SUPRA SAEINDIA 2017

DESIGN REPORT

Team ID : 103

Team Name : Team Mech-next Racing

College Name: YMCA UNIVERSITY OF SCIENCE AND TECHNOLOGY

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1. ABSTRACT:

‘TEAM MECH-NEXT RACING’ from YMCA UNIVERSITY OF SCIENCE AND TECHNOLOGY strives towards designing and fabricating a FORMULA ONE type vehicle giving the consumer thrill and pleasure, keeping in mind it’s safety, easy manufacturability, low cost and good aesthetics. The primary targets of the vehicle is to excel in all the automotive performance parameters including acceleration, braking, handling. Efforts have been made to centralize the weight of the vehicle and keep its centre of gravity low in order to increase the roll stability, traction and effective high speed cornering of the vehicle. Special emphasis has been given to make the car safe and technically sound to help the team qualify in technical inspection and perform well dynamic events while trying to minimize the weight of the vehicle.

2. TECHNICAL SPECIFICATIONS OF VEHICLE

1	KERB WEIGHT	240 Kg
2	WHEEL BASE	1651 mm
3	FRONT TRACKWIDTH	1295 mm
4	REAR TRACKWIDTH	1244 mm
5	GROUND CLEARANCE	100 mm
6	CG HEIGHT	10 inch
7	MAXIMUM TORQUE	41 Nm @ 4000 rpm
8	MAXIMUM POWER	27 bhp @ 5250 rpm
9	MAXIMUM SPEED	105 Km/h
10	TIRE DIMENSIONS	175-50R13
11	RIM DIAMETER	13 inch
12	FAW/RAW	53:47

3. CHASSIS

The frame was designed with an objective of providing safety to driver during impact without compromising on accessibility, ergonomics and weight. Tubular space frame design was constructed using Mild Steel AISI 1018 as it has low cost, good yield strength of 370 MPa and has good weldability. Metal Inert Gas (MIG) welding process was used because of high welding speed and less post welding cleaning. The team ensured that the frame would comply with all of the templates and envelopes required by the rules and designs were iterated to incorporate the same. Ergonomics rig was constructed and studied to determine critical cockpit dimensions such as seat back angle, width of the cockpit, steering and shifter locations. Seat back angle was set to 28 degrees to attain lower center of gravity, retaining the upright driving position. This also facilitated better packaging of drivetrain components. With an emphasis on node to node triangulation and weight reduction using tubes of different thickness as per load and the structural guidelines, team was able to reduce the frame weight to 37 Kg. CAD modelling was done using Unigraphics and FEA was carried out for impact analysis.

4. Impact Analysis

Aside from exceeding the minimum material requirement set by the rules, structural integrity of the roll cage was verified by analyzing the various iterations. Analysis was done using hypermesh. FEA stresses were calculated by simulating different induced load cases that are front impact, side impact, and roll over. Various iterations were done on hypermesh in order to achieve better results in all the impact tests with minimum number of frame members taking care about the maximum stress and displacement and keeping the factor of safety within proper safety limit.

5. DRIVETRAIN

Engine Selection: - The objective was to attain maximum torque in mid rpm range keeping the weight of the drivetrain assembly minimum. Royal Enfield Bullet 500cc engine was selected as it is a simple air cooled engine with carbureted fuel intake. It was preferred over KTM Duke engine as it was readily available at lower price. Another factor that was considered for selecting the engine was the fuel intake system. Not having much experience, we decided not to go for a fuel injected engine with complicated electronics.

The engine is positioned with an objective of minimizing the height of center of gravity. The mountings are designed aiming proper load distribution by attaching them on nodes, and avoiding longer cantilevers to reduce the risk of bending. Polyutherane bushes and rubber padding are used to minimize the transmission of engine vibrations to the rollcage.

Electrical: - The electrical system is powered by a 12V, 14Ah lead acid rechargeable battery. Stock wiring harness is used after removing unnecessary wiring. A 12V, 21/5W tail lamp mounted as required by the rules.

Intake: - The intake manifold geometry is designed to eliminate sharp bends and corners to help improve air flow. The design was tuned for 3500-4500 rpm range with a runner length of 106.25 cm. The intake restrictor was designed with 19 mm throat diameter and an approximate length. CFD was done for multiple iterations to finalize inlet and outlet angles, which were finalized at 18 and 8 degrees respectively. Stock Royal Enfield carburetor is used for throttling and fuel intake. Fuel is fed to the carburetor through gravity.

Exhaust: - The design objective for exhaust system was to keep backpressure minimum at each bend. The Royal Enfield OEM muffler was used to dampen the exhaust sound. The exhaust system is mounted on the base between the engine and the firewall, to keep it mass low and centered. The tail pipe is bent rearwards to deflect the emissions away from the driver.

Transmission: - The vehicle uses the stock gearbox integrated with the engine. A chain drive is used to transmit power from gearbox to differential. It was preferred over belt drive as it is positive drive, and has larger power transmission capacity. The final drive ratio is chosen in order to achieve a maximum speed of 105 Km/h at peak rpm of engine, with fifth gear engaged. The rear sprocket was designed accordingly.

The suspension system is stiff enough with preloaded coils with slightly heavier wheel assemblies, traction is usually insured so an open differential is chosen in order to provide more torque to the wheel with more grip to achieve better performance. Another factors for choosing open differential are it lower cost and easy availability. The differential assembly is modified to suit the final drive, which features the driven sprocket bolted to the differential housing. The differential is mounted using a set of pillow block bearing. Chain adjusters are also incorporated in the differential mountings using rod end bearings. Sequential gear shifting is done manually using a cable actuated shifter positioned in the cockpit.

6. ERGONOMICS

The chassis has been designed keeping in mind the various templates mentioned in the rulebook and to accommodate 95^{th} percentile male without compromising accessibility and weight of the vehicle.

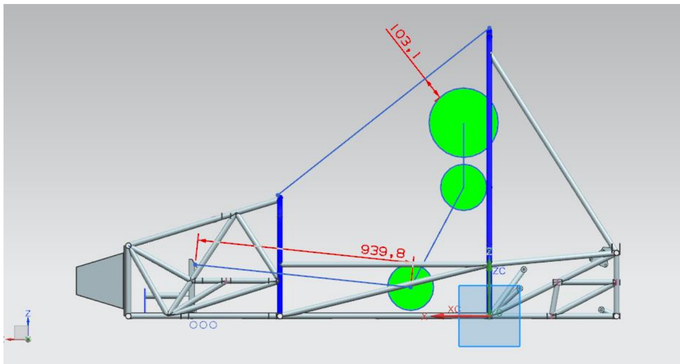


Figure 6.1 – 95TH percentile

Figure 6.2 - Bamboo Model

7. BRAKES

The objective of the brake system is to lock all four wheels at the same time and ensure safety. The brake system consists of 4 wheel disc brakes actuated by a tandem master cylinder having a 19.5 mm bore. The brake pedal uses a pedal ratio of 5:1 to multiply the input force applied by the driver. Tandem master cylinder is used to meet the requirement of having two independent hydraulic brake circuits. We chose this setup over a dual master cylinder and balance bar system because it was easier to install and was only half the cost and weight. The callipers we used have a piston area of 1232 mm^2 per calliper. For obtaining different braking forces we used different disc sizes in front and rear wheels. Considering our 13" rim size we used 220 mm diameter disc in front wheels, and calculated the rear disc size according to the required torque distribution of 53:47 (front: rear). Based on calculations and market availability we used 200 mm diameter disc in rear wheels. The discs are mounted on Maruti OEM hubs through collars made of aluminium.

8. SUSPENSION

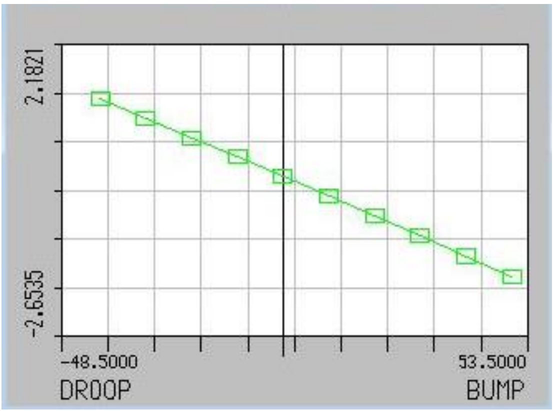
Three criteria had to be met while designing the corresponding system. Firstly, allowing a minimum of two-inch total travel. It was required that suspension system must be efficient enough to accommodate a travel of one inch in both drooping and rebounding. Secondly, gave an allowance for track adjustability. Suspension system was designed keeping in mind the adjustability, packaging and easy assembly of the components without compromising with the robustness of system. Thirdly, minimizing changes in the contact patch area so that traction remains constant throughout the ride.

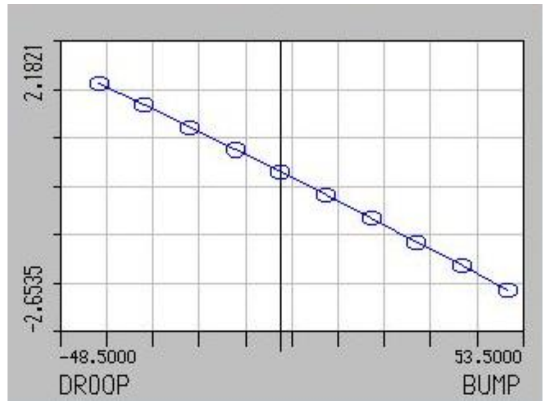
Suspension Design

The type of Suspension geometry used is Push Rod geometry because the control arms provide maximum control on suspension parameters like Camber, Caster, kingpin etc. and also provides a great flexibility to select coil spring rates moreover it also addresses to the rising and falling rates problem in coil spring. The upper and lower A-arms are angled in such a way that the roll center remain within center of gravity and ground within 2.5 degrees of roll and optimization in contact path area is achieved by minimizing changes in camber angle. The geometry is designed to accommodate a negative camber of -1.49 degree at 40 mm bump and 1.9 degree at 50 mm rebound and maintains a camber change of about 1.41 for a 2.5 degree of body roll. The control arms are made of AISI 1018 and are welded using MIG. The ends of control arms are provided with high strength spherical rod ends for ease of assembly and easy adjustment of static angles.

The rear suspension is also a double wishbone push rod suspension with unequal length of A-arms. The rear incorporates a toe link and utilizes push-rod for spring actuation. Rear suspension geometry is designed to accommodate a 0 degree static camber angle. The design provides a camber change of +1.97 degree during a body roll of 3 degrees while it shows 1.3 degree of camber change during bump and droop.

The lower A-arms also incorporate the pushrod mounting points, close to the upright point thus reducing the bending moment on the A-arm. The uprights are made of EN 24 mainly due to its high strength and low cost. The coil spring shockers are custom made and bell-cranks were made out of mild steel to keep the overall cost of the system low and maintain the robustness of the system.





REAR FRONT

Calculations:

Sprung weight (Front/Rear):1000N/1500N

.Motion Ratio (Front/Rear): 1.54/1.31

Spring Rate (Front/Rear):16250 (N/m)/ 16250 (N/m)

Wheel Rate = (Spring Rate)*(Motion Ration) ^{2}

Wheel Rate (Front/Rear):9140/6865 (N/m)

Spring Rate= $4\pi^2$ fr^2 (Sprung Mass) (Motion ratio) ^{2}

fr = Ride frequency (Hz)

Ride Frequency: 1.31Hz (front) 1.26Hz (rear)

9. STEERING

The dynamic events require a sensitive steering system while trying to keep the steering effort to a minimum for the ease of the driver. On these consideration and because of ease of mounting, procurement, light weight ‘rack & pinion’ type gearbox is used in our vehicle. Ackerman steering geometry is chosen to change the dynamic toe setting of the vehicle as it is easy to achieve and takes less space when compared to Davis geometry which consists of sliding joints which wears out more easily. The rack is located at the bottom of the rollcage to lower the CG of the vehicle and to allow easy egress. Rack casing and rack of Tata Nano is used, and the number of turns of steering wheel is reduced from 3.5 to 0.75 turns by replacing the OEM pinion with the pinion of pitch circle diameter 38.1 mm and a separate casing was made for pinion from aluminium and welded to the rack casing. A universal joint is used in the column to achieve the required inclination of the steering wheel. Steering stops are welded on the rack on both sides to limit the movement of rack. Steering wheel is to be made out of aluminium tube in a near circular shape.

Specifications

Turning Radius	3.024m	Ackerman %age	124.9
Inner Turning Angle	36.56	Outer Turning Angle	23.36
Rack Length	459mm	Steering Ratio	3.55:1
Rack Travel(Lock to Lock)	90mm	Steering Wheel Turn(Lock to Lock)	.75
Steering Wheel Diameter	228mm	Steering Wheel Torque	15 Nm
IBJ/OBJ Distance	343mm	Steering arm length	136mm

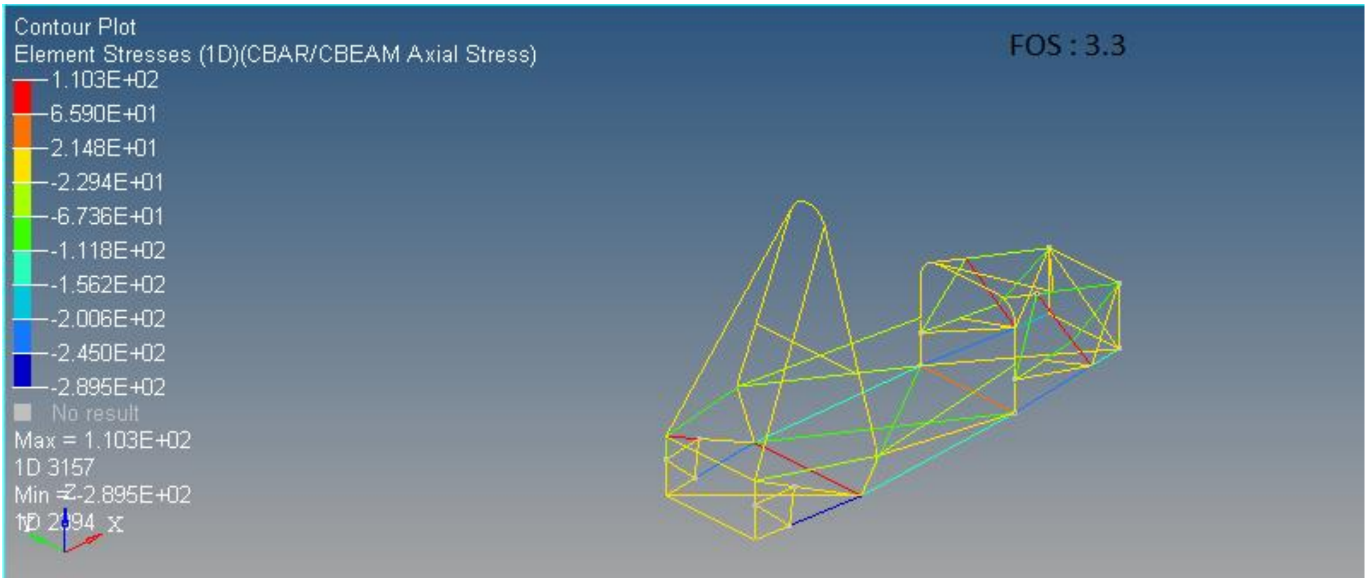


Figure 1 - Front Impact Analysis

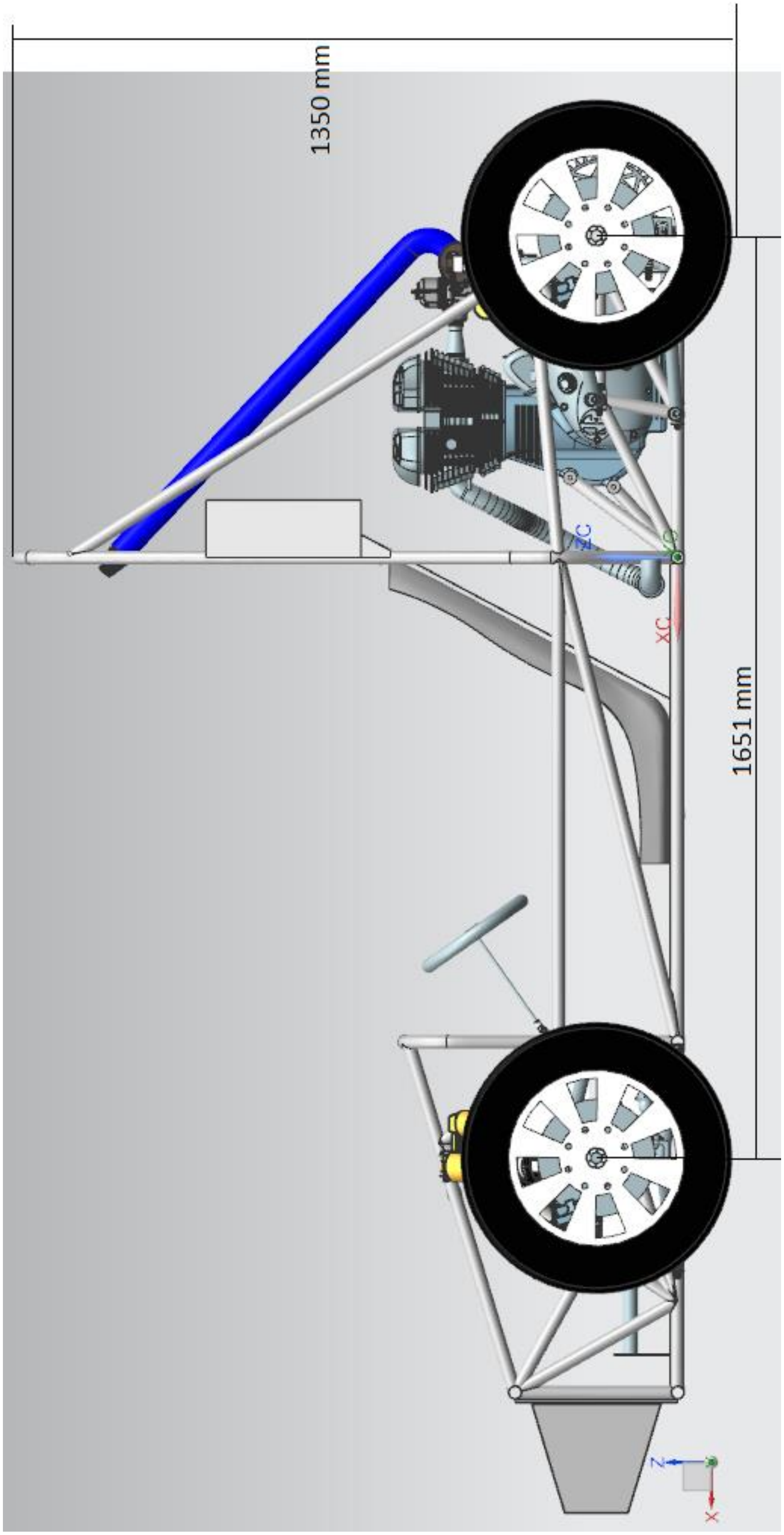


Figure 2 - Side View

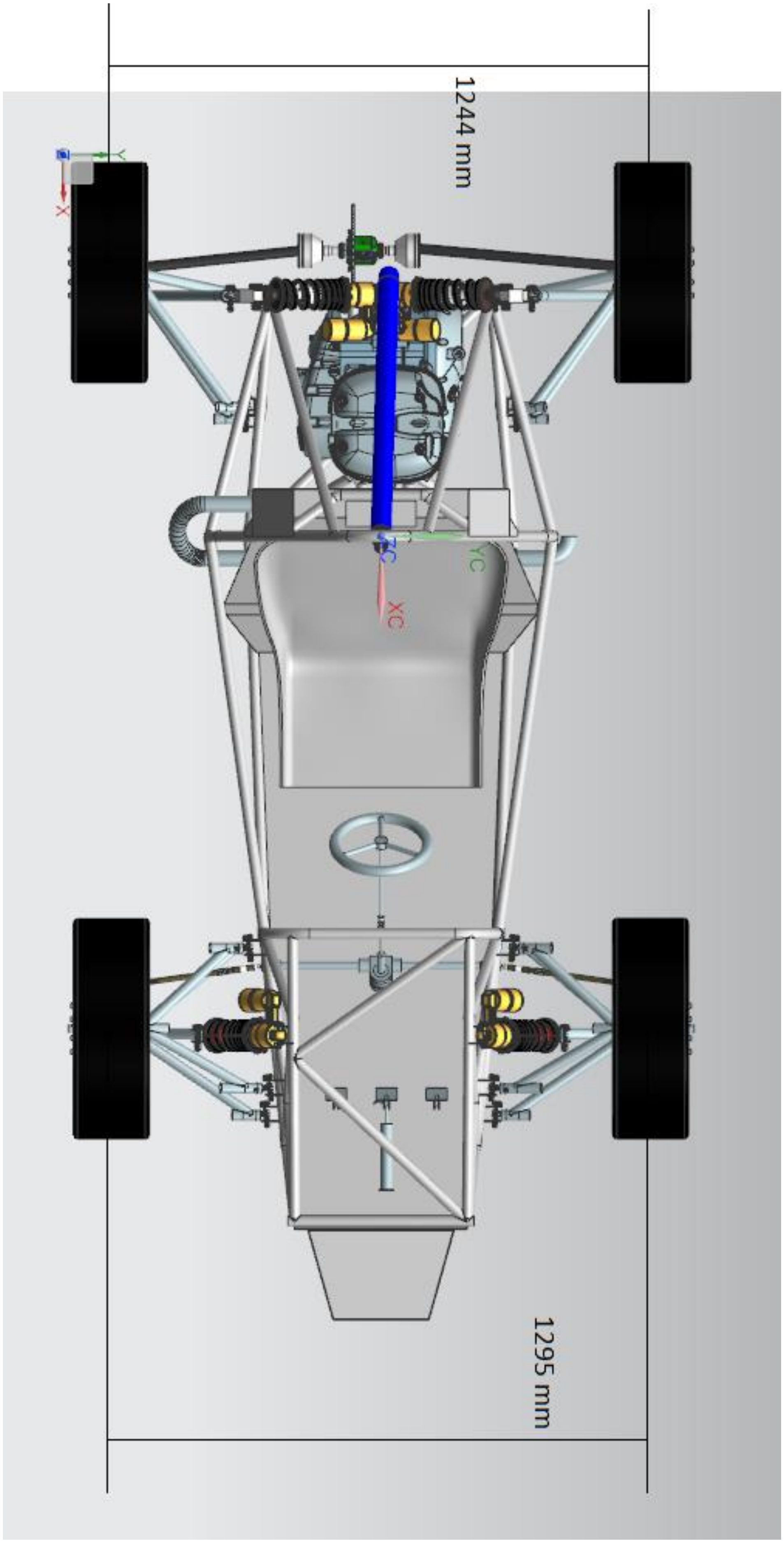


Figure 3 -Top View

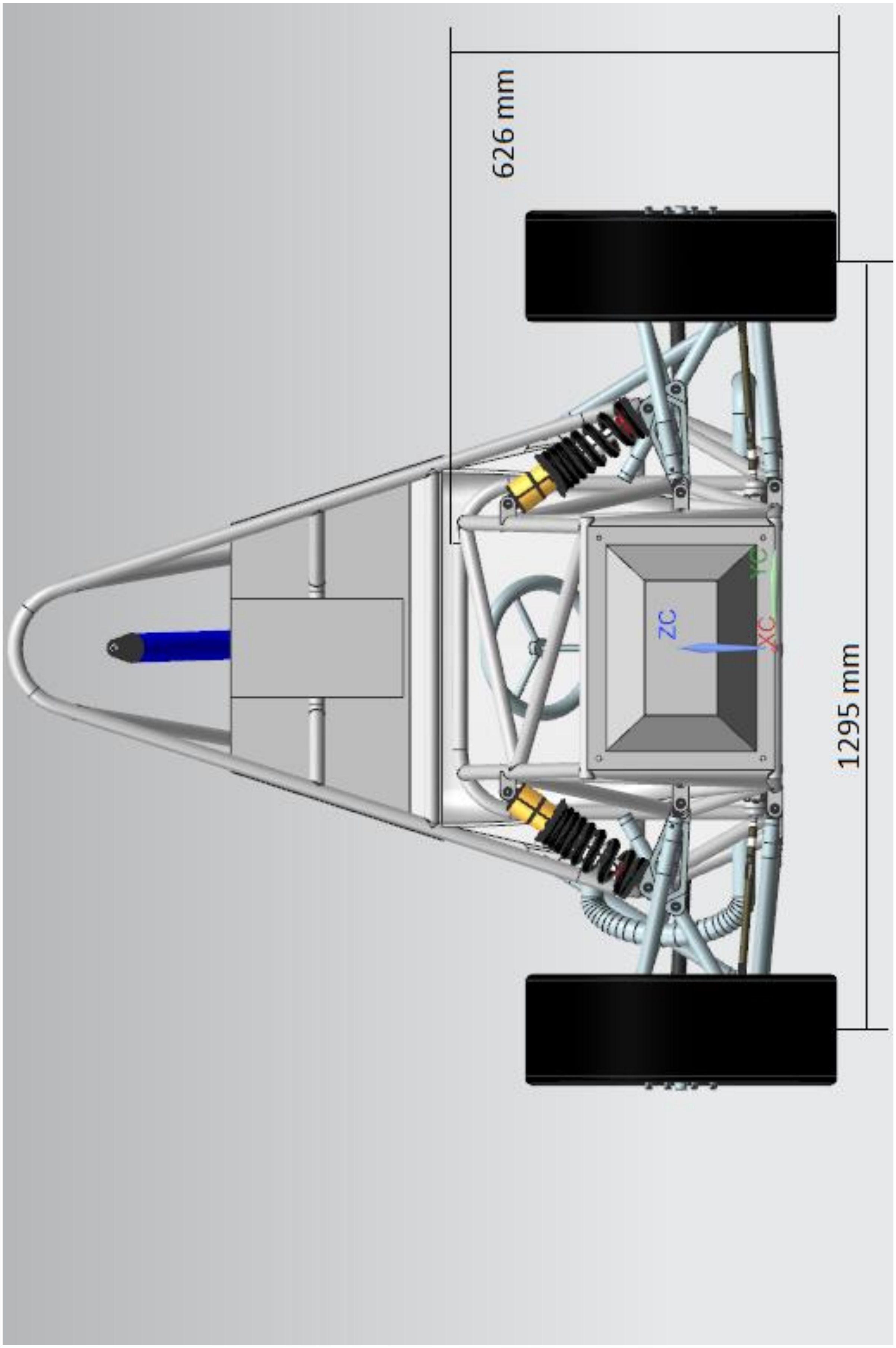


Figure 4 - Front View

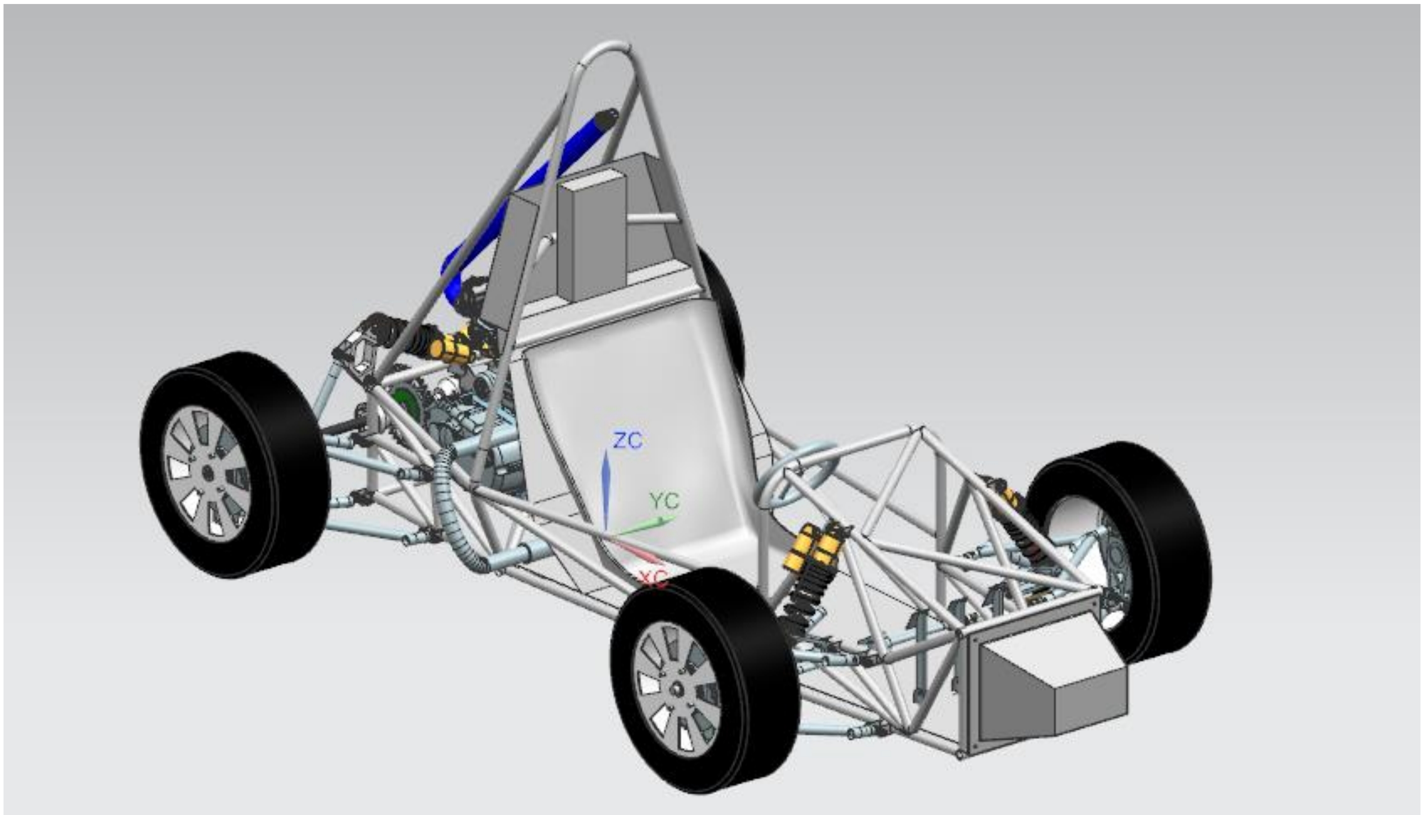


Figure 5 - Isometric View