

2016-2017 SAE Baja Design/Manufacturing Project

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Introduction to SAE (Society of Automotive Engineers) Baja Competition~2017

- Four day long competition (May 25th to 28th)
- Hosted by Pittsburg State University
- Multidepartment project (MECET, Automotive Technology)



Components of the Event

- Inspection
- Dynamic Event
- Endurance Test
- Design Finals



Problem Statement

- Car that can function pass SAE inspection
- Strategic car that perform well during the competition
- Meet the budget requirement



Material For The Tubing

Material: ASTM A36 Steel

Yield Strength: Min. 36,000 psi

Tensile Strength: 58,000 – 80,000 psi

The reason behind using this material?

Frame

Consideration for manufacturing phase:

- SAE Guideline
- Design compatibility

Manufacture Tools



CHOP SAW



STEEL BURR



BURR REMOVAL

Manufacturing Tools



BURR REMOVAL AND SCUFFING



MILLING MACHINE

Manufacturing Tools



BENDING MACHINE



WELDING MACHINE

Manufacturing Tools



TUPING COPING

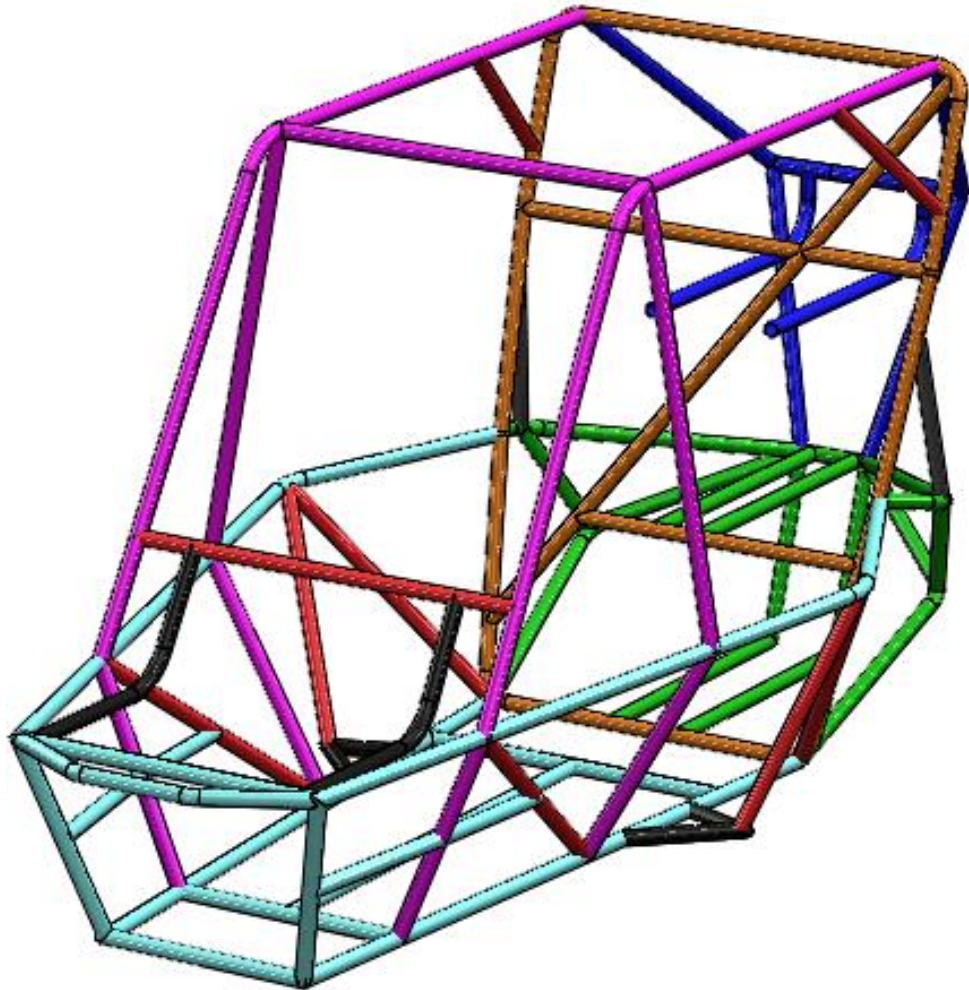


WATER JET

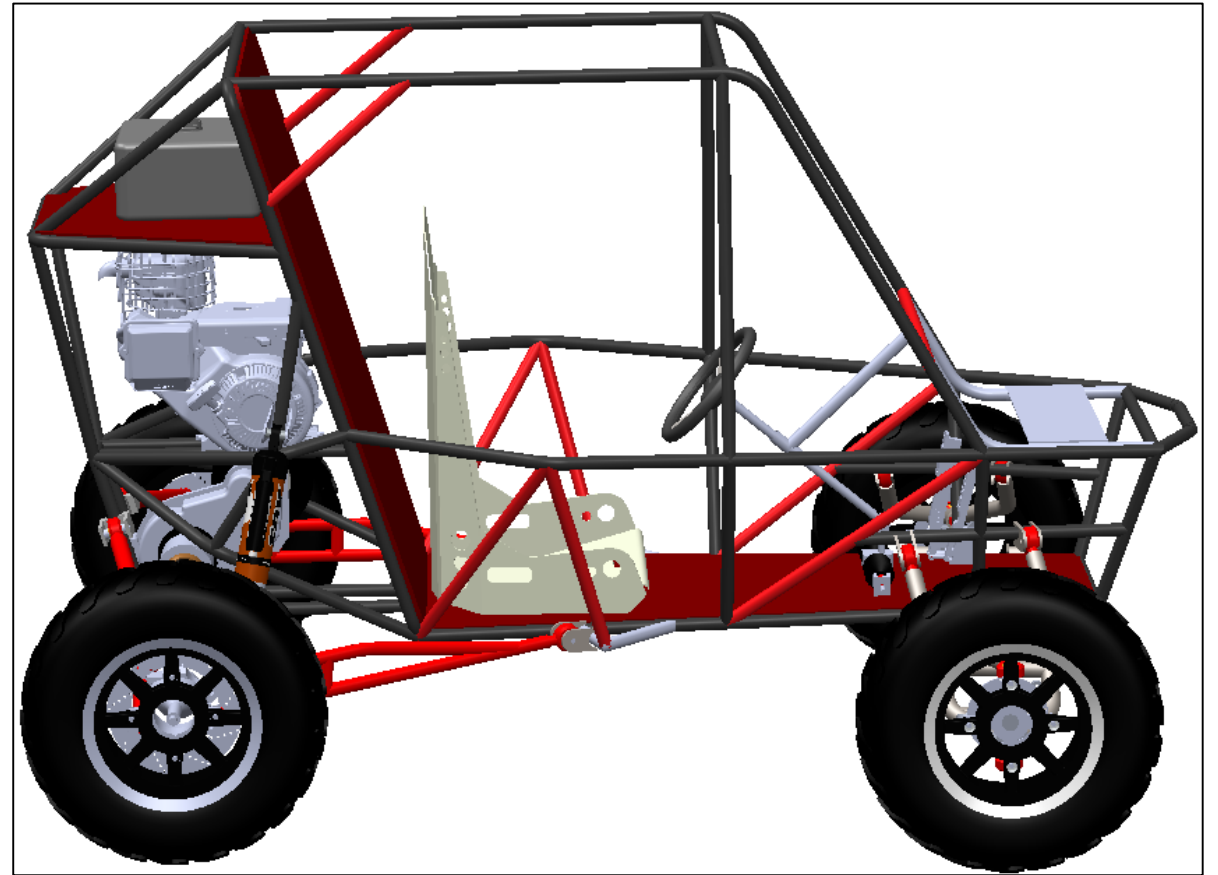
Frame Length, Height, and Width

Objective	Outcome
Maximum of 108 inches in length	91 inches
Height is based on the driver	60 inches
Maximum of 64 inches in width	59 inches

Frame Height and Width



Frame Length:



SAE Baja Suspension

- Overview

- Definition

- Suspension is the term given to the system of shock absorbers and linkages that connects between a vehicle and its wheels.

- Purpose:

- to keep the wheel in contact with the road surface as much as possible
 - to protect the vehicle itself from damage
 - to keep the driver as isolated possible from bumps and vibrations

Front Suspension

- Objectives

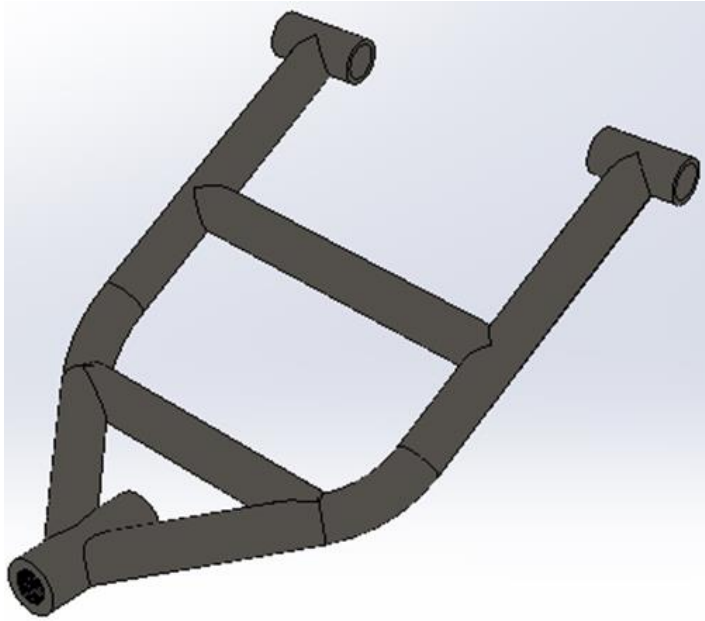
Objective	Outcomes
8 inches' suspension travel (minimum)	✓ Complete
No more than 64-inch distance between front wheels (maximum)	✓ Complete
15 inches' front clearance (maximum)	✓ Complete
Compatible dimensions for A-arms design	✓ Complete
Design and fabricate new suspension system	✓ Complete

Front Suspension

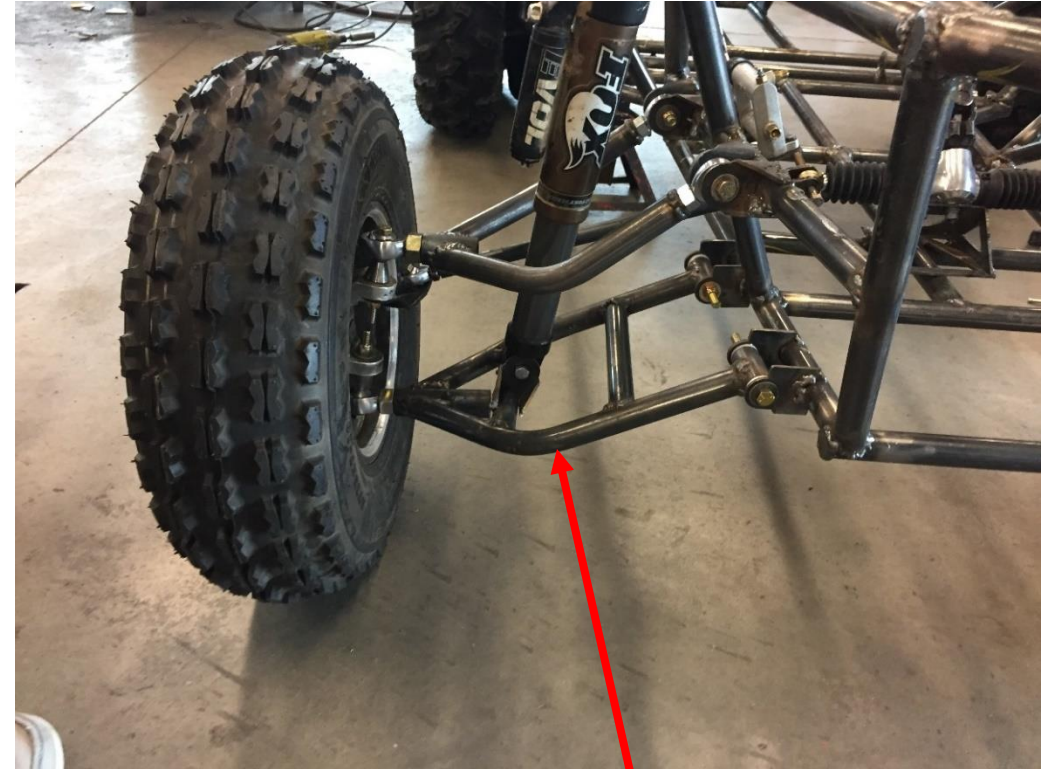
- Design phase of the front suspension
 - A-arm suspension
 - Mounting tabs or brackets
 - Nylon solid stock inserts
 - Steel heim joint inserts
 - Knuckle spacer
- Material:
 - ASTM A36 Steel Pipes
 - Nylon



Front Suspension Outcomes

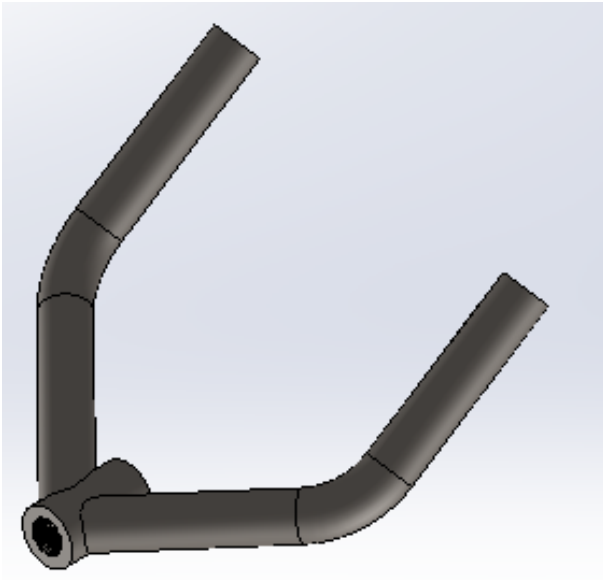


Lower A-arm on SolidWorks

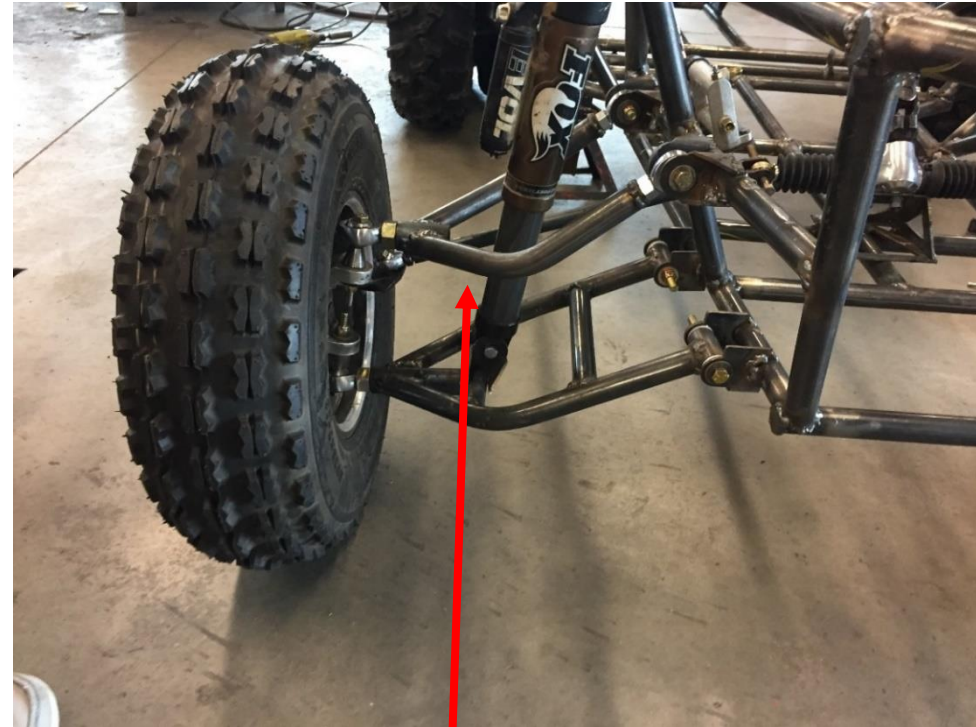


Lower A-arm

Front Suspension Outcomes



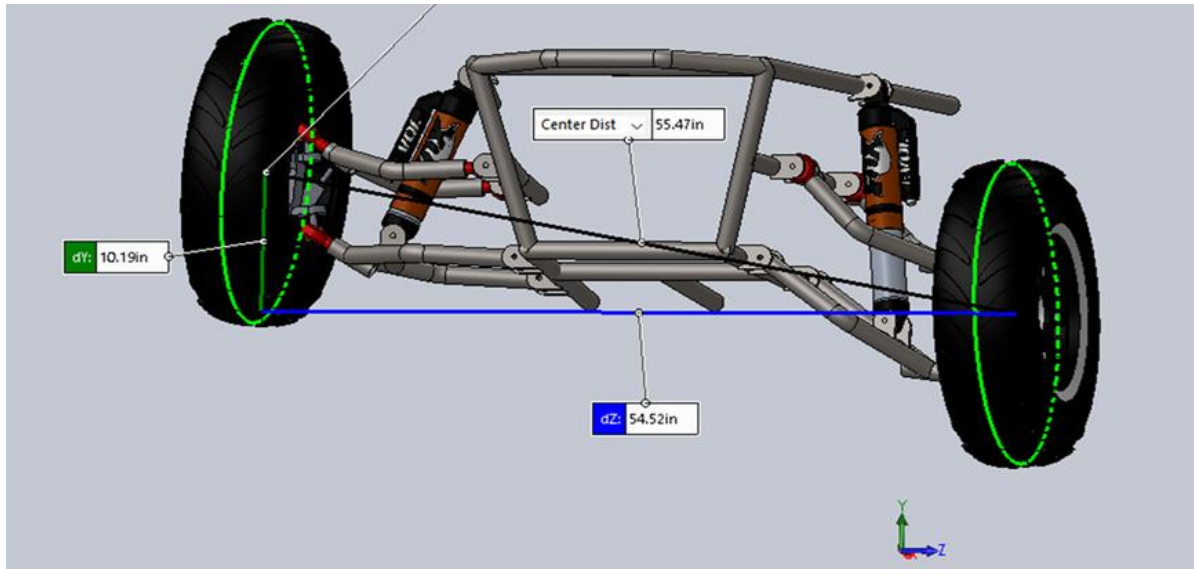
Upper A-arm on SolidWorks



Lower A-arm

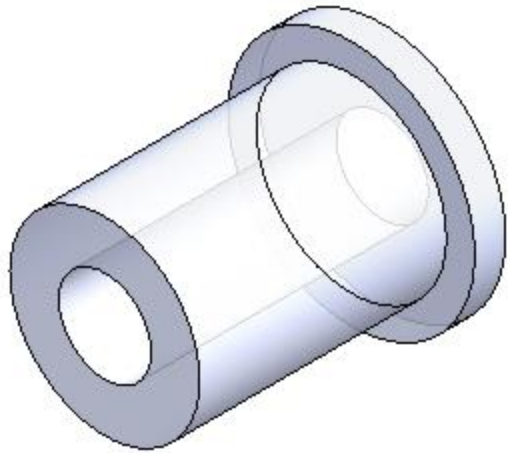


Front Suspension Outcomes



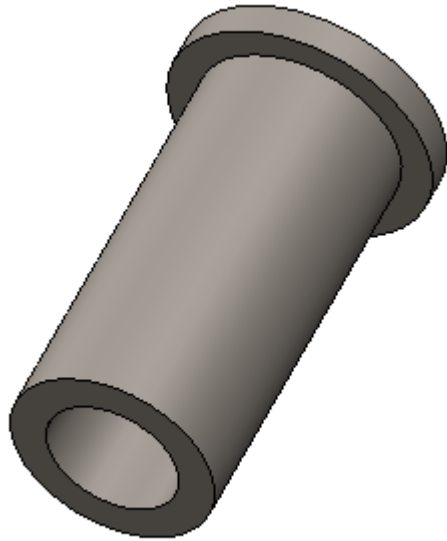
- a) Suspension travel is almost 9 inches (8 inches min.)
- b) Distance between front wheel is 59 inches (64 inches max.)
- c) Front suspension clearance is 15 inches (max.)

Front Suspension Outcomes



Nylon solid stock inserts
on SolidWorks

Front Suspension Outcomes

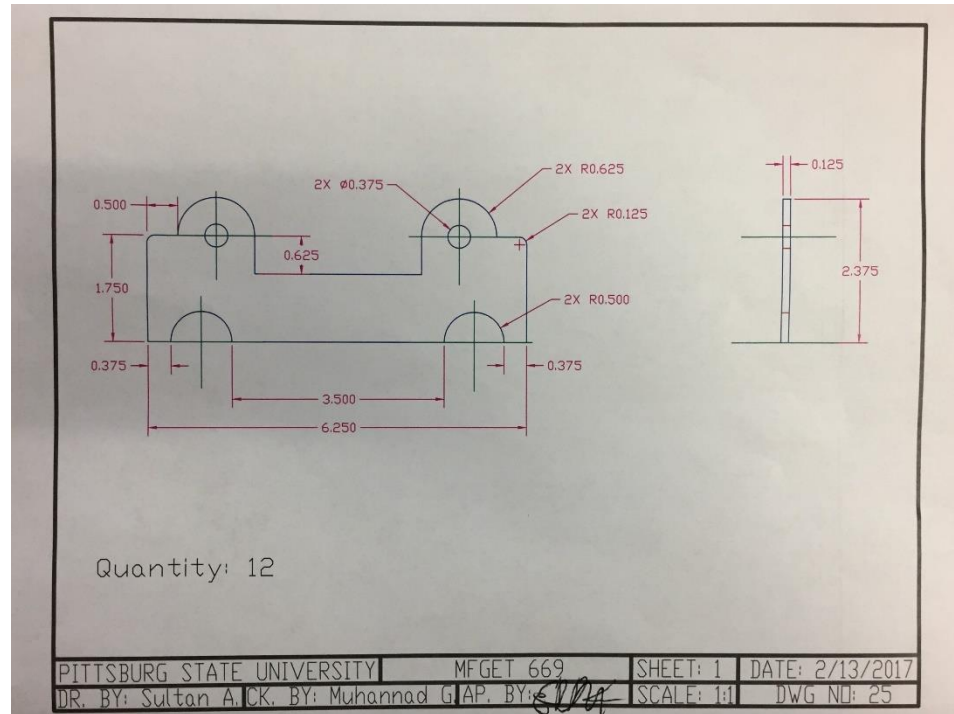


Steel heim joint inserts
on SolidWorks



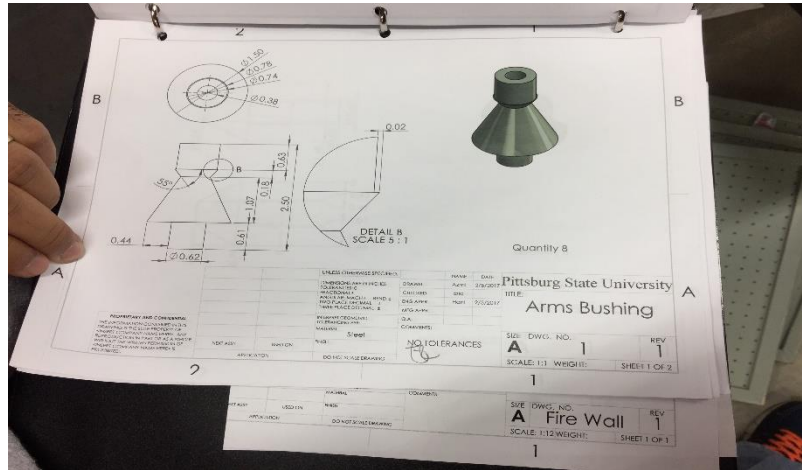
Steel insert

Front Suspension Outcomes

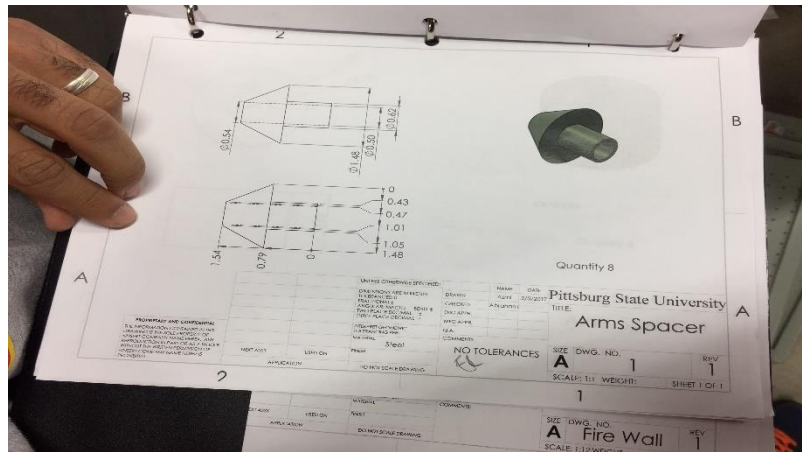


Mounting tabs or brackets
(water jet)

Front Suspension Outcomes



Knuckle spacer_
designed
by Azmi
Awari



Knuckle
head
spacer_
designed
by Azmi
Awari



Knuckle
spacer

Rear Suspension

Three Links Arms:

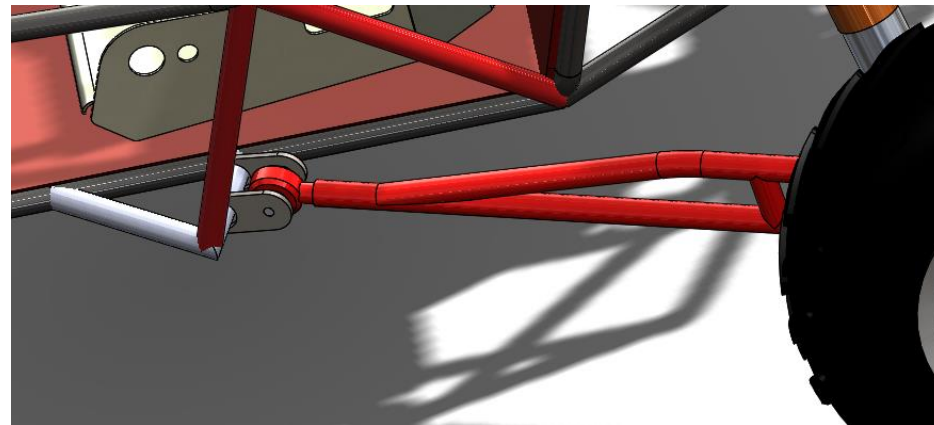
- Purpose?
- What is the goals?



Rear Suspension

- How to link it to the frame?

The angle shape at the middle of the frame will be Used to link the trailing arm.



Rear Suspension

- Manufacture process:

Purchase Parts:

- 2 off road Tires
- 2 Knuckles
- 2 Shafts
- 2 Fox Racing shocks
- 2 Hubs
- 10 Heim joints



Heim joints



Fox
shock

Knuckle

Rear Suspension

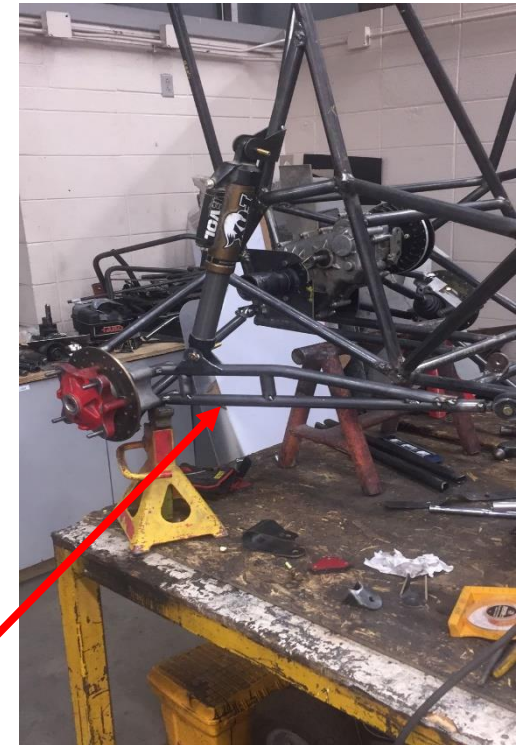
- Manufacture process:

Parts made in the shop:

- 2 Trailing Arms(24")
(ASTM A36 Steel)
- 4 Shock mount Brackets
(ASTM A36 Steel)
- 4 Support arms (17")
(ASTM A36 Steel)
- 10 Heim inserts
(ASTM A36 Steel)



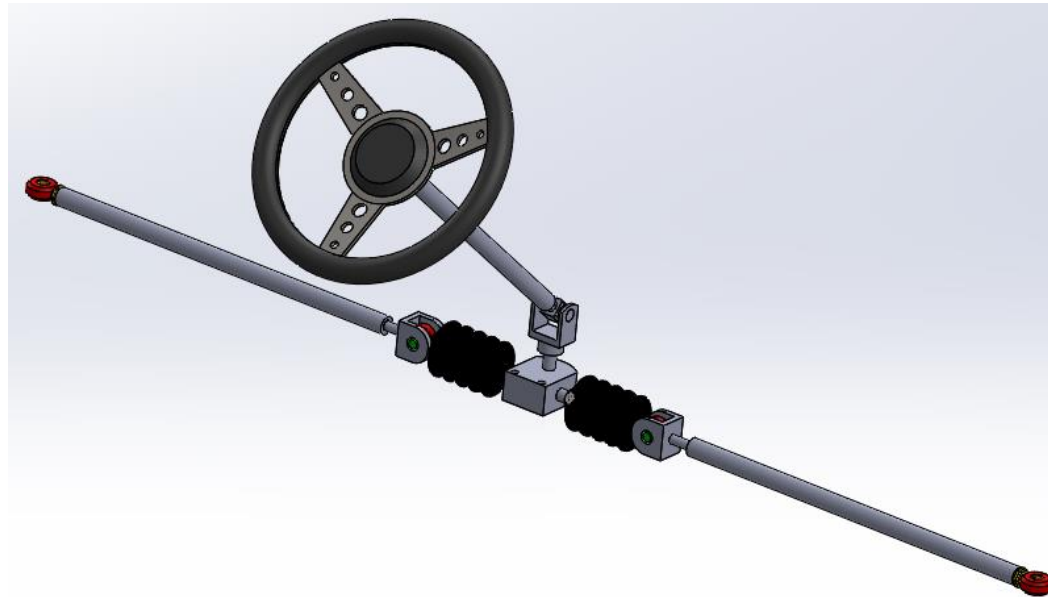
Shock mount
Bracket



Trailing arm

Steering System

- Purpose
 - To control the direction of the vehicle direction by turning the front wheels.



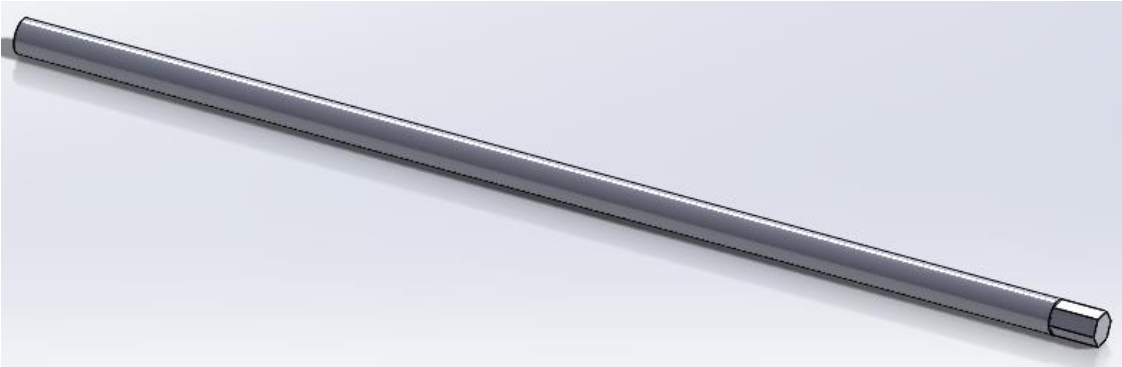
Steering System

- Component Parts
 - Steering Wheel Handel

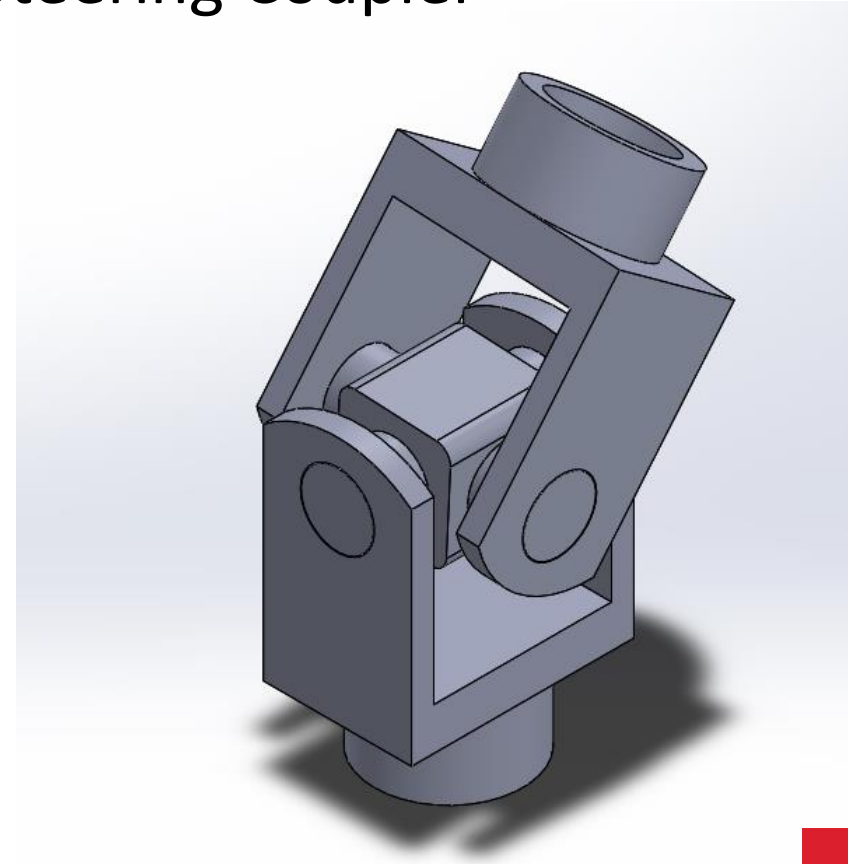


Steering System

- Steering Shafts

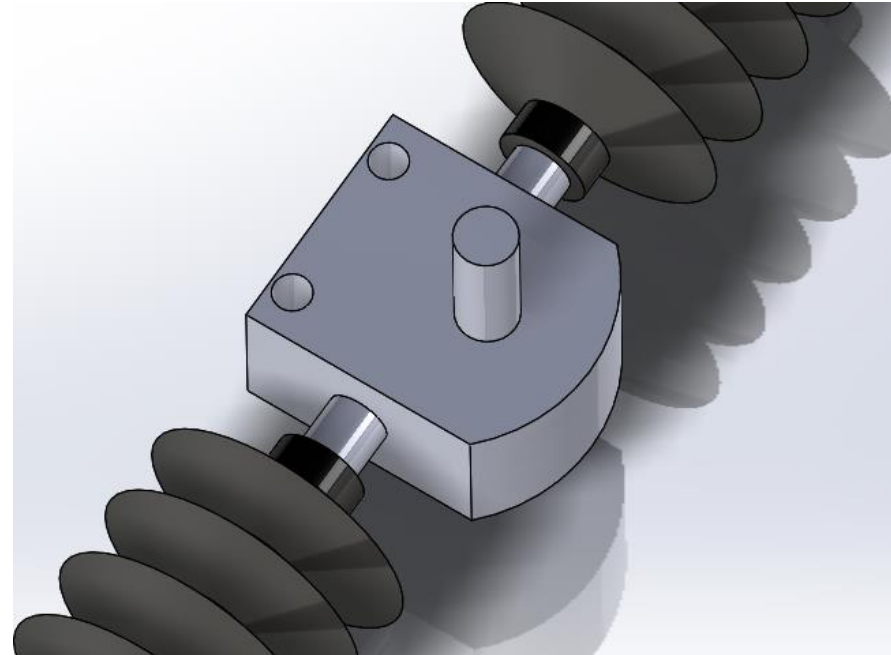


- Steering Coupler



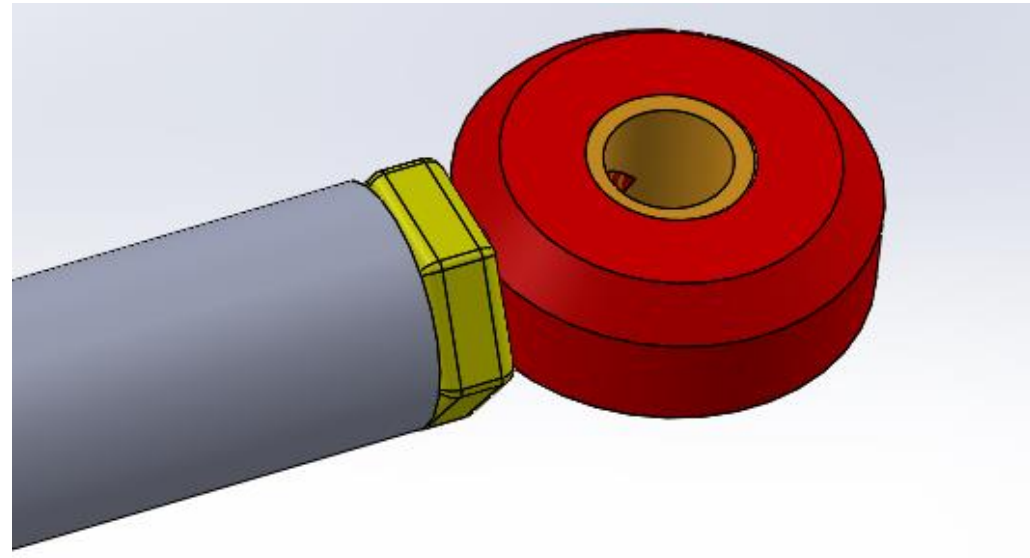
Steering System

- Rack and pinion & steering boot



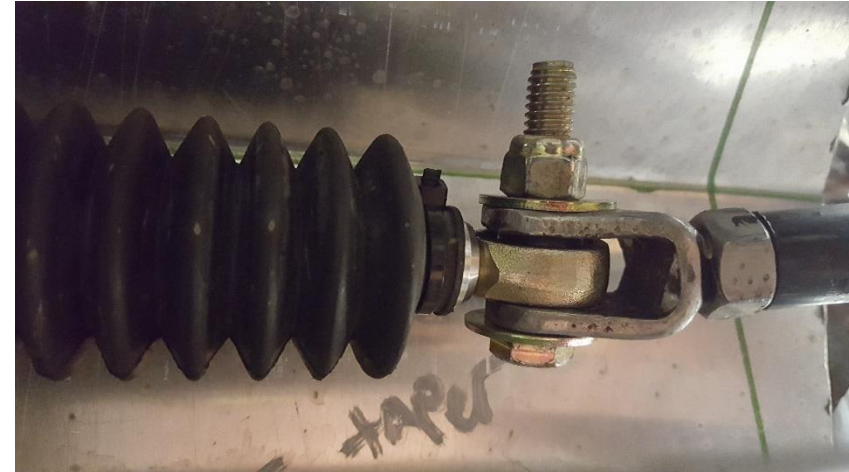
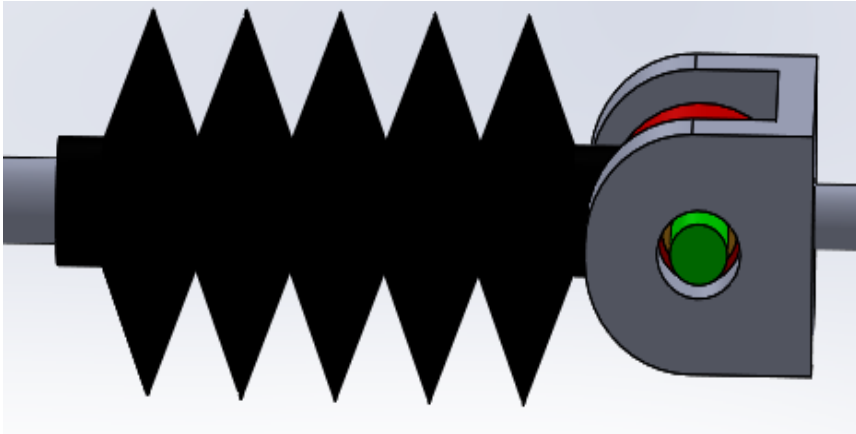
Steering System

- Heim Joints



Steering System

- Heim Joints



Steering System

- The Safety in the steering system
 - Good component quality.
 - Wheel alignment.
 - 1- To make the directions of the car more accurate.
 - 2- Avoiding the losing the control of the car.

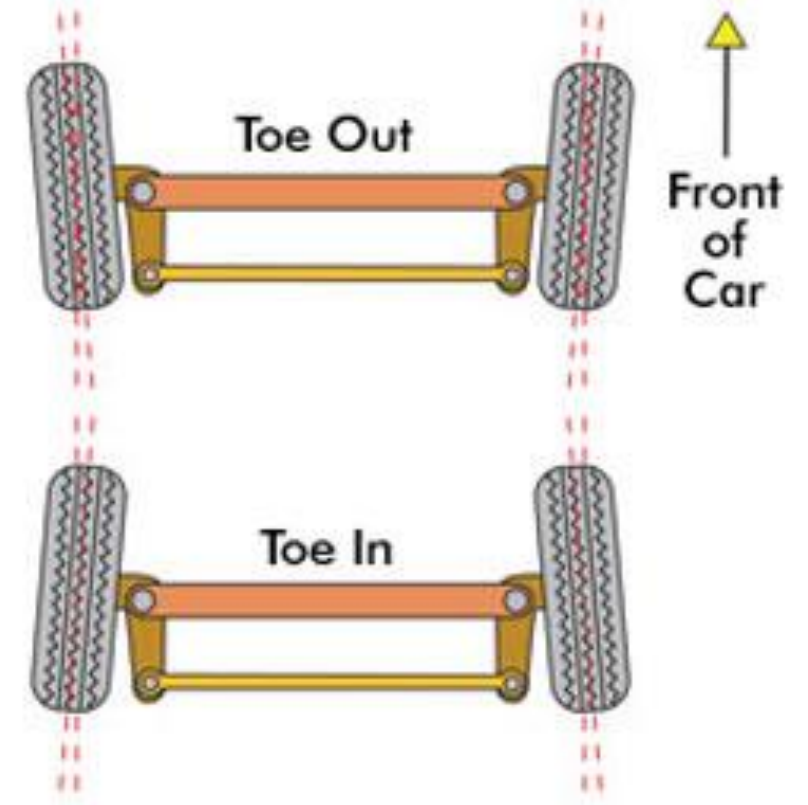
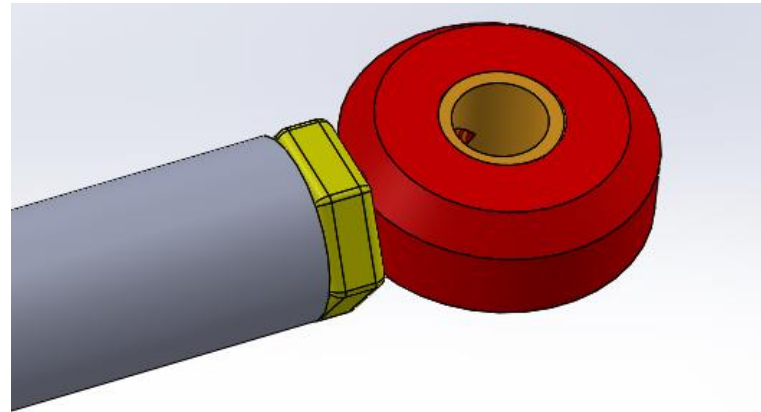
Steering System

- Wheel alignment.

Adjusting the angle of the Wheels.

Toe out

Toe in



Steering System

- Manufacture

DRILL SIZE	DECIMAL EQUIVALENT	TAP SIZE
27	.4150	
64	.4219	1/2 - 13
29	.4375	
64	.4531	1/2 - 20
31	.4688	
64	.4844	9/16 - 12

Starrett®
Precision, Quality and Innovation...
Since 1880

INCH/METRIC TAP DRILL SIZES & DECIMAL EQUIVALENTS

DRILL SIZE	DECIMAL EQUIVALENT	TAP SIZE	DRILL SIZE	DECIMAL EQUIVALENT	TAP SIZE	DRILL SIZE	DECIMAL EQUIVALENT	TAP SIZE
1	.1250		10	.1935		80	.9219	1 - 12
64	.1450		9	.1960		83	.9375	1 - 14
78	.1875		7	.2010		81	.9531	
77	.1880		6	.2031		84	.9688	1 1/8 - 7
76	.1920		5	.2040		84	.9844	
75	.1920		4	.2090		84	1.0000	1 1/8 - 12
74	.1925		3	.2130		1 3/16	1.0489	1 1/8 - 12
73	.1940		2	.2180		1 1/4	1.1094	1 1/4 - 7
72	.1950		1	.2210		1 1/8	1.1719	1 1/8 - 12
71	.1960		1	.2285		1 1/16	1.2188	1 1/8 - 6
70	.1980		A	.2340		1 1/4	1.2800	
69	.1992		B	.2344		1 1/8	1.2869	1 3/8 - 12
68	.2010		C	.2360		1 1/16	1.3438	1 1/2 - 6
67	.2032		D	.2420		1 3/8	1.3750	
66	.2030		E	.2460		1 1/2	1.4219	1 1/2 - 12
65	.2050		F	.2500				
64	.2060		G	.2570				
63	.2070		H	.2610				
62	.2090		I	.2656				
61	.2090		J	.2660				
60	.2090		K	.2720				
59	.2090		L	.2770				
58	.2090		M	.2810				
57	.2090		N	.2812				
56	.2090		O	.2860				
55	.2090		P	.2900				
54	.2090		Q	.2950				
53	.2090		R	.2969				
52	.2090		S	.2980				
51	.2090		T	.3020				
50	.2090		U	.3080				
49	.2090		V	.3125				
48	.2090		W	.3160				
47	.2090		X	.3180				
46	.2090		Y	.3220				
45	.2090		Z	.3260				
44	.2090			.3300				
43	.2090			.3348				
42	.2090			.3380				
41	.2090			.3438				
40	.2090			.3480				
39	.2090			.3580				
38	.2090			.3594				
37	.2090			.3660				
36	.2090			.3750				
35	.2090			.3770				
34	.2090			.3860				
33	.2090			.3906				
32	.2090			.3970				
31	.2090			.4040				
30	.2090			.4062				
29	.2090			.4130				
28	.2090			.4219				
27	.2090			.4219				
26	.2090			.4375				
25	.2090			.4531				
24	.2090			.4688				
23	.2090			.4844				
22	.2090			.5000				
21	.2090			.5156				
20	.2090			.5312				
19	.2090			.5469				
18	.2090			.5625				
17	.2090			.5781				
16	.2090			.5938				
15	.2090			.6094				
14	.2090			.6250				
13	.2090			.6406				
12	.2090			.6562				
11	.2090			.6719				
10	.2090			.6875				
9	.2090			.7031				
8	.2090			.7188				
7	.2090			.7344				
6	.2090			.7500				
5	.2090			.7656				
4	.2090			.7812				
3	.2090			.7969				
2	.2090			.8125				
1	.2090			.8281				
	.2090			.8438				
	.2090			.8594				
	.2090			.8750				
	.2090			.8906				
	.2090			.9062				

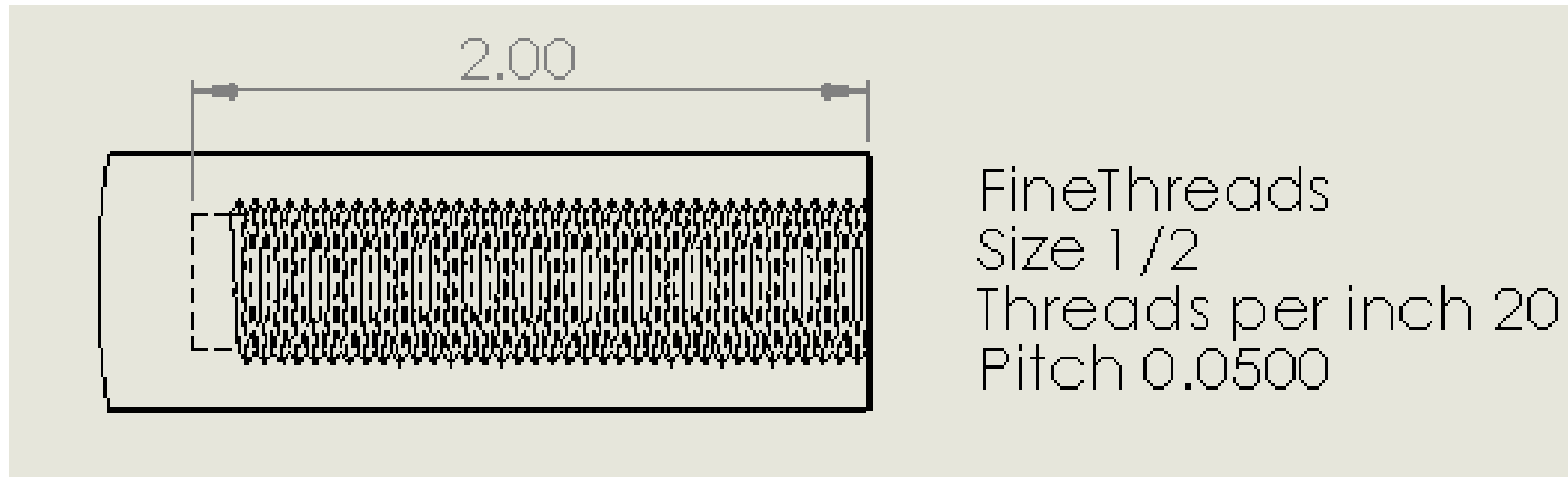
METRIC TAP DRILL SIZES		
METRIC TAP	TAP DRILL (mm)	DECIMAL (in)
M1.6 x 0.35	1.25	.0492
M1.8 x 0.35	1.45	.0571
M2 x 0.4	1.60	.0630
M2.2 x 0.45	1.75	.0689
M2.5 x 0.45	2.05	.0807
M3 x 0.5	2.50	.0984
M3.5 x 0.6	2.90	.1142
M4 x 0.7	3.30	.1299
M4.5 x 0.75	3.70	.1457
M5 x 0.8	4.20	.1654
M6 x 1	5.00	.1969
M7 x 1	6.00	.2362
M8 x 1.25	6.70	.2638
M8 x 1	7.00	.2756
M10 x 1.5	8.50	.3346
M10 x 1.25	8.70	.3425
M12 x 1.75	10.20	.4016
M12 x 1.25	10.80	.4252
M14 x 2	12.00	.4724
M14 x 1.5	12.50	.4921
M16 x 2	14.00	.5512
M16 x 1.5	14.50	.5709
M18 x 2.5	15.50	.6102
M18 x 1.5	16.50	.6496
M20 x 2.5	17.50	.6890
M20 x 1.5	18.50	.7283
M22 x 2.5	19.50	.7677
M22 x 1.5	20.50	.8071
M24 x 3	21.00	.8268
M24 x 2	22.00	.8661
M27 x 3	24.00	.9449
M27 x 2	25.00	.9843
M30 x 3.5	26.50	1.0433
M30 x 2	28.00	1.1024
M33 x 3.5	29.50	1.1614
M33 x 3	31.00	1.2205
M36 x 4	32.00	1.2598
M36 x 3	33.00	1.2992
M39 x 4	35.00	1.3780
M39 x 3	36.00	1.4173

PIPE THREAD SIZES (NPS)			
THREAD	DRILL	THREAD	DRILL
1/8 - 27	11/32	1 1/2 - 11 1/2	1 1/4
1/4 - 18	7/16	2 - 11 1/2	2 1/32
3/8 - 18	27/64	2 1/2 - 8	2 1/32
1/2 - 14	29/32	3 - 8	3 1/4
3/4 - 14	59/64	3 1/2 - 8	3 3/4
1 - 11 1/2	1 1/32	4 - 8	4 1/4
1 1/4 - 11 1/2	1 1/2		



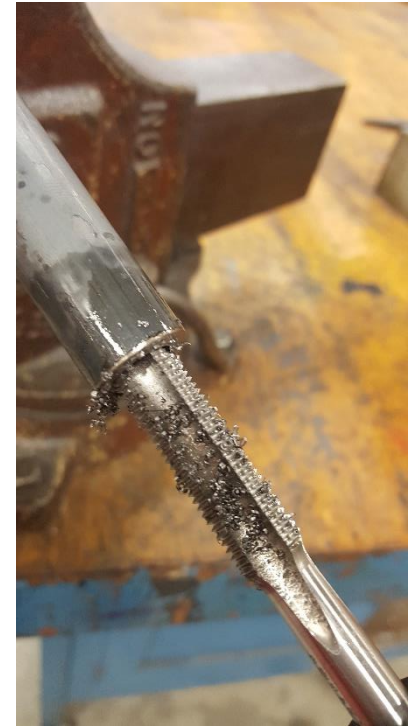
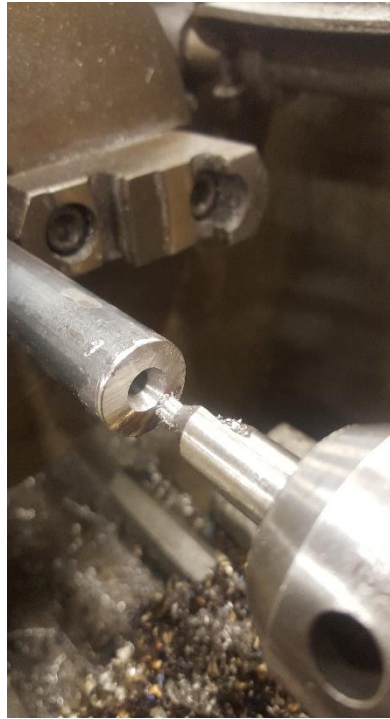
Steering System

- Drawing



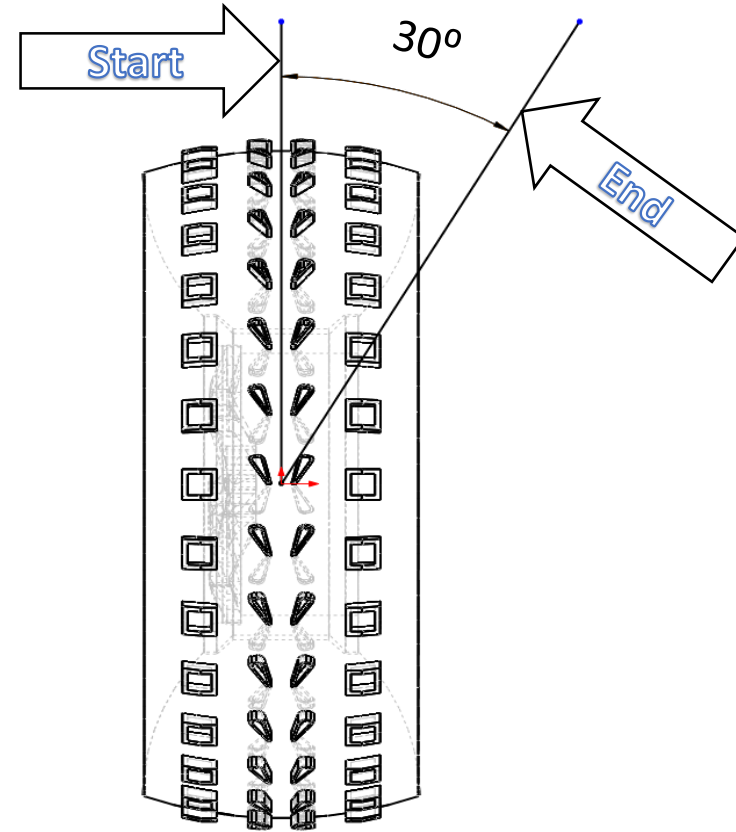
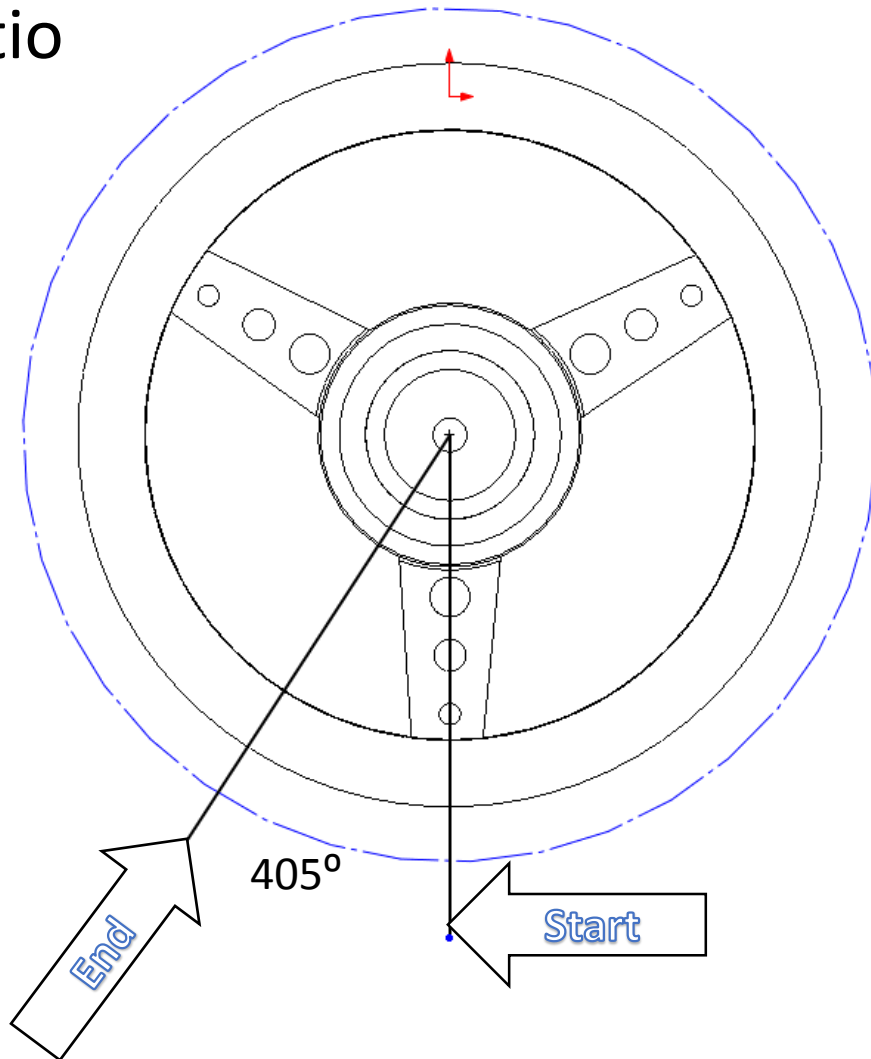
Steering System

- Manufacture



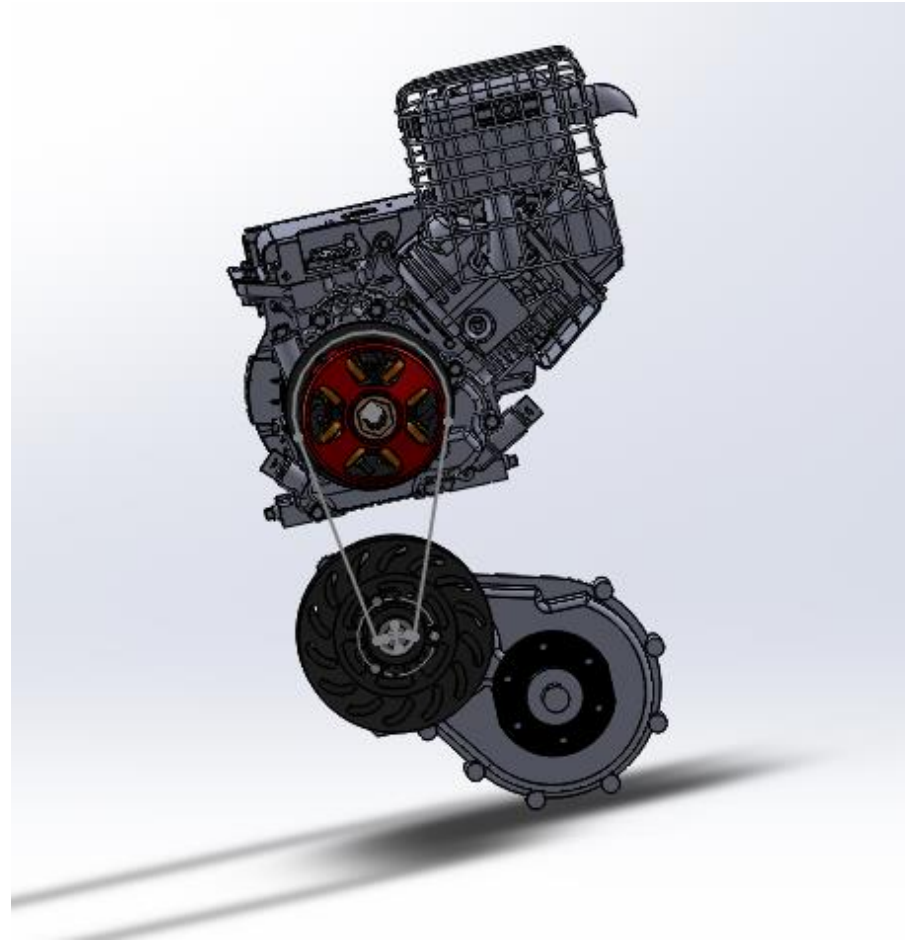
Steering System

- Ratio



Powertrain: Design & Manufacturing Process

- Strategic (Torque vs Speed)
- Availability of products
- Cost



Powertrain Dynamic Test: Torque Requirements 1

- Uphill Climb

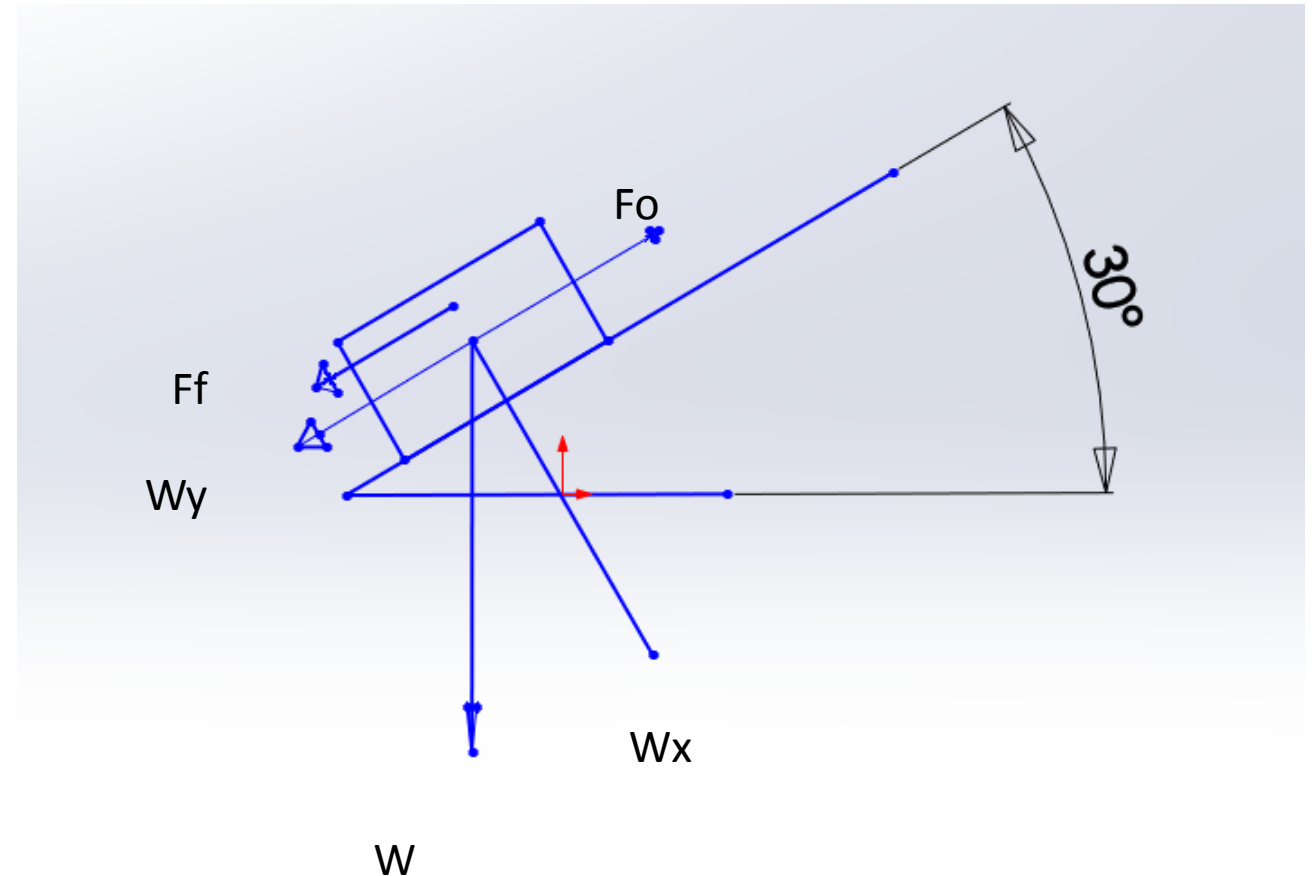
F_o = Force needed to be overcome

W = Weight (x and y components included)

F_f = Frictional Force

$F_o = W_y + F_f$

Torque = F_o * Radius of the wheel



Powertrain Dynamics Test: Torque Requirements 2

- Load carrying capacity test
- Functional requirement: **Overcome static friction**

F_o = Force needed to be overcome to put the car in motion

W = Weight (Car + Driver)

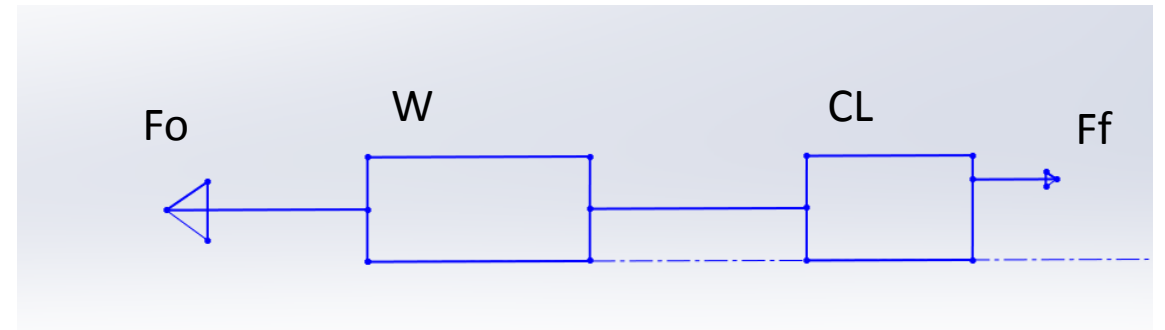
CL = Carried Load

F_f : Frictional force

F_f = Friction Coefficient * Total Load

$F_o > F_f$

Torque = F_o * Radius of the Wheel



Dynamic Test : Inclined Plane Uphill Climb

Weight Cars (lbs)	450	Total Load to overcome	482.6166235
Weight Driver (lbs)	200	Total Torque on System	402.1805196
Max Inclination	30		
Friction Coefficient	0.28		



Dynamic Test: Load Carrying Capacity on a Flat Plane



Attached Load (lbs)

200

Friction Coeff.

0.62

Load Overcome

527

lbs

Torque Needed

439.1666667

ft*lbs

Engine Speed (RPM)	Driving Pulley Diameter (in)	Driven Pulley Diameter (in)	Transaxle Input	Transaxle Output	Tire Diameter (in)	Efficiency	Torque (HP)
1315.00	7.00	3.00	1.00	10.50	20.00	0.65	10.50
		.					
	2.333333333		Transaxle Ratio	0.095238095			

Driveshaft RPM	Engine Output Torque (ft*lbs)
292.222222	
2	440.3292776

Ground Speed (Rear Tires)
11.3017



Manufacturing Process

1. Assembly (assembling the purchased parts together)
2. Fabrication (Safety cover)

Purchased parts:

- Engine
- Differential
- CVT Pulleys
- Transmission belt



Engine: Briggs & Stratton 10 HP
OHV Intek, Model
19

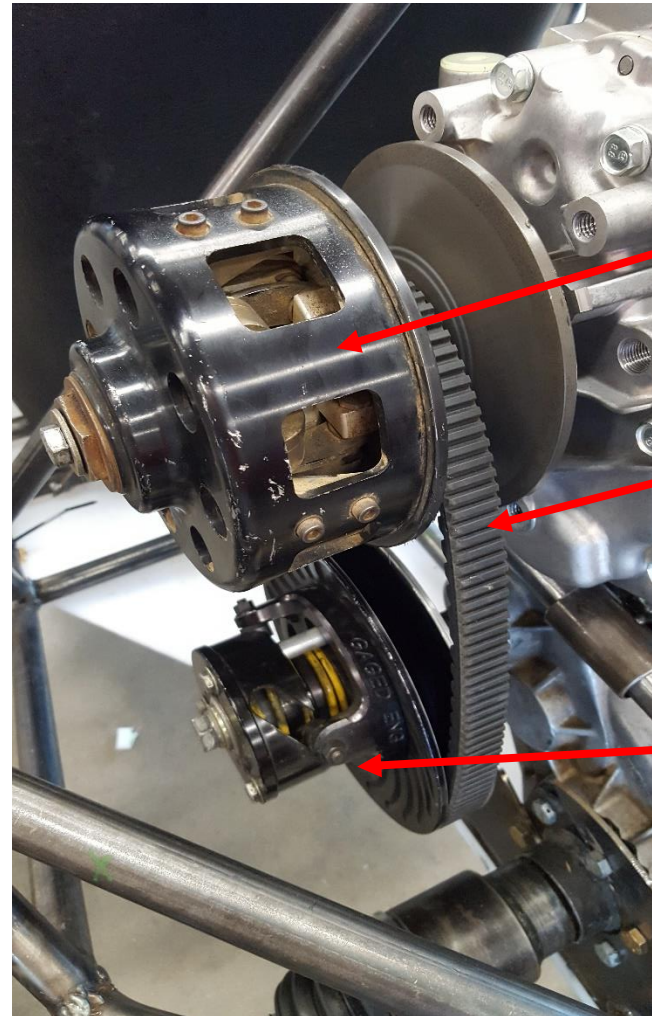


Output shaft for
the engine, prior
to attaching the
CVT drive Pulley

Input shaft for the
differential, prior to
the attaching the
CVT driven pulley

Differential

CVT Assembly

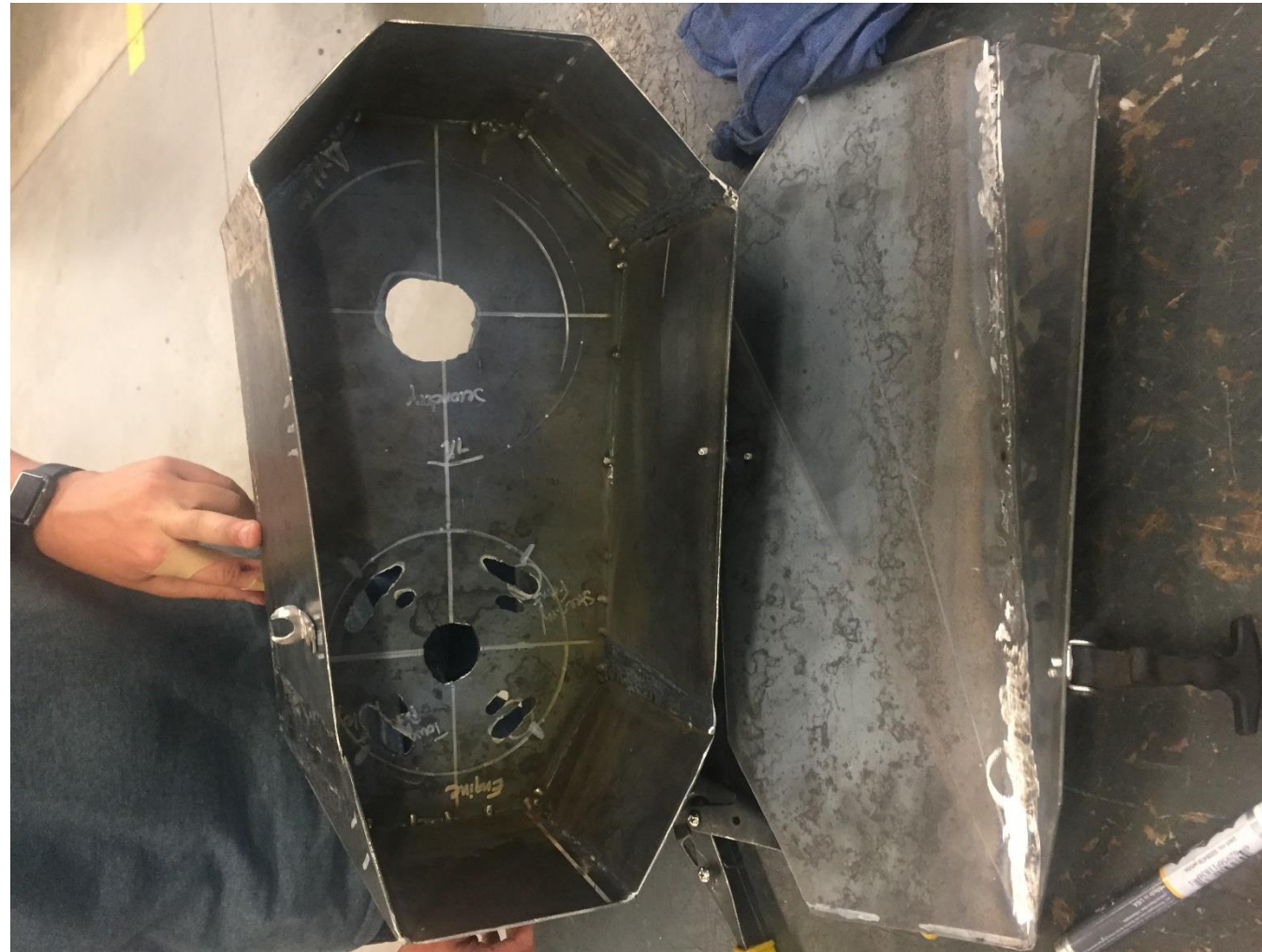


Drive Pulley

Belt

Driven
Pulley

Fabricated Part: Safety Cover



Drivetrain Speed Expectations Vs Manufacturing Outcome

Values	Expected Value	Actual Output
Overall Efficiency	80%	65%
Ground Speed	35	32

Engine Speed (RPM)	Driving Pulley Diameter (in)	Driven Pulley Diameter (in)	Transaxle Input	Transaxle Output	Tire Diameter (in)	Efficiency	Torque (HP)
3800.00	7.00	3.00	1.00	10.50	20.00	0.65	10.50
		.	Transaxle Ratio				
	2.3333333333		0.095238095				

Driveshaft RPM Engine Output Torque (ft*lbs)

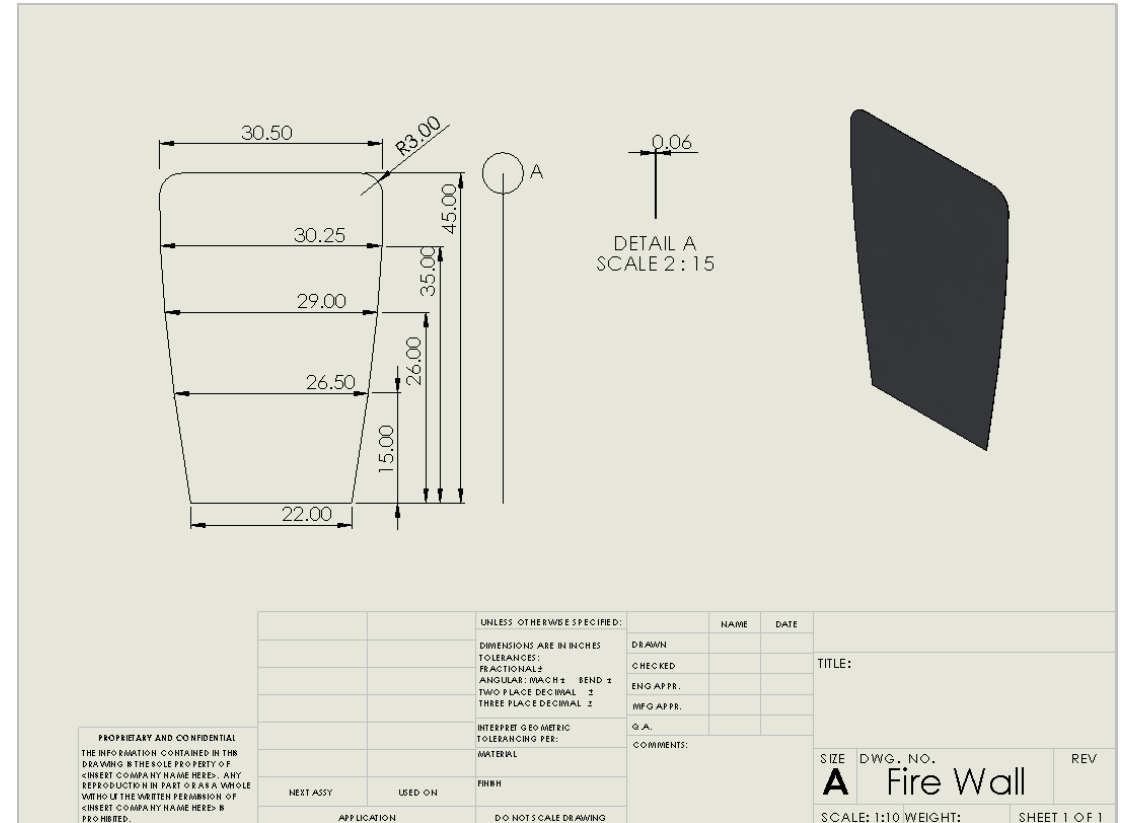
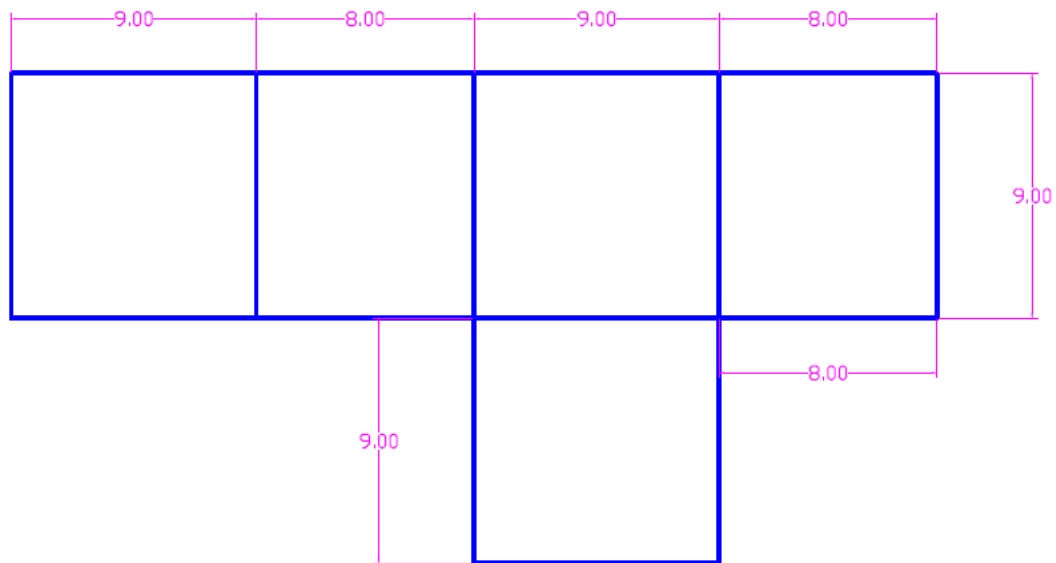
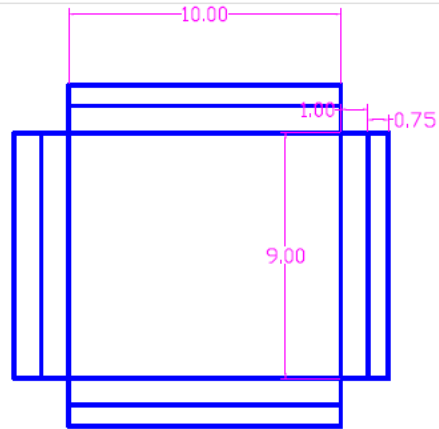
844.4444	
444	152.3771053

Ground Speed (Rear Tires)

32.6588



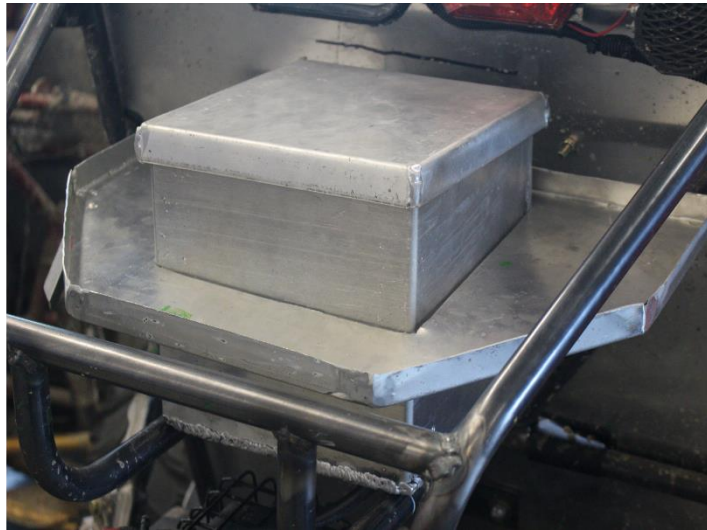
Drawing:



Machines Used to make Fuel Box:



Water Jet Cutter



Fuel Box

Safety: Design Requirement

1- Brake Light:

Type: Polaris #2411450



2- Reverse Light:

Type: Backup light J759



Safety: Design Requirement

3- Kill Switches:

Type: Stock Polaris #4013381.

2 Kill Switches.

External Switch Mount.

4- Belt Restraint:

Metal to Metal Buckle (50 in).

Safety Harness at least (5 point).

Lab Belt and Shoulder Belt.



Front Kill switch



Back kill switch



Belt restraint



5- Helmet & Head Restrain:
Driver helmet (6 in) clearance.
Shoulder, Knee, Hips, Arms Elbow ,
Hands (3 in) clearance.



Head clearance for the driver

6- Fire Extinguisher:
Quick Release.
Mount on the cockpit Labeled.



Fire extinguisher

Other Safety Features:

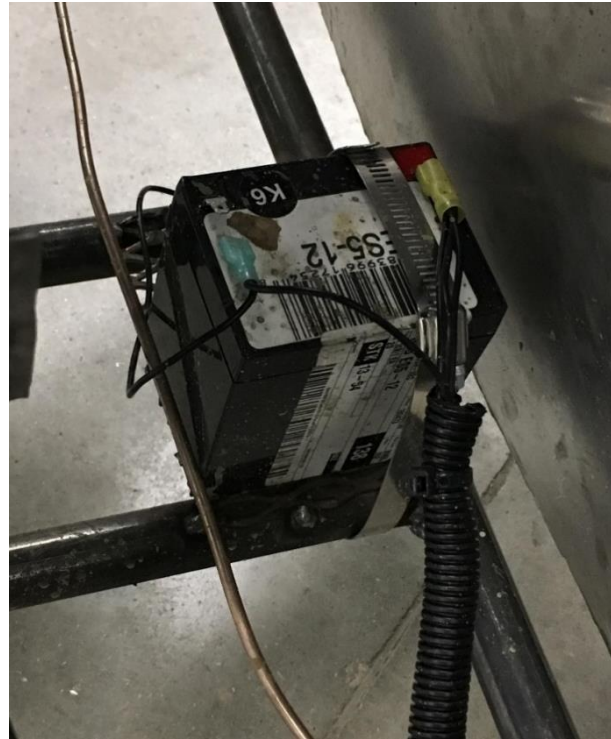
7- Steering Wheel able to replace easily.

8- All wiring must be sealed.



Sealed wires

9- Batteries mounted with sound engineering, and able to provide power to brake light etc.



Battery

Created By Hani Alnakhly



2017 Baja SAE Official Costing Sheet

Gorilla Racing

YOU MUST ENTER YOUR CAR NUMBER FOR EACH EVENT.
Enter numbers only (ie: 2,6,13,24) If you are NOT entering the event leave blank

	CAL	KAN	ILL
Car Number		113	
Total Cost		\$14,146.34	

Enter Team Name in Cell F3

Sect #	Item	Description	Subassembly Costs		Vehicle Assembly Labor		Subtotal		Cost Adj. Form	Adjustment	Judges
			Material	Labor	Time(min)	Cost	Material	Labor			Adjusted Cost
1	Engine		\$831.27	\$65.20		\$0.00	\$831.27	\$65.20			\$896.47
2	Transmission		\$2,617.77	\$108.65		\$0.00	\$2,617.77	\$108.65			\$2,726.42
3	Drive Train		\$1,073.92	\$14.58		\$0.00	\$1,073.92	\$14.58			\$1,088.50
4	Steering		\$471.14	\$112.52		\$0.00	\$471.14	\$112.52			\$583.66
5	Suspension		\$2,504.84	\$356.20		\$0.00	\$2,504.84	\$356.20			\$2,861.04
6	Frame		\$743.30	\$826.61		\$0.00	\$743.30	\$826.61			\$1,569.91
7	Body		\$161.21	\$171.72		\$0.00	\$161.21	\$171.72			\$332.93
8	Brakes		\$1,738.72	\$54.15		\$0.00	\$1,738.72	\$54.15			\$1,792.87
9	Safety Equipment		\$165.00	\$8.75		\$0.00	\$165.00	\$8.75			\$173.75
10	Electrical Equipment		\$311.06	\$20.42		\$0.00	\$311.06	\$20.42			\$331.48
11	Fasteners		\$134.54			\$0.00	\$134.54	\$0.00			\$134.54
12	Miscellaneous		\$727.56	\$122.50		\$0.00	\$727.56	\$122.50			\$850.06
13	CAL Event		\$0.00	\$0.00		\$0.00	\$0.00	\$0.00			\$0.00
14	KAN Event		\$798.88	\$5.83		\$0.00	\$798.88	\$5.83			\$804.71
15	ILL Event		\$0.00	\$0.00		\$0.00	\$0.00	\$0.00			\$0.00
		CAL Total:	\$11,480.33	\$ 1,861.29		\$ -	\$ 11,480.33	\$ 1,861.29			\$13,341.63
		KAN Total:	\$12,279.21	\$ 1,867.13	0	\$ -	\$ 12,279.21	\$ 1,867.13			\$14,146.34
		ILL Total:	\$11,480.33	\$ 1,861.29		\$ -	\$ 11,480.33	\$ 1,861.29			\$13,341.63



Conclusion

- How can we improve it better for next year?
- Causes for unmet expectations
- Better analysis

Short Video

