NATIONAL ELECTRIC KART CHAMPIONSHIP

TEAM NAME : **TACHYONS**

TEAM ID : **NEKC2018003**

INTRODUCTION

- ✓ The main aim of this design report is to explicate the design processes and technical specifications of our Vehicle.
- ✓ The report stands as a proof of a safe vehicle engineered by a team of 25 engineers.
- ✓ The team worked on a basic functional requirement of building a capable Rally vehicle that would be completely stable.
- ✓ Design approaches were simple, sound and safely structured.
- ✓ CAD/CAE approaches based on Implicit and Explicit Dynamics were used for modelling and analyzing various functionally critical parameters of our vehicle's design.

IMPORTANT RULE BOOK CONSTRAINTS

- ✓ The tube used in the fabrication of the chassis must be seamless and holes in chassis are not permitted.
- ✓ Material having Carbon Content greater than 0.18% can be used.
- ✓ The Kart must have wheelbase within the range of 40 inches to 56 inches and the Wheel Track must be no less than 70% of the Wheel Base.
- ✓ The pipe material used for chassis must have minimum wall thickness of 1.5mm.
- ✓ The Cost of the Vehicle must not exceed 1,00,000.
- ✓ Overall height of the kart should be less than 38 inches.
- ✓ The power train compartment should be 1.5 inches away from the firewall..
- ✓ The overall length of the vehicle must be less than 76 inches and overall width must be less than 60 inches.
- ✓ The Total Allowed Steering free play is limited to 7 degrees.
- ✓ Minimum of 1.5 inches of ground clearance is mandatory.

DESIGN METHODOLOGY

TARGET SPECIFICATION

- Good Battery Life
- Less Cost
- Top Speed=60km/hr
- Greater Efficiency

RESOURCES AND COST

- Mild Steel
- CI and Steel Components
- Plastic Body
- Plastic Steering Wheel
- Motor and Battery
- Sensors and Electricals
- Miscellaneous

CHASSIS

- ASTM A 106 Grade B
- Analysis
- Bending Process
- Welding
- Inspection of constraints
- Testing

STEERING

- Steering Shaft
- Lever Arm Assembly
- Tie Rods
- Assembly
- Steering Locks
- Steering Free play

POWER TRAIN

- Motor Selection
- Testing of Motor
- Axle or Shaft
- Battery
- Efficiency Test
- Final Assembly

BRAKES AND WHEELS

- Disc or Drum Brake
- Number of Discs
- Circuit Design
- Cylinder Pressure
- Stopping Distance
- Temperature Raise
- Testing

ELECTRICALS AND SAFETY

- Circuit Design
- Kill Switch
- Rear Lights
- Seat Belts
- Extinguishers
- Testing

ASSEMBLY AND TESTING

- Mounting Other Components on Chassis
- Load Testing
- Efficiency Testing
- Safety Testing
- Performance Testing

OVERALL KART SPECIFICATIONS

DIMENSIONS	
Overall length	69.70 inch
Overall width	51.10 inch
Overall height	33.45 inch
Wheelbase	48 inch
Front Track width	38 inch
Rear Track Width	40 inch
Ground clearance	1.56 inch
C.G Height	5 inch
Seating capacity	1
Seat Belt	5 point seat belt

WEIGHT	
Kerb weight	125 kg
Gross weight	185 kg

BRAKE	
Front	Nil
Rear	Hydraulic Disc

TYRES	
Front	10 x 4.5 x 5
Rear	11 x 7.1 x 5
Type	Slick Tyres

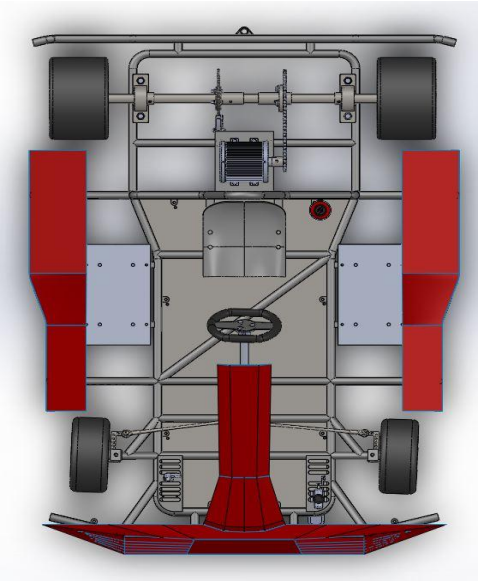
STEERING	
Steering Type	Lever Arm Type

MOTOR	
Type	BLDC
Drive Train	Chain Drive
Wattage	2000 W
Maximum Torque	18.5 Nm @1033 RPM
Battery Limit	48V (48V/12V*4)

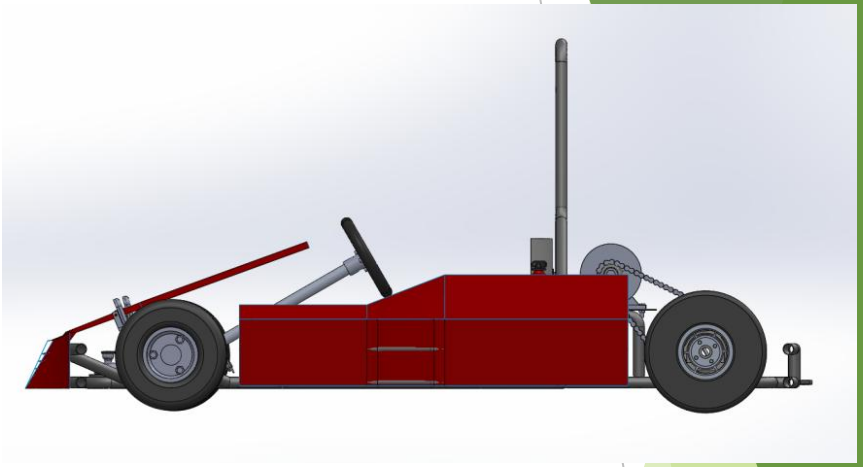
BATTERY	
Voltage	48V
Capacity	55Ah

Kart Assembled views

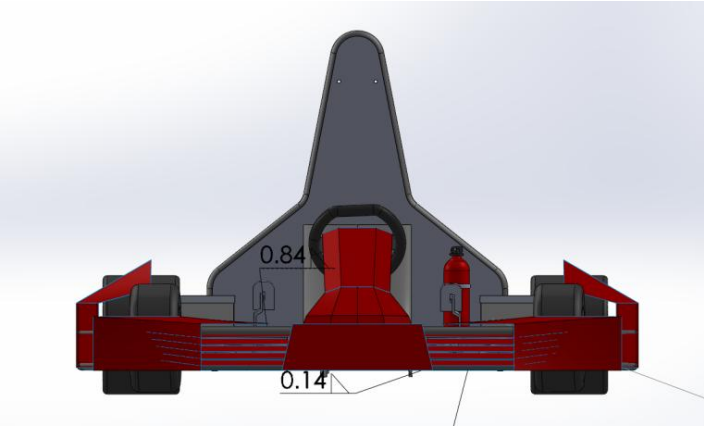
Top View



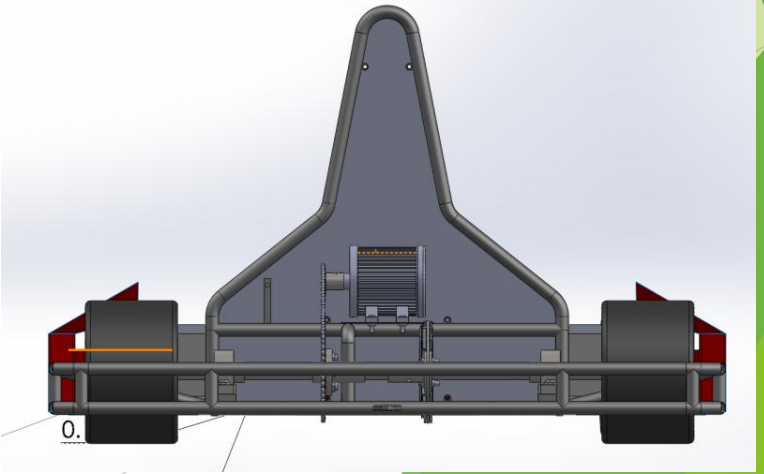
Side View



Front View



Rear view

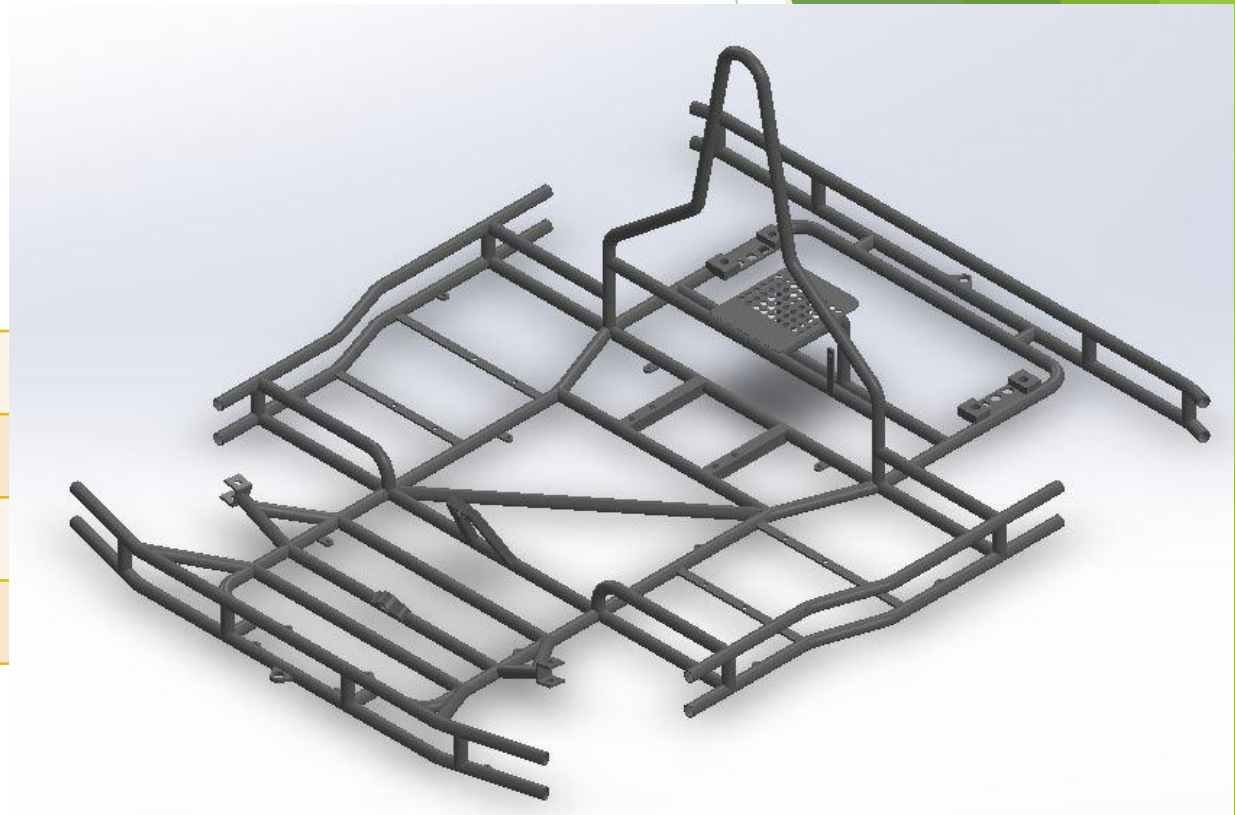


CHASSIS

DESIGN CONSIDERATIONS

- Weight reduction
- Material Optimization
- Ease of fabrication
- Aesthetics & safety

Members	Dimensions
Primary Member	O.D= 25.4 mm I.D= 22.4 mm
Secondary Member	O.D=25.4 mm I.D=22.4 mm
Tertiary Member	Sheet Metal (1.5 mm)



SELECTION OF TUBE MATERIAL

The list of materials which were shortlisted according to the requirements of our design,

Tube Material	Description
AISI 4130	AISI 4130 has good weldability and strength properties but has good machinable properties only in annealed condition
AISI 4340	AISI 4340 has good machinablity and strength but it can be welded only using fusion and resistance welding processes
AISI 1018	AISI 1018 has good machinablity and average strength properties
ASTM A 106 Grade B	ASTM A 106 Grade B has good machinability, weldability and strength properties

There was debate between what material to use, which becomes important later in the analysis process. A decision was reached by weighing the strength, cost, machinability, weldability and availability for each material against one another.

The list of materials narrowed down to two materials

AISI 4130 and ASTM A 106 Grade B.

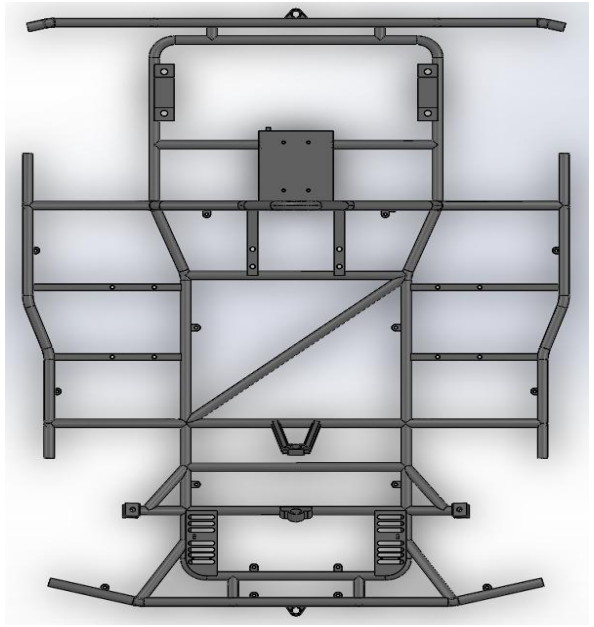
It was very tough to choose between AISI 4130 and ASTM A 106 Grade B as they had properties closer to each other. But it was the availability and cost factors that narrowed down our material research to **ASTM A 106 Grade B**.

MATERIAL SPECIFICATIONS

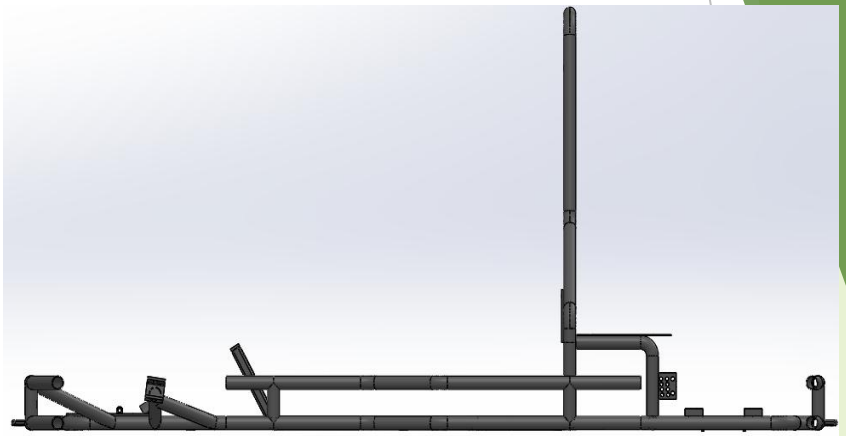
Parameter	Values
Material	Mild Steel
Grade	ASTM A 106 Grade B
Outer Diameter	25.4 mm
Wall Thickness (chassis)	1.5 mm
Wall Thickness (support Members)	1.5 mm
Carbon Content	0.26 %
Yield strength	240 MPa
Density	7859 Kg/m^3
Young's Modulus	205 GPa
Poison Ratio	0.31
Estimated Mass Of Chassis	27 Kg
Welding Type	TIG(Tungsten Inert Gas)

CHASSIS

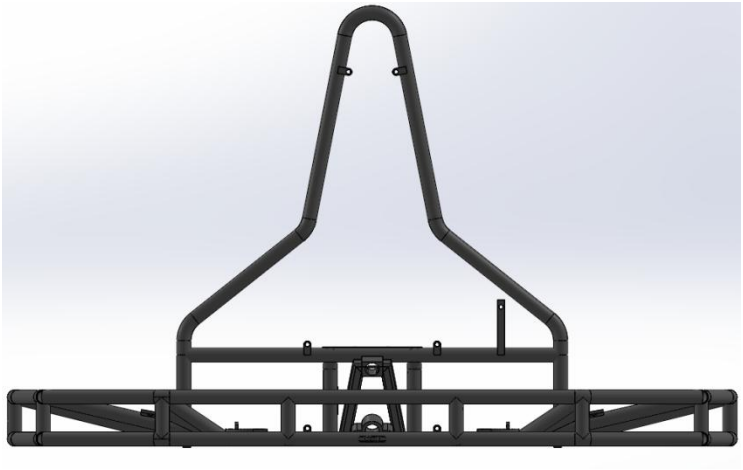
Top View



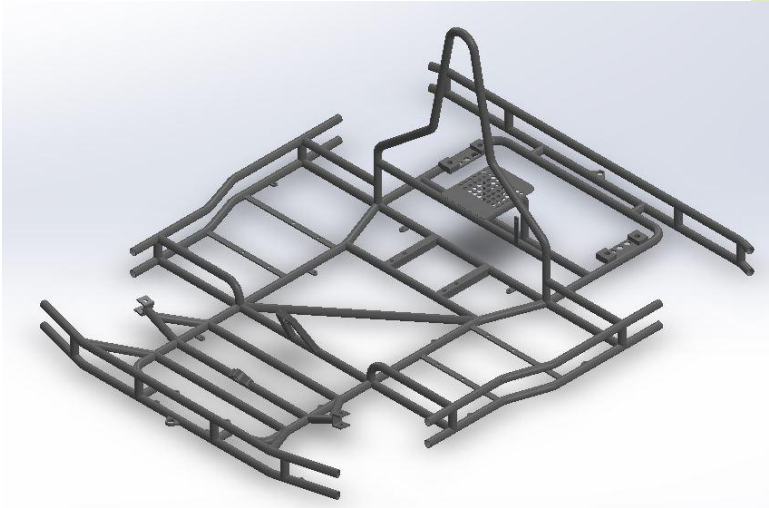
Side View



Front View

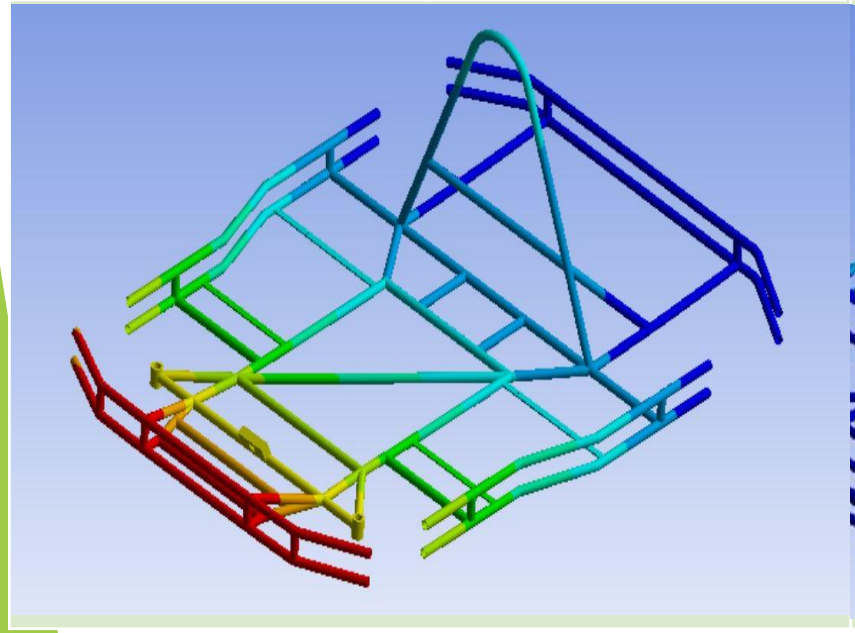


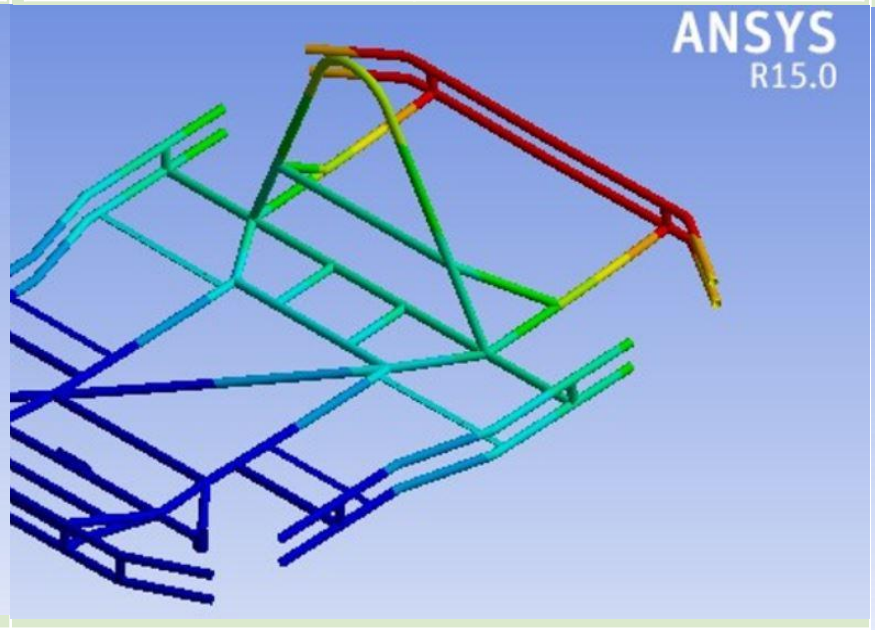
Isometric view

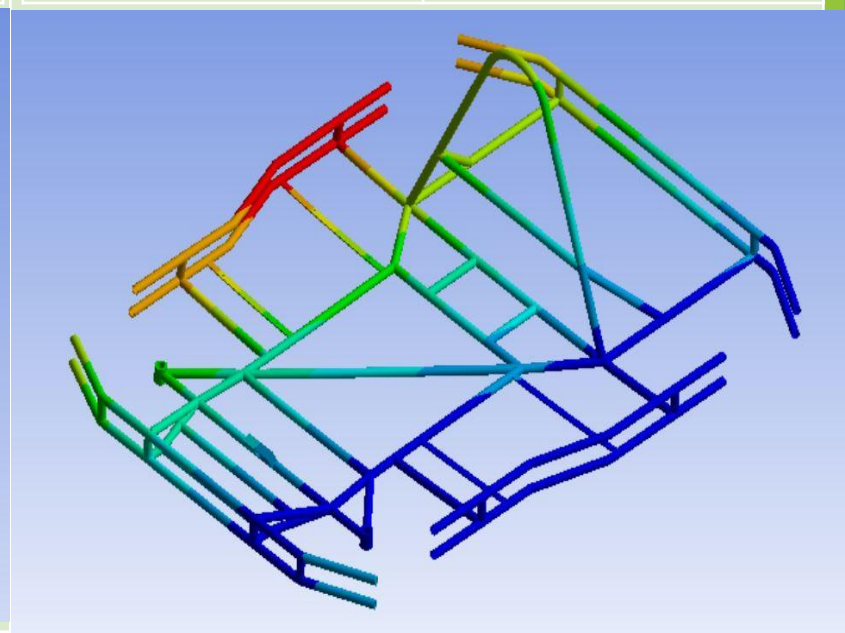


DESIGN ANALYSIS

Front Impact		Rear Impact		Side Impact	
Impact Load	**429.5 N**	**Impact Load**	**429.2 N**	**Impact Load**	**429.2 N**
Deformation	2.596 mm	Deformation	5.87mm	Deformation	3.96mm
Max. Stress	616.65 N/m^2	Max. Stress	271.68 N/m^2	Max. Stress	669.66 N/m^2
Factor of Safety	9.167	Factor of Safety	7.23	Factor of Safety	6.79







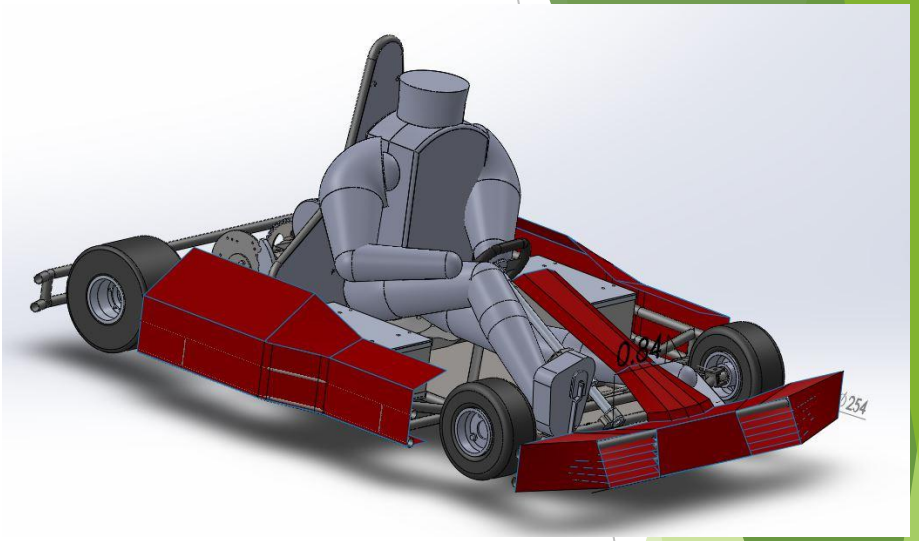
BODYWORKS AND SAFETY

BODY WORK	
Body Material	Polyethylene Plastic
Tensile strength	31.71 MPa
Shear strength	23.3 MPa

BODY WORKS

- The body of the vehicle is designed in such a way that it is safer for the driver and it suits all rulebook constraints.
- Plastic material is used for body works to enhance weight reduction.

FRONT AND SIDE BODY WORKS



STATIC ERGONOMICS:

- Seating
- Safety Belts, Helmets
- Clear Visibility
- Positive Steering Locks

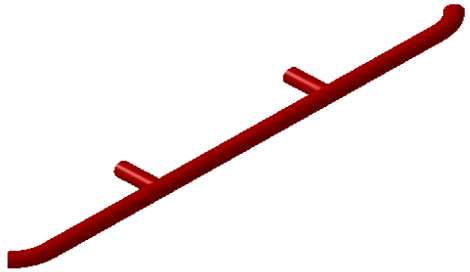
DRIVABILITY AND CONTROL:

- Access of Steering Wheel
- Access to Kill Switch
- Foot Pedal Orientation

ESTINGUISHERS

SEAT BELTS

BUMPERS



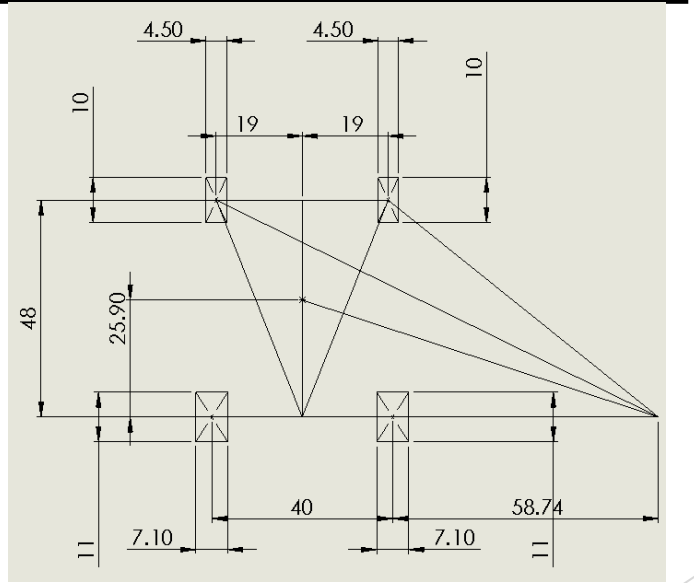
STEERING SYSTEM

Parameters	Value
Type	Lever Arm Steering System
Wheel Base	48 inches
Steering Ratio	1.13:1
Mean Turning Radius	2.065 m
Steering Wheel Diameter	180mm
Inner Lock Angle	38.78 degrees
Outer Lock Angle	26.16 degrees
Tie-Rod Length	13.11 inches
Lock to Lock Turns	0.24 turns
Ackerman Angle	21.6 degrees
Kingpin Inclination Angle	10 degrees
Castor Angle	8 degrees
Steering Angle	31.36 degrees
Steering Free Play	5 degrees
Kingpin Centre Distance	32 inches

Why this steering

- Reduced weight when compared to other steering mechanisms.
- Simple construction.
- Cost effective.
- Easy to adjust and repair.
- Provides good steering ability.

Turning Radius Determination



Ackermann geometry relation,
cot θo -cot θi = (t/b) = 0.7916
(2.0363 ~ 1.2446) i.e., Proper Steer

BRAKING SYSTEM

DESIGN CONSIDERATIONS:

- Weight reduction
- Better Heat Dissipation from Disc
- Better Factor of Safety
- Brake Disc and Caliper of Apache RTR 180 is used considering the below features

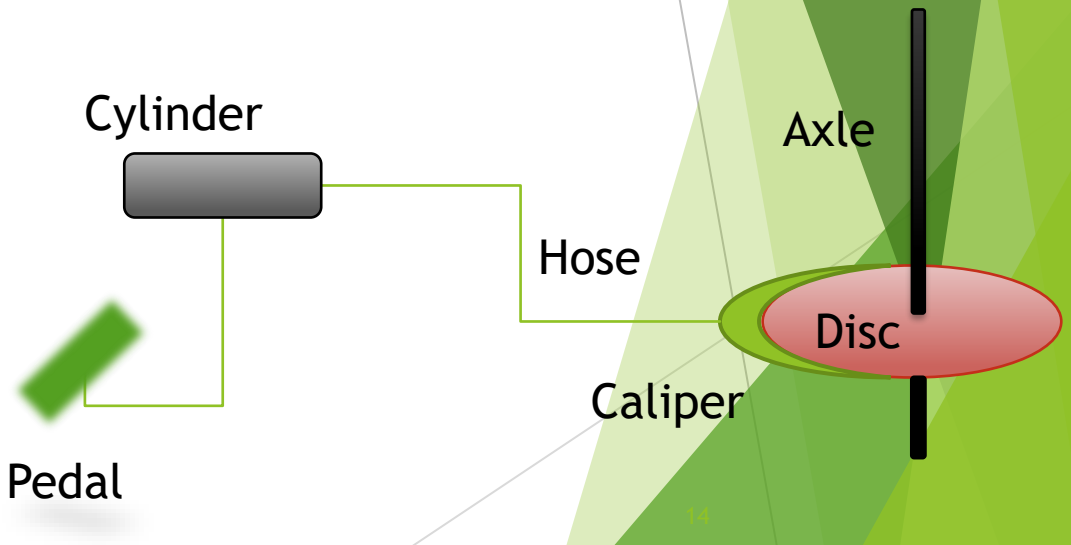
1) Braking Efficiency
2) Clamping Force
3) Stopping Distance

BRAKING SYSTEM	
Hydraulic Disc Brake	In the rear axle
Brake Fluid	Castrol GT LMA
Brake Line	Rubber Hose- 3/16” OD
Friction Coefficient	0.9 (For Slicks)
Target Weight	15 Kg (Including Wheels)
Maximum Temperature Raise	61 °C

COMPONENTS:

- Custom made Brake Pedal
- Dual Piston Fixed Caliper
- OEM Brake Lines
- OEM Brake Light (visible up to 10m)

BRAKE CIRCUIT:



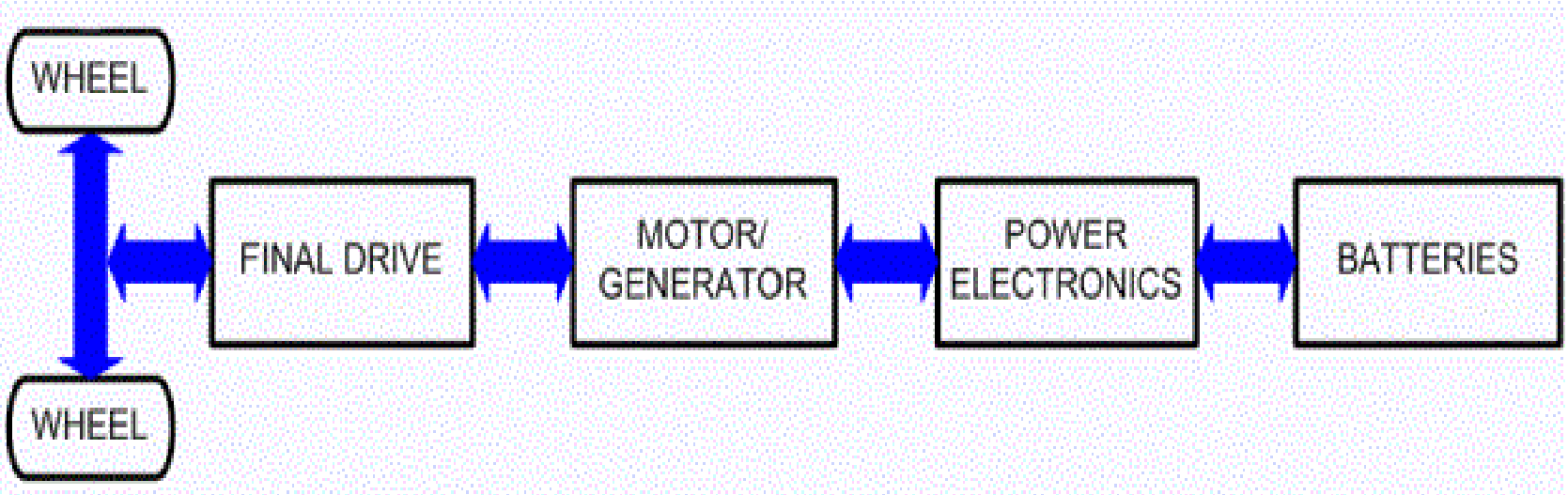
BRAKING CALCULATIONS

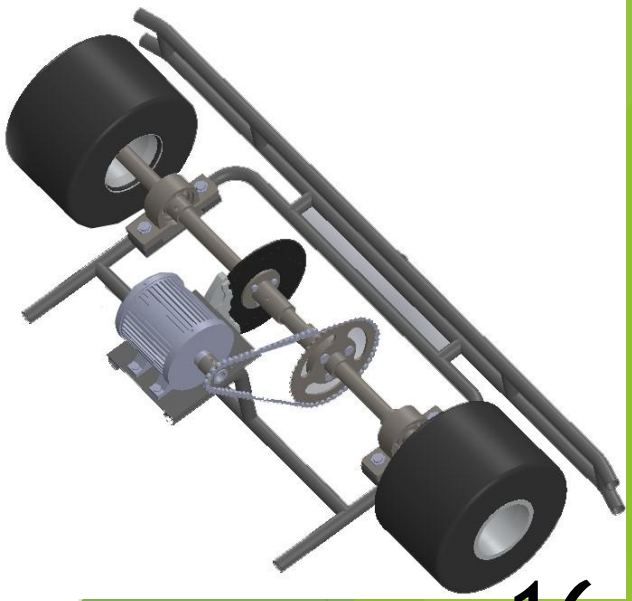
Particular	Value	Particular	Value
Braking Force	1633.3 N	Brake line Pressure	17.825 N/mm^2
Deceleration	0.9 g (8.829 m/s^2)	Pedal Effort	350 N
Stopping time	1.42 s	Pedal Ratio	4:1
Stopping distance	8.85 m	Brake Efficiency	89.98 %
Brake torque Generated	121.76 Nm	Static Axle load At Front	767.79 N
Rotor Disc Diameter	200 mm	Static Axle load At Rear	1046.71 N
Area of Master Cylinder	78.539 mm^2	Dynamic Axle load At Front	876.82 N
Static Weight Distribution Ratio	57.67 : 42.33	Dynamic Axle load At Rear	937.64 N
Dynamic Weight Distribution Ratio	51.66 : 48.34	Dynamic Weight Transfer	169.9 N
Rear Tire Diameter	11 inches	Front Tire Diameter	10 inches
Caliper Bore	25.4 mm	Caliper Area	506.71 mm^2

TRANSMISSION SYSTEM

We chose this gear ratio 3.29 in order to obtain optimal torque and speed with the objective of obtaining max efficiency

Transmission System	
Gear Ratio	3.29
Drive sprocket	14 teeth
Driven Sprocket	46 teeth
Chain Length	1.2192 m
Efficiency (chain drive)	98%





ELECTRICAL SYSTEM

The electrical system consists of the following major components,

- Motor
- Controller
- LED brake light
- Horn
- Safety Kill Switches
- Battery

MOTOR AND CONTROLLER

The motor was chosen as per the rule. The motor that was chosen was a BLDC motor.

- The most obvious advantage of BLDC is its lack of brushes and physical commutator .
- It is more reliable , last longer , and more efficient.
- It has high torque and speed .

The ratings of the motor are as follows,

Motor Specifications	
Rated Power	2000 W
Rated Speed	3000 Rpm
Rated Voltage	48 V (DC)
No Load Current	5 A
Rated Current	45 A
Max. Torque	18.5 Nm
Rated Torque	7.6 Nm
Peak Protection current	60A

Controller Specifications	
Rated Power	2000 W
Rated Voltage	48 V (DC)
Under voltage Protection	42V
Rated Current	45 A
Phase commutation angle	120 deg
Throttle voltage	1V to 4.5V

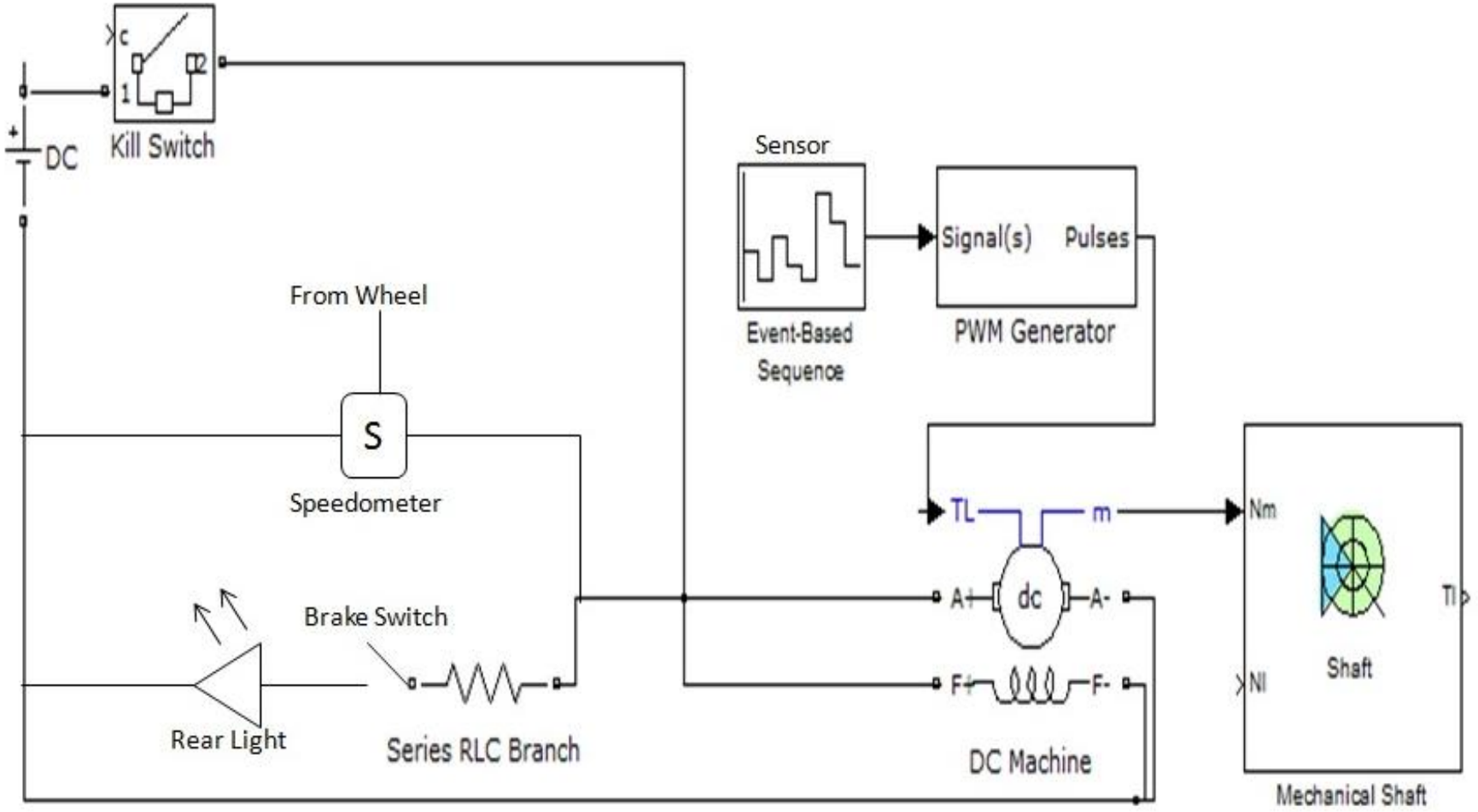
Battery and Charger

- We have planed to use four 12V 55AH battery connected in series which provides 48V 55ah which is enough to power the Kart to run for about an hour under loaded conditions.
- We chose this battery based on its availability , motor capacity and weight factor.
- This battery suits our kart best in terms of power and efficiency .
- We chose a 48V 10A charger which is enough to charge the battery set in 5.5 hrs

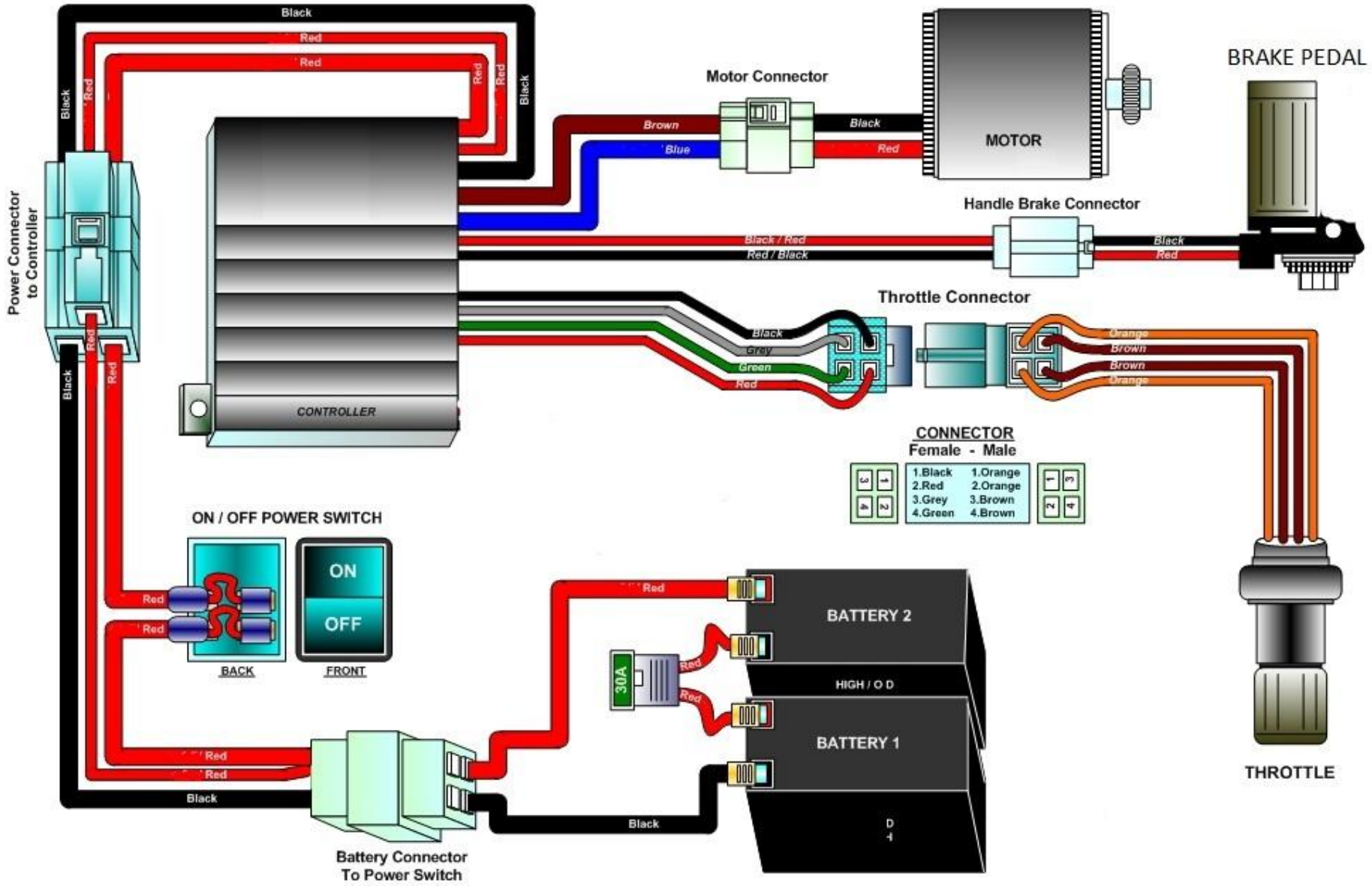
Battery Specifications	
Manufacturer	EXIDE
Capacity	55 AH
Voltage	12V
Type	SMF
Weight	15 kg(s)

Charger Specifications	
Input	220V, 50Hz
Output voltage	48V
Charger current	10 A

SAFETY KILL SWITCH CIRCUIT



SYSTEM BLOCK DIAGRAM

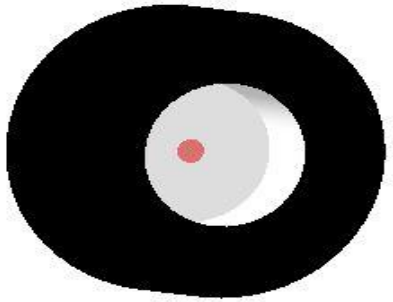


WHEELS AND POWER TRAIN

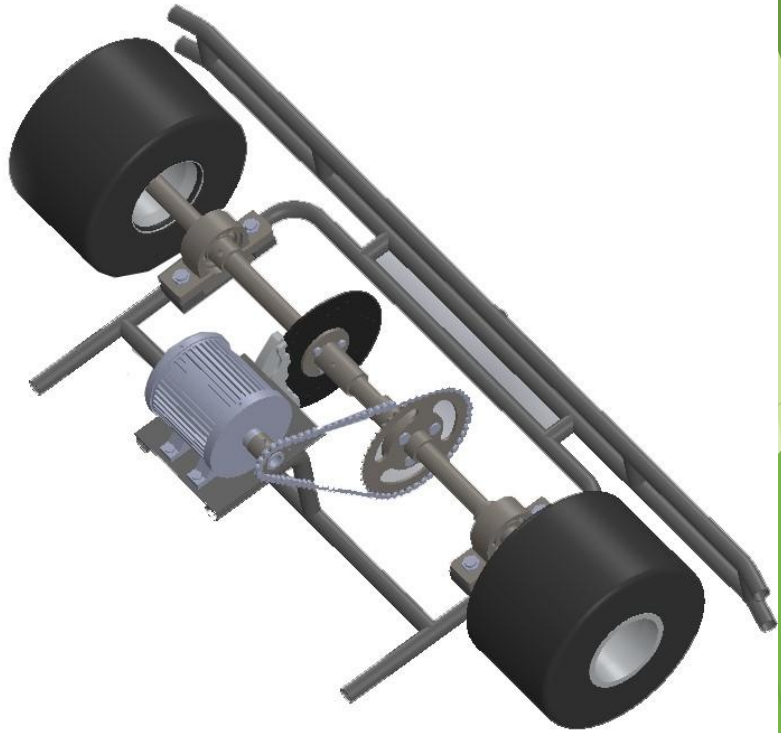
RIM AND TYRE SPECIFICATION	
Rim Material	Aluminium Alloy
Rear Tire Size	11 X 7.1-5 Inches
Front Tire Size	10 X 4.5-5 Inches
Tire Type	Slick Tyres
Hub	Aluminium hub

RIM

TYRES

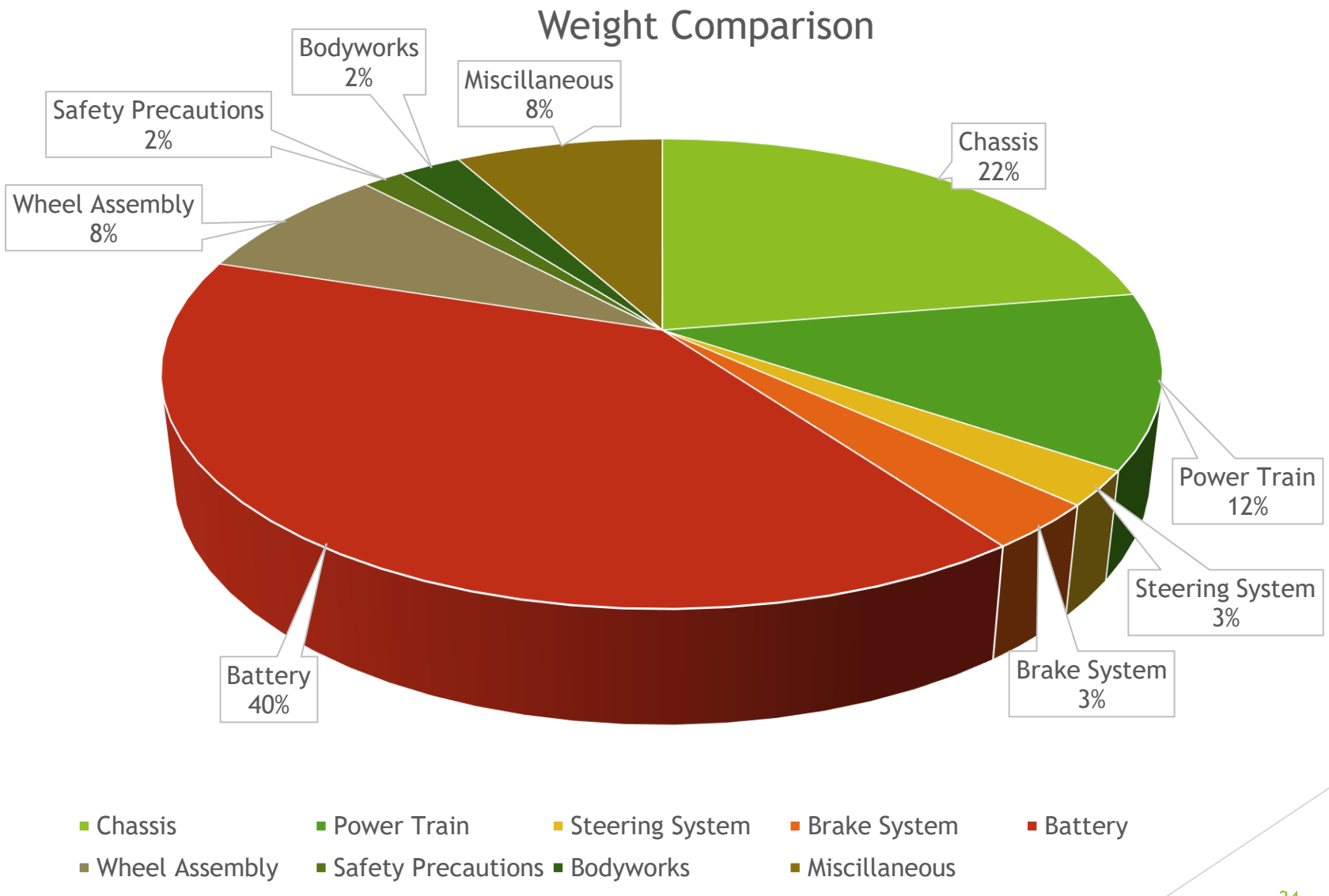


POWER TRAIN SPECIFICATION	
Rear Axle	Live Axle
Axle Diameter	30 mm
Axle Material	ASTM A 106 Grade B
Gear Ratio	3.29 : 1
Drive Type	Chain Drive / Non Geared
Motor Type	BLDC 2000W 48V
Max. Speed	56 Km/hr
Torque on wheels	71.06 Nm



PRELIMINARY COST ANALYSIS

ITEM NAME	USED IN	MAKE	BUY	MATERIAL	QUANTITY	Manufacturing cost	Selling cost
Frame	Chassis	X		ASTM A 106 Grade B	5	5,000	7,000
Rear Axle	Power Train	X		ASTM A 106 Grade B	1	500	700
Sprocket	Power Train	X		Steel	2	1,000	1,200
Motor	Power Train		X	N/A	1	15,000	18,200
Battery	Power Train		X	N/A	4	20,000	25,000
Steering Wheel	Steering		X	Plastic	1	200	300
Steering Column	Steering	X		Al 6061	1	400	500
Lever Arm Rods	Steering	X		Steel	1	500	1,000
Disc and Caliper	Brake		X	CI	1	1,000	1,200
Cylinder	Brake		X	N/A	1	500	700
Oil Hose	Brake		X	Rubber	1	150	200
Wheels & Tyres	Power Train		X	Rubber & Al	4	20,000	24,000
Controller	Electricals		X	N/A	1	6,000	9,000
Body works	Safety	X		Plastics		1,000	2,000
Seat & Extinguisher	Safety		X	N/A	1	2,000	3,000
Labour	Vehicle	N/A		N/A	N/A	4,000	6,000
Miscellaneous	N/A	N/A		N/A	N/A	15,000	20,000
TOTAL						92,250	1,20,000


Weight Comparison
Bodyworks 2%
Miscillaneous 8%
Safety Precautions 2%
Chassis 22%
Wheel Assembly 8%
Power Train 12%
Steering System 3%
Brake System 3%
Battery 40%
Chassis
Power Train
Steering System
Brake System
Battery
Wheel Assembly
Safety Precautions
Bodyworks
Miscillaneous

DESIGN FAILURE MODE EFFECT AND ANALYSIS

Process step	Possible Failure	Effect of failure	Potential causes	S*O*D= RPN	Corrective Action(CA)	Revised RPN
Chassis	Vibration from Motor	Roll cage/motor failure	1.Degradation of motor 2.Reduced efficiency	7*7*4=196	Proper padding of motor	7*5*4=140
	Fatigue load	Parts weakened	1.Vibration comes to effect 2.Inconvenience in driving	6*6*5=180	Clamping, fasteners	6*5*5=150
Wheels	Shimmy	Wobble of front wheels	1.Loose linkages 2.Wheel imbalance	6*4*5=120	1.Correct balancing 2.Replacing worn parts	6*3*5=90
	Wander	1.Vehicle drifts 2.Vehicle instability	Loose linkages	5*6*6=180	Tighten loose parts	5*4*6=120
Welding	Welding breakage	Sudden misalignment	1.Excess load 2.Impact	8*4*5=160	TIG welding	8*2*5=80
Brake	Braking noise	1.Noise while braking 2.Intolerable squeal	1.Loose brake pad 2.Caliper problems	6*6*3=108	1.Anti squeak shim 2.Anti squeal component	6*3*3=54
	Leakage in cylinders	Brake failure	Damage in cylinder	8*5*6=240	Proper positioning of cylinder	8*4*6=192
Steering	Breaking of tie rod	No steer	Impact	8*4*3=96	Providing impact absorbers	8*3*3=72
Power Source	Overload	Battery drain	Reduced Acceleration	**7*6*4=168**	Limited loading	**7*3*4=84**

S - Severity
O - Occurrence
D - Detectability
RPN - Risk Priority Number

DESIGN VALIDATION PLAN

S NO	SPECIFICATION& TEST METHOD	TEST DESCRIPTION	ACCEPTANCE CRITERIA	TEST RESPONSIBILITY	TEST REQUIREMENTS	STARTING DATE	ENDING DATE	REMARKS
1	Tilt test	Tilt the vehicle to 45 ° using a jack plane	Centre of gravity should be safe enough	Sreenivasan	Tilt table, jack plane			
2	Test for turning	To check manoeuvrability during turns	Radius of curvature less than xx and proper functioning of steering	Pravin	Tarmac road, Steering test equipment			
3	Brake test	Abrupt stopping of vehicle	Deceleration rate should be within the limit	Nantheesh	Speed measuring Equipment and Tarmac Road			
4	Weld Test	Take tensile test in UTM	On the bases of inspection	Manuraj	Workshop			
5	Acceleration test	Frequent power cycling	Vehicle should reach the 100m in xx time	Mathanesh	Accelerometer, tarmac road			
6	Battery gauge reset	Complete charging and discharging of battery	Charging and discharging cycle should complete in xx time	Sunantha	Battery charger, loading device			
7	Endurance test	Check the stability	It should be stable for xx time	Vasanth	Suitable lab condition			
8	Wear and tear test	Continuously contacting wheels	It should be stable for xx rpm	Praveen	Four ball wear testing machine			

PROJECT PLAN

S.no	ACTIVITY	RESPONSIBILTY HOLDERS	No. of Days	START	FINISH
	CHASSIS	Manuraj	**19**	**12-11-17**	**30-11-17**
1	Purchase		5	12-11-17	16-11-17
2	Bending		6	17-11-17	22-11-17
3	Welding		5	23-11-17	27-11-17
4	Testing		3	28-11-17	30-11-17
	STEERING SYSTEM	Vasanth	**8**	**01-12-17**	**07-12-17**
5	Purchase		2	01-12-17	02-12-17
6	Mounting and assembly		3	02-12-17	04-12-17
7	Mounting of wheels		2	04-12-17	05-12-17
8	Testing		2	06-12-17	07-12-17
	BRAKE SYSTEM	Nantheesh	**8**	**08-12-17**	**15-12-17**
9	Purchase of Standard accessories		3	08-12-17	10-12-17
10	Assembly and fitting		3	10-12-17	12-12-17
11	Testing		3	13-12-17	15-12-17
	POWER TRAIN	Sreenivasan	**7**	**16-12-17**	**22-12-17**
12	Purchase		2	16-12-17	17-12-17
13	Assembly		4	17-12-17	20-12-17
14	Testing		3	20-12-17	22-12-17
	ELECTRICAL SYSTEM	Pravin	**5**	**23-12-17**	**27-12-17**
15	Purchasing motor and battery		1	23-12-17	24-12-17
16	Assembly		1	24-12-17	25-12-17
17	Mounting electrical circuit		2	25-12-17	26-12-17
18	Testing		1	26-12-17	27-12-17
	FINAL PROCESS	Mathanesh	**4**	**28-12-17**	**31-12-17**
19	Painting		1	28-12-17	28-12-17
20	Other Purchases(seat, seat belt, etc.,)		1	28-12-17	29-12-17
21	Body work and stickering		1	29-12-17	30-12-17
22	Performance Test		1	30-12-17	31-12-17

INNOVATION

- Brake Failure Indicator
- Remote Kill Switch
- Drug Monitor
- Heart Beat Based Warning System
- Jack Effect Detection System
- Fingerprint recognition system
- Temperature sensing system
- SOS Emergency system
- Automatic battery cooling system
- Human-Machine Interface (HMI)
- Remote controlled parking assistant
- Reverse guidance system
- Battery Charge Monitor
- Wheel Speed Sensor
- Motor Overload Indicator

COLLEGE FACILITIES

- Lathe
- Milling Machine
- Shaping Machine
- Cutting Machine
- Drilling Machine
- Grinding Machine
- Welding Machine
- Material Tester
- Modelling Lab

THANK YOU