INTERNATIONAL GO-KART CHAMPIONSHIP 2020

Organized by- LPU SAEINDIA COLLEGIATE CLUB

ENGINEERING DESIGN REPORT (EDR)

TEAM NAME- TEAM CARPE-DIEM

TEAM ID- E20102

COLLEGE NAME- METROPOLITAN INSTITUTE OF TECHNOLOGY AND MANAGEMENT, SINDHUDURG (M.H.)

ABSTRACT

The objective of this report is to highlight the final design report of **TEAM CARPE-DIEM** Go-Kart vehicle to compete in International Go-Kart Championship 2019-20.

This aims to design and development of working model of cost effective electric go-kart. Main objective behind designing and fabricating the electric go -kart is to make it available in cheap price, making it simple in working for even nonprofessional drivers, increasing is strength so that it can sustain more weight and providing it with all the best available facilities in lower cost . The paper mainly focuses on the material selection and designing of cheaper electric system compared to other electric go-karts manufactured, calculations required for designing the kart, basic required analysis.

INTRODUCTION

The go-kart will be built from the ground up to maximize the efficient use of space, and to ensure that the needs of the client are met. We approached our design by considering all possible alternatives for a system & modeling & analysis them in SOLIDWORKS software. Based on analysis result, the model was modified and retested and a final design was frozen.

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

- **Chassis 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. We pre analyze the overall costing.

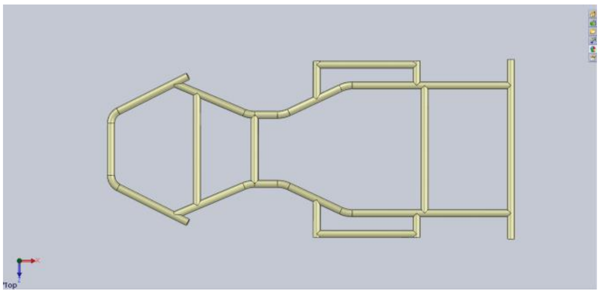
Sr. No	Description	Amount
1	BLDC motor (3kW)	23000
2	Transmission System	4000
3	Steering System	3000
4	Hydraulic Braking System	8000
5	Battery and electrical	15000
6	Round Tubing Pipes	8000
7	Safety Equipment’s	8000
8	Tyres nos. 04	9000
	Total	78,000

DESIGN METHODOLOGY

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

- The design objectives
- The design calculations and analysis
- Considerations
- Testing

I. CHASSIS



A. Goals

- To ensure safety of the driver.
- To maintain low center of gravity.
- To ensure that all the systems fit onto the chassis.
- To design a chassis with high strength and low weight.

II. MATERIAL SELECTION

Cost, availability, weight, strength & weld ability are the four key factors which determine the material selection. Proceeding from these factors, the following material was chosen as the most suitable one for the kart.

Chassis Pipe Material Specifications:
AISI 4130
Mild Steel

25.4 mm O.D.

2 mm wall thickness.

Chemical properties –

Carbon C	0.28%
Silicon Si	0.26%
Manganese Mn	0.50%
Sulphur S	0.006%
Phosphorus P	0.008%
Nickel Ni	0.019%

Physical Properties-

Density (kg/m^3)	8000
Yield strength (MPa)	686.97
Ultimate strength (MPa)	847.92
Young modulus (MPa)	205000
Poisson’s ratio	0.29

A. *Bumper Material*

- AISI 304.
- Stainless Steel,
- 26 mm O.D.
- 2 mm wall thickness

B. *Solid Modeling*

After carefully reading and understanding the design parameters, the basic design of the chassis was decided. After incorporating steering mounting points and engine mounting considerations, the team has carried out several iterations to decide support members and compliance of the same has been verified and the chassis has been finalized.

III. CAE ANALYSIS

CHASSIS 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. Analysis was conducted by use of finite element analysis FEA on Solidworks software.

FRONT IMPACT ANALYSIS-

$P = M \times V$

$= 140 \times 17.8$

$P = 2492\ kgm/s$

And the frontal impact force i.e.-

$F = P \times \Delta T$

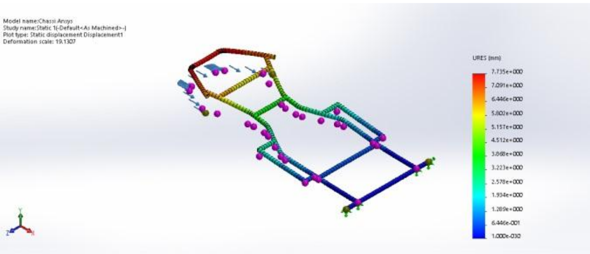
$= 2492 \times 0.85$

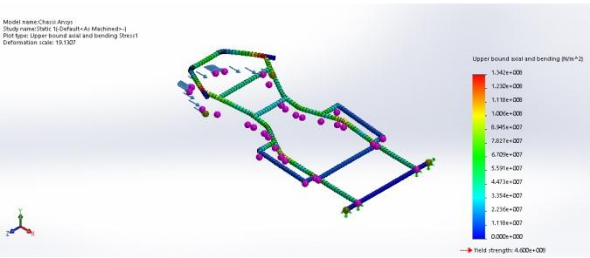
$F = 2119\ N$

Applied load= 2119N

Deflection= 7.35 mm

Stress= 1.341 x 10^8 N/m^2





SIDE IMPACT ANALYSIS –

$P = M \times V$

$= 140 \times 13.3$

$P = 1862\ kgm/s$

The side impact force –

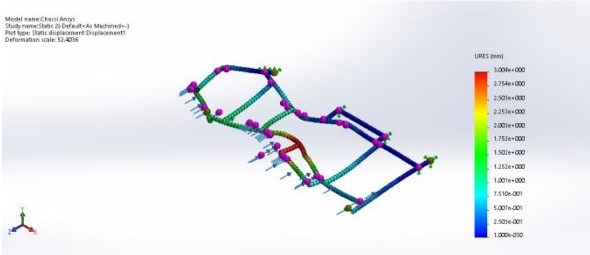
$F = 1862 \times 0.85$

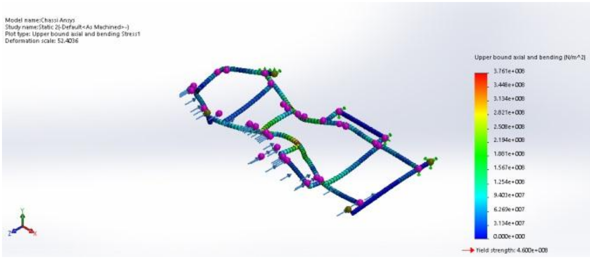
$F = 1583\ N.$

Applied load= 1583N

Deflection= 3.00405 mm

Stress= 3.761 x 10^8 N/m^2





REAR IMPACT ANALYSIS –

$P = M \times V$

$= 140 \times 13.8$

$P = 1932\ kgm/s$

The rear impact force –

$F = P \times \Delta T$

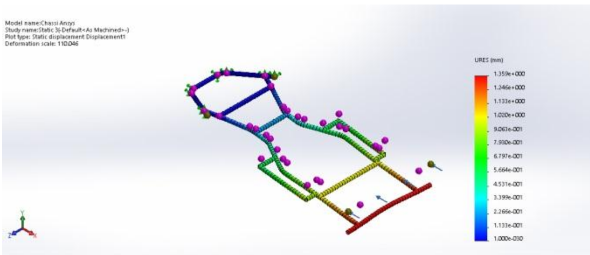
$= 1932 \times 0.85$

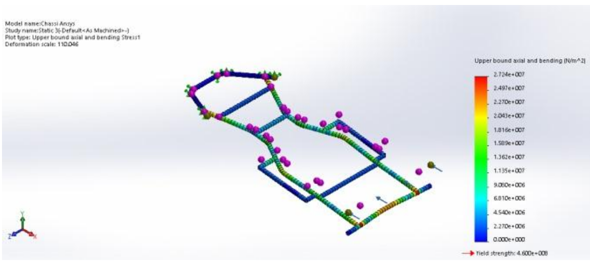
$F = 1643\ N$

Applied load= 1643N

Deflection= 1.35941 mm

Stress= 2.723 x 10^7 N/m^2





Hence the conclusion of the safety analysis with result is tabulated as-

FACTORS	FRONT	REAR	SIDE
Impact Force	2119 N	1583 N	1643N
Stress Generated	1.34 x 10^8 N/m^2	2.72 x 10^7 N/m^2	3.76 x 10^8 N/m^2
Total Deformation	7.73548 mm	1.35941 mm	3.00405 mm
F.O.S.	2.58	2.51	2.93

STEERING SYSTEM

INTRODUCTION

Four bar linkage mechanisms which consist of following steering component which were designed in CAD software.

DESIGN OBJECTIVES

- Each component must be properly designed, analyzed and optimized before manufacturing and prototyping.
- All forces and loads must be considered while analyzing the CAD geometry.
- Most precise meshing should be used in order to get most accurate results.

STEERING PARAMETERS

Wheel base	40’’
Track width	29’’
King pin distance	964.96mm
Tie-rod length	10’’
Minimum turning radius	1.95m
Caster angle	0
Ackerman angle	22.89°

WEIGHT DISTRIBUTION

The total weight of vehicle is 90 kg (including driver)

The weight distribution is very important to understand the vehicle dynamics and analyzing the vehicle in various aspects.

The weight distribution is very important to understand the vehicle dynamics and analyzing the vehicle in various aspects. The weight distribution was assumed to be 43% of total weight (that is 90kg) in the front and 57% in rear portion of vehicle. By the theoretical calculation the location of center of gravity was calculated. The height of center of gravity is 3 inches

STEERING CALCULATION

-

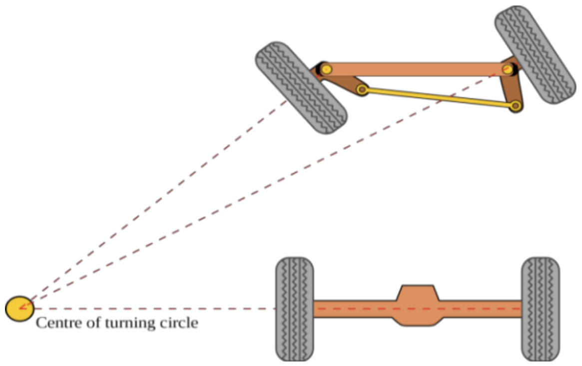
Outer steering angle Inner steering angle
Outer steering angle= L/(R+t/2)
Inner steering angle= L/(R-t/2)
Outer steering angle =25.10
Inner steering angle =37.78
Where,
L=wheelbase
R=turning radius
t=track width Ackerman arm angle

α=tan-1 [0.5*t/l]
α=22.89

Turning radius R=L/2*sin (α)
R=1.95m

Assumptions:-
Mass in front tires (m) =55.9kg
Average velocity (v) = 30 km/hr =8.33 m/s
μ =0.6
Normal Force on Stub Axle:
N=m*g =55.9*9.81
= 548.37 N
Lateral Force on stub axle:
Lateral Force = mv2 /r = 2021.68 N

Tractive force:
Force due to traction = μ*Normal force
= 329.02 N



DESIGN CONSIDERATIONS-

Consideration	Priority	Reason
Simple Design	Essential	Minimize weight to maximize Power to weight ratio of car.
Low Steering Ratio	Essential	Quick steering response
Ackerman geometry	High	To avoid skidding without using differentials
Minimize Bump steer	Desired	Conserve momentum while Steering

BRAKE SYSTEM-

CALCULATIONS

a) Gross weight of vehicle:
(W) = 90 * 9.81 =882.9 N

b) Brake Line Pressure:
Pedal ratio: 3:1
Normal force on pedal : 400N
Area of master cylinder: 334.06mm²
Brake line Pressure = 23.94 N/mm²

c) Clamping Force:
CF = B Pressure * (Area of caliper Piston * 2)
CF = 23.94 * (π/4) * 27² * 2
CF = 27413.94 N

d) Rotating Force:
RF = CF * no of caliper piston * Coeff. Friction of brake pads
= 27413.94 * 2 * 0.4
= 21931.152 N

e) Braking Torque:
= RF * effective disc radius
= 21931.152 * 0.07
= 1535.18 Nm

f) Braking Force:
BF = (braking torque/ tyre radius)*Coeff. of friction
= (1535.18 / 0.14) * 0.8
= 8772.457 N

g) Deceleration:
B F = - ma
i.e a = - BF/m = - (8772.457 / 90) = -97.47 m/s²

h) Stopping Distance:
$v^2 - u^2 = 2 * a * ds$
Where, u = 60 km/hr = 16.67 m/s
$v = 0$ $ds = v^2 - u^2 / 2a$
$ds = 0^2 - 16.67^2 /2 * (-97.47)$
ds = 1.425 m

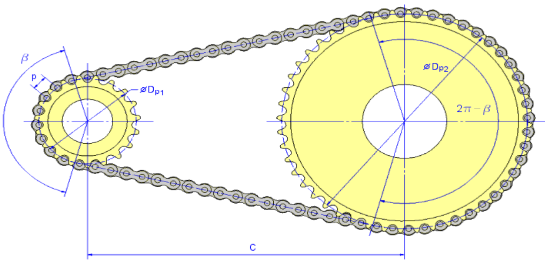
Sr. no.	Description	Value
1	Pedal Ratio	3:1
2	Brake Line Pressure	23.94 N/ mm²

3	Braking Torque	1535.18 Nm
4	Braking Force	8772.45 N
5	Stopping Distance	1.425 m

<u>TYRE SPECIFICATION</u>

Position	Diameter (inch)	Width (inch)
Front	10	5
Rear	11	7.1

TRANSMISSION SYSTEM



Sl. Particulars Values

1. No. of teeth in Drive Sprocket= 15
2. No. of Teeth in Driven Sprocket= 43
3. Transmission Ratio= 2.86
4. Dia. Of Drive Sprocket= 4.5 cm
5. Dia. Of Driven Sprocket= 17 cm
6. Pitch of Chain= 1.587
7. No. of Chain link= 90
8. Length of chain= 430 mm
9. Acceleration of kart= 0.43 g
10. Max. Velocity= 80 kmph
11. Induced Torque= 25.7 N-m
12. Peak Torque= 73.4 N-m

ELECTRICAL SYSTEM

<u>MOTOR-</u>

In AC/ BLDC/PMDC motor we are using BLDC motor with 48V and 3kW. Because it is fulfilling our requirements it also provides maximum torque at the beginning comparison to other motors.

Advantages of BLDC motor over AC Induction motor:

- BLDC Motors are Expensive
- These are Very efficient upto 85-90%
- These are lighter in weight.
- Compact in size.
- Simpler to control the speed and reverse function than ACIM's

<u>TORQUE PRODUCED</u>-

- Power= 3000W
- Efficiency= 85%= 0.85
- Speed(n)= 949 rpm
- $\eta = \frac{P(output)}{P(input)}$
- P(output)= $\eta x P(input)$
- P(output)= 2550 watt
- $p = \frac{2\pi nT}{60}$
- 2550 $= \frac{2*3.1416*949*T}{60}$
- Torque= 25.659 Nm

So, Torque Produce by a Motor is 25.7 Nm

<u>MOTOR POWER</u>-

- Vehicle Weight (with driver) : 140kg
- Efficiency (n) : 85% : 0.85

- Wheel Size (R) : 5.5“ : 139.7 mm : 0.1397 m
- Length : 63.5’’ : 1612.9 mm : 1.612 m
- Width : 40’’ : 1016 mm : 1.016 m
- Required Speed : 70 kmph

1. Linear Distance

   =2 * Pi * R= 2*3.146*0.1397

   = 0.8777 m
2. Speed

   = V * 1000 / 3600= 19.44 m/s
3. RPM

   =Total Distance Covered per hr/ Linear Distance

   = 70000/ 0.877

   = 79748.17 RPH = 1329 RPM

- Power

$p=(m\cdot a\cdot v\cdot R\_\gamma\ )+(\rho\_((air)\ )\cdot \varepsilon\_((draq)\ )\cdot v^3\cdot A)$

Where,

- Mass(m): 140kg
- Acc. Due to gravity: 9.81 m/s^2
- Velocity: 19.44 m/s
- Rolling Resistance(Rr): 0.01 (assume)
- Air Density (p): 0.6465 (assume)
- Coefficient of drag: 0.88 m/s
- Area: 1.5483 m^2
- Power= 6743.19/ 85 % = 7933.17 watt
- Required Power of Motor is 7.9 kW

But, we selected 3 kW Motor

So we get 1000 RPM & Speed 53 kmph

MOTOR CONTROLLER-

A motor controller include a manual or automatic means for starting and stopping the motor, selecting forward or reverse rotation, selecting and regulating the speed, regulating or limiting the torque, and protecting against overloads and faults.

Sr. no.	Component	Description
1	Motor	BLDC
2	Power	3kW
3	Voltage	48v
4	Torque	25.67N-m
5	Battery	Li-ion
6	Battery Capacity	75Ah
7	RPM	950

ENERGY STORAGE SYSTEM

We are using one 48V and 75 Ah Li-ion batteries. It is better than the lead acid battery because its weight is less than the wet batteries, as well as it require the less maintenance.

BATTERY SELECTION-

Power= 3000 watt

Efficiency= 80%

Peak power= 3600 watt

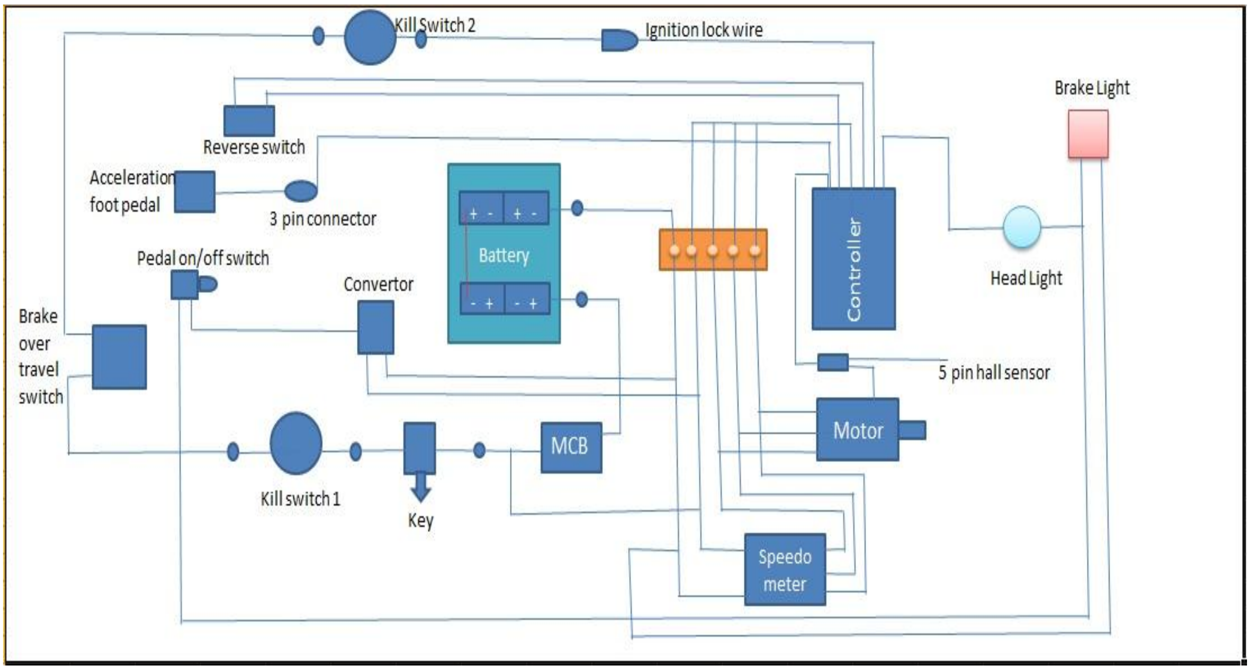
Battery voltage= 48 volt

Battery capacity= p/v= 75 Ah

So, Ah required for battery is 75 Ah

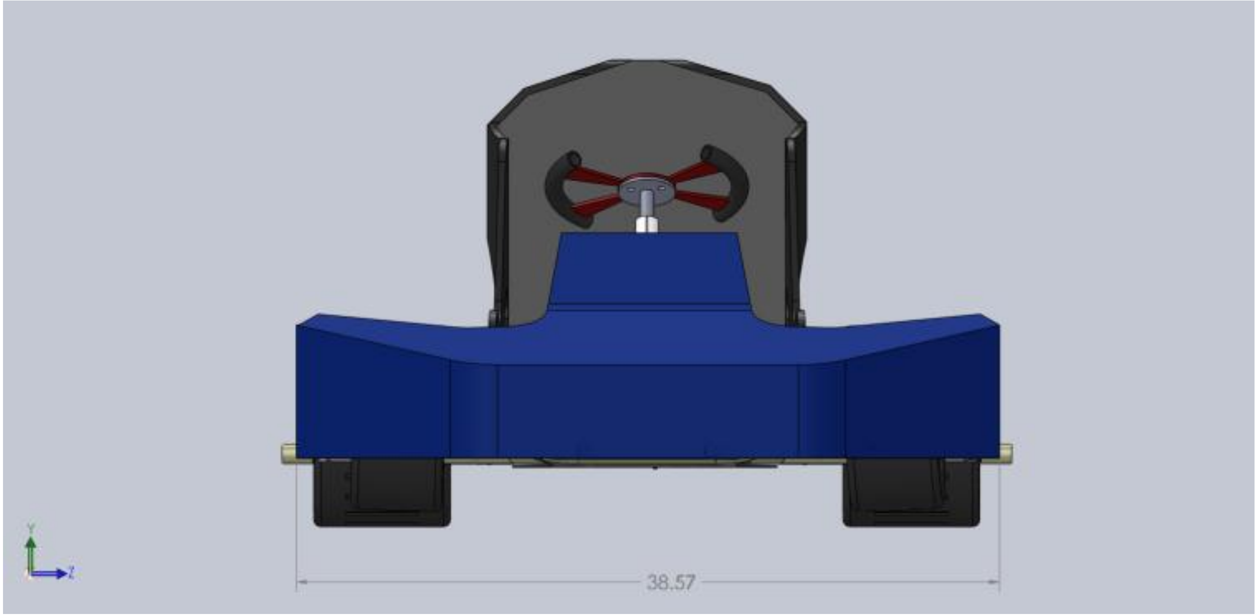
So, we had selected 80 Ah capacity.

ELECTRICAL CONNECTION-

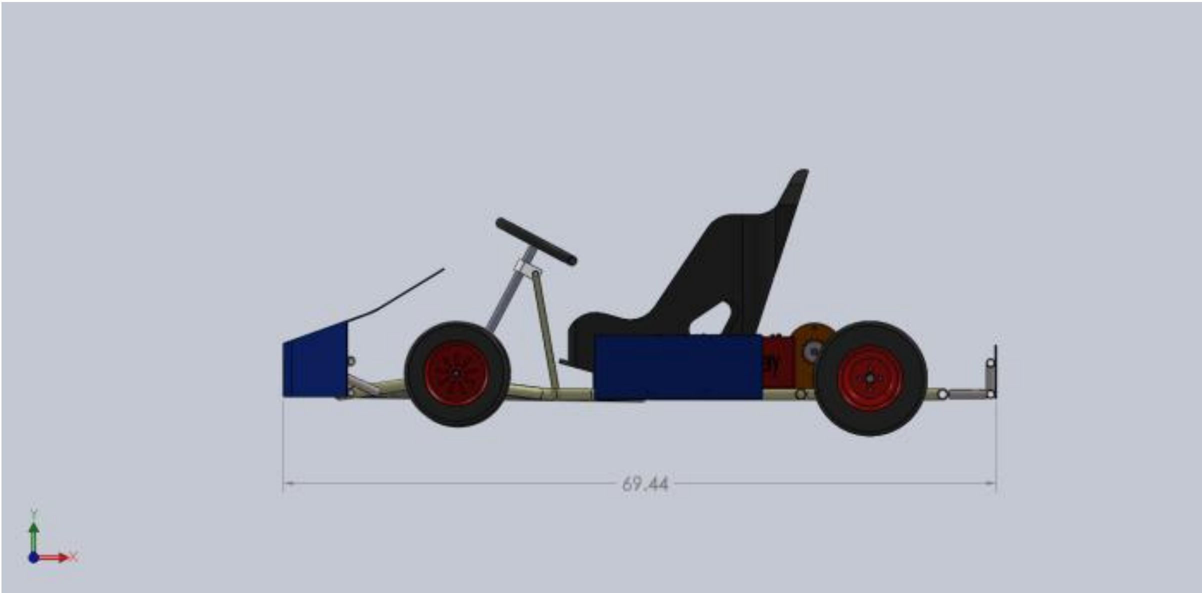


VEHICLE VIEWS-

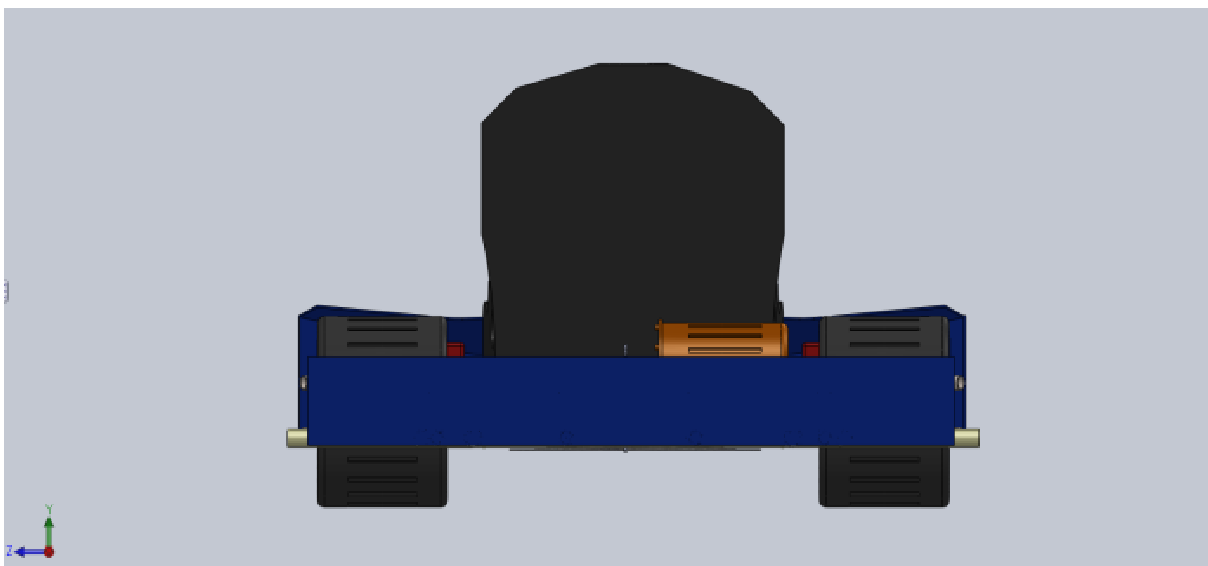
FRONT VIEW



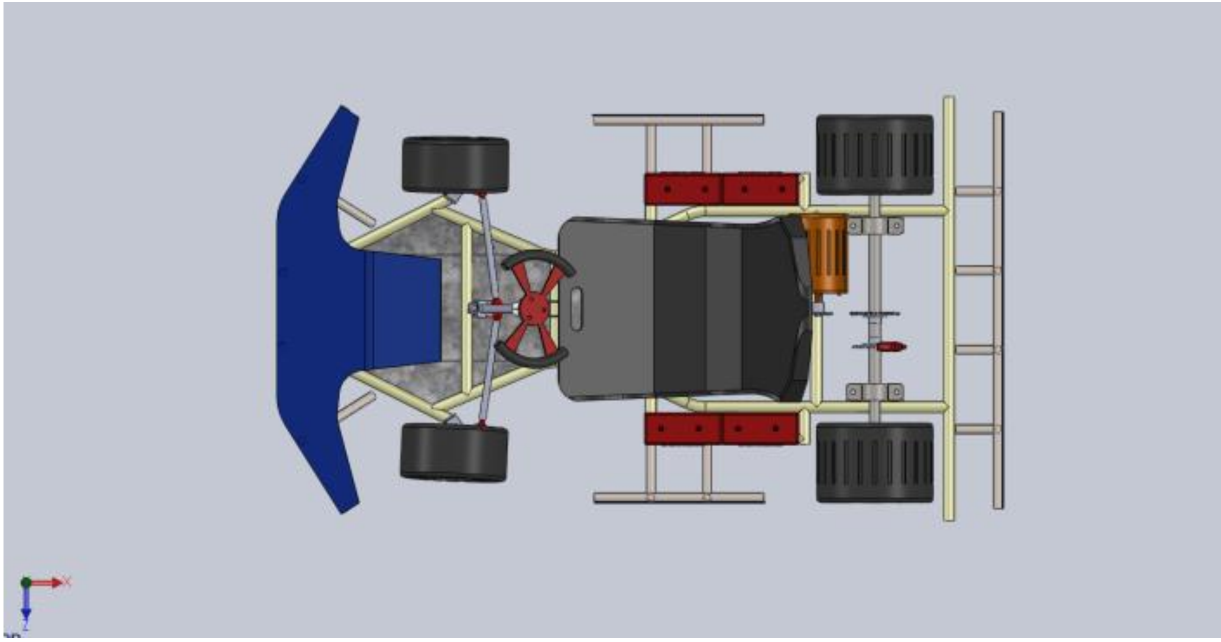
SIDE VIEW



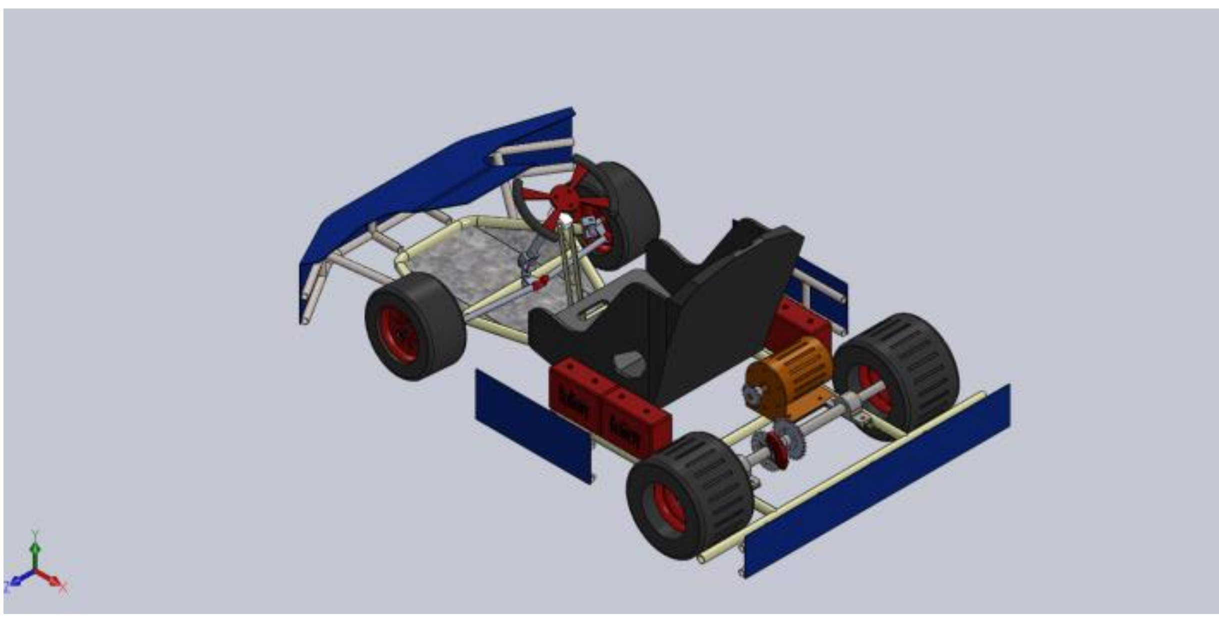
REAR VIEW



TOP VIEW



ISOMATRIC VIEW



DVP-

SR. NO.	DESCRIPTION	VALIDATION CRAITERIA	ACTUAL PARAMETER	REMARK
1	**FRAME**			
1	Frame Material	Equal to or more than AISI 1018	AISI 4130	OK
2	**KART DIMENSIONS**			
1	Maximum Length	90"	63.5"	OK
2	Minimum Wheel Base	40"	40"	OK
3	Track width	65% -75% of the wheelbase	29"	OK
4	Height of steering from the ground	Adjust it according to driver	500mm	OK
5	Ground Clearance	1.25" to 4"	2"	OK
6	Maximum Weight	**230Kg** (without driver)	80	OK
3	**STEERING**			
1	System	Front wheel drive	Front wheel	OK
2	Stopers	positive steering stops	Stop On Chassies Bracket	OK
3	Mechanism used	mechanically connected to the front wheels.	Ackerman Steering	OK
4	**BREAKING**			
1	Type	Hydraulic System	Hydraulic Breaking	OK
2	Brake light	**ONE FOOT** above the ground.	One Feet	OK
5	**MOTOR & CONTROLLER**			
1	Motor Type	DC/AC	DC	OK
2	Maximum Power	10kW	3 kW	OK
3	Maximum Voltage	96V	48V	OK
4	Maximum capacity	96V	48V/60v	OK
6	**THE BATTERY**			
1	Maximum voltage	96V	48V	OK
2	Maximum Capacity	120AH	72AH	OK
3	Types of the batteries	Lead acid, Li-ion	Li-ion	OK
7	**BATTERY PACKAGING**			
1	Battery cover material	an insulating coating	Rigid plastic	OK
2	Battery casing fixing	welded/fastened	Fastened	OK
8	**FUSE OR CIRCUIT BRAKER**			
1	Number of circuit braker or fues	One or more Fuses or circuit breaker	1	OK
8	**FUSE OR CIRCUIT BRAKER**			
1	fues	One or more Fuses or circuit breaker	1	OK
9	**TRACTIVE SYSTEM INSULATION, WIRING AND CONDUIT**			
1	Insulation temprature rating	90°C	100	OK
10	**DRIVER SEAT**			
1	Mounting	four mounting with the chassis	Four Bolt Mounting	OK
11	**WHEELS AND TIRES**			
1	Specification	FRONT-10x4.5-5REAR-11x7.1-5	Front 10x5, Rear 11x7.1	OK
12	**SWITCHES**			
1	Kill Switch	Two kill switches	2 push pull kill switches	OK
2	Brake Over Travel Switch	Brake light must glow on over travel too	Yes	OK
13	**FIRE WALL**			
1	Thickness	1mm	2mm thick	OK
2	From driver seat	2 inch	2 inch	OK
3	Clearance between fire wall and component	at least 1".	1 inch	OK
14	**FASTENER**			
1	Fastener Grade Requirements	must meet or exceed either, SAE Grade 5, Metric Grade 8.8 and/or AN/MS specifications	8.8/10.3	OK
2	Thread outside nuts	Must be at least 3 threads outside of nut.	4 threads	OK
15	**BUMPER**			
1	Front and Rear	4 point Attachment	Yes	OK
		Minimum dia of 19mm and a minimum thickness of 1.5mm	2mm thick & 26mm OD	OK
2	Side bumpers	2 point Attachment	Yes	OK
		Minimum dia of 19mm and a minimum thickness of 1.5mm	2mm thick & 26mm OD	OK
16	**SAFETY**			
1	SEAT BELT	The seat belt must be either a 3 point or a 5 point harness.	3 point harness type	OK
2	FIRE EXTINGUISHER	Atleast two fire extinguishers of ABC type 1 kg each	ABC type 1 kg 2nos	OK
		It should be accompanied with a sticker of team id and college name and a bill clearly mentioning its expiry	Yes	OK
3	DRIVER'S SAFETY GEARS	Driver's Suit, Underclothing, Helmet, Balaclava, Neck Support, Gloves, Shoes, Socks	As per standerd	OK

NOTE:THIS REPORT VALIDATE ALL THE POINTS OF DESIGN CRITERIA AS PER IGC RULE BOOK

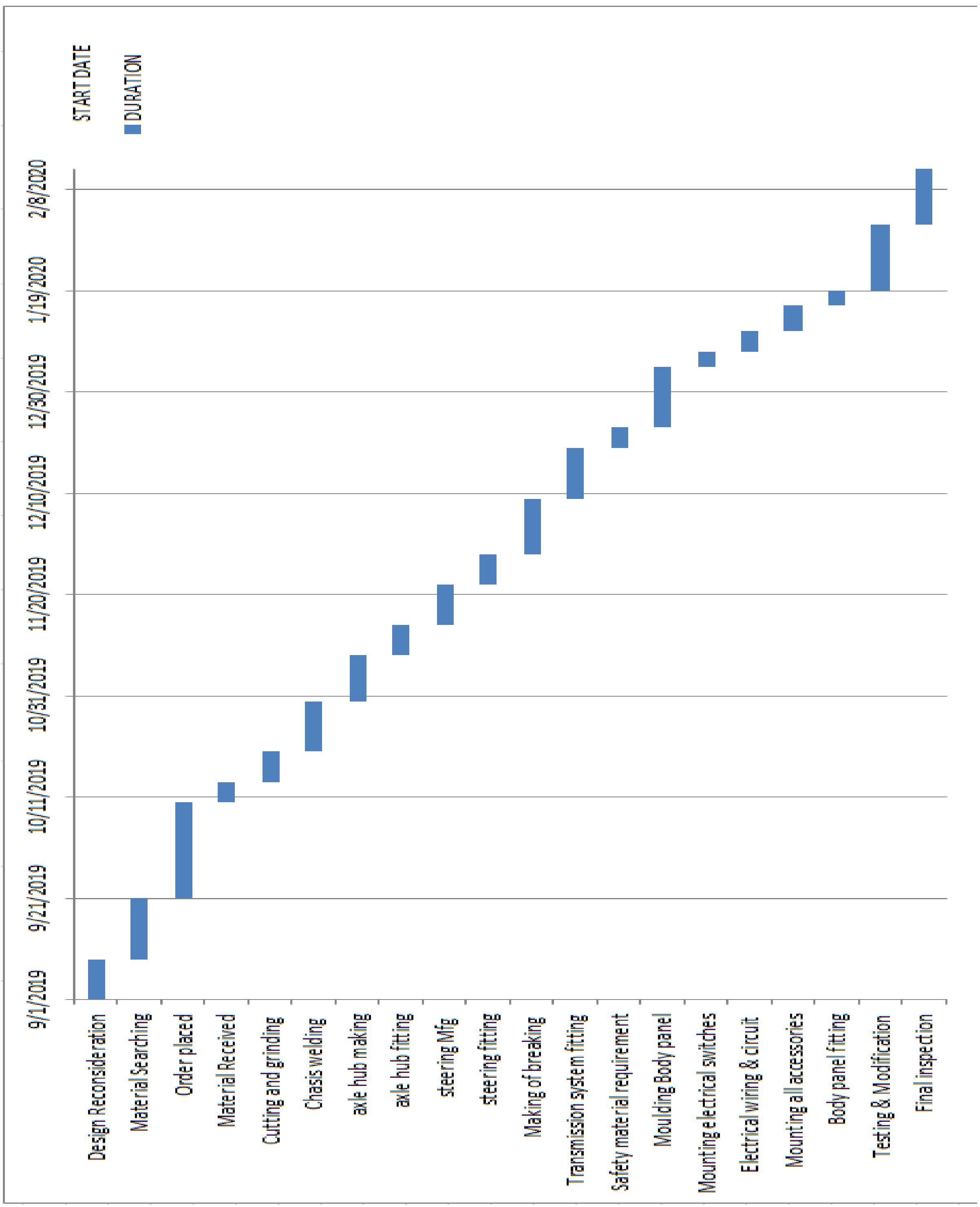
DMFEA-

S.No	FUNCTION	POTENTIAL FAILURE MODE	EFFECT OF FAILURE	POTENTIAL CAUSES OR MECHANISM FAILURE	O	S	D	RPN	ACTION TAKEN	O	S	D	RPN
1	Frame	Disengagement and bending of roll-cage members.	Damage to roll over protection, vibrational shocks to motor, failing of frame, drivers safety is compromised.	Welding cracks, serve vertical and torsional twisting and bending forces	#	5	8	400	Select the material of high factor of safety and yield strength, keep the tube thickness of primary members bit more than secondary members, weld properly without leaving any crack.	2	2	1	4
2	Steering	Hard steering, looseness in steering, car wandering, shimmy front wheels, scuffed tyres, steering wheel jerking.	Abnormal response, steering failure, driver's safety compromised.	Too tight steering gear, incorrect/insufficient lubrication, incorrect caster, camber, kingpin inclination and toe-in, low tyre pressure, worn tie rod ends, welding cracks.	9	7	6	378	Proper lubrication between rack and pinion and at tie rod ends, weld properly, tie rod pins should be fastened correctly.	2	2	1	4
3	Bracket	Bending and breakage.	Instability of various rollcage members like rear roll hoop & side impact members.	Various excessive loads causing the bending and bearing stresses severely high.	9	4	8	288	Select material of high factor of safety, weld properly without residual cracks.	2	2	2	8
4	Knuckle	Bending of the steering arm, structural cracks.	Poor response to steering reducing operability of kart, malfunctioning disc brake callipers.	Fatigue load and impact load, cyclic load, improper mounting.	7	2	6	84	Mount the knuckle carefully; choose a standard knuckle & if required fabrication then select the material of high FOS. Rivet properly with modified arms, proper lubrication.	2	2	2	8
5	Rim	Brittle or ductile fracture, rim-out.	Abnormal response to steering, damage to the axles and the frame, driver's safety compromised.	Impact loads, foreign transverse excessive load.	6	2	10	120	Use standard rims, never put unnecessary transverse loads on the wheel, check and repair the flanges in case of rim-out.	2	2	1	4

PFMEA-

S.No	FUNCTION	POTENTIAL FAILURE MODE	EFFECT OF FAILURE	POTENTIAL CAUSES OR MECHANISM FAILURE	O	S	D	RPN	ACTION TAKEN	O	S	D	RPN
1	Battery	Separator failure, short circuit, electrolyte loss, electrolyte stratification	Reduced performance and in some cases not operable at all.	High temperature, high charging rates, overcharging, improper insulation of wires and their connections, inefficient battery casing.	5	4	2	40	Always check wire connections and their insulation, battery casing. Don't overcharge.	2	2	2	8
2	Kill Switch	Electrical failure	Vehicle become inoperable.	Short circuit, vibrational cause	9	6	3	162	Properly insulated wiring.	2	2	1	4
3	Brake Pedal	Paddle not pressed fully.	Brake not pressed well.	Excess of torsion due to chain and excess bending due to wrong position of rotors.	6	9	2	108	Change the leverage	2	2	2	8
4	Motor Controller	Short circuit in any component, failure in any component.	Motor doesn't start Rpm variations.	Faulty connections, BIOS incompatibility, failure in bipolar junction transistor.	5	2	2	20	Connections are checked properly, repair electrical component if required.	2	2	2	8
5	Motor	Winding rupture, short circuit, rotor and stator faults, bearing failure.	Rpm decreases, abnormal starting, overheating that can block bearings and damage it, repair cost increases	Impact loads, foreign transverse excessive load.	3	6	2	36	Improper installation, vibrational shocks,overloading, presence of foreign debris, erroneous lubrication of drive gear	2	2	1	4

GANTT CHART-


START DATE
DURATION
9/1/2019
9/21/2019
10/11/2019
10/31/2019
11/20/2019
12/10/2019
12/30/2019
1/19/2020
2/8/2020
Design Reconsideration
Material Searching
Order placed
Material Received
Cutting and grinding
Chasis welding
axle hub making
axle hub fitting
steering Mfg
steering fitting
Making of breaking
Transmission system fitting
Safety material requirement
Moulding Body panel
Mounting electrical switches
Electrical wiring & circuit
Mounting all accessories
Body panel fitting
Testing & Modification
Final inspection

TEAM STRUCTURE-

Roles and Responsibilities			
Sr. No.	**Roles**	**Responsibility**	**Team Member**
1	Team Captain	• All Decision and All Work Inspection	Sanket Ghadigaonkar
2	Vice-Captain	• All work and Handle all queries	Devendra Dhond
3	Design	• To study rulebook and to ensure all design details are fitted in all parameters.	Devendra Dhond (Head)
4	Account	• To Maintain Debit & Credit Register • To Maintain All Tax Invoices & Bills. • Maintain Receipt • Collect all amount regarding team members contribution, sponsorship amount, college amount etc.	Sanket Ghadigaonkar (Head) Balkrishna Sawant
5	Purchase(Marketing)	• To find Supplier for required material. • Make pre expenditure quotation.(With the help of Documentation dept.) • To purchase tickets and arrangement of travelling(with the help of mfg. dept.)	Chetan Patil (Head) Shuham Surve Sanket Ghadigaonkar
6	Documentation	• To make all reports • To make pre expenditure quotation • To make all application letters. • To make PPT (For sponsorship as well as competition)	Nikhil Gokhale(Head)

7	Sponsorship	• To maintain all Sponsors detail • Make good Presentation as per information of sponsor.(with the help of documentation dept) • Find all required information about Sponsor. • Maintain Record of all meetings done with sponser by any member. • Enlist and share all queries ask by a sponsors(share their experience to help others)	Balkrishna Sawant(Head) Chaitany Chavan Sanket Ghadigaonkar
8	Manufacturing	• To study rulebook well and ensure all manufacturing done in all valid parameters. • Make DVP report as per rulebook.(With the help of documentation dept.)	Ronak Vadher (Head) Shuham Surve Nubed Bawade
9	Store	• To Store all Material as well as spanner safely. • Maintain Record of all material In And Out.	Nubed Bawade(Head) Chaitany Chavan
10	Workshop	• To maintain detail of all work day wise. • Maintain deadlines of mfg. • Detail of members attendance in workshop work.	Chetan Patil (Head) Bhavesh Shah

CONCLUSION-

The TEAM CARPE-DIEM used the finite element analysis system to evaluate, create, and modify the best vehicle design to achieve its set goals. The main goal was to simplify the overall design to make it more light-weight without sacrificing performance and durability. The result is a lighter, faster, and more agile vehicle that improves go kart design.

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