TRAILBLAZERS

INDIAN INSTITUTE OF ENGINEERING SCIENCE AND TECHNOLOGY, SHIBPUR

TEAM ID - 24102

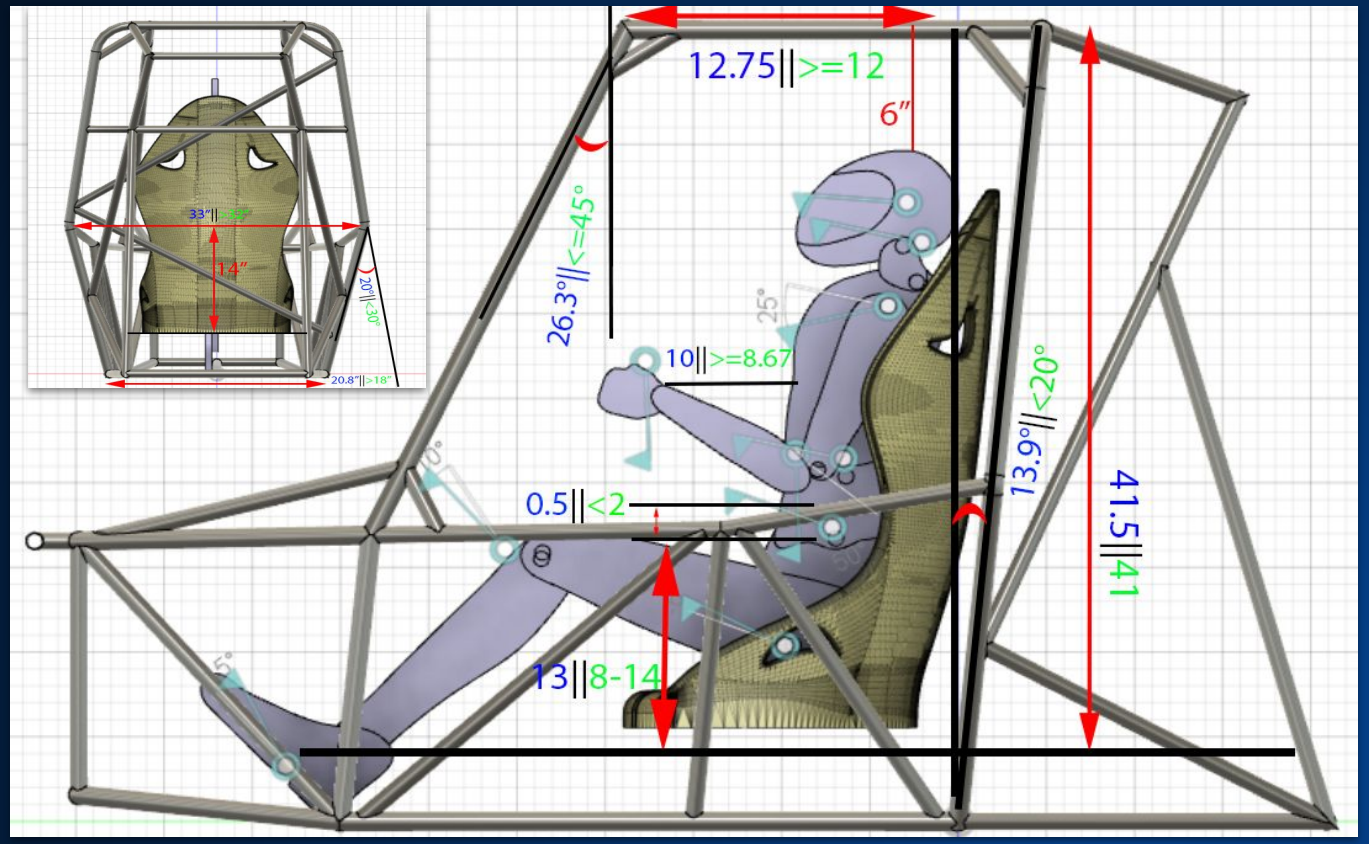
Estimated Vehicle Cost, Weight & Specs.

Category	Items	Cost (₹)
Frame	Steel tubes, Sheet metal, Welding Supplies, Rollcage Padding, etc.	35,000
Wheels and Tyres	Rims and Tyres	48,000
Suspension	Shocks, Springs, Uprights,Spindles, A-Arms	30,000
Steering	Rack & Pinion, Steering Column, Steering Wheel, Tie rods, etc.	19,000
Braking	Calipers, Master Cylinders, Disc, Brake lines, etc.	15,000
Power Train		60,000
Safety Equipments	Driver's Suit, Seat Belts, Seat, Fire Extinguishers, Kill Switch, etc.	60,000
Miscellaneous	Fasteners, Brake oil, Gear oil, Electricals, etc.	5,000
Total		**2,72,000**

Components	Weight (kg)
Roll Cage	32
batteries	19
Transmission(PMSM motor, Controller, FNR,Speed reduction gear-box, CV joint Shafts)	30
Wheels	34
Suspension Assembly(Shocker, wishbone)	24
Steering Assembly(rack, column, steering wheel, tie rod, hub,uprights)	16
Braking Assembly(disc, callipers, brake lines, master cylinders)	10
Seat & Panels	10
Miscellaneous(fasteners, safety equipments, etc.)	5
Total	**180**

VEHICLE STATISTICS	MEASUREMENT/DIMENSIONS			
	FRONT		REAR	
	Length/Dia.	Width	Length/Dia.	Width
Overall Vehicle	Length = 71.2”		Width = 63.4”	
Track Width	59.05”		58.58”	
Wheel Base	61.02”			
Ground Clearance	12”		12”	
Wheel/Type	23”	10”	23”	10”
Maximum Speed	43km/hr			
Gradeability	88.74 %			
Stopping Distance	6.874 m			
Kerb Weight	180 kg			
Weight Distribution	40%		60%	
Sprung Mass	180 kg			
Unsprung Mass	80 kg			

ROLL CAGE DESIGN



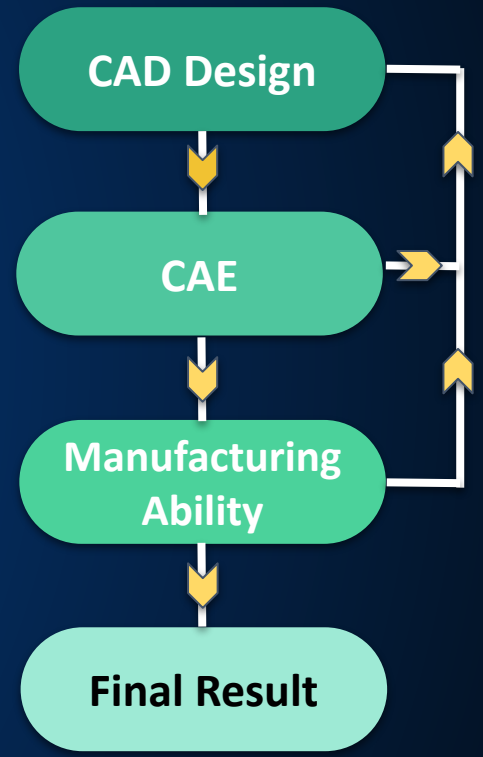
Priorities

1. BAJA Rulebook
2. Drivers comfort
3. Drivers Safety
4. Cost to Manufacture
5. Lightweight Rollcage

Ergonomic Analysis

- Upper Arm Score=+1
- Lower Arm Score=+1
- Wrist Score=+1
- Neck Score=+1
- Trunk Score=+1
- Leg Score(REBA)=+2
- Leg Score(RULA)=+1
- Force/Load Score=1
- Muscle Score=+1
- Activity Score=+1
- Coupling Score=0

Design Process



MEMBER	OUR SPECIFICATIONS		RULEBOOK SPECIFICATIONS	
	Primary Members	Secondary Members	Primary Members	Secondary Members
Material	AISI 4130	AISI 4130	AISI 4130	-
Size(mm)	29.21*1.65	25.4*1.2	25*3	>25.4*0.89
Bending Stiffness	2790.55Nm^2	1371.79Nm^2	2619.416Nm^2	1056.3Nm^2
Bending Strength	428.88Nm	242.374Nm	373.10Nm	150.12Nm

	RULA	REBA
Table A	1	2
Table B	1	1
Table C	2	2
Final Score	2	3

TRAILBLAZERS
SAE IIEST CHAPTER

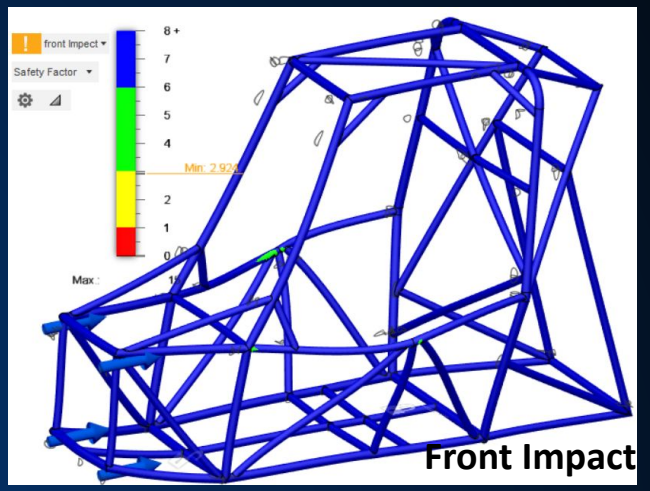
CAE & APPLICATIONS

*Pictures shown here on Structural Simulation are Deformation pictures and the deformation is scaled for visualization.

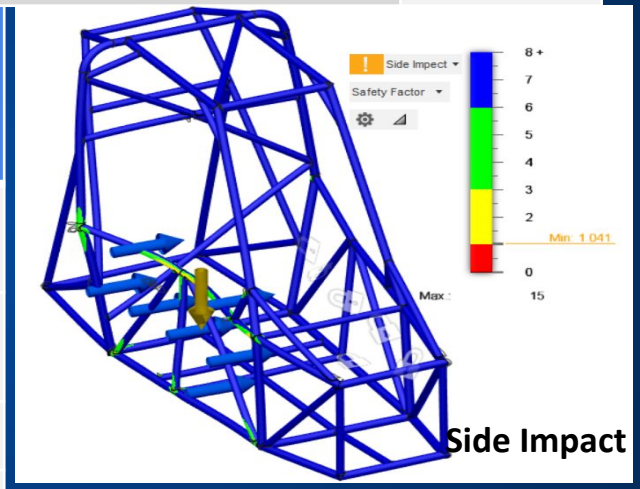
INDEX

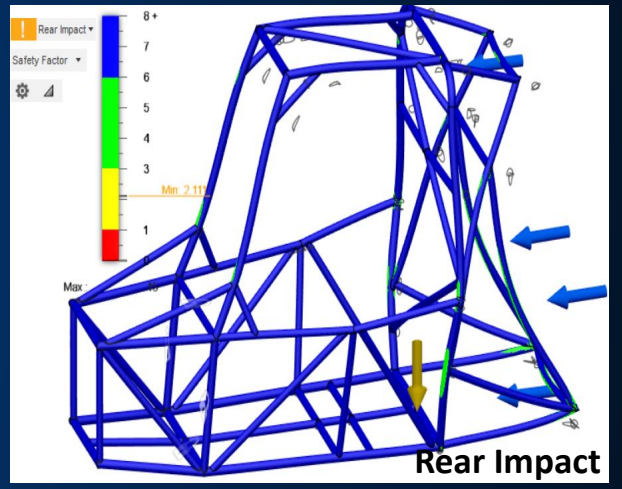
→ Force Load

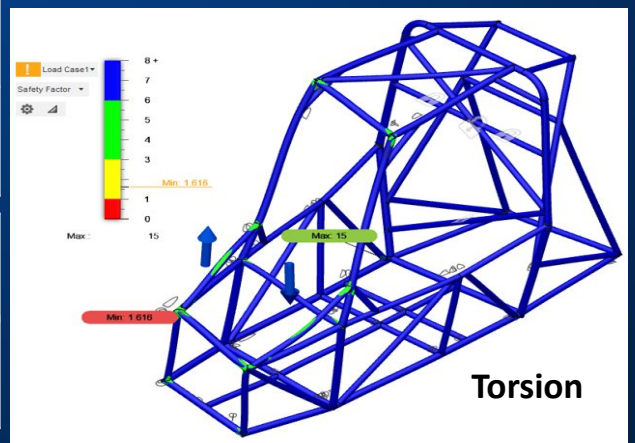
MATERIAL PROPERTIES	
Carbon Content	0.3
Yield Strength	460 MPa
Ultimate Strength	560 Mpa
Percentage Elongation	21.50
Modulus of Elasticity	205

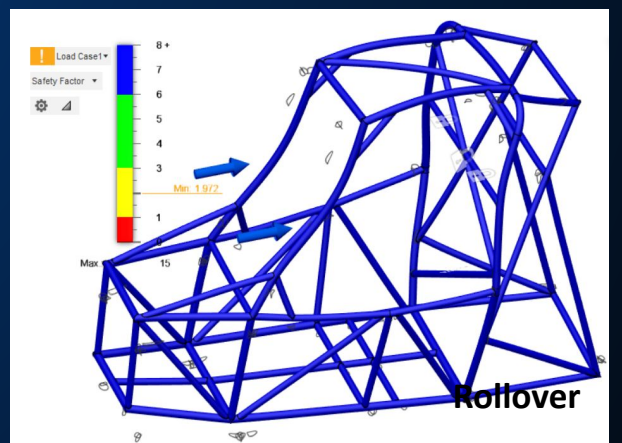


	Load case	F.O.S	Von mises Stress(MPa)	Displacement (Max) (mm)
Front Impact	10G	1.52	305.6	3.65
Side Impact	4.5 G	1.091	422.4	8.616
Rollover	3 G	1.752	262.6	3.177
Torsion	2.5 G (M)	1.616	284.4	5.734
Rear Impact	4.5 G	1.811	255.3	7.125









	Mesh type	Element Size	Solver
Structural Simulation	Tetrahedral	7mm	Nastran

TRAILBLAZERS
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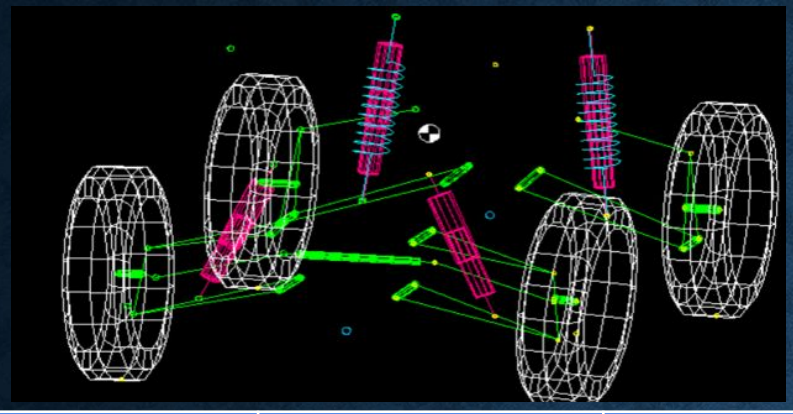
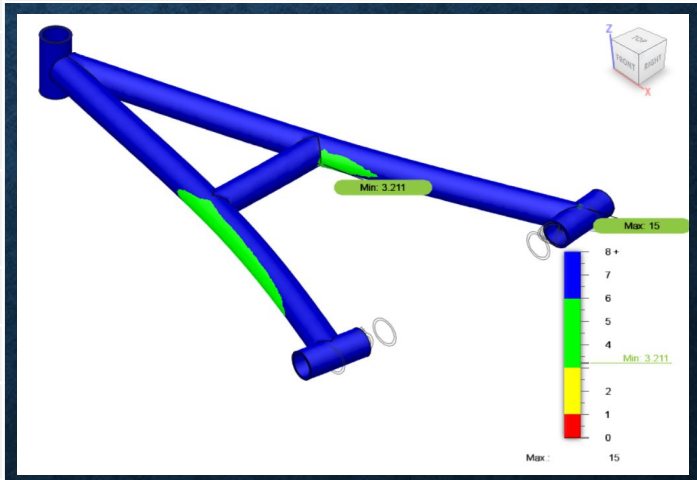
SUSPENSION

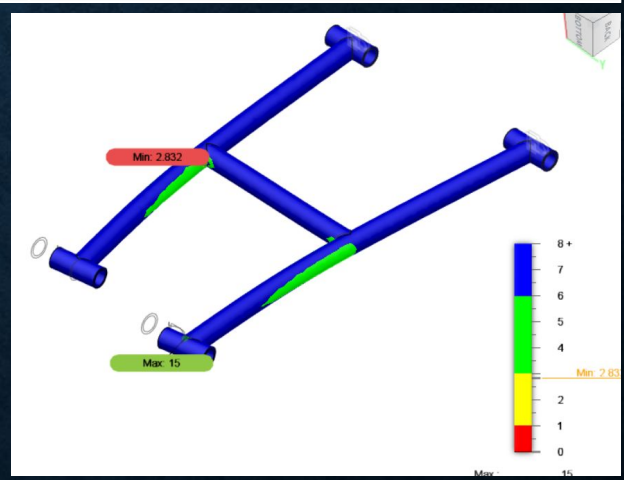


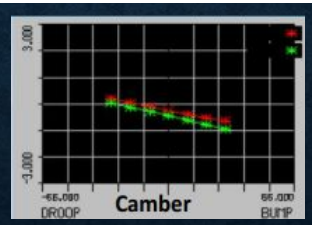
PARAMETER	FRONT	REAR
Type	Double A Arm, Damper to Lower	H-arm with Single Upper Link
Roll Centre Height	262.96 mm	343.9 mm
CG Height	24"	24"
Camber/Toe/Castor	-0.25/0.35/0.72°	-0.45/0.35/0°
Kingpin Inclination	5.11°	-
Scrub Radius	0.537"	-
Motion Ratio	0.62	0.58
Ride Frequency	2.99 Hz	2.69 Hz
Spring Rate	4.884 N/mm	5.189 N/mm
Wheel Rate	12.705 N/mm	15.426 N/mm
Ride Rate	3.059 N/mm	3.194 N/mm
Sprung Mass	36 kg	54 kg

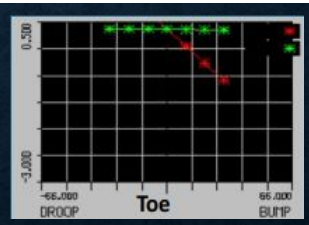
DECISION MATRIX

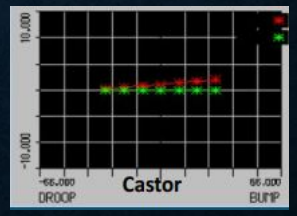
Types Sub	FRONT (1-10)			REAR (1-10)		
	Macpherson	Double-wish bone	Trailing arm	Semi-trailing	H-arm	Double-wishb one
Size & weight	5	7	3	4	8	7
Wheel control	3	8	8	7	8	9
Independent movement	3	9	5	3	9	9
Stability	3	8	8	6	9	8
Complexity	6	8	4	5	9	8
Total	20	40	28	25	43	39

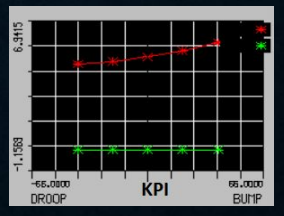












STEERING & WHEEL GEOMETRY

CENTRALIZED RACK AND PINION STEERING

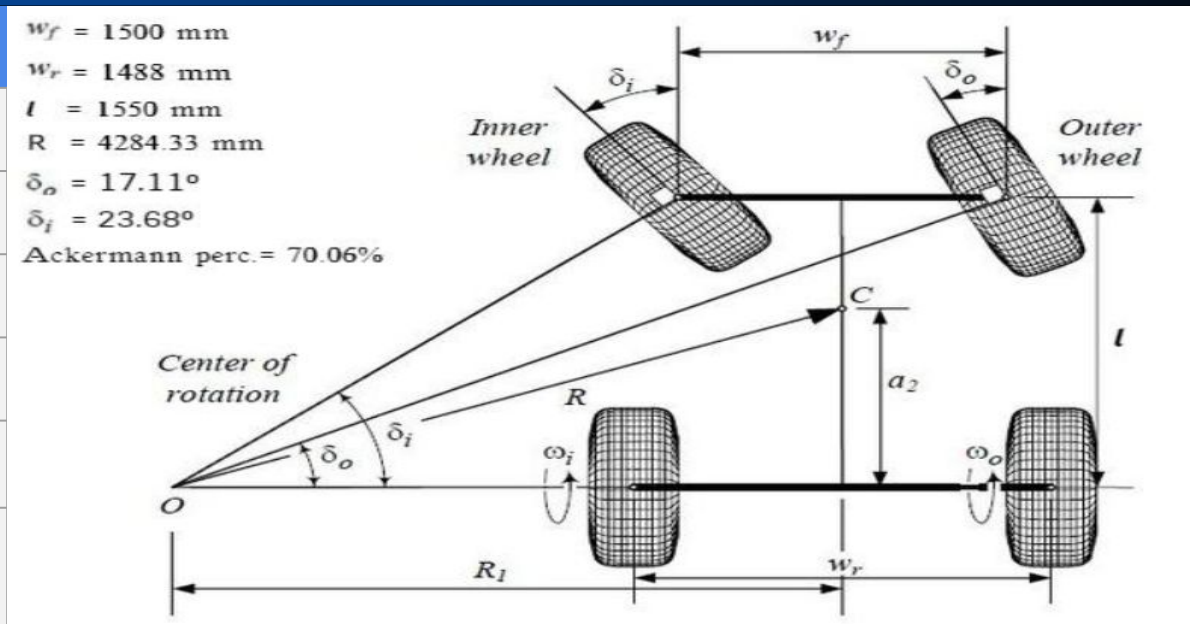
Wheelbase	1550 mm
Track Width	Front-1500mm Rear - 1488mm
MIn. Turning Radius	4284.33
Ackermann Percentage	70.06 %
Steering Angles	Inner - 23.68° Outer - 17.11°
Rack Length	14 inches
Rack Travel	231.96 mm
Steering Ratio	11.4 : 1
Steering Effort	74 N
Torque on Pinion	11250 N-mm
Steering Condition	Understeer

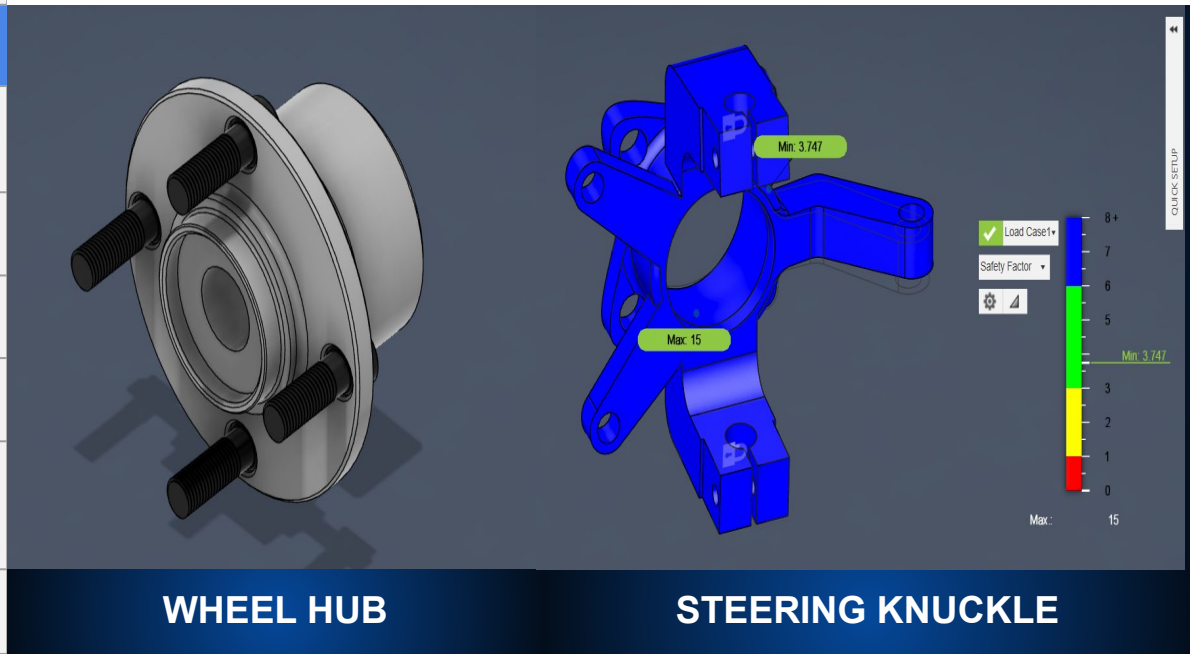
WHEEL GEOMETRY

Camber Angle	-0.25°
Toe Angle	0.35°
Castor Angle	0.72°
Castor Offset	4.64 mm
Kingpin Angle	5.11°
Kingpin Offset	At Wheel - 39.29 mm At Ground - 13.63 mm

STEERING SPECIFICATIONS

Steering Column Type	Collapsible
Tie Rod Length	473.14 mm
Lock to Lock Angle	540°
Tie Rod Material	AISI 4340
Upright and Wheel HUb Material	Al 6061 T6
Steering Wheel Diameter	12 inches





WHEEL HUB

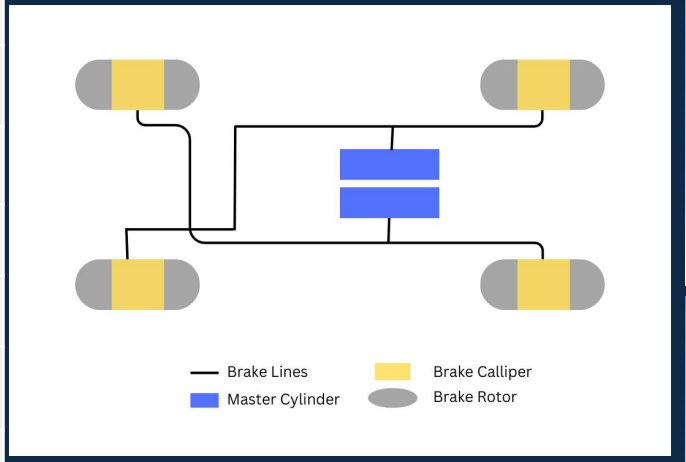
STEERING KNUCKLE

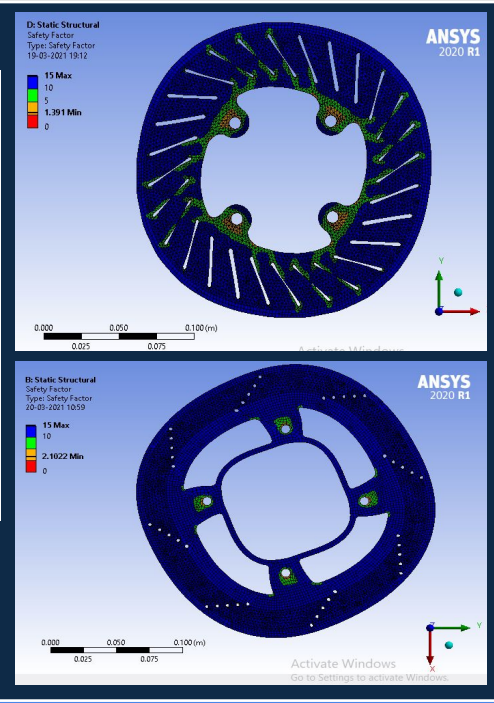
BRAKING SYSTEM

SPECIFICATIONS	VALUES
Pedal Force	400
Pedal Ratio	6:1
Pedal Travel	167.64 mm
Brake Pad Area	706.858 mm^2
Mean Braking Radius (front/rear)	0.105m / 0.095m
Coefficient of Friction of Brake Pad	*0.4*
Deceleration	9.909 m/s^2
Braking Force	4954.586 N
Static Rolling Radius	0.2921 m
Static Axle Load(front/rear)	981 N/ 1471.5 N
Dynamic Axle Load(front/rear)	1863.9 N/588.6 N
Weight Transfer (40 km/hr to 0 km/hr)	99.09 kg (990.9 N)
Brake Torque Applied (Front/Rear)	497.576 Nm/ 452.342 Nm
Brake Torque Required (Front/Rear)	326.667 Nm /103.158 Nm
Coefficient of Friction of Road	0.6
Stopping Distance (40 km/hr to 0 km/hr)	6.228 m
Stopping Time (40 km/hr to 0 km/hr)	1.212 s

BRAKING SYSTEM

1. Inboards in Rear , Outboards in Front.
2. Front - Rear Applied Braking Force Split (70:30)
3. All wheels of the ATV lock together.





Braking Circuit

PARTICULARS OF BRAKING SYSTEM AND TYRES

Parts	Quantity	Specifications
Master Cylinder	2	0.75” dia. & Stroke length – 1.1”
Brake Caliper	4	30 mm dia.
Brake Disc	4	220 mm (F)/ 200 mm(R) dia.
Brake Fluid	-	DOT4
Tyres	4	BKT 23x10x10

POWERTRAIN

MOTOR SPECIFICATION

Motor Type	Permanent Magnet Synchronous Motor 48V
Rated Current(A)	95
Rated Speed (RPM)	2500±200
Rated Torque(Nm)	18.23@2420
Output Max Torque(Nm)	62.65@486
Continuous Rated Power(Kw)@RPM	4096@2503
Max. Power(Kw)@RPM	4619@2420
Efficiency(η)	>88%
Number of Poles	8

	Gear Ratio	Power on Wheels(W)	Torque to wheels(N-m)	Force on wheels(N)	Speed(kmph)
Continuous 18.23(Nm)@2420rpm	6	1.11E+04	43.752	149.7331	44.415
	7	1.29E+04	51.044	174.6886	38.07
	8	1.48E+04	58.336	199.6441	33.31
Max 62.65(Nm)@486rpm	6	7.65E+03	150.36	514.5791	8.9
	7	8.93E+03	175.41	600.3422	7.64
	8	1.02E+04	200.48	686.1054	6.68

Gear material : AISI 4340
Tensile Strength: 745 Mpa
Yield Strength: 470 MPa
Bulk Modulus: 140 GPa
Shear Modulus: 80 GPa
Hardness, Brinell: 217
Thermal Property
Thermal expansion coefficient: 12.3µm/m°C
Thermal Conductivity: 44.5 W/mK

FNR SPECIFICATIONS

- **Specification**: 1 module, 20 teeth, bevel gear with 2 x M4 screw holes, 8mm shaft, 1 input shaft drive 2 forward and reverse output shafts (2 output shafts rotating in opposite directions).
- 1:1 Right Angle Bevel Gearbox for Simple DIY Mechanical Application.

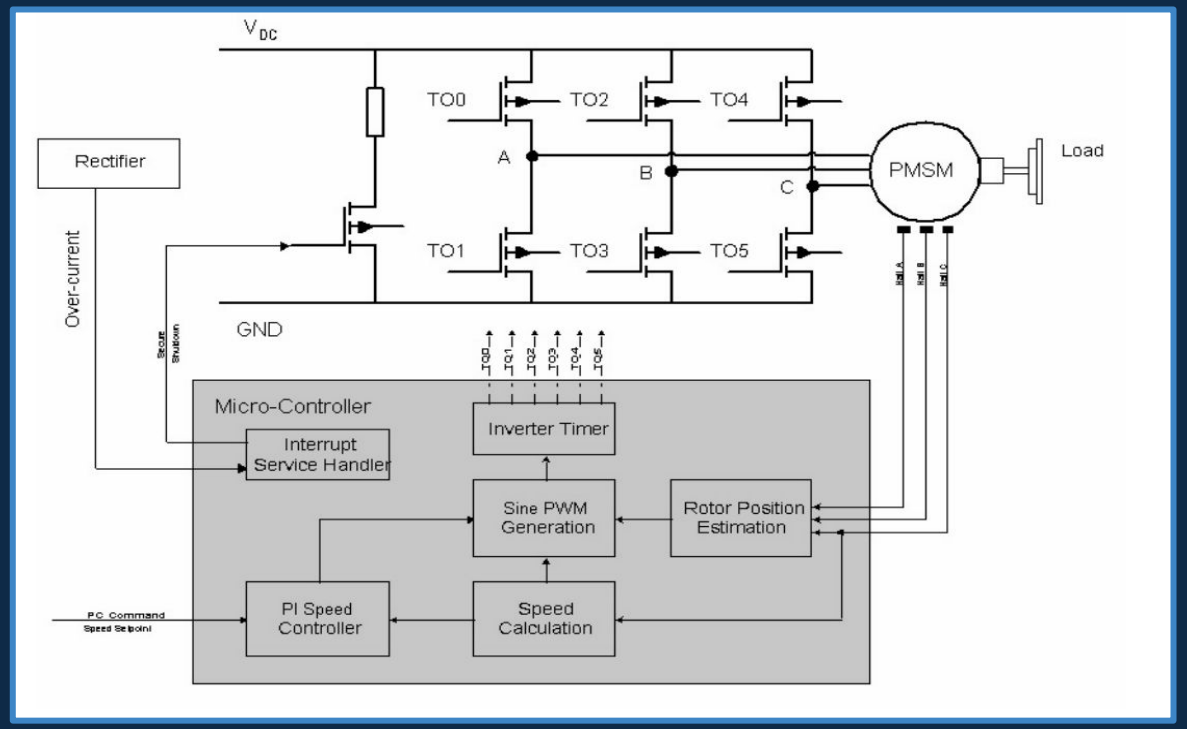
TRAILBLAZERS
SAE IIEST CHAPTER

TRACTIVE SYSTEM & CIRCUIT DESIGN

MOTOR CONTROLLER SPECIFICATIONS

Rated Voltage	48V
Peak Protection DC Current	250A
Rated DC Current	250A
Rated Power	7500W
Under Voltage Protection	42V
Natural cooling Ambient Temperature	20-60 degree C
Throttle Voltage	1V to 4.5V
Ambient Temperature	20-60°C

MOTOR CONTROLLER CONNECTION CIRCUIT DIAGRAM



BATTERY PACK SPECIFICATIONS

Battery Pack:

50V Capacity- 70Ah

Cell Arrangement: 14 Series, 14 Parallel

Total Weight: 20 kg (Approx)

Cell Specification:

26650 5000mAh Cylindrical Li-ion rechargeable cell

Normal voltage: 3.6V

Charging voltage 4.2 ±0.05 V

Discharge ending voltage: 2.75±0.05 V

Standard charging current: 0.5C(2500mA)

Standard discharge current 0.5C(2500mA)

Max recommended charge and discharge cell body temperature:

Charge:0~60°C, Discharge:-20~60°C

Weight: 93±3g

TRAILBLAZERS

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GLV SYSTEM & COMPONENTS

Components	Specification	Components	Specification
Ignition Switch or Master Switch	Operating Voltage: 12 V Connector Type: Plug In Actuator Type: Rotatory Weight: 480 g	READY-TO-DRIVE-SOUND (RTDS)	Rated Voltage: 12 VDC Sound Pressure Level: 85 to 95 decibels Max. Current: 10 mA Weight: 3 g
Kill Switch:	Current Rating: 200 A Power/Voltage: 12 V	LV Harness	Harness is made from ISI approved cables of 1 mm^2. Length of LV harness will be supplied: - 3.5 mtrs
Brake Light	Brightness: 100 lm Color: Red Color Temperature: 41 K Operating Wattage: 55 W Operating Voltage: 12 V	HV Harness	HV Harness is made from ISI approved cables of 16 mm^2 . Length of HV Harness supplied: - 1.5 mtrs
TRACTIVE-SYSTEM-ACTIVE LIGHT (TSAL)	Light Colour: Amber Voltage: 12 V Light Source Type: LED Power:12W IP Rating:IP65 Frequency: 2 Hz	Reverse Alarm	Noise Level: 110 dB Voltage: 12 V Weight: 249 g

TRAILBLAZERS
SAE IIEST CHAPTER

PROJECT PLAN

Designing & Simulation

- Roll Cage
- Integration of Design
- Suspension
- Redesigning
- Transmission
- Simulation
- Design Research
- Steering
- Team Formation
- Braking
- Virtuals

May | June | July | August | September | October | November

March | February | January | December

- Roll Cage
- Suspension
- Raw Material Procurement
- Transmission
- Main Event
- Steering
- Testing
- Braking
- Assembling

Manufacturing

DFMEA & PFMEA

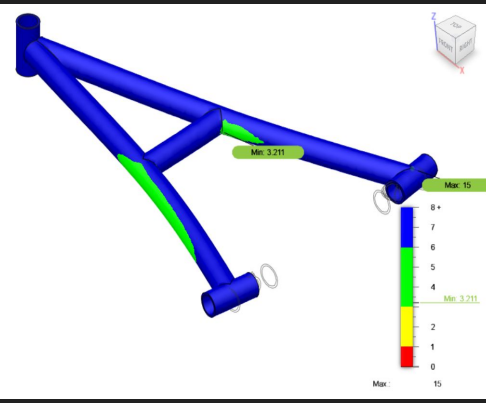
ASSEMBLY	FAILURE MODE	CAUSES OF FAILURE	EFFECTS OF FAILURE	S	O	D	RPN	CURRENT DESIGN CONTROL
Frame	Structure Displacement	Axial stress exceeds yield stress of material due to excess load and impact loading	Frame structure will become prone to failure.			5	36	{P}-Choose material with appropriate/high factor of safety(FOS),effective design and analysis.
	Bending of frame		Driver safety is at risk			7	126	{D}-Constant testing of the frame under different loads.
	Breaking of Frame					10	200	
Battery Pack	high-current cycling regime	SEI deterioration and non-uniformity on the anode	Battery failure			1	80	{P}-current limiters, avoid overcharging {D}-temperature monitoring
	storage at elevated temperatures	pitting corrosion on the cathode Al current collector.	Battery failure			1		
Transmission System	Motor Overheating	Continuous high loads or insufficient cooling	Reduced power output, damage to motor components, and risk of system failure			7	24	{P}-Incorporating thermal management strategies. {D}Use temperature sensors to continuously monitor motor's temperature.
	Gear Damage	Excessive torque, poor lubrication, or manufacturing defects in gears.	Gear noise, power loss, total failure of transmission system.			1	17	{P}-Use high quality gears and proper lubrication. {D}-Use vibration sensors to detect unusual vibrations due to damage to gears.
	Controller Malfunction	Software bugs, electrical issues, or sensor failures.	Inability to control the power delivery to motor efficiently, leading to erratic performance.			1	21	{P}-Redundant sensors for critical parameters. {D}-Diagnostic capabilities in the controller to identify issues.
Steering System	Breakage of steering wheel.	Excess load applied by driver.	Inability to control the vehicle.			8	64	{P}-Buying of steering wheel from a reputed manufacturer . Regular testing for the proper working of steering wheel.
Braking System	Mechanical failure	Improper fitting of the components.	Damage to vehicle in undesirable conditions			1	9	{P}-Proper torquing for the fitment using torque wrench {D}-Use of torque meter to ensure proper torquing .
	Leakage of brake fluid	Wrong selection of material ,joint dimension ,mismatch in rake pipe and master cylinder.	Braking system failure			2	40	{P}-Simulation for burst pressure ,stress and strain design calculation for flared thread dimension . {D}-Material test dimension measurement + burst pressure measurement +100% part leak test for 200 bar for 30 sec.
	Structure failure of brake pedals due to fatigue	Excess application of load by driver causes axial load to exceed yield strength of material.	Brake failure risking drive's safety			1	10	{P}-Choose material with high FOS and buying the pedal from reputed manufacturer. {D}-Regular testing of proper working of pedals.
Suspension	Mechanical failure of control arms	Axial stress exceeds yielding stress of material due to excess load and impact loading	Damage to suspension. System and rough Operation or non-operation of the vehicle.			7	112	{P}-Choose material with high FOS and according to vehicle specification; effective design and analysis. {D}-Regular testing of the control arms under different conditions.
	Breakage due to structural failure of Knuckle	Failure due to bending ,crushing and tensile stress and double shear.	Damage to suspension system and rough operation or non-operation of the vehicle			2	32	{P}-choose material with high FOS and according to vehicle specifications. {D}-Regular testing of the Knuckles.
Wheels	Breaking of the rims	Damage by debris pollution.	Vehicle inoperable.			1	8	{P}-Buying of wheel rims from a reputed manufacturer regular testing of wheel rims.

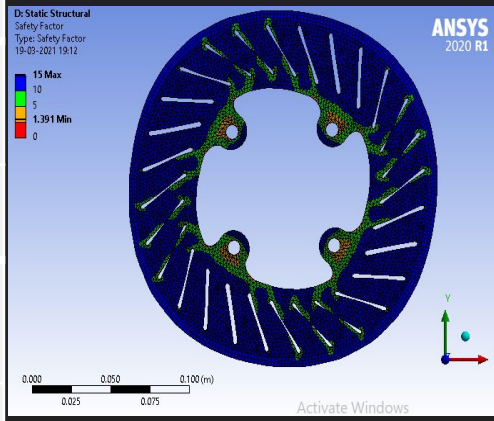
S=SEVERITY 8 9 10 O=OCCURRENCE 1 2 D=DETECTION RANKING RPN=RISK PRIORITY NUMBER {P}Prevention {D}Detection

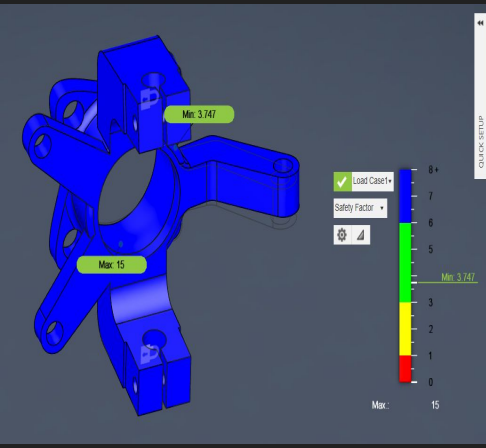
TRAILBLAZERS
SAE NEST CHAPTER

Design Validation Plan

COMPONENT	DESIGN VALIDATION & TESTING
Frame	Structural Simulation while designing the chassis
	Dynamic Crash Simulation in Radioss
	Welding the rods in CAD for manufacture ability
Ergonomics	Rapid Upper Limb Assessment / Rapid Entire Body Assessment
CVT	Modeling CVT of BAJA ATV using MATLAB,Simulink & Simscape
Brake Disk	Thermal Stress for brakes for testing brake failure
Suspension	Dynamic Analysis of bump and roll in Lotus Software
A-Arm & H-Arm	Structural/ Dynamic Analysis for A-Arm and H-Arm
Upright/Wheel Hub	Structural Simulation for upright and Wheel Hub
	Creating C.N.C tool paths for manufacturing ability
Steering	Simulating Steering System using software packages







TEAM & Workshop Facilities

Faculty Advisor
Dr. Aritra Ganguly

Suspension
Karthikeyan Gali(H)
- Shubham Jaiswal
- Kishore Pal
- Vaishnavi Devgire
- Sai Saketh

Transmission
Arunava Pal (H)
- Ishita Chaudhary (VC)
- Tuhin Mondal
- Modasshir Jamal
- Ritesh Gupta
- Tharun Nataraj Dhandapani
- Deeksha Yadav

Braking
Sabavath Akash(H)
- Koushik Ghosh
- Subhankar Mondal
- Ivan Jacob Thomas
- Krishnendu saha

Steering
Ankush Ghosh (H)
- Soham Banerjee
- Piyal Bhowmick
- Shivang Agrahari
- Sanatan Samantara

Roll Cage
Sayan Mondal (H)
- Ketan Masurkar(C)
- Piyush Pathak
- Shivani Saha
- Vaibhav Sarkar
- Sreyankur De
- Diya Hansda
- Arunabh Bagchi

COLLEGE FACILITIES		OUTSIDE FACILITIES
CAD/CAM LAB	Drilling Machine	FRP Fabrication
TIG Welding Machine	Cutting Tools	FRP Moulding
Universal Testing Machine	Bench and Hand Grinder	Hydraulic Press Fit
Electric Arc Welding Machine	Vertical Milling Centre (VMC)	Emission Test Equipment
Production lathe	Shaping Machine	Tyre Balancing
		Panel Fabrication


VMC


Milling Machine


Lathe Machine

INDEX
- Documentation
- Market Analysis
- Calculations


Drilling Machine


Shaping Machine