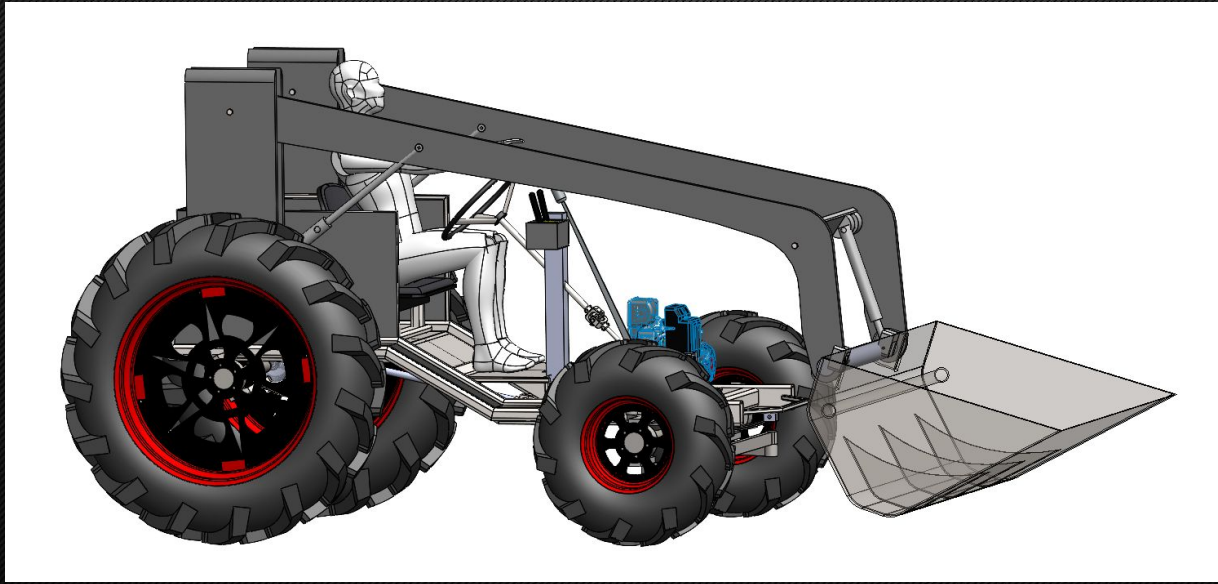
Final Design Report



Group 4
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Department of Mechanical Engineering
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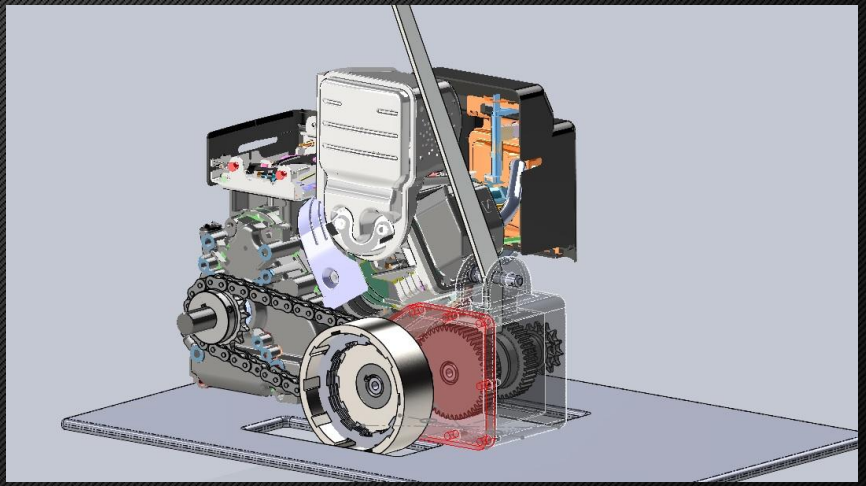
ME 3250.01L, Machine Design, Spring 2021

Req. #	Project Design Requirements
1	10 Horsepower Motor
2	Self-Designed Two-Speed Gearbox
3	Transporter is capable of moving 5 cubic yards per hour of clean dirt over a rough terrain at a distance of ½ mile between pickup and drop-off. Loading and unloading is not to be included.
4	Hydraulically Operated Bucket/Scoop (off-the-shelf hydraulic pump and components are permitted)
5	Budget must not exceed $12,000 for components. Cost of design and labor is not included and has no cost limit.
6	Terrain Tires
7	Safe Design (no exposed gears, pinch points, etc.)
8	Optional Four Wheel Drive
9	Soil Weight Density of 40lbf/ft^3
10	Able to traverse a maximum of 7% grade and 1 ft high obstacles

Transmission Design Changes



First gear pinion stress: With the original face width of first gear being 1 inch.

The stresses were high. The width of the face was changed to 2 inch wide to make the stress acceptable

2nd gear pinion stresses:

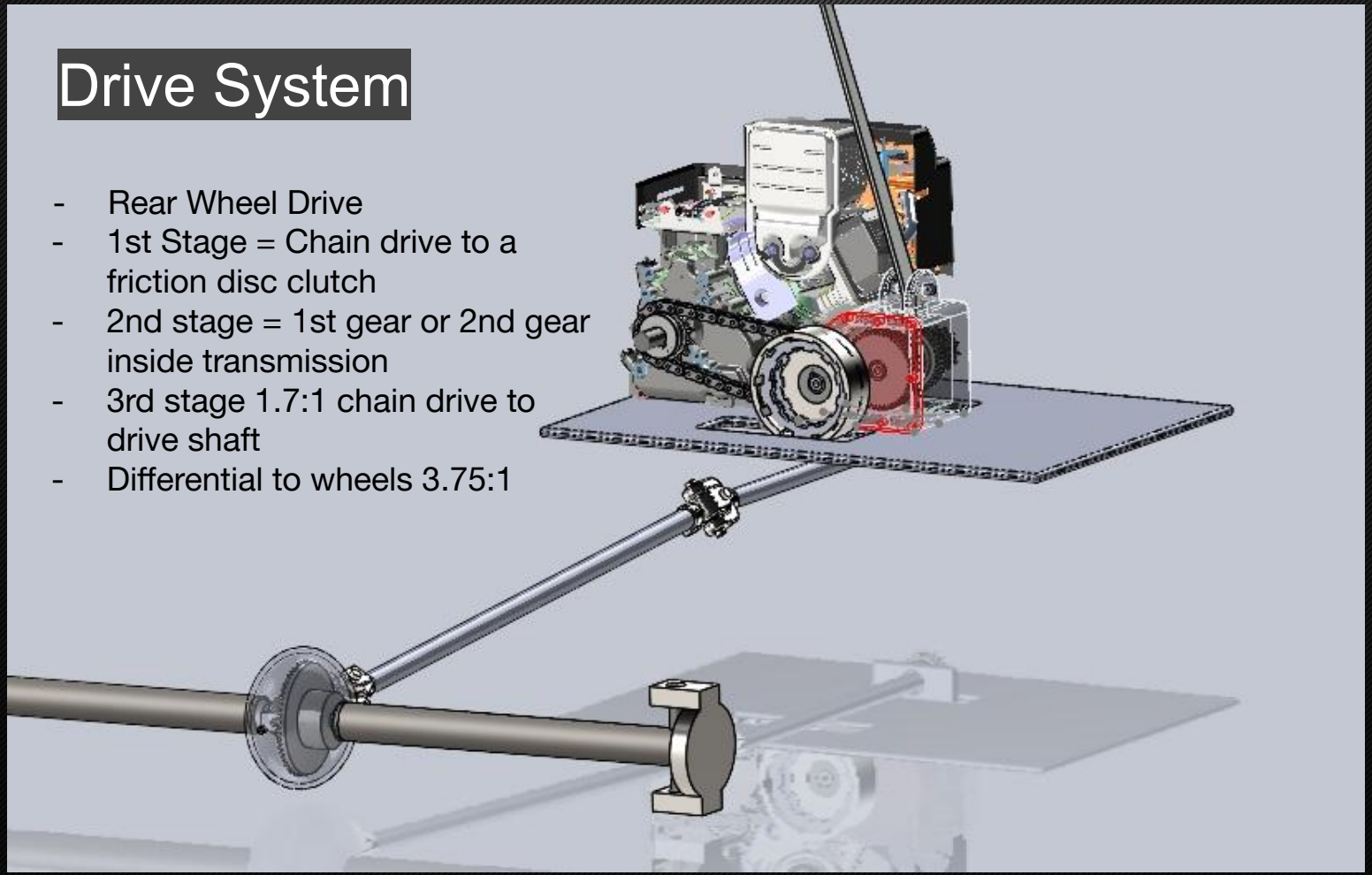
The face of this gear was wider than it needed to be so the face got more narrow to .75 inches.

Almost making the stresses on 1st and 2nd pinions equal.

Gear ratios were also slightly changed with the output sprocket of the transmission losing a tooth and the input sprocket on the drive shaft gaining two teeth.

Drive System

- Rear Wheel Drive
- 1st Stage = Chain drive to a friction disc clutch
- 2nd stage = 1st gear or 2nd gear inside transmission
- 3rd stage 1.7:1 chain drive to drive shaft
- Differential to wheels 3.75:1



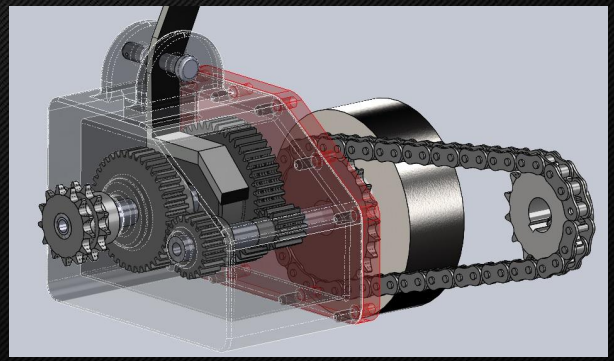
Gear Ratio and Drivetrain Specs

1. Chain drive ratio 1.73:1
2. 1st gear ratio 4:1
3. 2nd gear ratio 2:1
4. Transmission output chain to drive shaft 2.7:1
5. Differential to wheels 3.75:1

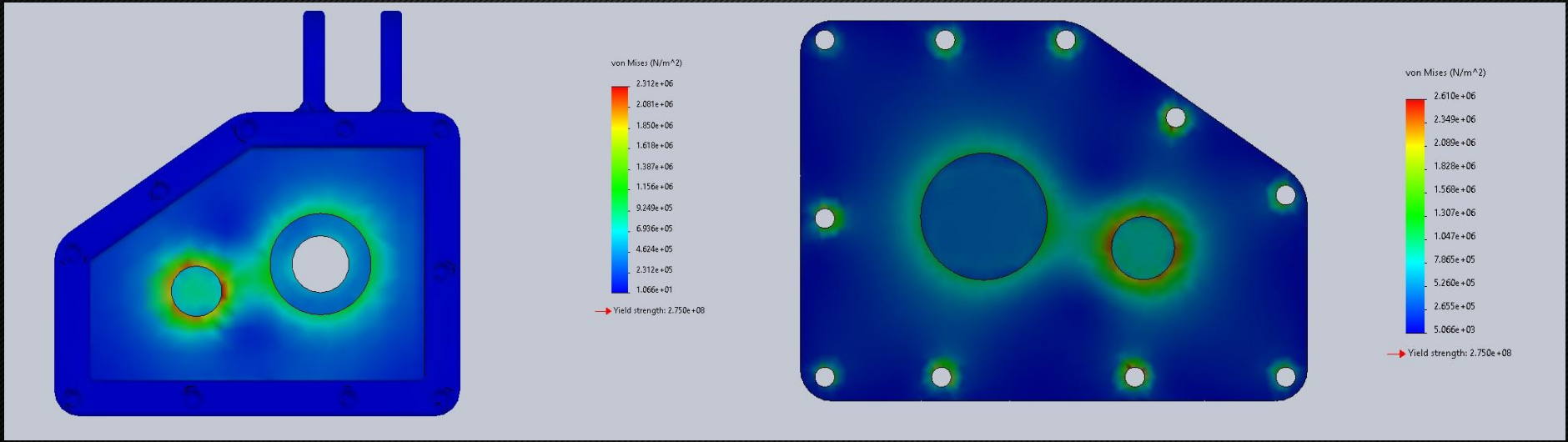
Overall Specs:
In 1st gear overall ratio is 69:1
In 2nd gear overall ratio is 34.4:1
1st gear speed of 7.5 mph @3200 rpm
2nd gear speed of 15 mph @3200 rpm

Engine output torque 14.7 ft lb@ 3200 Rpm

1. 25.3 ft lb
2. 101.2 ft lb
3. 50.6 ft lb
4. 270 ft lb and 135 ft lb
5. 1012 ft lb and 506 ft lb



Von Mises Stress on Transmission Case



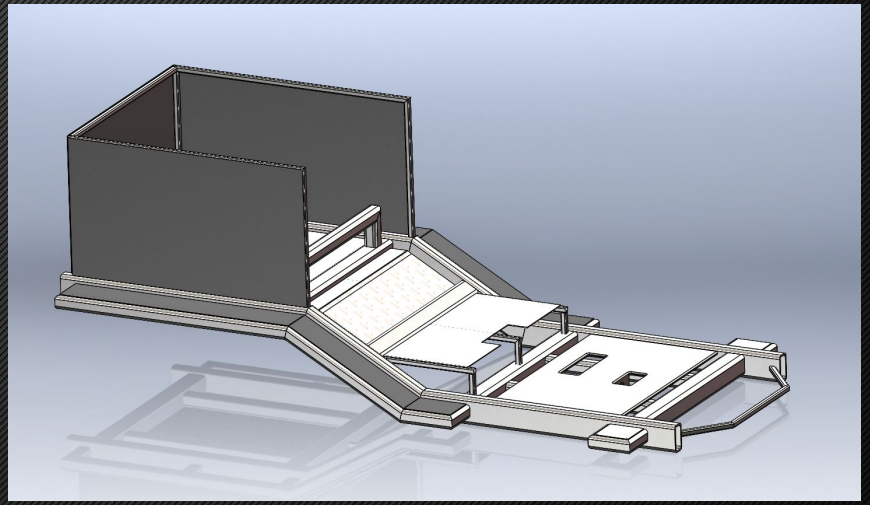
Vehicle Frame

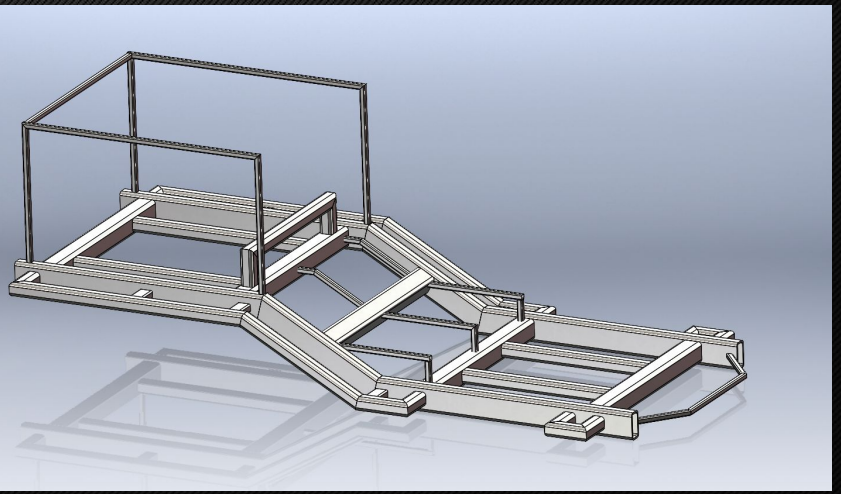
Ladder Frame Design

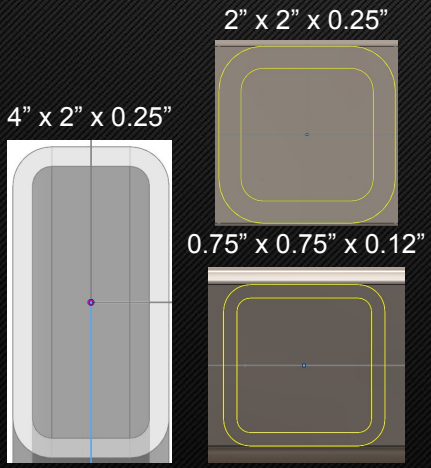
- Frame Material: A513/A500 Structural Steel
- Body Panels: 12 & 14 Gauge HR Steel Sheet Metal
- Rectangular and Square Tube Profiles

Overall Characteristics:

- Width: 45” (3.75’)
- Length: 100” (8.33’)
- Weight: 405 lbs/502lbs







*All Tube Profiles Are Found in the Parts List

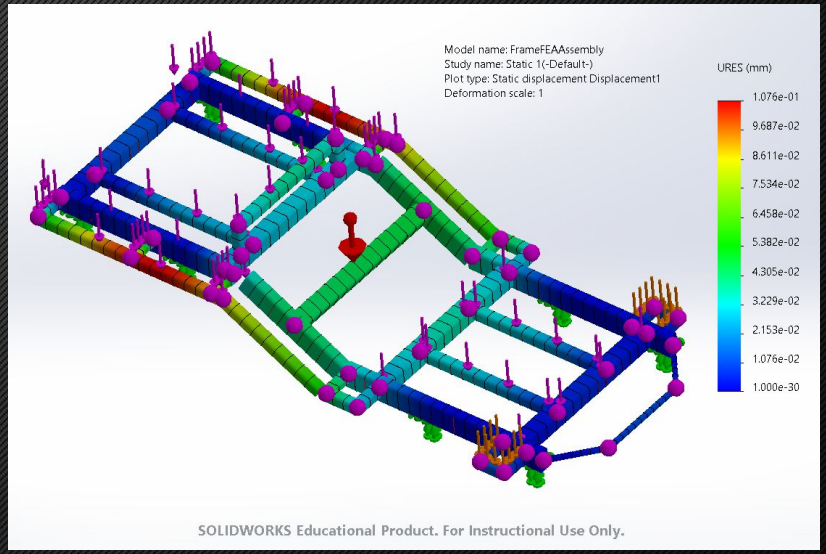
Vehicle Frame Design Analysis

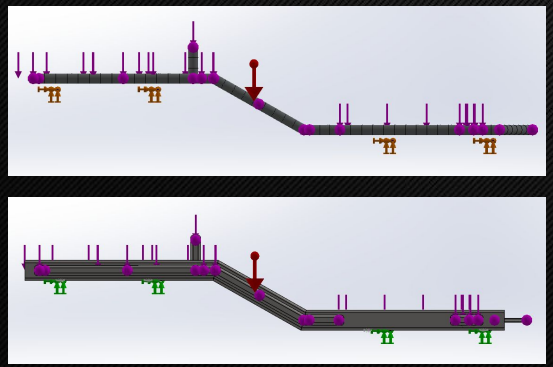
SolidWorks Weldment FEA Simulation

- Constrained at the Suspension Supports
- Sets of Distributed Loads

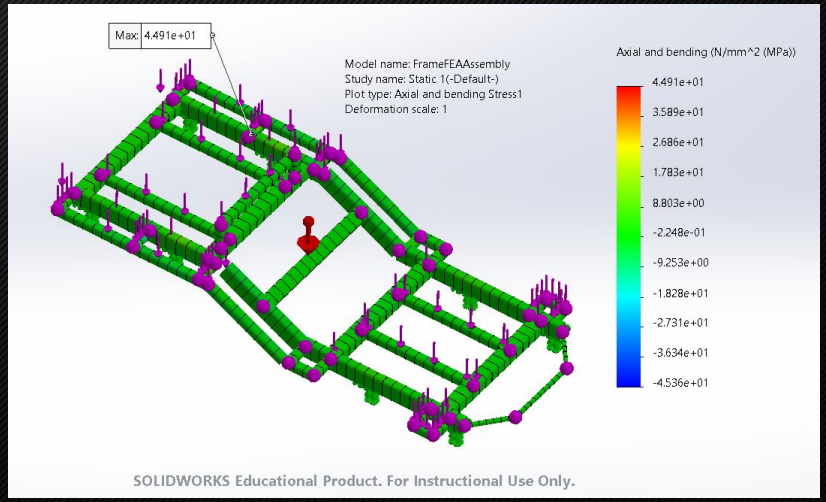
Results

- Maximum Bending Stress: 44.9 MPa
- FOS = 2.3





Model name: FrameFEAAssembly
Study name: Static 1(-Default-)
Plot type: Factor of Safety Factor of Safety1
Criterion : Automatic
Factor of safety distribution: Min FOS = 2.3



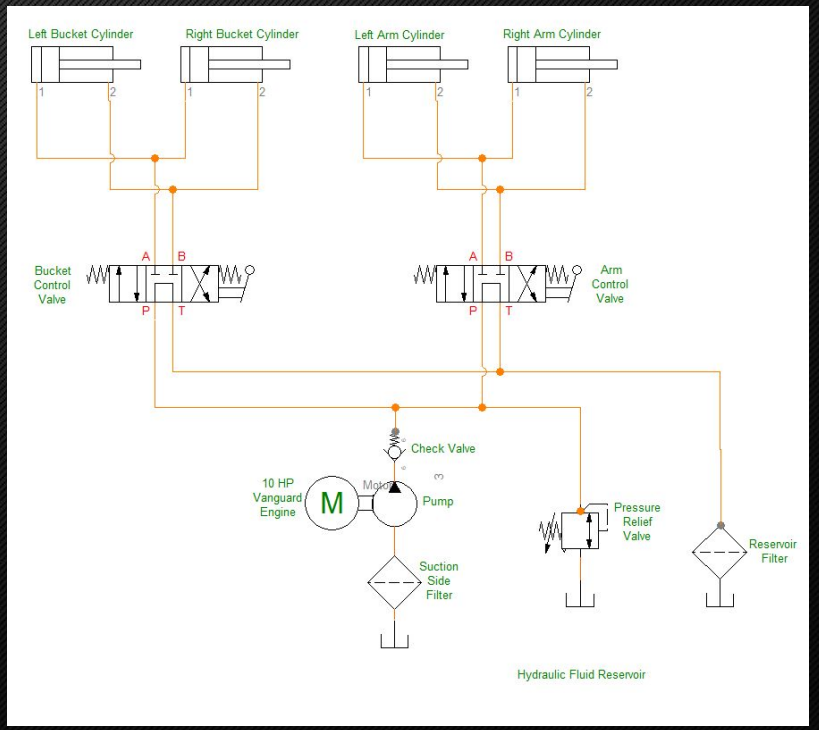
Hydraulics - Control System

Hydraulic System Containing:

- 0.76 CID Hydraulic Gear Pump 3/4“, 6.58GPM at 2000 rpm
- Pump Driven by Motor
- 10 HP Motor
- Pressure Relief Valve
- Chief LD Welded Cylinders 1.5” Bore 1” Diameter
- Pressure Return Lines and Fittings
- Hydraulic Directional Control Valve Double Acting with 2 Spool 11 GPM

Double Acting Hydraulic Cylinders at Arm and Bucket:

- 4 LD cylinders with 1.5” Bore
- Strokes from 12” to 24”
- 3000 PSI Operating Range



Hydraulics Structures Design Analysis

- Cylinders have 1.5” Diameter and will have a Max Load of 1500 lbs per Cylinder
- Required Pressure at Each Arm Cylinder is 850 psi
- <u>Arms:</u>

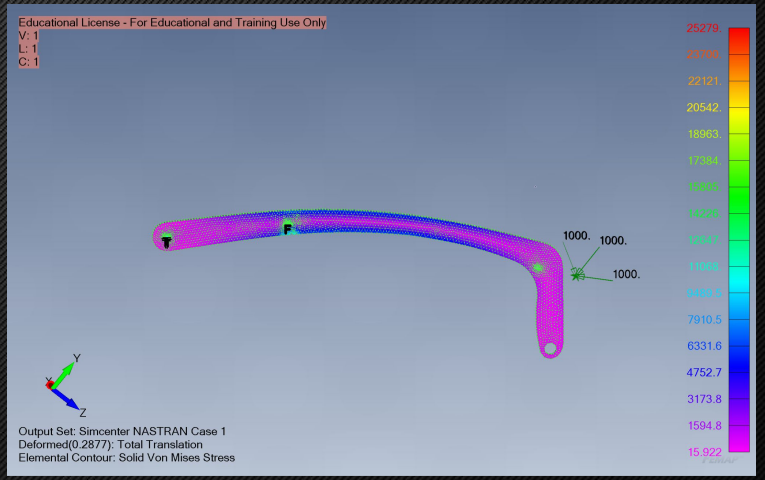
  Maximum Von Mises Stress: 25000 psi, FOS ≃ 2.2:1

- <u>Bucket:</u>

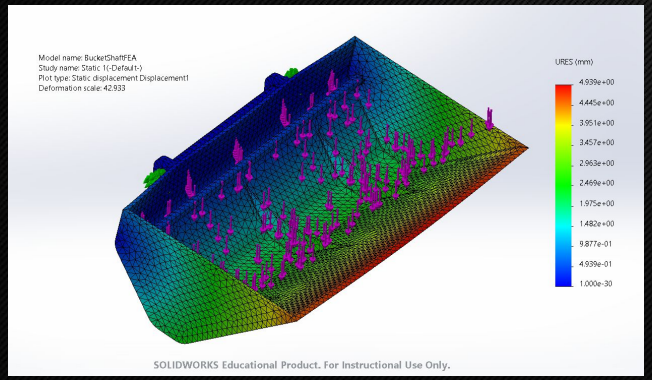
  Material: ASTM A36 1/8” Thick Steel Sheet with 1/4” Thick Side Plates

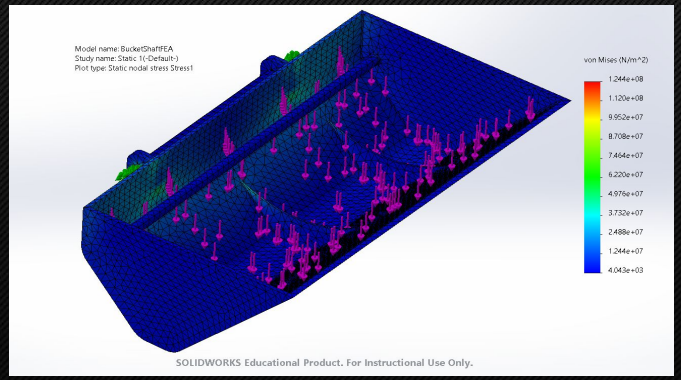
  Maximum Von Mises Stress: 124 MPa, FOS = 2.0

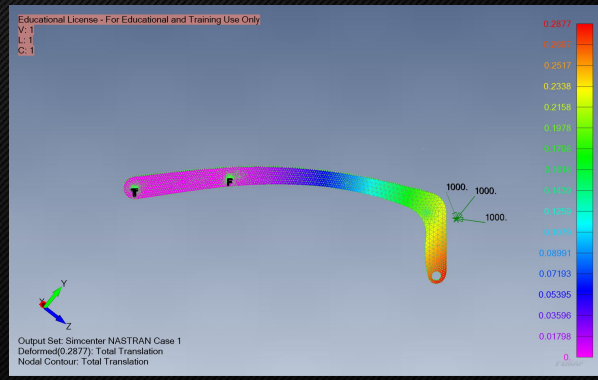
  Maximum Displacement: 4.9mm @ Bucket Tip



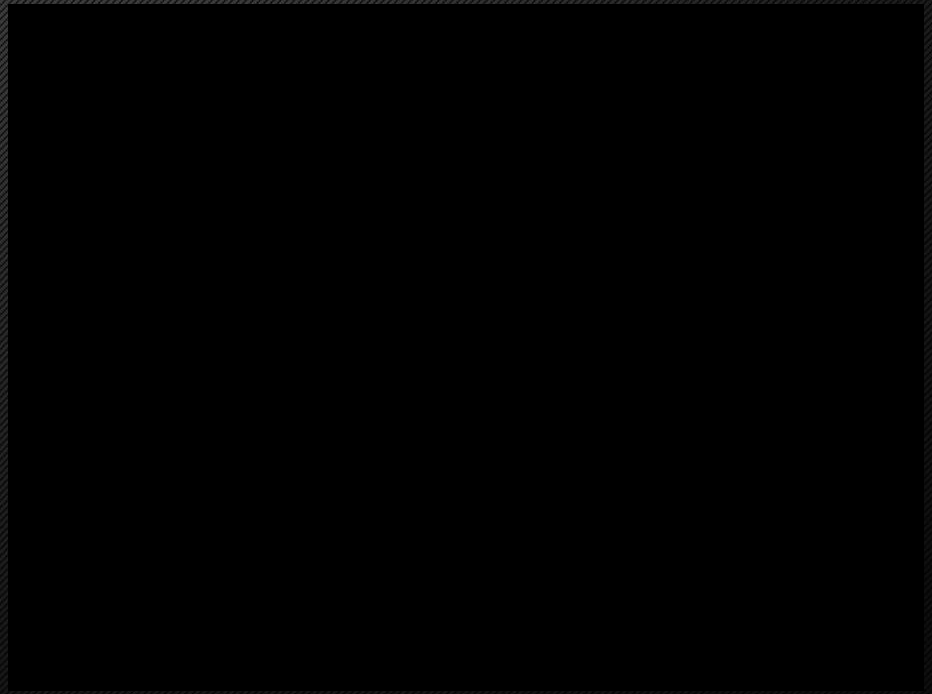
Model name: BucketShaftFEA
Study name: Static 1(-Default-)
Plot type: Factor of Safety Factor of Safety1
Criterion : Automatic
Factor of safety distribution: Min FOS = 2





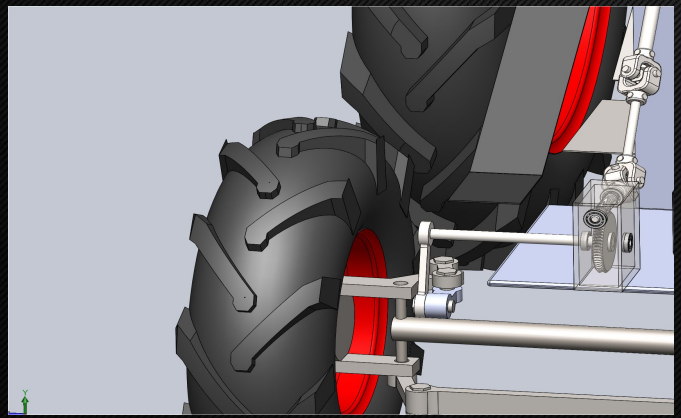


Hydraulics Scooping/Lifting Animation



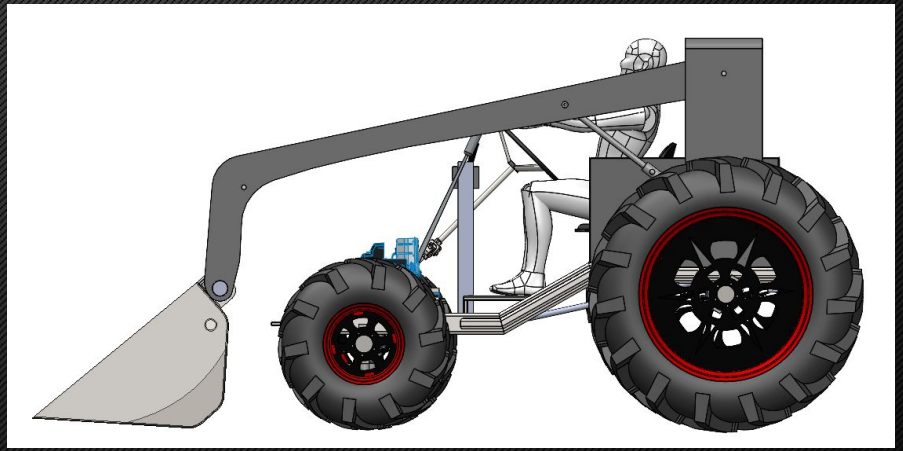
Steering

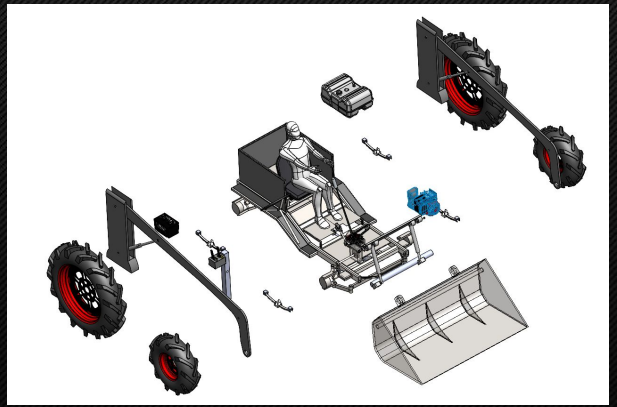
- The steering system uses a linkage system
- Has a worm gear for more torque on steering
- About 3 turns of the steering wheel to go from left to right
- Steering system is the lowest thing from the frame giving a 13 inch clearance

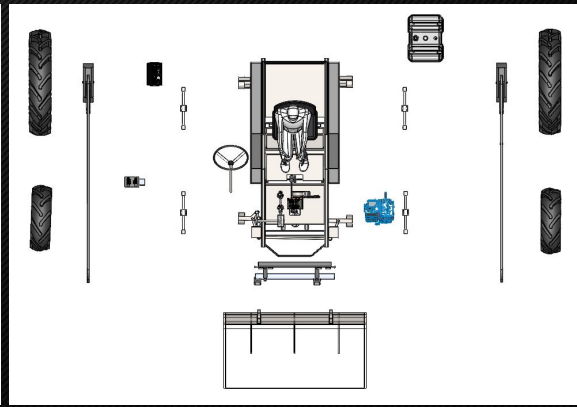


Full Assembly & Design Overview

- Overall Weight ≈ 3500 lbs
- Overall Length: 115”
- Wheelbase: 70”
- Wheel Track: 78.0”
- Bucket Capacity: 0.95cu yd.
- Ground Clearance: 13”
- Designed for 5 Trips







Complete Parts List

Subsystem	Component	Quantity	Cost
Drive System	10 HP Vanguard Gas Engine	1	$580.00
	ANSI 50 Roller Chain Sprocket, 15 teeth	1	$26.42
	ANSI 40 Chain Sprocket, 26 teeth	1	$311.65
	Metal Gear, 20 Deg, 12 Pitch, 12 teeth	1	$27.10
	Metal Gear, 20 Deg, 12 Pitch, 48 teeth	1	$88.71
	Ball Bearing, .5" Shaft Diameter	4	$27.56
	Metal Gear, 14-1/2 Deg, 12 Pitch, 20 teeth	1	$35.88
	Metal Gear, 14-1/2 Deg, 12 Pitch, 40 teeth	1	$59.17
	ANSI 40-2 Roller Chain Sprocket, 13 teeth	1	$58.44
	ANSI 40-2 Roller Chain Sprocket, 16 teeth	1	$59.98
	ANSI 41 Single Strand Roller Chain, 1/2" Pitch	1	$70.40
	Rear Tire(53.4in)	2	$1,150.00
	Front Tire(33.5in)	2	$543.99
	Metal Bevel Gear, 0.780" Face Width	2	$542.88
	Metal Bevel Gear, 0.350" Face Width	4	$267.28
	Metal Bevel Pinion, 0.350" Face Width	6	$184.92
	Aluminum Billet 6061-T6	1	$103.34
Steering	Shaft Mounted Worm, 1 Module, 2 Starts	1	$118.52
	Metal Worm Gear, 10 Pitch, 40:1 Speed Ratio	1	$123.60
	Ball Bearing, R18, 1-1/8" Shaft Diameter	2	$63.99
	Polycarbonate Washdown Enclosure	1	$36.28
	Rotary Shaft, 1566, 1" Diameter, 24" Long	1	$39.87
	Rotary Shaft 1566, 1" Diameter, 12" Long	2	$91.23
	Single U-Joint, 1" Diameter, 1-13/64" Deep	4	$358.48
	Aluminum Billet 6061-T6 0.125" 2' x 2'	1	$89.64
	Steering Wheel	1	$29.99
	Steering Wheel Shaft	2	$39.99
	Pivot Arm	1	$61.99
	Metal Shaft	1	$17.99
	Metal Control Arm	2	$49.99
	Bolts	6	$35.99
	Differential Enclosure	2	$79.99
	Axle	2	$227.99
	Metal Bevel Gear, 0.350" Face Width	4	$267.28
Hydraulics	Chief LD Welded Cylinder 1.5" Bore 1" Diameter	4	$559.96
	0.76 CID Hydraulic Gear Pump 3/4"	1	$116.00
	1/4" A36 Steel Plate, 36" x 36" (Bucket)	3	$452.48
	1/8" A36 Steel Plate, 36" x 36" (Bucket)	3	$360.00
	Apache 98392245 3/4" x 5' Low Pressure Hydraulic Return Line Hose with Worm Gear Clamps	4	97.48
	findmall Hydraulic Valve Hydraulic Directional Control Valve Double Acting Control Valve 2 Spool 11 GPM 3625 PSI SAE	1	$93.55
	Premium Universal Tractor Trans/Hydraulic Fluid, 5 gal.	1	$34.99
	Hydraulic Flow Control Valve, 5,000 psi, 8.0 gpm, Steel	1	$83.50
	A36 Steel Round Bar (Bucket)	1	$133.50
	Grade 5 Carriage Bolts	30	$95.70
	1" A36 Steel plate, 120" x 5" (Arms and supports 600 cubic inches per plate)	3	$318.85
Frame	A500 Rectangle Steel Tube, 4 X 2 X 1/4, 18 feet	1	$446.94
	A500 Square Steel Tube, 3 X 3 X 11GA, 14 feet	1	$182.64
	A500 Square Steel Tube, 2 X 2 X 1/4, 10 feet	1	$163.00
	A513 Square Steel Tube, 3/4 X 3/4 X 11GA, 18 feet	1	$76.10
	A500 Rectangle Steel Tube, 2 X 1 X 3/16, 4 feet	1	$85.32
	14 Gauge HR Steel Sheet, 2 x 8 feet	2	$275.20
	12 Gauge HR Steel Sheet, 2 x 4 feet	1	$108.60
General Purpose	12 Gallon Plastic Fuel Tank	1	$116.16
		total	$9,255.95

Member Responsibilities

Stephen: Steering, Differential, Steering Assembly, FEA of Arm, Overall Assembly

Matthew: Frame, Bucket, Gantt Chart, FEA of Frame and Bucket, Hydraulics Circuit Diagram, Hydraulics Animation, Exploded Views

Ryan: Transmission, Tires/Rims, Drive System Assembly, Power Distribution, FEA of Transmission Case

Josh: Arms, Hydraulics

Questions?

Thank You!

Supplemental Slides - Axle Mounting via Leaf Spring