Team Valor - Final Report of Go-Kart

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Abstract-The objective of this report is to highlight the final design report of team.

Transforming Dexterous.

The Team's primary objective is to design a safe and functional vehicle based on a rigid and torsion-free frame, well mounted power train and to understand the finer aspects of vehicle design with the ulterior motive of bricating prototype vehicle that could be manufactured for consumer sale, while strictly adhering to the competition rule.

The secondary objective is to enhance sdriver's comfort and safety, and to increase the performance and an euver ability of the vehicle. To achieve our goal the team has been divided into core groups responsible for the design and optimization of major sub- systems which were later integrated into the final blueprint.

I. INTRODUCTION

We approached our design by considering all possible alternatives for a system & modeling them in CAD software like CATIA and subjected to analysis using ANSYS FEA software. Based on analyses result, the model was modified and retested and a final design was frozen. The design process of the vehicle is iterative and is based on various engineering and reverse engineering processes depending upon the availability, cost and other such factors. So the design process focuses on following objectives:

Safety, Serviceability, Strength, ruggedness, Standardization, Cost, Driving feel and ergonomics, Aesthetics

The design objectives set out to be achieved were three simple goals applied to every component of the car: durable, light-weight, and high performance, to optimizing the design by avoiding over designing, which would also help in reducing the cost. With this we had a view of our kart. This started our goal and we set up some parameters for our work, distributed ourselves in groups.

Sub-Teams for Design Frame design

Body and Composites

Steering system design

Brake and Wheels

Drive train design

Electrical design

We proceeded by setting up the budget for the project. Throughout the design process we distributed the budget in such a way that if we assign more money to one system, then we reduce that amount from some other system.

II. TECHNICAL DATA (Vehicle Specification)

PARAMETER	*VALUE*	
Wheel base	47"	
Vehicle Track	42 (rear) 38 (front)	
Tube Dimension	1"	
Roll Cage Material	AISI 4130	
Max. Speed	60 kmph	
Battery	12 v	
Roll Cage Mass	17Kg	
Total Mass	165 Kg (INCLUDING DRIVER)	
Ground Clearance	2.5" (approx)	
Brake disc	7" (diameter)	
Wheels	Front	Rear
	10*4.1-5	11*7.1-5

III. DESIGN OF VEHICLE

The design section of this report is broken into four major topics-

1. The design objectives

2. The design calculations and analysis

3. Considerations

4. Testing

Based on the overall design objectives of durability, performance, and light- weight design, the component is evaluated by the design team and must meet all of the criteria to become a part of the overall successful design alternatives were also considered during each process and testing commenced once the chosen design met the design objectives.

IV. DESIGN METHODOLOGY

The design process of the single person go-kart is iterative and is basically based on several engineering and reverse engineering processes. Listed below are few of the major points that were considered for designing the following go-kart:

1. Endurance

2. Safety and Ergonomics

3. Market availability

4. Cost of components

5. Standardization and serviceability

6. Manoeuvrability

7. Safe engineering practices

Frame Design

• *Objective*

The frame is designed to meet the technical requirements of competition the objective of the chassis is to encapsulate all components of the kart, including a driver, efficiently and safely. Principal aspects of the chassis focused on during the design and implementation included driver safety, drive train integration, and structural weight, and operator ergonomic. The number one priority in the chassis design was driver safety. By the competition rules and Finite Element Analysis (FEA), the design assured. DESIGN

The main component of the frame are divided into the two major parts first the front block (cockpit) for steering and seat positions etc. and second rear block(engine compartment) for transmission and brake assembly. Both the blocks are separated by the firewall. The frame modal can be viewed as shown below-

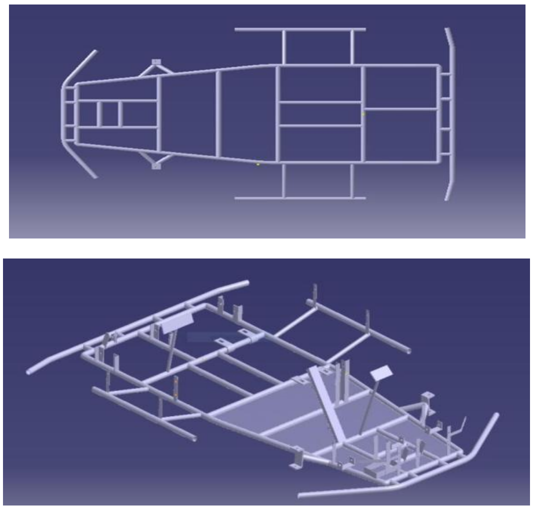
• CAD *Design*

Round tubing pipes of outer diameter = 1"

Thickness of pipe = 1.67 mm

Material used AISI 4130

Designing: CATIA software



Chassis Design (CATIA)

CAD Model

Material

The material AISI 4130 is used in the frame design because of its good weld ability relatively soft and strengthens as well as good manufacturability. A good strength material is important in a roll cage because the roll cage needs to absorb as much energy as possible to prevent the roll cage material from fracturing at the time of high impact. AISI 4130 has chosen for the chassis because it has structural properties that provide a low weight to strength ratio.1 inch diameter tube with a thicker wall is used instead of 1.5 inch diameter tube with a thinner wall for manufacturability purposes. Although the thinner wall, 1.5 inch diameter tube would be slightly lighter than the thicker wall, 1 inch diameter tube, it would have been more material and more difficult to weld. Then it is also assured by analysis in ANSYS software. The various Physical properties of the material are as follow-

S.N.	PROPERTIES	VALUES
1	Tensile strength, Ultimate	560.5 Mpa
2	Tensile strength, Yield	360.6 Mpa
3	Bulk Modulus	140 Gpa
4	Shear Modulus	73 Gpa
5	Modulus of Elasticity	190 –210 Gpa
6	Poisson’s ratio	0.27 – 0.30
7	Elongation at break (in 50 mm)	21.50 %

The chemical composition of the material is as – Iron Fe = 97.03 – 98.22

Carbon C= 0.28 - 0.33

Manganese Mn = 0.40 – 0.60

Silicon Si = 0.15 – 0.30

Sulphur S = 0.0 - 0.040

Phosphorus P = 0.0 - 0.035

The above mentioned properties satisfy the technical requirement of material which is to be used in frame.

Safety

Roll cage feature were first implemented by keeping on mind the safety requirement of the event .The first primary safety standard focused on during design was maintaining the proper clearance of the driver's body rest to the other rigid parts like engine compartment, firewall structure, and panel bracing of the vehicle. Once the basic requirements fulfilled the other safety design were implemented. The chassis was designed to give occupant extra space to operate the vehicle easily.

The place of the fire extinguisher is designed in the easily accessible point and also the ethane foam padding is provided over the pipes adjacent to driver.

Frame FEA Safety Analysis-

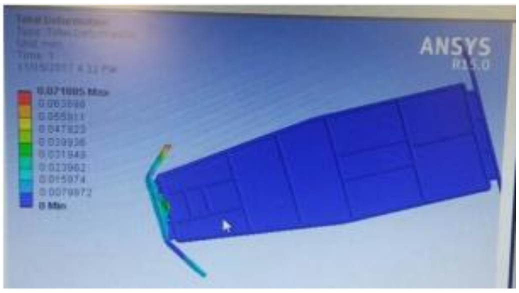
Aside from exceeding the minimum material requirement set by the discussion in team members. Structural integrity of the frame was verified by comparing the analysis result with the standard values of the material. Theoretical calculated loads were placed on a wireframe model of the frame at critical points to simulate the amount of force that the vehicle would undergo from its own weight and the driver in the event of collision.

Analysis was conducted by use of finite element analysis FEA on ANSYS software. To conduct finite element analysis of the chassis an existing design of chassis was uploaded from the computer stresses were calculated by simulating three different induced load cases .The load cases simulated were frontal impact, side impact, and rear impact, A 4- node quadrilateral (Quad4)shell type element was used when developing the mesh to model the hollow tubing the value of the force indifferent cases of impacts is calculated by the procedure as follow-

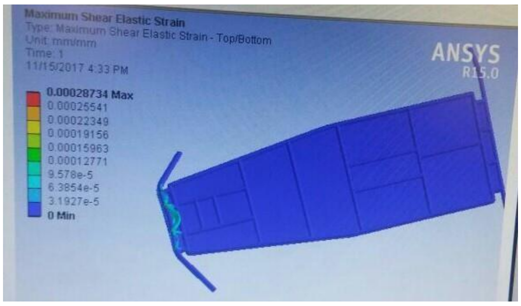
Front Impact Analysis-

Generally in the case of pure elastic collision in frontal impact the linear velocity remains at 64 Kmph according to ENCAP (The European new car assessment program)

Maximum deformation- 0.071885 mm



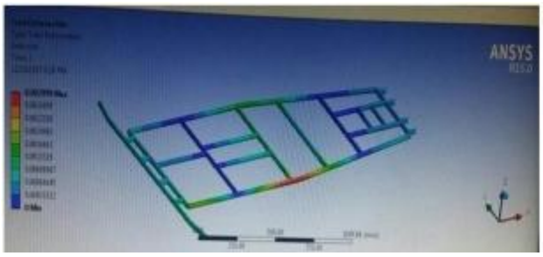
Maximum Shear Elastic Strain- 0.00028734



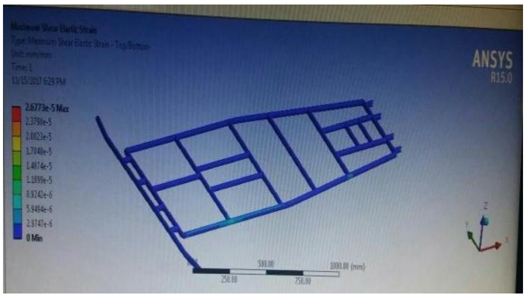
Side Impact Analysis

In the case of collision by side impact the value of the impact force generated is calculated in the same way as in front impact. For the side impact the velocity of vehicle is taken 48kmph or 13.3m/s according to ENCAP Standard .

Maximum deformation- 0.002999 mm



Maximum Shear Elastic Strain- 2.6773

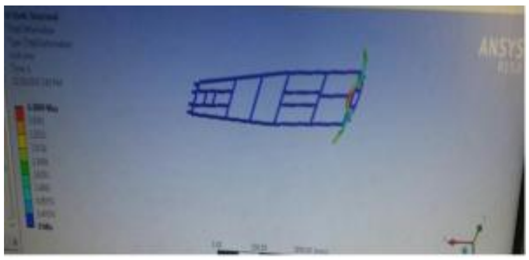


Rear Impact Analysis

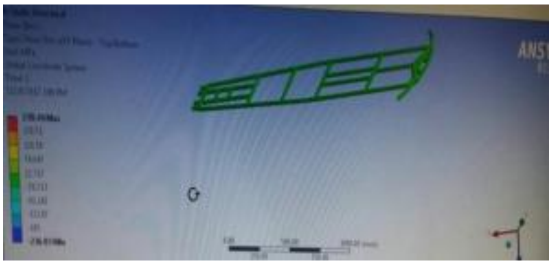
The rear impact force is also calculated in the same way as remaining two. In this case the velocity of collision were taken 50kmph or 13.8m/s by the calculations and also as according to the ENCAP standards .the calculations are as-

The analysis result is shown below.

Maximum deformation- 4.3089 mm



Maximum Shear stress- 263.44 Mpa



The results from these different analysis modes are accurate for the type and amount of loading that was applied to the known material and geometry. They also assure the safety of the frame in the different cases of impacts. However, these loading scenarios generally do not exactly represent actual impact modes To accurately depict an impact or collision incident, dynamic loading would have to be used to simulate the types of impact loading that would occur during an actual collision. It would be very difficult to accurately model this event without known data gathered from an actual collision in various lateral position along with the longitudinal directions. This data could be gather using strain gauges attached to the frame of the vehicle. This result also illustrate that the frame ensure the maximum amount of driver safety restraint. Attaching the seat belts to the most rigid and structural chassis components guarantees reliability of the seat belt under the extreme forces possible in a collision. Using a quick release lever style at belt clasp gives the driver the ability to get out of the vehicle in a safe amount of time in The safety restraints provided in the car will be sufficient for keeping a driver safe in the event of a collision, while still allowing the driver to escape in the required amount of time.

Consideration	Priority	Reason
Light Weight	Essential	A light race car is a fast race car
Durable	Essential	Must not deform during rugged driving Meet
Meet Requirements	Essential	Must meet requirements to compete
Simple Frame	High	Majority of frame fabrication done in workshop
Attractive Design	Desired	Easier to sell an aesthetically pleasing vehicle

Frame Design Considerations-

• *Safety Harness-*

A five point racing harness attached to the most rigid members of the roll cage was utilized to ensure the maximum amount of driver safety restraint. Attaching the seat belts to the most rigid and structural chassis components guarantees reliability of the seat belt under the extreme forces possible in a collision. Using a quick release lever style seat belt clasp gives the driver the ability to get out of the vehicle in a safe amount of time in. The safety restraints provided in the car will be sufficient for keeping a driver safe in the event of a collision, while still allowing the driver to escape in the required amount of time.

• *Structural Rigidity-*

Overall frame structural rigidity is important to enhance the capabilities of a 4-wheeler vehicle. To measure the overall frame rigidity, tensional rigidity analysis was conducted through CAD. The objective of the tensional rigidity analysis was to manipulate the chassis design within the CAD software to increase the amount of torque per degree of chassis deflection. By theoretically increasing this value, the actual vehicle could have the ability to be more torsion-ally rigid, making it able to withstand more intensive without failure. Which is equivalent to the gross weight is calculated i.e Gross weight = 120kg and the equivalent force that is

–

$F = M \times g$ $F = 120 \times 9.81$ $F = 1177.2$ N

The calculated force is placed on one of the corner of the frame while other three corners were kept fixed by constraining.

Hence according to the result obtained, the frame would be torsion-ally rigid.

• *Weight –*

Keeping the frame as light as possible was a top priority. When power is limited, vehicle weight is a large factor in vehicle performance. The frame is one of the large stand heaviest components of the car, and which is why special attention was given to it.

The strategy utilized to minimize weight consisted of determining defined goals for the chassis and employing the correct material in the best places to accomplish those goals. Once baseline safety design requirements were met, CAD aided the material decision making process. CAD specifically helped to determine whether a member was under high or low stresses, in the scenarios discussed previously, making the chassis design process efficient and effective. Chassis members were made out of inch (2mm) wall thinness and 1inch (25.4mm) outer diameter AISI 4130, this material was chosen because of its weight reduction capability and beneficial material properties, as was stated previously. Through accurately determining stresses on the chassis in different scenarios, weight reduction was able to be maximized through material selection and placement. Also the simplicity of the frame design that is used for less number of members tends to the reduction in the weight. The final weight of the chassis was measured in software as 22kg and the gross (final) weight of the vehicle along with the driver is estimated to be 120 kg.

Asthetic

Aesthetically, the roll cage design is improved by the use of more rounded corners than the straight. The unique use of rounded corners allows for a more pleasing look to the vehicle's body as well as a reduced number ofwelded joints. The use of continuous bended pipes alsoreduced the no of jointsthelack of sharp edges on the rollcage allows for the design of more streamlined body panels which not only look smoother, but may also havea positive effect on the overall aerodynamic drag forces.

Manufacturability-

All design work for the go kart championship has been done on the CATIA &Ansys software. Using this program to produce three dimensional model allowed easy revision of prebuilt designs, and gave design team members a visual picture of what the frame would look like. After the design of the frame was finalized, a list of required support members was created and the frame modal was modified. The design for manufacturability, ergonomics, and aesthetics for the roll cage are favour able for its reproduction, serviceability, and comfort. The material selected AISI 4130 has good manufacturability qualities. To increase manufacturability, many bends were used as frame members. These bends not only give the vehicle as leek, attractive look but also reduce the total amount of frame members and welds between these members resulting in a lighter, cheaper, and customized chassis. By implementing bends into the design of the frame, the number of cuts and welds were decreased. Decreasing the number of cuts and welds lowers the production cost and increases overall chassis strength. For example, by using more bends,

A bending die can perform the job of bending behalf of the welding and joining hence reducing man-hours and production costs. All bends were designed to be made using a tube bender fitted with primary die of 10 cm, secondary die of 15cm, and tertiary of 30 cm, diameter die, which would eliminate costly tooling changes from the manufacturing process.

Welding –

The material which is used AISI 4130 has good weld ability. All welds on the vehicle are made using a MIG(metal inert gas) welding process.MIG welding uses an arc of electricity to create a short circuit between a continuously fed anode (+ the wire fedgun) and a cathode (- the metal being weld). MIG is selected because it provided the best Control of heat affected zones while also reducing internal stress in the frame selected it order to allow the weld to flex slightly without Cracking. It provides strongest welds, faster welding speed and is clean and efficient makes welding easier.

Body and Composites

• Objectives

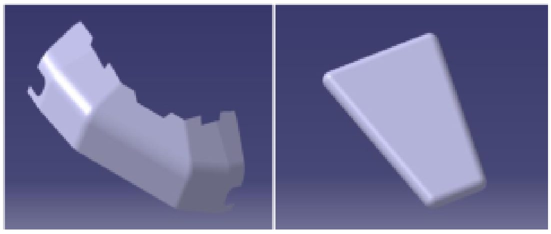
The purpose of the body is to prevent debris fromentering the vehicle, with the intent of protecting thedriver and the vehicle's components. The seat wasdesigned to support the driver comfortably and safelywhile they are operating the vehicle.

• Design

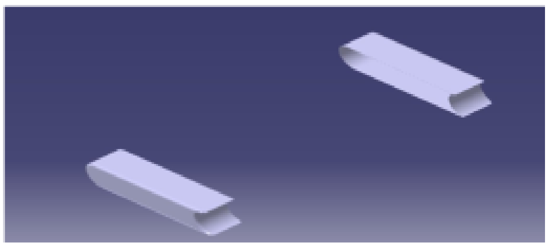
The design of the body and composites has done in thecad software and the FRP is selected for the body worksof very less weight.

Body Panels-

the body panels are made out of .080 inch thick FRP(fiber reinforced plastic) .FRP is a composite material made of a matrix reinforced with fibers the polymer is usually epoxy, vinlester or polyster thermosetting plasti care used in FRP.It is very light material that hasd esirable properties for a body panel. The panels are designed such that they tends to reduce the aerodynamic moments like pitching from front, yawing from side and also helps to create the down ward force to which tends to make the good traction of vehicle with the road & also provide the properties necessary to protect the driver and vehicle components from rocks and other debris. When the panels were integrated into the car, the panels were recessed into the chassis to provide visibility to the chassis members, making the caraesthetically pleasing.



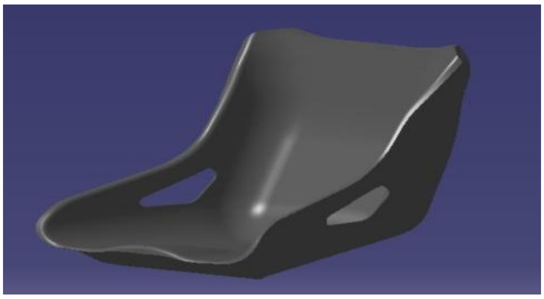
Front Panels



Side Panel

Seat-

The seat in this kart is also designed to be very light it is very simple made of plastic material and is attached to the chassis by four points only and can be adjusted in angle of back rest according to the requirement of the drivers comfort the back side angle of the seat is at 17 degrees which is the good position of the drivers body rest according to the ergonomics point of view and is kept almost parallel to the fire wall .the seat implemented in our go kart provides a good combination of weight reduction and ergonomics.



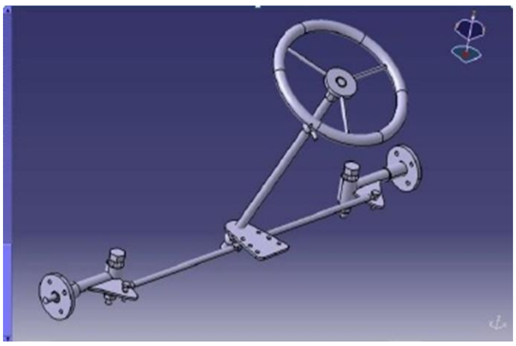
Steering System Design

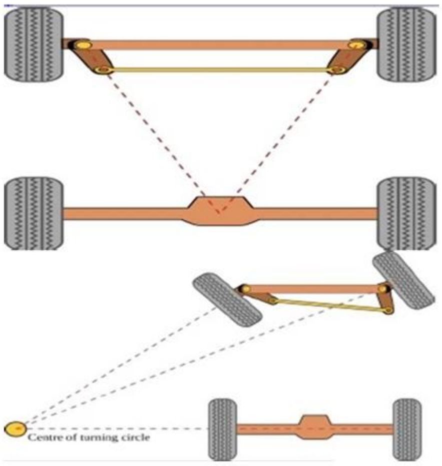
• Objective

The steering system is designed to withstand the stress of safely maneuvering the vehicle through any type of possible condition at the time of driving. The purpose of the steering system is to provide directional control of the vehicle with minimum input. The main goal for steering is to have steering radius of4m or less and to have 100% Ackerman steering.

• Design

Simplicity and safety were the main design specifications for the vehicle's steering system. While designing the steering system the constraints that we possessed were center alignment of steering system, track width, human effort at the steering wheel and the desired response of the steering system. A Pivot Pin steering arrangement was chosen due to its light weight, simple design and low cost. Very less play due to limited number of joints. We are also introduced the multi sensitive steering system. This system has a tendency to increase or decrease the sensitivity of our steering by means of multi port pivot plate, by changing the position of tie rod from port one by one. This system provides the driver simplicity and directional control over vehicle according to condition.





The formulae's used for steering calculation are:

R = d/2+Lcosec (A/2+B/2)

%Ackerman =

Where,

R is the turning radius, L is the length of the car,

A is the angle of the inside angle of the wheel

B is the angle of the outside wheeld is the width of the car.

To determine the Ackerman percentage, equation (2)was used. Given that, 100% Ackerman angle is desired,A at 38-degrees and B at 42-degree was the best option.

This gave a turning radius of 3.2m.In this geometrywhen a car taking a0

relative wide turn, the point whereaxel lines intersect is the point about which the car isturning. This is shown in a fig.

Our tires is not skidding because the inside front wheelis angled just a little more than the outside front wheel.Inner and outer turning angle is calculated by theformulae-Outer angle-

TanA = L/(R-d/2)

Inside angle-

TanB = L/(R+d/2)

Caster angle is the most important factor governing how the kart will handle. It will make the kart more stable in rough condition and the kart's straight line stability will also be improved. King pin inclination is used to making a steering tend to return to the straight ahead or centre position. If king pinis incline at 12 degree, it gives self centering effect and leads to less steering effort.

V. CALCULATIONS

Various calculations are tabulated as follow according to the vehicle specifications

Inner Turning Angle	38deg	
Outer Turning Angle	42 deg	
Turning Radius	3.2 m	
Caster Angle	12 deg	
Camber Angle	5deg	
King Pin Inclination	07deg	
Tie Rod Length	Right= 19.9 inch	Left= 11.50 inch
Steer wheel diameter	14 inch	

Brake System-

• *Objective*

The purpose of the brakes is to stop the car safely and effectively. In order to achieve maximum performance from the braking system, the brakes have been designed to lock up rear wheels, while minimizing the cost and weight.

• *Design*

The brake system design includes the single disc at the rear axle to stop the vehicle. It is mounted in the one third part position of the axle with opposing the position of drive train sprocket hence also enables the good balancing requirement. Master cylinder is used at the front near the brake pedal providing the occupant to easily accessible space. A proper master cylinder bore size was found by doing brake calculations based on the mass, center of gravity, master cylinder volume size, and various dimensions of the vehicle. Though braking power increased with a decrease in bore size, the volume of brake fluid that was able to be displaced decreased with decreasing bore size.

Design Methodology

Disk brake on rear wheels.

Single master cylinder.

Diameter of disc : 7 inches

Technical Data

Time taken by our vehicle to stop from a speed of 40 Km/hr is 1 second. Stopping distance is 6.02 m with coefficient of friction 0.8

Braking force =999N

Energy dissipated = 11,108.889Nm

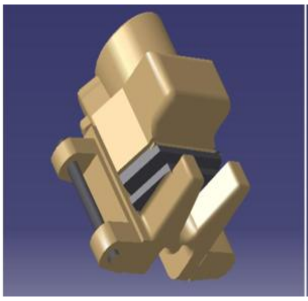
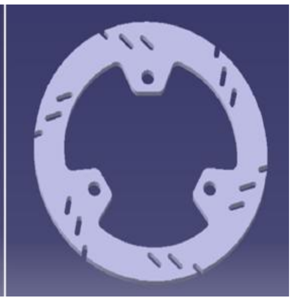
Procedure and Calculations

Stopping distance = V*V/ 2*µ*g

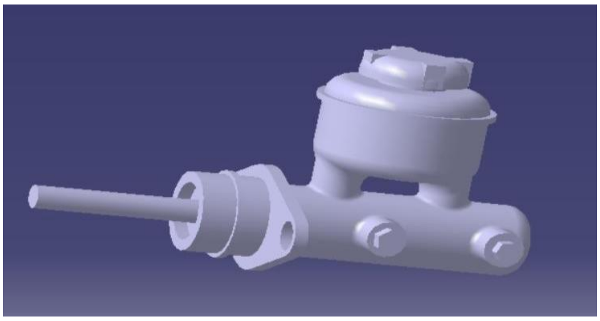
Braking force = mass of vehicle* deceleration

Deceleration = V/ time taken

Energy dissipated = [M*{V2(initial)- V2(final)}]/2

Break Calliper Disc



Master Cylinder

- TRANSMISSION AND SYSTEM USED
- SPECIFICATION AND CALCULATION

Engine	CG 135 cc
Type	4-stroke, DTS-i, Air Cooled, 4- valve single cylinder
Displacement	134.66 cc
Bore X Stroke	54.0 mm x 58.8 mm
Rated Power & Rotating Speed	13.3 bhp @9000 rpm
Max. Torque & Rotating Speed	11.4 Nm @7500rpm
Ignition	Electric/kick self
Lubricating	Pressure / Splash
Clutch	Wet Multi-plate Clutch
Number of gears	5

Taking into account the specification parameter in the rule book, we have chosen this engine.

On the basis of maximum torque, rpm, power On the basis of its efficiency

On the basis of Bore x Stroke value amongst 135 cc engines.

- TIRES/WHEELS

Taking into account the desired ground clearance and disc availability, we choose from a range of tires available.

- Specification of Tires

Front - 10*4.5-5 Rear - 11*7.1-5

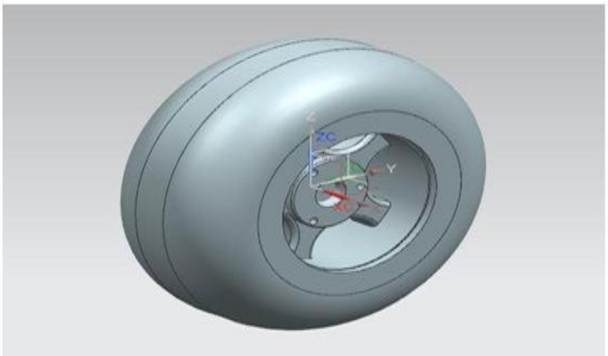
- Type of tires

BKT tires - tubeless

- Rim

Type - bearing type

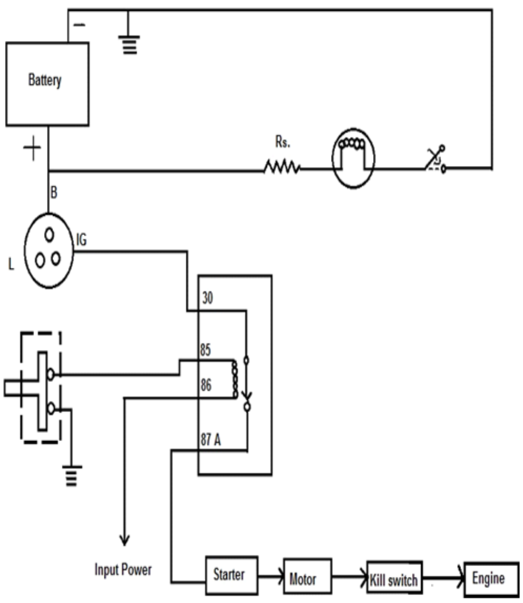
Size - (according to our design requirement)



REAR TYRE

FRONT TYRES

Electrical System-



➢ *Failure Mode and Effect Analysis*

Following can be the modes of failure of the above presented electrical system :

1. Under overloading condition

2. Due to loose connections

3. Due to overheating of engine which may damage the circuit

➢ *Validation Report*

Following circuit is valid under following conditions

1. If motor works on its rated rpm and won't disfunction

2. If kill switch is not pressed

3. If the coil of the starter won't burn due to excess voltage

➢ *Weight of Vehicle*

Parameters	Weight (in kg)
Roll Cage	17(aprx)
Tyre and wheel hub assembly	20
Engine	25
Steering system	3
Brake assembly	5
Driver	65
Exhaust	5
Miscellaneous (seat, battery, fuel tank, etc.)	15
Chain, sprocket, front and rear drive shaft	25
Total (approximate)	180

- EXHAUST
- CARBON FILTER BEING USED WITH FUEL VAPOUR PREVENTION CAP (FVPC)

Advantages

- Up to 15-17 % fuel saving on your mileage per litre.
- Up to 40 % reduction in carbon monoxide emission.
- Up to 30 % increase in life of your catalytic convertor exhaust system.

Proposed Cost Report

SYSTEM	TOTAL COST(Rs.)
Engine	28000
Steering & Electrical	5000
Brakes & Tyres	12000
Pipes & Materials	10000
Fuel Tank	800
Exhaust	1500
Finishing & Painting	2000
Safety & Innovation	2000
Miscellaneous	8000

VEHICLE COST	69300
Registration	12500
Transportation(spon)	18000
Driver Suit & Accessories	22000
TOTAL COST	121800(approx)

DFMEA

- FMEA is a deliberate and thoughtful method for focusing on "expected quality" that:
- Identifies possible faults (failure modes) in a system.
- Evaluates the effects of the fault on the operational status of the system
- Determines the risk priority of the failure (based on severity, probability of occurrence, and probability of detecting and avoiding the failure
- Recommends corrective actions for high risk items
- Implements corrective actions until risk is reduced
- Documentsthe design process and allows for efficient review and communication with respect to system safety

failure modes (what can go wrong)

Analyze operating conditions, environment conditions,all potential failure modes.

Structural systems	Fracture (max load & fatigue), excessive deflection, excessive wear
Kinematic systems	Bearing seizure, reduced accuracy of relative movement, interference
Thermodynamic systems	Overheating, reduction of efficiency
Fluid flow equipment	Leakage, blockage, distorted flow
Electrical equipment	Short circuit, open circuit, loss of power
Material properties	Incorrect material, incorrect geometry
Environmental effects	Temperature, contamination, corrosion, excessive friction

Cause of failures:

- Design deficiencies
- Failed to consider effects of notches & stress concentrations
- Inadequate knowledge of service loads and environment
- Incorrect use of finite element analysis for complex parts
- Relying on analysis results without adequate experimental validation

Material selection deficiencies

- Inadequate material data / use of inappropriate data
- Cost emphasized over quality
- Manufacturing defects that remain in the final part
- Inadequate maintenance, inspection, and repair
- Overload
- Effect of Operating environment
- Unexpected conditions, beyond those allowed for in the design
- Deterioration of material properties due to prolonged exposure to the environment

Effect on Environment / Society

The competition as well as our report will definitely be helpful for other enthusiastic minds and will help the society to grow more stronger in the technical field.

PFMEA (PROCESS FAILURE MODE AND EFFECT ANALYSIS)

Process Failure Mode and Effect Analysis

Effect Criteria	Criteria 1	Criteria 2
Degradation of Secondary Function	Degradation of secondary function (vehicle operable, but comfort/convenience functions at reduced level of performance).	A portion of the production run may have to be reworked off line and accepted.
Loss of Secondary Function	Loss of secondary function (vehicle operable, but comfort/convenience functions inoperable).	100% of production run may have to be reworked off line and accepted.
Degradation of Primary Function	Degradation of primary function (vehicle operable, but at reduced level of performance).	A portion of the production run may have to be scrapped. Deviation from primary

		process including decreased line speed or added manpower.

Loss of Primary Function	Loss of primary function (vehicle inoperable, does not affect safe vehicle operation).	100% of the production run may have to be scrapped. Line shutdown or stop ship.
Failure to Meet Safety and/or Regulatory	Potential failure mode affects safe vehicle operation and/or involves noncompliance with government regulation with warning.	May endanger operator (machine or assembly) with warning.

Team Structure And Responsibilities :

Faculty Advisor-

1. Saumitra Sharma

2. Ashish Kumar Chaturvedi

CAPTAIN - Md. Nazish

DRIVER - Aadarsh Rai M

ANAGEMENT - Ashish Singh

MARKETING - Atul Mishra