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Calculations for Go-Kart Vehicle

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Abstract: Team barriers breakers Moto is to design and fabricate the sophisticated and simple kart design with factor of high fuel economy as well as with more suitable driver comfort without reconciliation the kart performance.This paper aims to increase thefactor of safety of go kart chassis which is designed keeping in mind the rules imposedby INDKC 2019. This paper tends to design all the convenient features established in the go kart vehicle. There is involvement of many systems in manufacturing of go kart such as steering, braking, transmission, chassis etc. We have extensively designed and carried out the design analysis regarding separate all the systems involved in the kart's specifications The designhas been modeled in Catia V5 and Solidworks while the analysis was done in Ansys R1 and same rendering was done using Solidworks Keywords

I. INTRODUCTION

The go kart has been designed by team barrier breakers consisting of under graduated students from G.H.Raisoni College Of Engineering affiliated to R.T.M.N.U University, Nagpur.

We approach our design by considering all alternatives for a system and molding them in CAD software; Solidworks and Catia subjected to analysis using Ansys. The specimen was altered as a result of the analysis. retested and final designed was fixed.The primary objective of work is to design and develop a safer and functional vehicle based on a torsional free and rigid frame, well mounted power to learn and comprehend the finer points of vehicle design an in tension of working it easy to manufacture for consumer sale, while strictly following the rulebook.

The second objective is to make a kart with driver comfort to increase the performance maneuverability of the vehicle to achieve our goal the team is divided into core groups which are responsible for design and optimization of major sub systems which were later integrated into the final kart. The design has been approached in view of all possible substitutions for a system.

II. CHASSIS

A. *Shear Force & Bending Moment Calculation of Chassis –*

Taking moment at A

$-0.590\times690-0.637\times320-0.889\times90+R_b\times1.05$

$R_b = 658.05N$.

Now,

$\sum Fy=0$

$R_a= -690-310-90+R_b=0$

$R_a = 441.95N$

1) *Shear Force Calculation*

Shear Force Diagram (SFD):

SF at A= 441.95N

SF at C= -248.05N

SF at D= -568.05N

SF at E= -658.05N

SF at B= 0

2) *Bending Moment Calculation*

Calculating moment at each point,

$M_B= 0$

$M_E= 658.05\times0.161$

$= 105.94N\text{-}m$

$M_D= -90\times0.252+658.05\times0.413$

= 249.09N-m

M_C=-320×0.047-90×0.299+658.05×0.46

=260.753N-m

M_A= 0

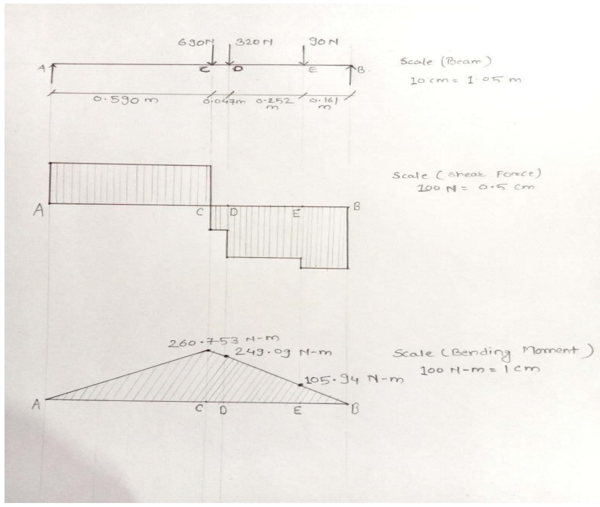

Fig. 1. SFD & BMD of Chassis

3) Chassis Diameter calculation

Taking Maximum moment

M = 260.753N-m = 260.753 $\times 10^3$ N-mm

By Selecting Material: AISI 4130

Yield Strength= 460MPa

Factor of Safety (N_f) = 5

Tensile Stress (σ_t) = Y / N_f

(σ_t) = 460/5

= 92 N/mm^2

Now, $\sigma_t = \sigma_b$

$$\sigma_b = \frac{32*M}{\pi*D}$$

$$12 = \frac{32*260.753\times10^3}{\pi*D^3}$$

D = 30.67mm = 32 mm

III. STEERING SYSTEM

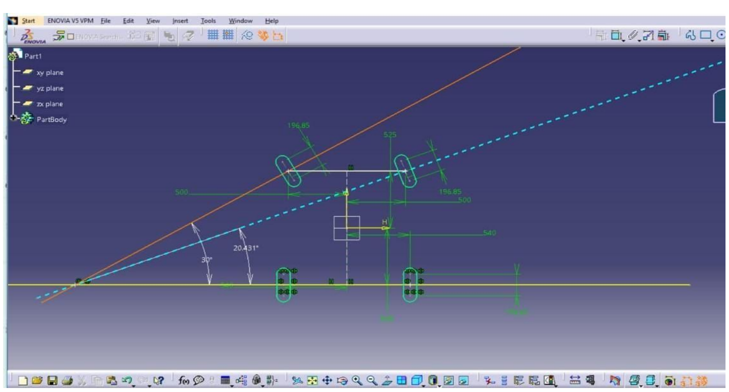

Fig. 2. Steering Geometry

Where,

□= Steering angle of inner front wheel = 30^{o}

□= Steering angle of outer front wheel = 20.431^{o}

a = Track width

b = Wheel base

c = Distance between pivot points

Our dimensions are in inches

a = Front wheel track width = 39.37”

b = Wheel base = 41.34”

c = distance between pivot points = 42.52”

a) *Radius of inner front wheel,*

$$R_{IFW} = \frac{b}{\sin\theta} - \left(\frac{a-c}{2}\right)$$

$$= -\frac{41.34}{\sin(30)} - \left(\frac{39.37-42.52}{2}\right)$$

= 84.255”

b) *Radius of Outer Front Wheel,*

$$R_{OFW} - \frac{b}{\sin\emptyset} + \left(\frac{a-c}{2}\right)$$

$$= \frac{41.34}{\sin(20.431)} - \left(\frac{39.37-42.52}{2}\right)$$

= 116.850”

c) *Radius of inner rear wheel,*

$$R_{IRW} = \frac{b}{\tan\theta} - \left(\frac{a-c}{2}\right)$$

$$= \frac{41.34}{\tan(30)} - \left(\frac{39.37-42.52}{2}\right)$$

= 75.677”

d) *Radius of outer rear wheel,*

$$R_{crw} - \frac{b}{\tan\emptyset} + \left(\frac{a-c}{2}\right)$$

$$= \frac{41.34}{\tan(20.431)} + \left(\frac{39.37 - 42.52}{2}\right)$$

= 106.90”

Radius with C.G

RCG= tan θ =(L/(R-t/2))

= tan (30) =(41.33/(R-39.37/2))

= 91.27”

e) Actual turning Radius,

$$T = \frac{a}{2} + b * \csc\left(\frac{\mathrm{RIFW}}{2} + \frac{\mathrm{ROFW}}{2}\right)$$

$$= \frac{39.37}{2} + 41.37 * \csc\left(\frac{30 + 20.431}{2}\right)$$

= 116.83 inch

f) Ackerman angle,

= $\tan^{-1}$(tan Ø-a)

= $\tan^{-1}$ (tan(20.431) -100) = 29.99°

g) Ackerman Percentage,

$$= \frac{\theta}{Ackerman\ angle} * 100$$

$$= \frac{30}{29.99} * 100$$

=100%

h) Steering Effort,

Maximum load on front tyre on full brake = 1671.86N

Maximum load on each tyre = 835.93N

Material of Knuckle = AISI-1040

Scrub radius (z) =110mm

Steering effort at static condition

Normal reaction of front wheel = 666.8 N

Normal reaction for each wheel = 333.4 N

SE_S = □*normal reaction*scrub radius

$= 0.7*333.4*110*10^{-3}$

= 25.67N-m

Steering effort at static condition = 25.67 N-m

Table -1 Steering Result

Parameters	Values
Radius of inner front wheel	84.25”
Radius of outer front wheel	116.85”
Radius of inner rear wheel	75.67”
Radius of outer rear wheel	106.90”
Actual turning radius	116.83”
Ackerman Angel	29.99^0
Ackerman Percentage	100%
Steering effort at static load	25.67 N-m
Caster Angle	5^0
Camber Angle	0^0
FOS of steering column	4
FOS of Knuckle	8.8
Wheel Base	41.33”
Track Width	39.37”

IV. TRANSMISSION SYSTEM

A. *Specification of Engine*

Engine: Bajaj Discover 125 ST

Displacement: 124.6cc

Maximum Power: 12.8 HP @ 9000rpm

Maximum Torque: 11 N-m @ 7000rpm0

No. of cylinders: 1

No. of Gears: 5

B. *Power Transmission*

1) *Sprocket Calculations*

Largest Sprocket (T_g): 30 no. of teeth

Smallest Sprocket (T_p): 14 no. of teeth

T_g = Numbers of teeth on Gear sprocket.

T_p = Numbers of teeth on Pinion sprocket.

$$Gear\ Ratio, = \frac{T_g}{T_p} = \frac{30}{14} = 2.14$$

Chain Pitch: 12.7 mm

$$\text{Roller Diameter} = \frac{5*p}{8}$$
$$= \frac{5*12.7}{8}$$
$$=7.9375 \text{ mm}$$

Tooth Width (t_1) = 0.91*b

= 0.91*7.9375

= 7.22mm

Max. Height of pin link plates (h1) = 0.95*p

= 0.95*12.7

= 12.065mm

a. Pitch diameter of Sprockets

Pitch (P) = 12.7mm

DP = Pitch diameter of pinion

$$= \frac{p}{\sin(\frac{\pi}{p})}$$
$$= \frac{15}{\sin(\frac{180}{14})}$$
$$= 57 \text{ mm}$$

Dg = Pitch diameter sprocket gear

$$= \frac{P}{\sin(\frac{\pi}{q})}$$
$$= \frac{15}{\sin(\frac{180}{30})}$$
$$= 122 \text{ mm}$$

b. D_{po} = Outside diameter of sprocket pinion

= DP + 0.8*d
= 57 + 0.8*7.9375
= 63.35 mm

c. D_r = Shroud diameter of sprocket pinion

$$= p * \cot(\frac{180}{p}) - 1.3 * h$$

$$= 12.7 * \cot(\frac{180}{14}) - 1.3 * 12.065$$

= 40 mm

d. *D_{go} = Diameter of gear sprocket*

= Dg+0.8*d

= 122+0.8*7.9375
= 128.35 mm

2) *Chain Calculations*
C = Centre Distance= 30 cm

a. *Length of Chain = L*

$$= \frac{Tp+Tg}{2} + (\frac{Tg-Tp}{2*n})^2 * \frac{P}{C} + 2*C$$

$$= \frac{14+30}{2} + (\frac{30-14}{2*n})^2 * \frac{1.27}{30} + 2*\frac{30}{1.27}$$

= 69.51 cm = 70 cm

b. *Chain Sag*

Chain length elongation = 2% of chain length

Chain length elongation = 0.02*700

=14 mm

c. *Pitch line velocity*

NP = R.P.M. of pinion = 2300 rpm

$$\text{Pitch line velocity} = V = \frac{n*Dp*Np}{60}$$

$$= \frac{n*0.057*2300}{60}$$

= 6.86 m/sec = 412.6 m/min

d. *Driving force*

$$Df = H.P.*\frac{4500}{V}$$

$$= 12.8*\frac{4500}{412.6}$$

= 140 kg

e. *Total Load on driving side of chain*

WT = DF+Pc+Pf

Pc = Chain tension due to centrifugal load

$$= \frac{vv}{g} * V^2$$

Where, w = weight per meter chain of length = 1.75 kg

$$= \frac{1/5}{9.81}(6.86)^2$$

=8.39kg

Pf = k*w*C

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=3.15kg

W_T = 140 + 8.39 + 3.15

= 151.54 kg

f. Breaking Strength

F_b = Breaking strength

= $1060*(p)^2$

= $1060*(1.27)^2$

= 1709.67 kg

g. Factor of safety

$$= \frac{F_b}{W_T}$$

$$= \frac{1709.67}{151.54}$$

= 11.28 = 11 (say)

3) Axel Calculations

Material: AISI 1040

Bending moment equation,

$$\frac{M}{I} = \frac{\sigma_b}{y}$$

Maximum Bending Moment (M) = $2.37*10^6$ N-mm

Ratio between Inside and outside diameter (k) = 0.75

Bending Stress σ_b = 620 MPa

We have, $\frac{M}{I} = \frac{\sigma_b}{y}$

d_o = 38.48 mm = 40 mm

d_i = 0.75*40 = 30 mm

4) Maximum Speed at the wheels @ 7000 rpm of engine

Table -2

Primary gear reduction	3.08
1st gear reduction	2.38
2nd gear reduction	1.71
3rd gear reduction	1.33
4th gear reduction	1.08
5th gear reduction	0.91
Max engine rpm	9000

a) 2.83

$$\frac{3.08 * 30}{14 * 2.83} = 18.678$$

$$= \frac{rpm}{value * 60}$$

$$= \frac{9000}{18.678 * 60}$$

= 8.031

$$= \frac{2 * \pi * 5.5 * 25.4 * 0.95 * 8.031}{1000}$$

= 6.696

$$= \frac{6.696 * 18}{5}$$

= 24.10 km/hr

b) 1.71

$$= \frac{3.08 * 30}{14 * 1.71}$$

= 11.286

$$= \frac{9000}{11.286 * 60}$$

= 13.29

$$= \frac{2 * \pi * 5.5 * 25.4 * 0.95 * 13.29}{1000}$$

= 11.08

$$= \frac{11.08 * 18}{5}$$

= 39.89 km/hr

c) 1.33

$$= \frac{3.08 * 30}{14 * 1.33}$$

= 8.778

$$= \frac{9000}{8.778 * 60}$$

$$= \frac{2 * \pi * 5.5 * 25.4 * 0.95 * 17.088}{1000}$$

= 14.24

$$= \frac{14.24 * 18}{5}$$

= 51.29 km/hr

d) 1.08

$$= \frac{3.08 * 30}{14 * 1.08}$$

= 7.128

$$= \frac{9000}{7.128 * 60}$$

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= 21.043

$$= \frac{2 * \pi * 5.5 * 25.4 * 0.95 * 211.043}{1000}$$

= 17.54

$$= \frac{17.54 * 18}{5}$$

= 63.16 km/hr

e) 0.91

$$= \frac{3.08 * 30}{14 * 0.91}$$

= 6.006

$$= \frac{9000}{6.006 * 60}$$

= 24.975

$$= \frac{2 * \pi * 5.5 * 25.4 * 0.95 * 24.975}{1000}$$

= 20.82

$$= \frac{20.82 * 18}{5}$$

= 74.97 km/hr

5) *Air Resistance*

$$= \frac{1}{2} * \rho * A * V^2 * C_d$$

= 130.04 N

6) *Rolling Resistance*

= coefficient of friction*mass*gravity

= 0.6*170*9.81

= 1000.62 N

7) *Total Resistance*

= Air resistance + Rolling Resistance

= 130.04+1000.62

= 1131.26 N

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C. Final Result

Table -3 Transmission Result

Parameters	Values
Pitch diameter of sprocket pinion	57 mm
Pitch diameter of sprocket gear	122 mm
Outside diameter of sprocket pinion	63.35 mm
Shroud diameter of sprocket pinion	40 mm
Diameter of gear sprocket	128 mm
Length of chain	70 cm
Chain sag	14 mm
Pitch line velocity	6.86 m/s
Driving Force	140 kg
Total load on driving side of chain	151.54 kg
Breaking Strength	1709.67 kg
Factor of safety	11
Outer diameter of axel	40 mm
Inner diameter of axel	30 mm
Air resistance	130.04 N
Rolling resistance	1000.62 N
Total Resistance	1131.26

V. BRAKE SYSTEM

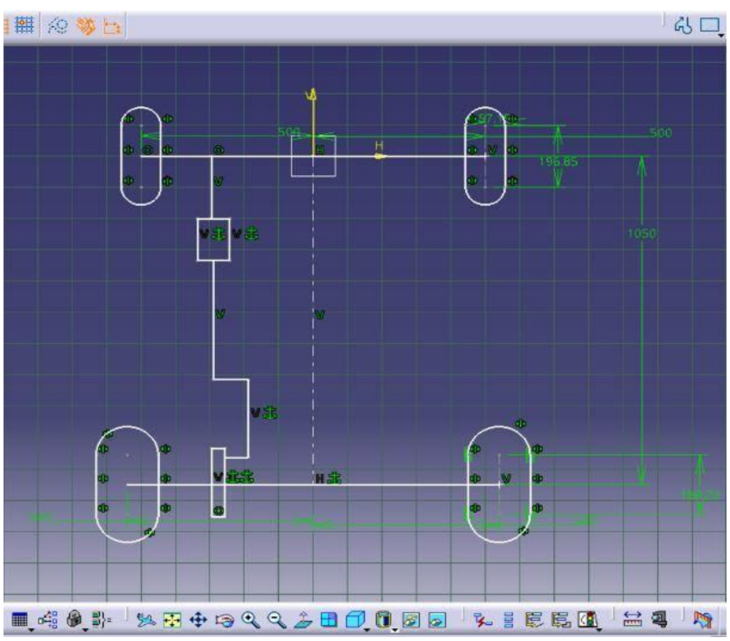

Fig. 2. Line diagram of Braking System

1) *Gross weight (W)*

= g * weight of vehicle

= 9.81*170

= 1667.7 N

2) *Area of Calliper & Master Cylinder*

Diameter of Calliper piston (D_c) = 32 mm

Diameter of master cylinder (D_m) = 11 mm

$$\text{Area of Calliper} = \frac{\pi}{4}(D_c)^2$$

$$= \frac{\pi}{4}(32)^2$$

= 804.24 mm^2

$$\text{Area of Master Cylinder} = \frac{\pi}{4}(D_m)^2$$

$$= \frac{\pi}{4}(11)^2$$

= 95.03 mm^2

3) *Pressure in the system*

Pedal force= 250 N

Pedal Ratio= 4:1

$$\text{Pressure in the system} = \frac{\text{net force on master cylinder}}{\text{area of master cylinder}}$$

$$= \frac{4 * 250}{95.03}$$

= 10.52 N/mm^2

4) *Clamping Force*

= Brake line pressure*Area of piston

= 10.52*804.24*2

= 16921.20 N

5) *Rotating Force*

= Clamping force * Coefficient of friction

= 16921.20*0.4

= 6768.5 N

6) *Braking torque*

Braking torque produce = Rotating Force * effective disc radius

= 6768.5* 95*10^{-3}

= 643.00596 N-m

= 643005.96 N-mm

7) Force at Tyre

Effective Radius Of tyre = 139.7 mm

Force at Tyre $= \frac{Braking\ Torque}{\text{Effective Radius}}$

$= \frac{643005.96}{139.7}$

= 4602.76 N

8) Deceleration (a)

$= \frac{-\ Force\ at\ tyres}{Mass}$

$= \frac{-4602.76}{170}$

= -27 m/s^2

*9) Braking Force = m*a*

= 170*27

= 4590 N

10) Stopping Distance

$v^2 - u^2 = 2as$
$(0^2 - 16.16^2) = 2*(-27)*s$
S=5.14

11) Stopping Time

$t = \frac{16.67}{27}$

t = 0.61 sec

12) Height of center of gravity
l = wheel base = 105 cm = 1050 mm
Front Track Width = 100 cm = 1000 mm
Rear Track Width = 108 cm = 1080 mm

13) Horizontal location of C.G.
Assuming weight distribution of vehicle in the ratio 40:60
W_F = static load on front wheels
= 0.40 * 1667.7
= 666.8 N

= 68 kg

W_R = Static load on rear wheels

= 0.60 * 1667.7

= 1000.2 N

= 102 kg

Now,

$$x = W_R * \frac{l}{w}$$

$$x = 102 * \frac{1050}{170} = 630mm$$

$$y = W_F * \frac{l}{w}$$

$$y = 68 * \frac{1050}{170} = 420mm$$

14) Vertical Height of C.G.

W_f = Weight when the

W_f = 55 kg

W_k = Weight of the kart

W_k = 100 kg

We have,

h=0.420 m

Where,

R_{LF} is loaded radius of front = 0.127 m

R_{LR} is loaded radius of rear = 0.14 m

Now,

$$l_1 = l * \cos\theta$$

and taking the moment about O.

$$W_f * l_1 = W * b_1$$

from which

$$b_1 = \frac{w_f}{w} \cos\theta$$

Also

$$b_1 = \frac{b1}{(x+c)} * l * \cos\theta$$

From which

$$b_1 = \left(\frac{w_f * l}{w}\right) - b$$

Now,

$$\tan\theta = \frac{h_1}{c}$$

$$h1 = \frac{(W_f * l) - (W_k * y)}{W_k * \tan\theta}$$

$$= \frac{(550 * 1.05) - (1000 * 0.420)}{1000 * \tan 30}$$

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= 0.2727 m

$$R_{LCG} = R_{LF} * \frac{y}{l} + R_{RF} * \frac{x}{l}$$

$$= 0.127 * \frac{0.420}{1.05} + 0.14 * \frac{0.630}{1.05}$$

= 0.1348 m

 h = 0.2727 + 0.1348

h = 0.4075 m or 16”

A. *Final Result*

Table -4 Breaking Result

Parameter	Value
Gross Weight	1667.7 N
Area of Calliper	804.24 mm^2
Area of Master Cylinder	95.03 mm^2
Pressure in the System	95.03 mm^2
Clamping Force	16921.20 N
Rotating Force	6768.5 N
Braking Torque	643.00596 N-mm
Force on tyre	4602.76 N
Deceleration	-27 m/s^2
Braking Force	4590 N
Stopping Distance	5.14 m
Stopping time	0.61 sec
Height of C.G.	0.4075 m
Static load on front axel	666.8 N
Static load on rear axel	1000.2 N

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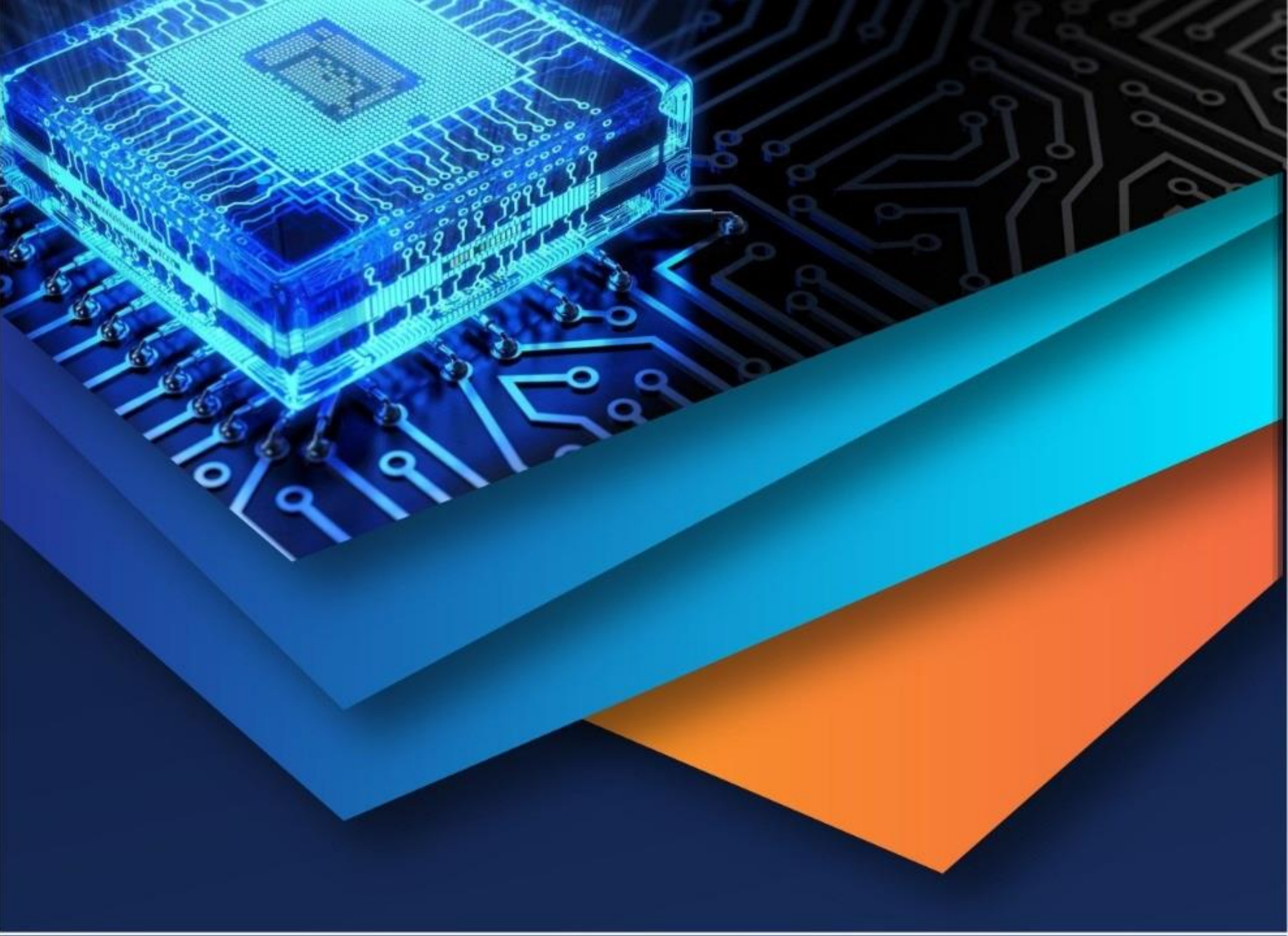

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