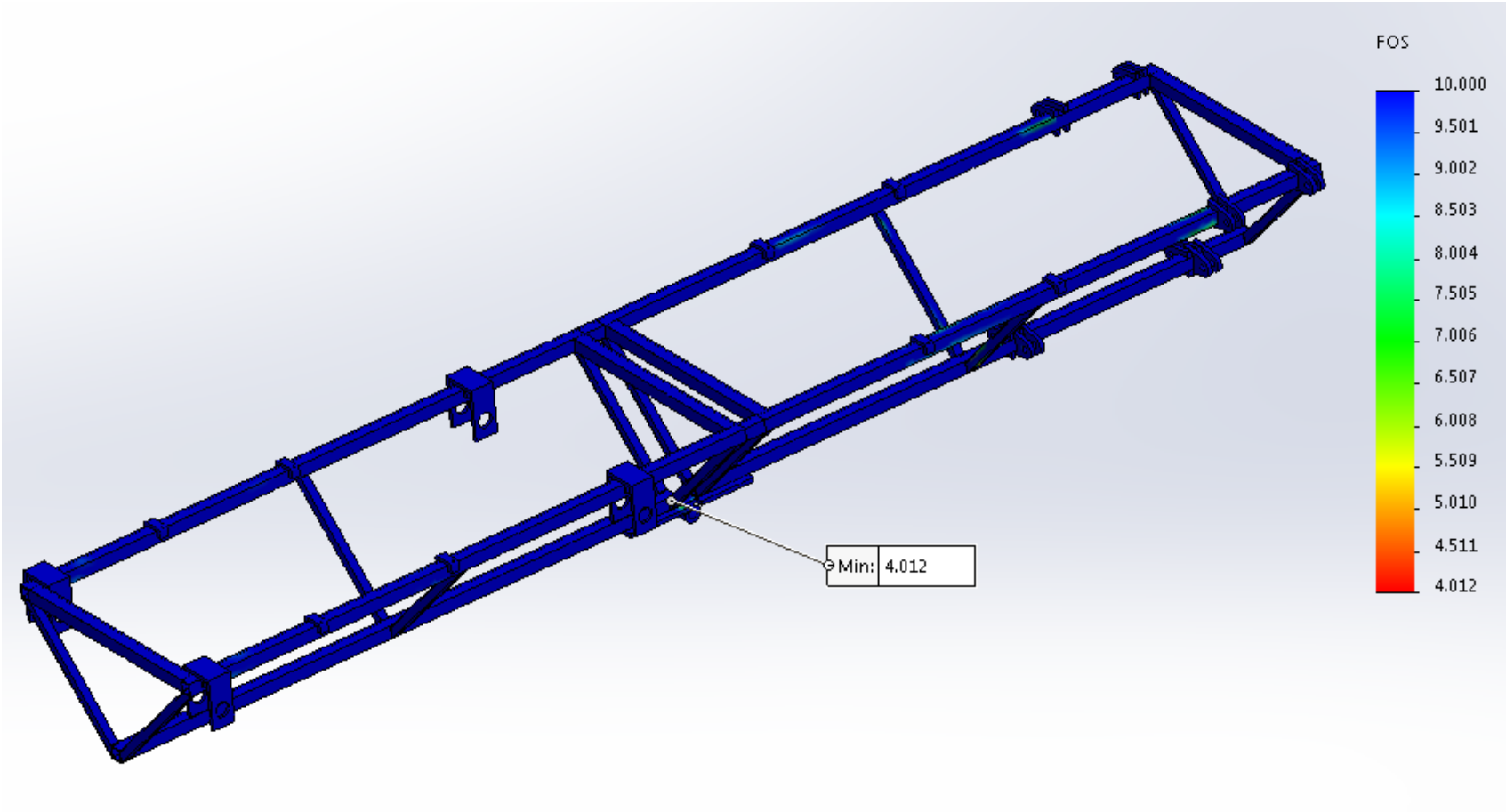
Component	Potential Failure Mode	Potential Effects from Failure	Severity	Occurance	Detection	Risk Priority Number
Suspenion	Leaf spring snaps	Cannot complete course	5	2	1	10
	Bolt snaps on shackle	Cannot complete course	5	3	2	30
Drivetrain	Chain breaks	Cannot complete course	5	2	1	10
	Hub breaks	Cannot complete course	5	3	1	15
Steering	Steering overcenters	Time penalty for getting off rover	4	3	1	12
	Tie rod deforms	Difficulty driving rover	4	3	1	12
Wheels	Bolt/Fasteners holding wheel together snaps	Cannot complete course	7	3	1	21
	Aluminum deforms from side load	Cannot complete course	6	2	1	12

Center of Gravity Test

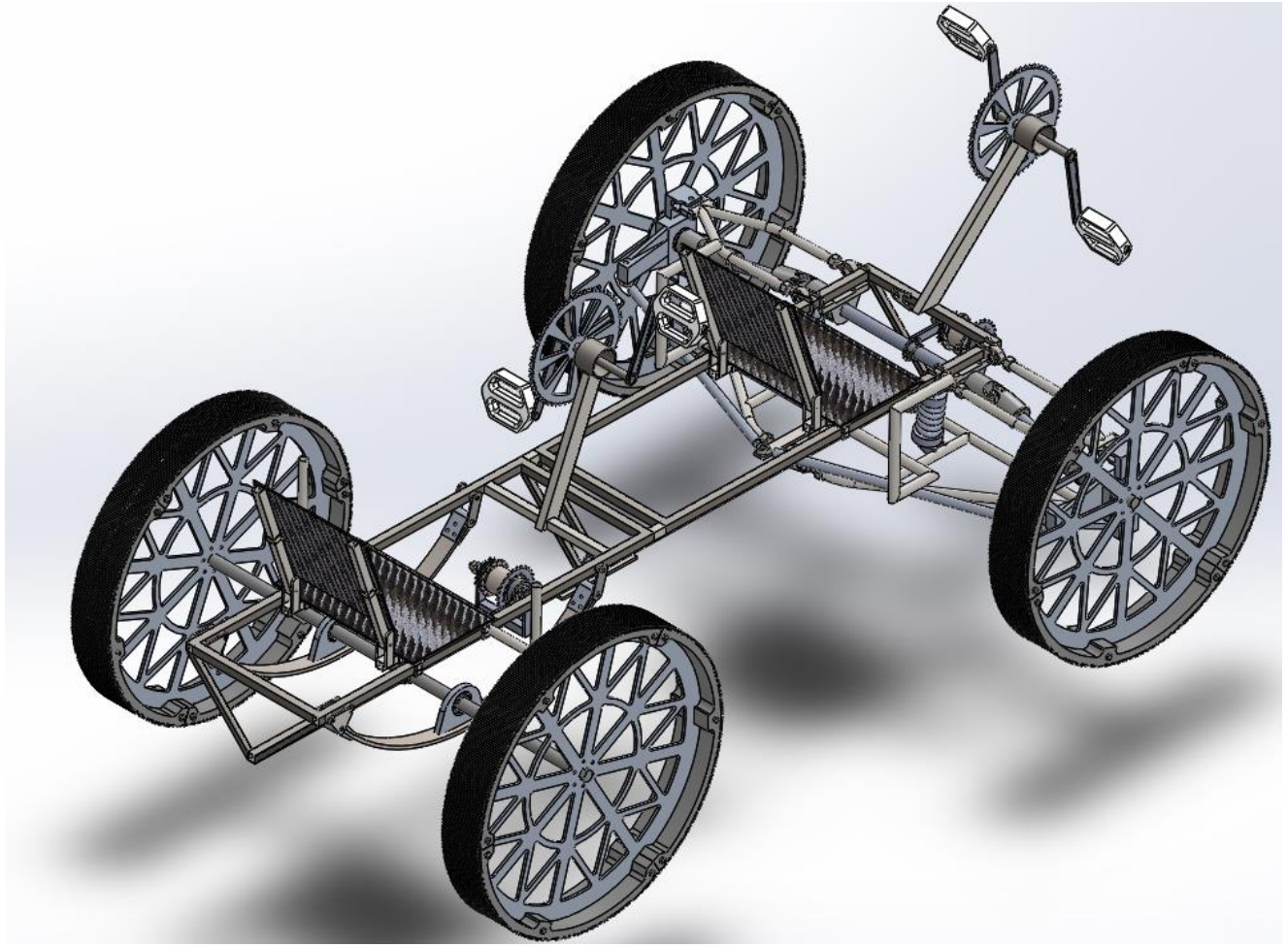


Frame FEA

Lowest FOS is near the edge of the center hinge



Rover Full Concept Design



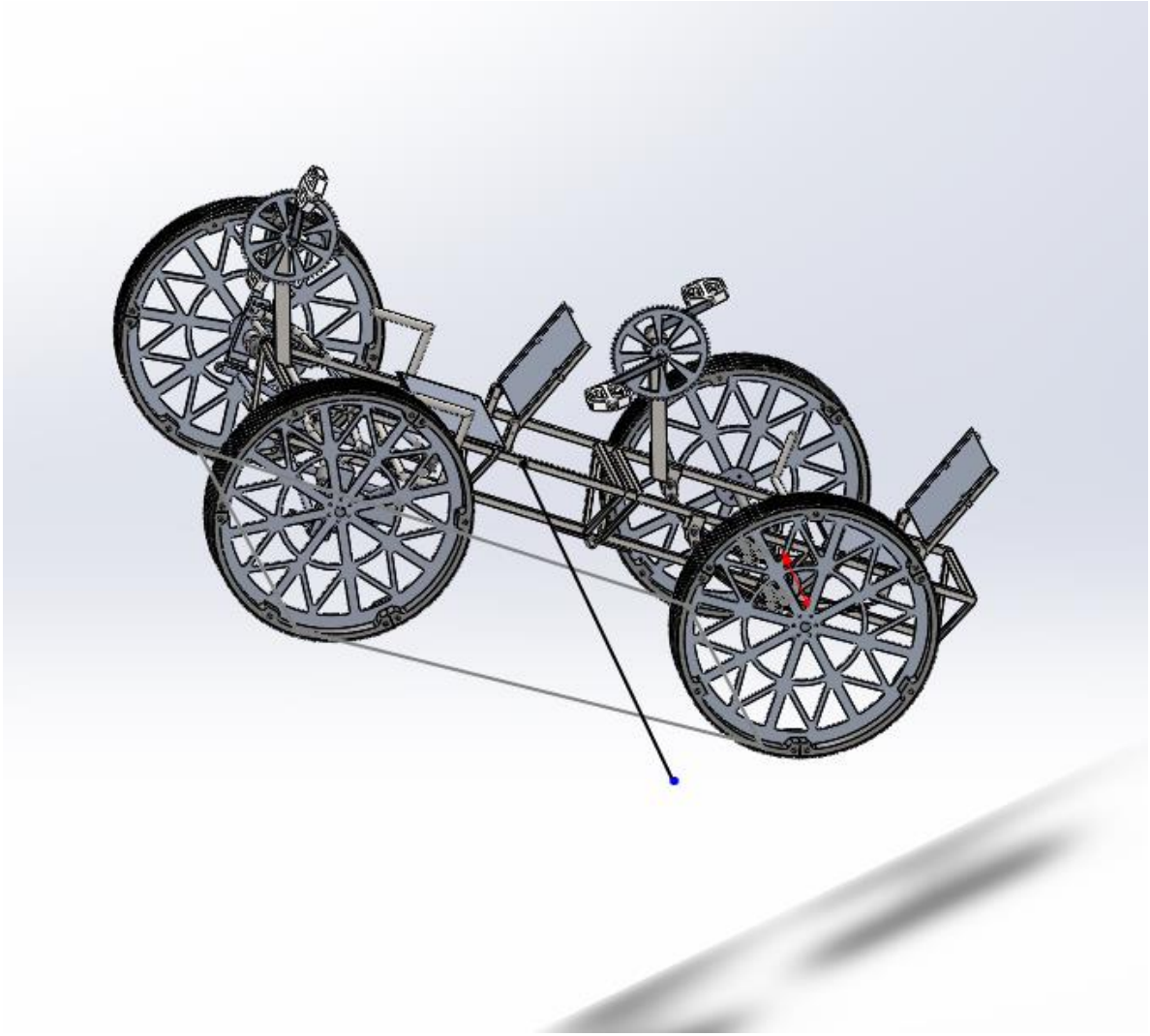
Center of Gravity Test Continued

Course Requirement:

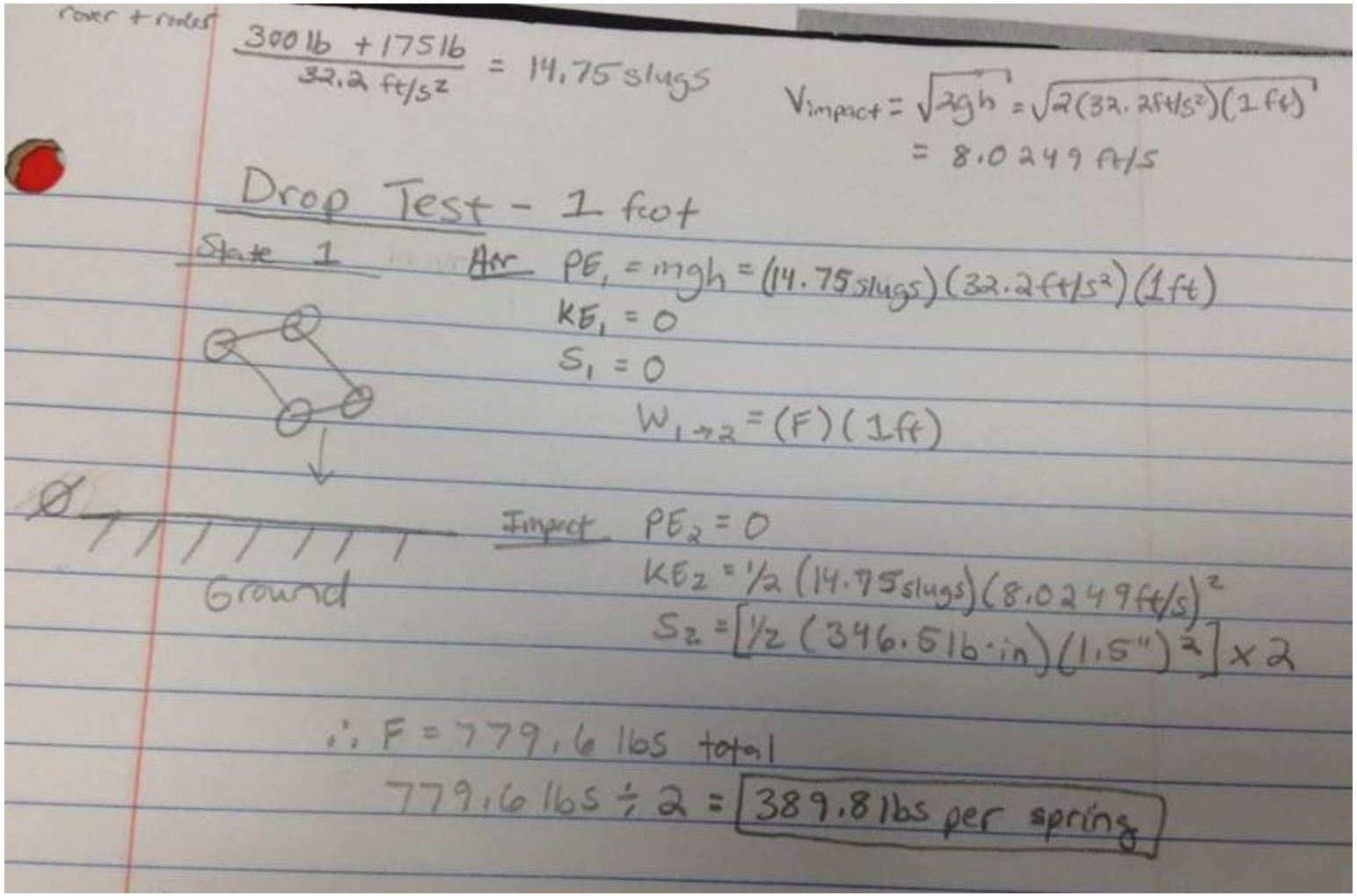
- Handle 30 degree incline

Test Result:

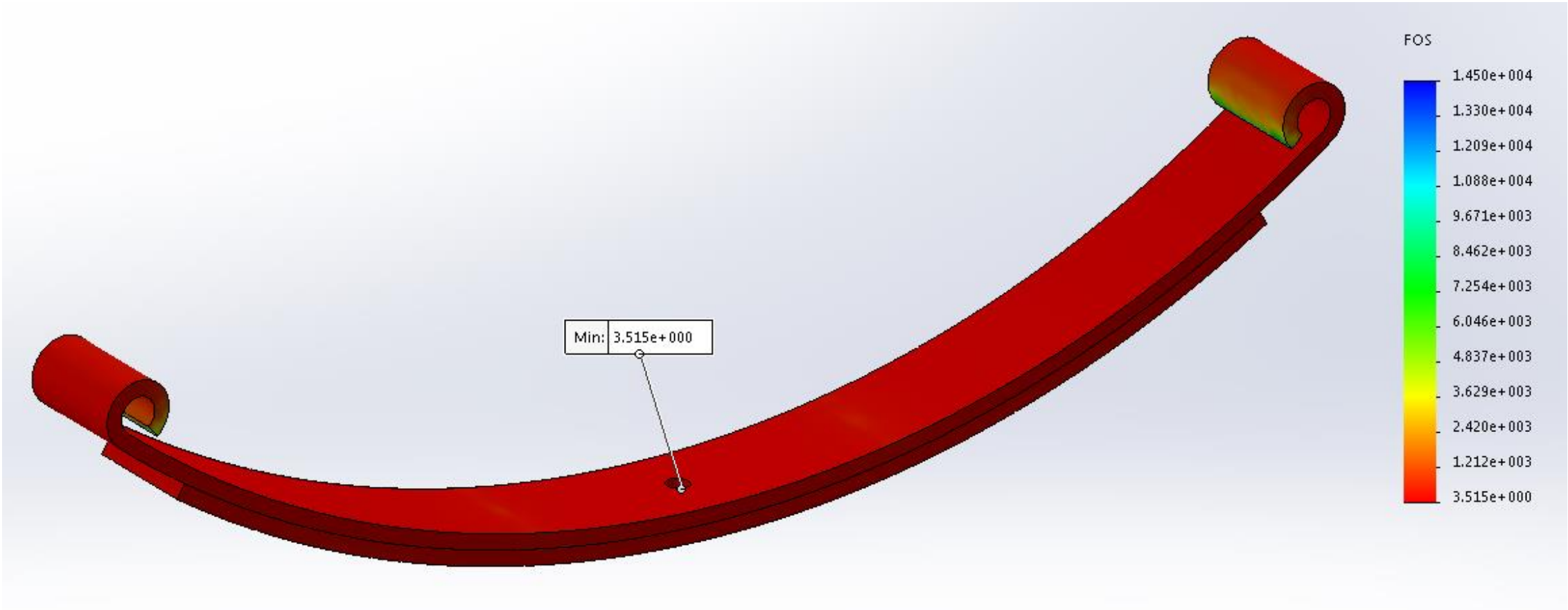
- Ours passes and can handle 45 degrees



Hand Calculation for loading



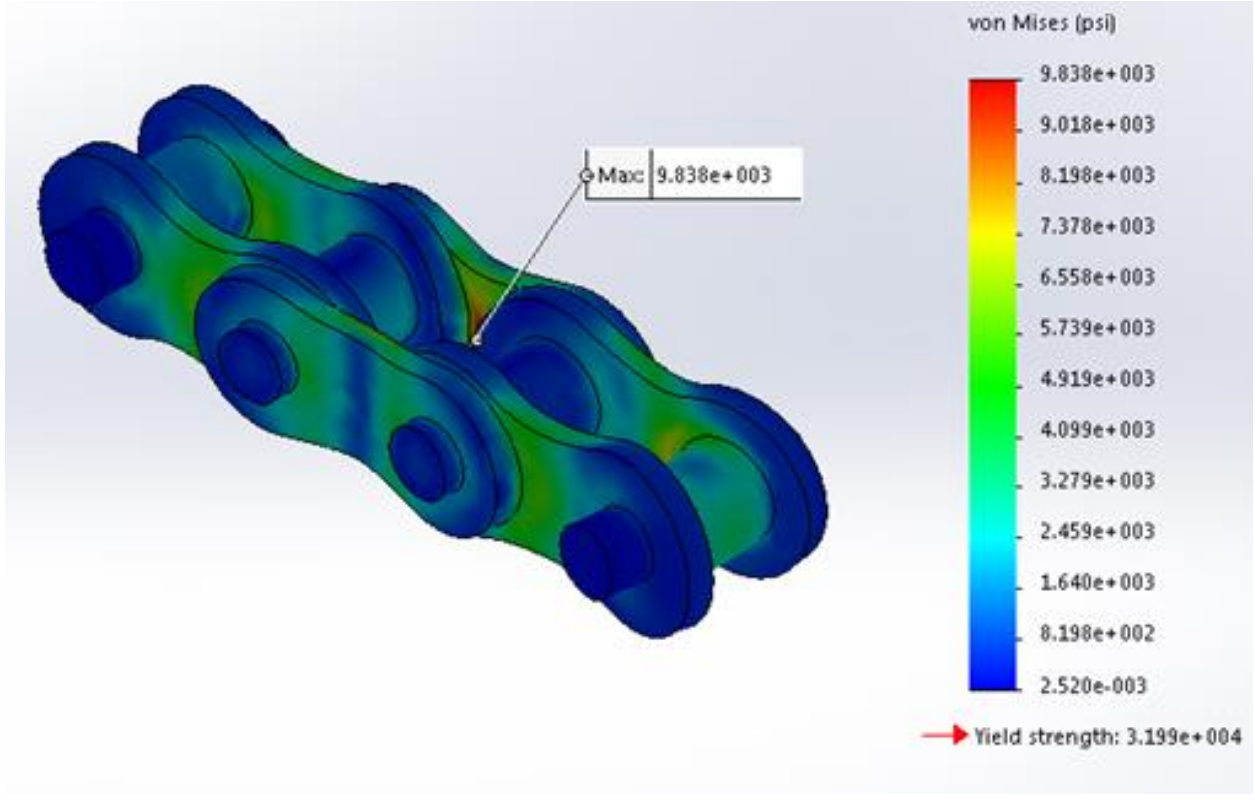
Rear Suspension FEA

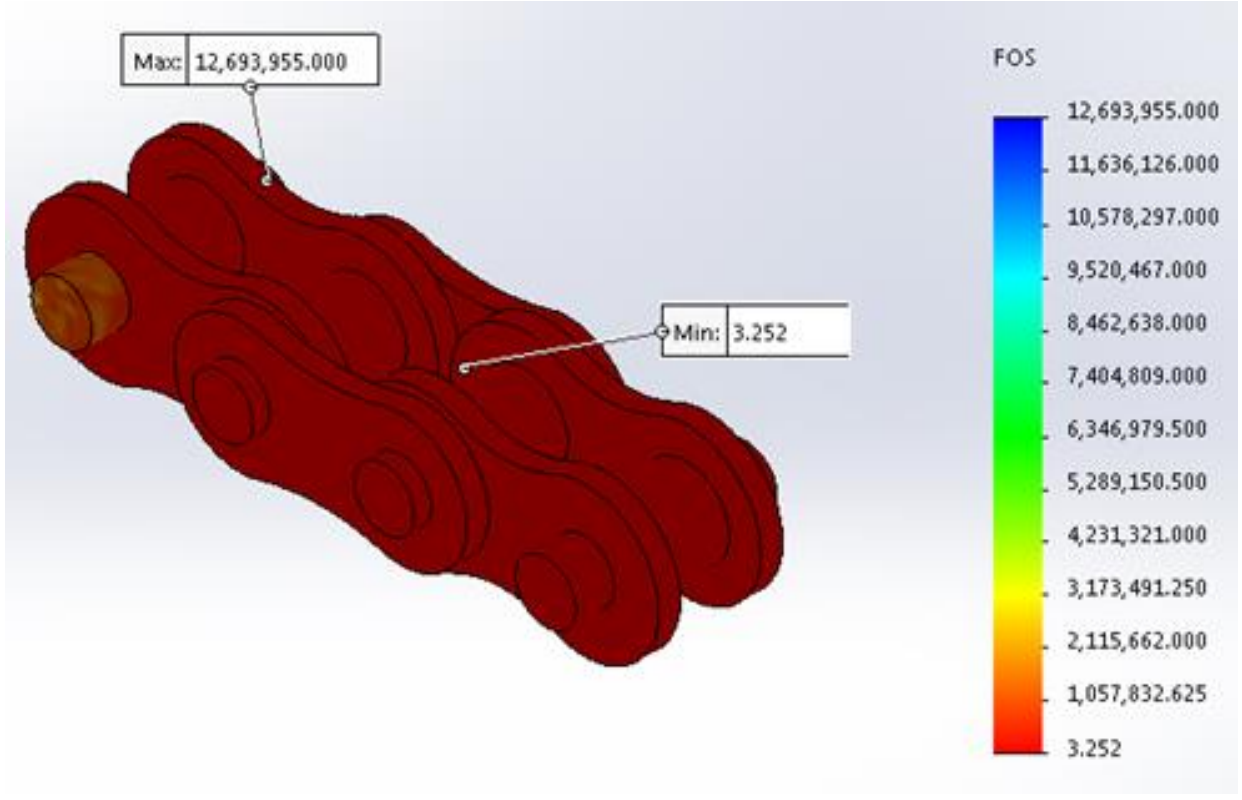


Chain FEA

- 100lb loading in tension
- Max Stress in center of chain
- Chain does not yield

Minimum Safety Factor: 3.252

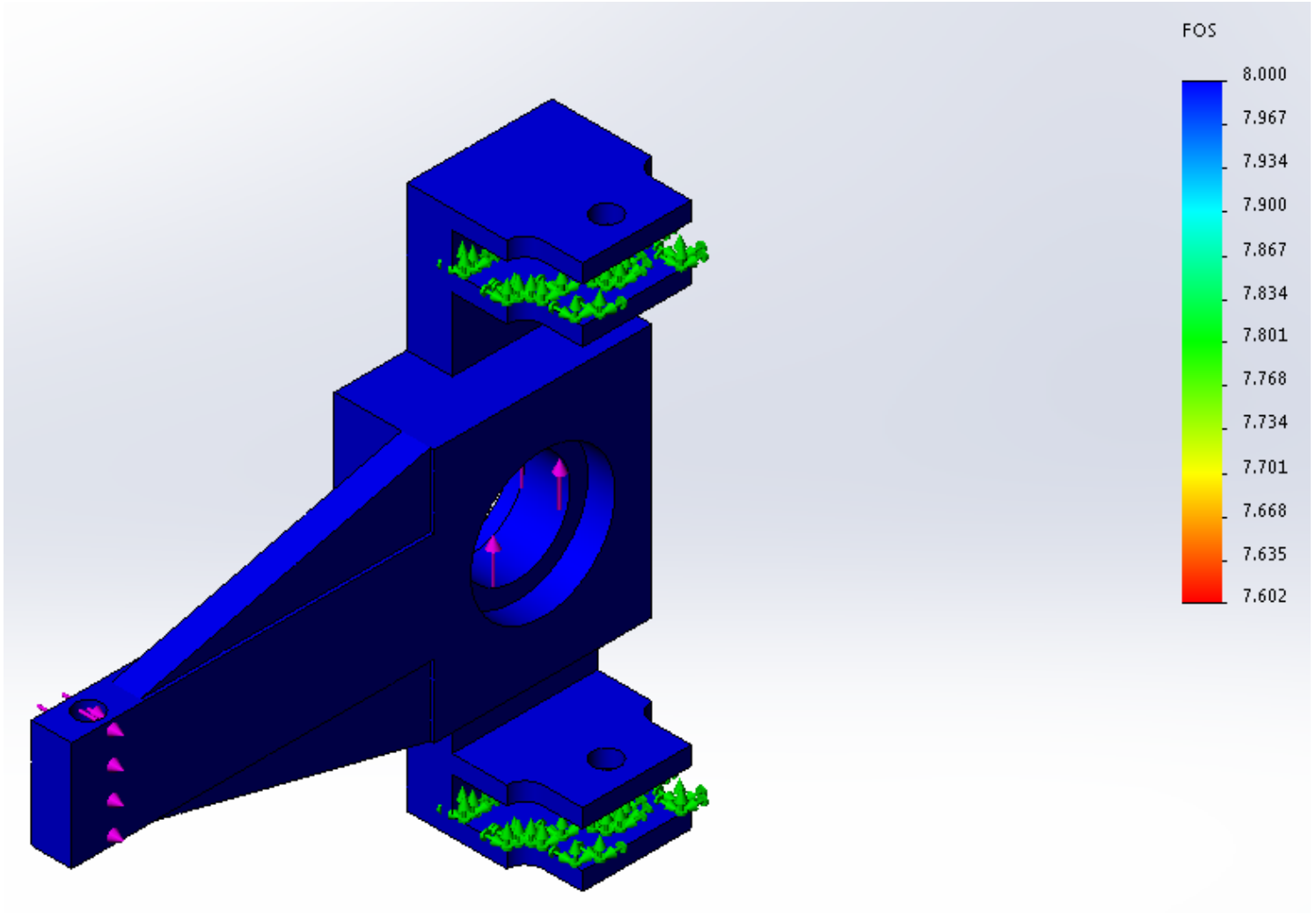




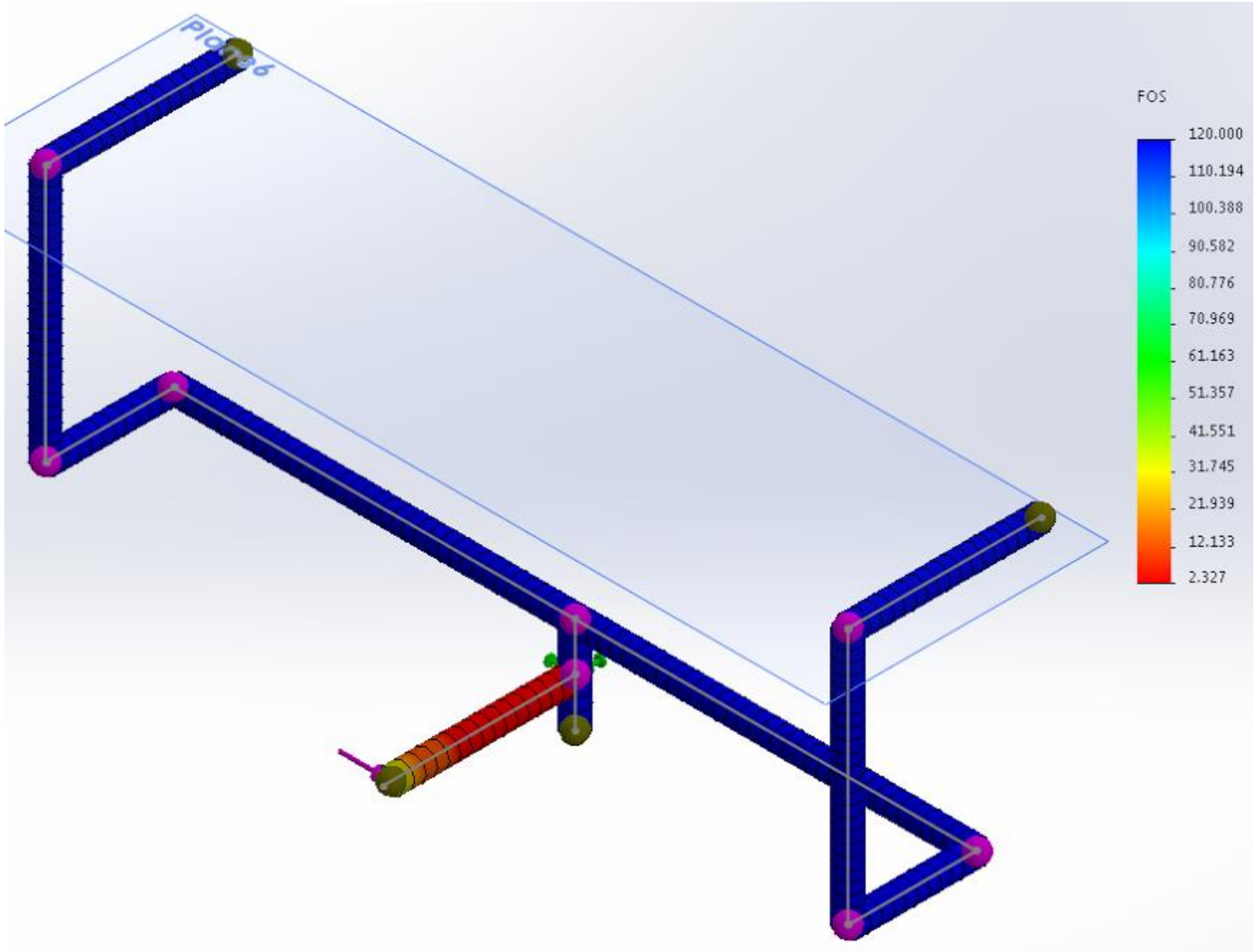
Front End Suspension FEA

- 500lb upward force
- 200lb turning force

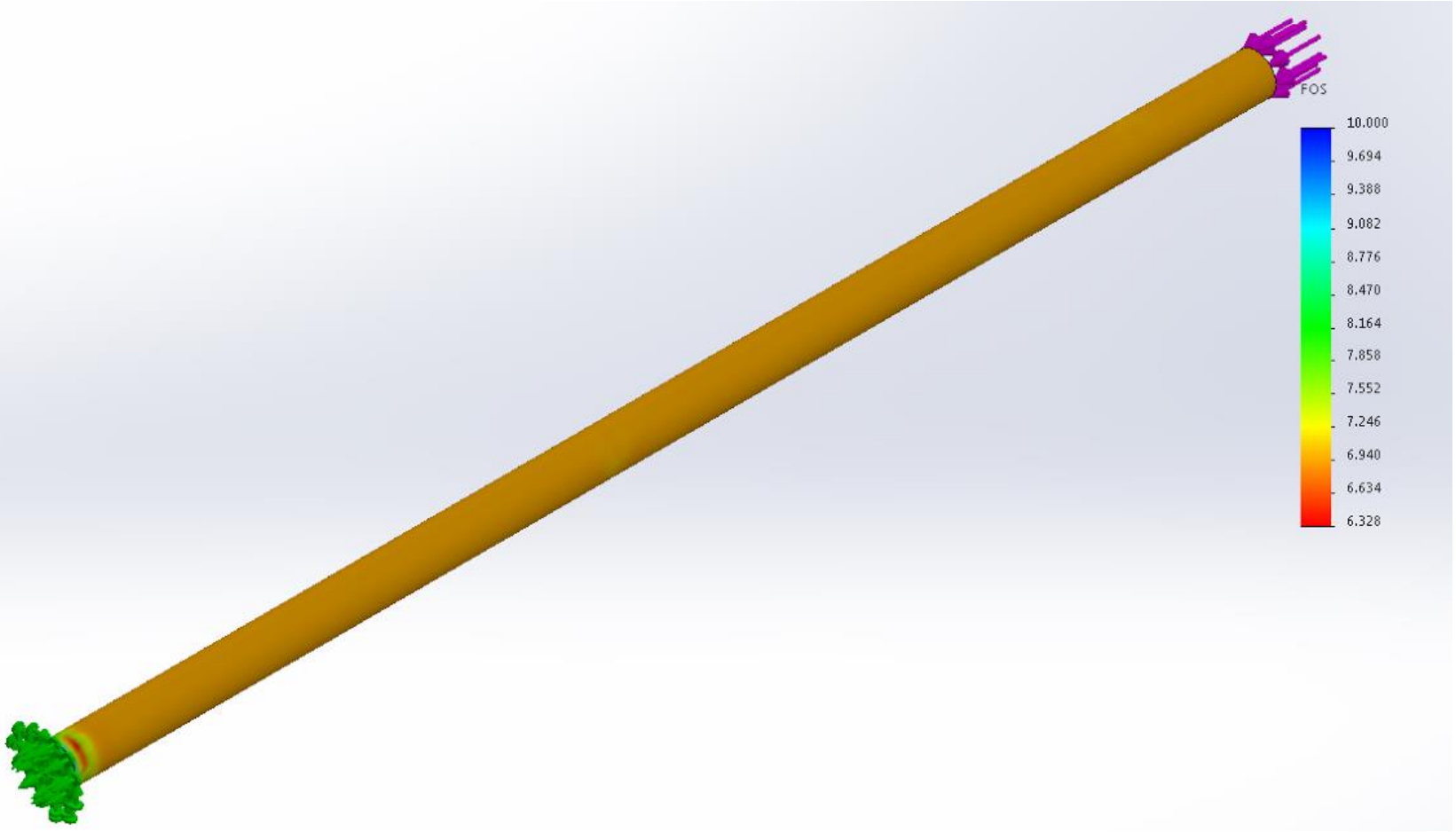
Safety Factor: 7.602



Steering FEA



Front End Suspension FEA



Wheel FEA

Worst Case Scenario:
Drop Test: 1ft

Wheel absorbs
all the loading