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DESIGN, ANALYSIS AND FABRICATION OF RACING GO-KART

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ABSTRACT

A Go-kart is a small four wheeled vehicle. Go-kart, by definition, has no suspension and no differential. They are usually raced on scaled down tracks, but are sometimes driven as entertainment or as a hobby by non-professionals. 'Karting is commonly perceived as the stepping stone to the higher and more expensive ranks of motor sports. Kart racing is generally accepted as the most economic form of motor sport available. As a free-time activity, it can be performed by almost anybody and permitting licensed racing for anyone from the age of 8 onwards. Kart racing is usually used as a low-cost and relatively safe way to introduce drivers to motor racing. Many people associate it with young drivels, but adults are also very active in karting. Karting is considered as the first step in any serious racer's career. It can prepare the driver for highs-speed wheel-to-wheel racing by helping develop guide reflexes, Precision car control and decision making skills. In addition, it brings an awareness of the various parameters that can be altered to try to improve the competitiveness of the kart that also exist in other forms of motor racing.

The aim of this Design Report is to elucidate on design methodologies that were adopted at various stages during the design phase of building our Go-Kart. The intention of this report is to serve as a technical brochure for other engineers paving way for innovative ideas that generate automotive products to meet the forthcoming needs.

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INTRODUCTION

Karting competitions which is conducted by various reputed organization in association with different partners is a pan-India platform for students from various streams of engineering to get exposed and tested on their theoretical and practical knowledge by building Go-Karts and compete with similar auto-enthusiasts. The objective of this competition is to bridge the gap between classroom and workplace knowledge by demanding the participants to try and implement the concepts learnt at classes, by designing and fabricating a Go-Kart.

To achieve this objective a group of 20 passionate students formed the Team Tornado and started to conceptualize and visualize the Go-Kart. The design methodology was a bottom up approach which involved identifying the demand, starting from the scratch (groundwork) and working towards the solution. The CAD models were designed using Catia, a designing software and were analyzed using Hypermesh, an analysis software.

The above mentioned processes were iterated until completely satisfied design was obtained. Various factors like safety, serviceability, strength, ruggedness, standardization, cost, driving feel and ergonomics were considered during the design phase, so that the feasibility of usage of the Go-Kart is maximum.

Technical Specification Of The Vehicle

Vehicle Length	1950 mm
Vehicle Width	1220 mm
Roll Cage Material	AISI4130
Tube Dimension	25.4 mm
Roll Cage mass	20 Kg
Total mass	165 Kg
Ground Clearance	2 inches
Battery	12 V, 10A
Max. Speed	80 km/hr
Brake	Disc Brake
Steering	Bell – crank

Roll Cage

We have chosen rear drive chassis considering ergonomics and increasing driver safety as engine is placed behind the driver and in order to fabricate the vehicle within the specified dimensions. Rear drive chassis requires less support members in comparison with the other types and hence the weight is reduced. Other types of chassis would have complicated the fabrication increasing the risk factor.

- All the members in the roll cage are made up of AISI4130 grade.
- It has an outer diameter of 25.4 mm and

thickness 2 mm .

- The members are seam less in cross section.

Properties of the roll cage

Material	AISI4130 grade steel pipe
Ultimate Strength	812 Mpa
Yield Strength	220 Mpa
Carbon Composition	0.2% C
Estimated Weight of the roll cage	20 kg
Elongation	8.84%

Engine And Transmission

The engine used in our vehicle is Honda Stunner engine.

Manufacturer	**Honda**
Engine used	Stunner
Engine Type	Single cylinder, 4 –stroke engine
Bore	52.4mm*57.8mm
Oil Capacity	0.6lit
Engine Displacement	125cc
Compression ratio	9.2:1
Horse Power	11Bhp @8000 rpm
Maximum Torque	7.5 N-m @2600 rpm
Cooling	Air - cooled
Acceleration	2.46m/s2
Ignition	Self/Kick, DTS – i

Since HONDA Stunner engine has high torque and power so we have planned to use Stunner engine of HONDA make in our vehicle.

Steering System

Mechanical arrangement is planned to be used this type of steering system was selected because of its simple working mechanism and a steering ratio of 1:1 so to simple we have used mechanical type linkage.

Our steering geometry is having 100% Ackerman and also gives **60degree** lock to lock turn of steering wheel which is very suitable for the race track as it allows quick turns with a small input and being more precise at the same time. We also attain a perspective turning radius of 2.37meter.

Ackerman condition is

Cot δ_0 – Cot δ_i = w/L

δ_i= inner steer angle

δ_0 = outer steer angle

w = track

L = wheel base

Let as assumeδi as 35^0

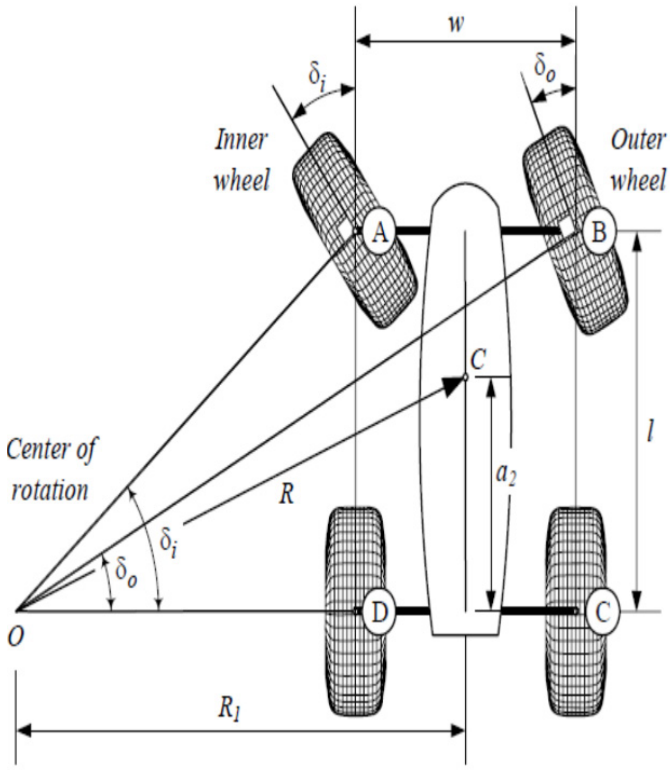
Wheel base of our vehicle is **1070 mm(L)**

Track of our vehicle is **920 mm (w)**

Cot δ_0 – Cot (35^0) = 920/1070(L/w)

δ_0 = 23.69^0

Turning Radius (R)



R1=(w/2) + (L/tan δi)

R1 = (920/2) + (1070/0.702)

R1 = **1984.22 mm**

Cot δ = R_1/L=1984.22/1070

Cot δ = **1.854**

CG of our vehicle is at 498mm so

a2 = **498 mm**

$R = \sqrt{(a_2^2 + L^2 \cot^2 \delta)}$

R = **2045.34 mm**

Our vehicle for a turn of 350 it turns by a radius of 2045.34(**2.05 m**)

Now outer and inner turning angles are:

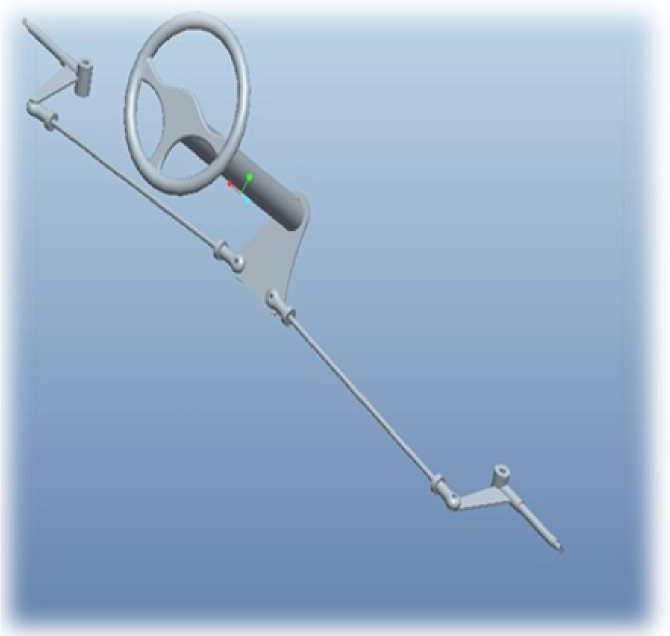
tan δ_o =L/(R+t/2)

δ_o =**23.13^0**

tan δ_i =L/(R-t/2)

δ_o =34^0

Space Requirement:
Since the outer point of the front wheel will have a maximum radius and the point on the inner side of the vehicle at the rear axle will have minimum radius. The space required for turning a vehicle is given below



$\Delta R = R_{max} - R_{min}$
$R_{min} = R_1 - (1/2\ w)$
$R_{min} = 1984.22 - (920/2)$
$R_{min} = \mathbf{1524.22\ mm}$
Wheel base is 1070 mm
g = 200 mm
$R_{max} = \sqrt{[(R_{min} + w)2 + (L + g)^2]}$
$R_{max} = \mathbf{2754.47\ mm}$
$\Delta R = R_{max} - R_{min}$
$= 2754.47 - 1524.22$
$\Delta R = \mathbf{1230.25\ mm}$

Inner wheel turning angle	34°
Outer wheel turning angle	23.69°
Ackerman angle	35.17°
Toe angle (Toe out)	4°51’
Inner turning radius	60“
Outer turning radius	108.5 “
Normal turning radius	48.5”
Ackerman percentage	97%
Kingpin C-C distance	27”
Ackermann Ratio	1:0.812

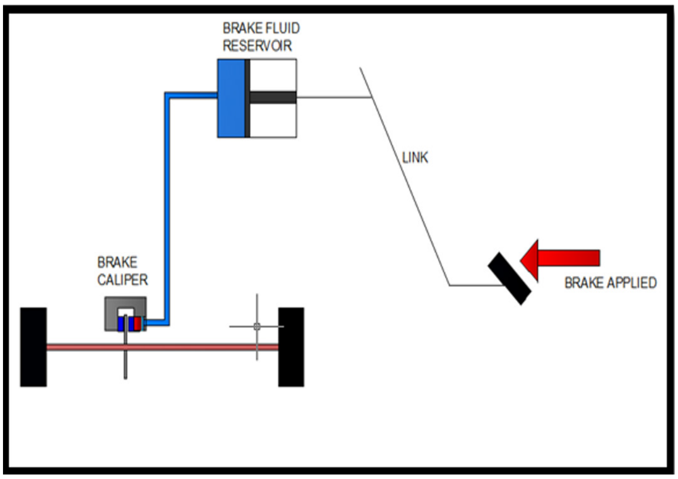
Chain Drive System
Chain drive is a way of transmitting mechanical power from one place to another. It is often used to convey power to the wheels of the vehicle, particularly motorcycles. The power is conveyed by a roller chain, known as the drive chain or transmission chain, passing over a sprocket gear with the teeth of this gear meshing with the holes in the links of the chain. The gear is turned and this pulls the chain putting mechanical force in to the system.

Chain Drive Analysis:
Driver sprocket = 14 teeth
Driven sprocket = 28 teeth
Hence,
Gear ratio G = driven sprocket teeth / driver sprocket teeth
So
G = 14 / 28
= 1: 2
Chain pitch = 0.365 inch
Let N1 and N2 be the speeds of driven and driven sprockets and T1 and T2be the number of teeth in driven and driven sprocket respectively
Then
N1 / N2 = T2 / T1
8000 / N2 = 28 / 14
From which we obtain the driven shaft speed as **N2 =4000rpm.**

Tyres
Tyre Dimensions:
FRONT TYRE: 10X4.5-5
REAR TYRE : 11x7.1-5

Braking System
The braking systemhas to provide enough braking force to completely lock the wheelsat the end of a specified acceleration run, it also proved to be cost effective. The braking system was designed by determining parameters necessary to produce a given deceleration, and comparing to the deceleration that a known braking system would produce.

Brake type: Single Disc Brake



Hydraulic brake is selected by us as it has higher efficiency when compared to other brakes and it has less wear so it lasts for longer time.

Brake Specification

Types	Single Disc Brake
Recommended fluid	Dot 4
Brake disc	Diameter-190 mm
Brake pad lining thickness	4.5mm
Master cylinder diameter	23.6mm
Caliper inside cylinder	27mm

Brake Analysis

Mass of the vehicle = 165kg

Weight of the vehicle W = 165*9.81

W=**1618.65 N**

Co-efficient of friction between the tyres and road = 0.7 (dry condition).

Distance of rear wheel from the center of gravity = 498 mm

X = **0.498m**

Ground clearance of the vehicle

h= **0.0508m**

Wheel base of the vehicle

w = **1.07m**

sincethe brakes are applied on the rear axle only.

R_f= [W(x+μh)] / [w+μh]

=[1618.65(0.498+(0.7*0.0508))]/ [1.070+(0.7*0.0508)]

R_f= **781.18 N**

Hence the normal reaction force on each front tire

RIf= 390.59 N

Now

$R_f + R_r = W$

781.18+ R_R = 1618.65 N

R_R = **837.47 N**

So the normal reaction force on each rear tyre

R_{IF} = 837.47/2

= 418.74 N

R_{IF} =418.74 N

Total braking force on the rear tyres

B_{FR} = μRF = 0.7 * 837.47

BFR= **586.229 N**

Total braking force on the front tyres

$B_{FF} = \mu_{RF}$ = 0.7*781.18

B_{FF} = **546.83 N**

So the net braking force on all the wheels

$B_F = B_{FR} + B_{FF}$

= 586.23+ 546.83

BF = **1133.06 N**

Radius of the rear tyrer_t=140mm

Mean radius of the rotor r_r=85mm

Hence force required to make tyres skid

$F_R = B_{FR}*(r_t/r_r)$

F_R= 586.23*(140 / 85)

F_R = **965.56 N**

Radius of brake pad r_p= 21.45 mm

Therefore area of the brake pad

A = 2*3.14*rp²

Area = 0.00289m²

Pressure applied = FR/A

=1023.14/0.00289

Pressure applied = 354.03 kpa

For single rotor pressure applied is

= 354.03/2

= **177.015 Kpa**

The maximum allowable pressure for rotor

= 2680kpa

Rotor material is adequate for use.

BRAKING DISTANCE:

Let us assume that the maximum force applied by the driver = **25kgf**

Force on master cylinder piston

= F_{ma} * 9.81*(mechanical leverage ratio)

= 25*9.81*2

= **490.5 N**

Area of master cylinder piston

= π/4*(0.0158)2

A = **1.24 * 10⁻⁴ m²**

Pressure generated by each caliper

Pm = (490.5/1.240 * 10-4)

Pm= **39.5pa**

Mechanical force generated by each caliper

F_c= 39.5 * 105*(π/4)*(0.0429)²*2

F_c= 11419.10 N

Clamping force generated by two calipers

11419.10 * 2 = **22838.2 N**

Frictional force = clamping force * co-efficient of friction between the brake pad and rotor.

= 22838.2 * 0.3

= 6851.46 N

Torque = Frictional force * Effective rotor radius

= 6851.46 * 0.1

T = **685.146 Nm**

Braking force = T/r

= 685.146 / 0.2

= 3425.73 N

Let us assume the average velocity of the vehicle to be 40 kmph = 11.11 m/s

Deceleration of vehicle = a = F/m

a = 3425.73 / 165
a = **20.762 m/s²**
Braking distance = (11.11)2 / 20.762
Braking distance = 5.94 m

Braking Time:
Let us consider the vehicle to be a particle. At the point of braking, final velocity is zero and the initial velocity is 11.11 m/s.let the uniform deceleration is 20.762 m/s^2 (or) 2.07g.

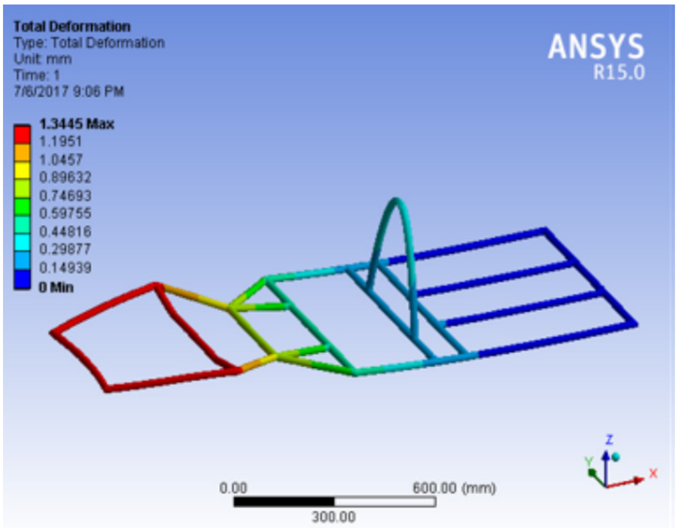
So Braking time is given by the equation
V = U + at
t = (V-U) / a
= (0 – 11.11) / 2.07
t = 5.36 seconds

BODYWORKS
External appearance of the vehicle depends upon bodyworks. It is an important part of the vehicle design. It also dominates sale and marketing of the vehicle.
We have selected fiber on the basis of market survey because of its
- Light weight
- Good electrical insulator

We have used CIK-FIA Bodyworks

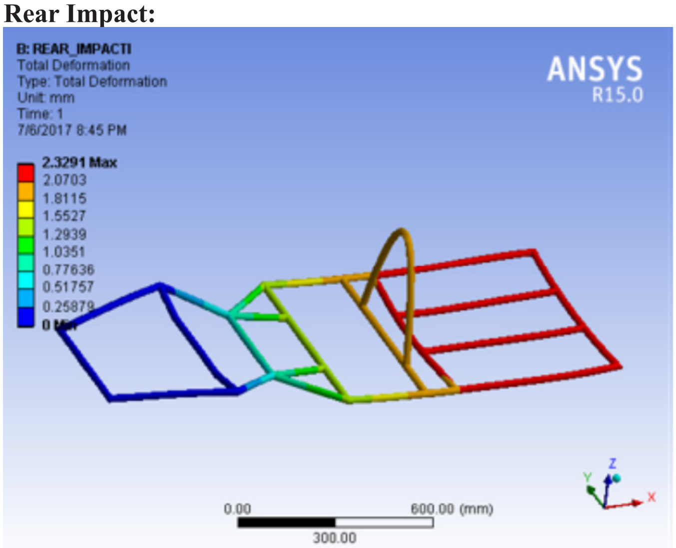
Electricals
12V DC Battery will be used to power all the electrical components.

ROLL CAGE ANALYSIS
Front Impact:



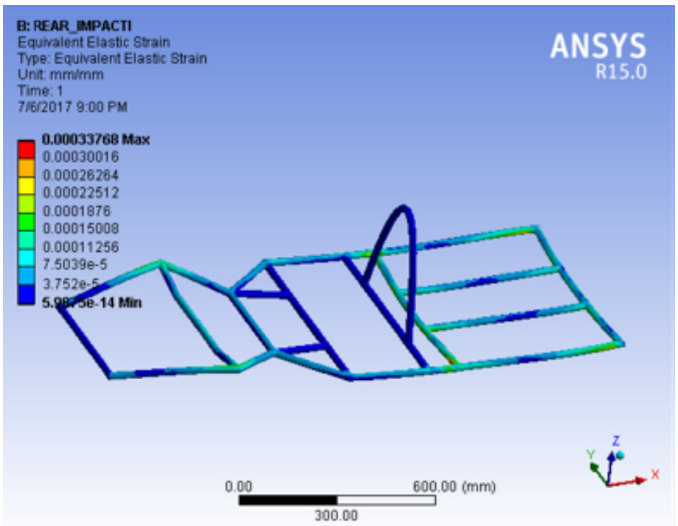
(mesh size = 5mm) ; Load applied = 5000N ; Max Stress= 272.35 Mpa
Factor of safety= 1.61

Rear Impact:



Rear Impact (mesh size = 5mm) ; Load applied = 5000N; Max Stress= 237.05Mpa ; Factor of safety= 1.85

Side Impact:



Side Impact (mesh size = 5mm) ; Load applied = 5000N ; Max Stress= 284.65Mpa ;Factor of safety= 1.54

Floor Plan:-

DRIVER ERGONOMICS

Driver ergonomics played a major role in designing of our vehicle chassis. The cockpit has been designed to allow considerable comfort of the driver. Large leg space and enough room for movement inside the cockpit are some salient points.

The approach adopted for driver ergonomics was to question our driver on his requirements and using him as our base for measurements, calculation and designing of our chassis. The output has been successful design of cockpit that is safe and comfortable with driver in. The chassis has been designed to enhance the driver's visibility.

All the essential controls in vehicle have been placed such a way that it can be accessed with ease. The accelerator, brake pedals are positioned such that the driver shall stretch his legs for a long time without any stress.

CONCLUSIONS

As discussed earlier, our approach is to design for the best and still optimize so that we avoid over designing. This would help us to reduce the cost. Thus we fabricated the Kart considering weight reduction and several economical factors. Henceforth during the process of designing our top priority was safety and driver ergonomics. Process of choosing various systems was considered mainly based on its availability in the market.

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Final Assembly of go Kart