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Design and Analysis of a Go-Kart

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***Abstract*: A Go-kart may be a miniaturized four-wheel vehicle. They usually have neither suspension attached nor differentials. They're usually raced upon tarmac tracks, but mostly driven for amusement purpose by many people. Carting is widely regarded as the proverbial stepping stone of sorts to the upper echelon ranks of motorsports. Kart racing enjoys widespread acceptance because of it being the most pocket friendly sort of motorsport available which can be participated without much experience. As a leisurely activity, it is very easily performed by almost any able-bodied person and permits licensed racing of this form to anyone upwards of the age of 8. This form of racing also helps to recognize talents for more complex motorsports at a very young age. Many people say it belongs to the young age people but adults are also actively involved and enjoy doing this. Karting is taken into account because of the initiative it brings towards the induction of any professional racer's career.**

***Keywords*: Go-kart, Analysis, Frame designing, Steering calculations and mechanism, Powertrain system, Innovation.**

1. Introduction

Go-kart is a miniaturized version of any car with single seating capacity used widely in European countries. The concept of go-karting was initially created within the mid-20th century during the post-war era as a good way to enjoy the leisure time. Art Ingles is said to be the inventor of karting concept. He built the first design of the kart in US during the year 1956. Ever since then, Go Karting has become very popular everywhere but more so in European countries. The standard definition of a Go Kart is that it is a small vehicle having no components belonging to the suspension or differentials subsystems. They're usually raced on smaller professional tarmac tracks, and are also sometimes driven for amusement by regular individuals. Carting is usually perceived to be as the start of an era to the upper echelons of motorsports. Kart racing is popular as it's the most viable motorsports in today's world without much complications involved. Most of us associate karting with younger drivers, but adults also are very prevalent in karting Karting is taken into account because of the initiative it brings to the start of any professional racer's career. It helps the driver by helping them develop appropriate reflexes, good command of car control and split seconds decision-making qualities. Additionally, it brings to the plate a deep awareness of varied parameters which will undergo change in order to bring about enhancement to the competitiveness of Go kart racing to the levels of competitiveness that exists in the other forms of racing.

2. Frame Design

A. Frame material

The frame raw material used is AISI 1080 steel because it is more economic and serves well for the concerned safety standards. The pipe used will be having OB of 1 inch and thickness of 3 mm. The physical properties for the material are tabulated below:

Table 1
Physical properties for the material

S.No.	Properties	Values
1.	Tensile strength	438 N/mm^2
2.	Shear Modulus	80000 N/mm^2
3.	Poisson's ratio	0.290
4.	Yield strength	372 N/mm^2
5.	Young's Modulus	204000 N/mm^2
6.	Bulk Modulus	140 N/mm^2

The chemical breakdown of the material is listed below:

Table 2
Chemical breakdown of the material

Materials	Percentage
Phosphorous	$\leq$ 0.040 %
Sulphur	$\leq$ 0.050 %
Carbon	0.14-.0.20%
Iron	98.8 - 99.26 %
Manganese	0.60-0.90

B. Vehicular design

Overall views of the go-kart:

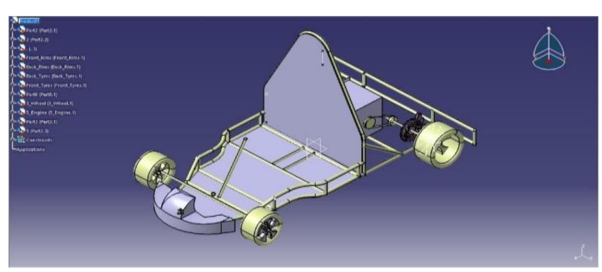

Fig. 1. Front Isometric View of the go-kart

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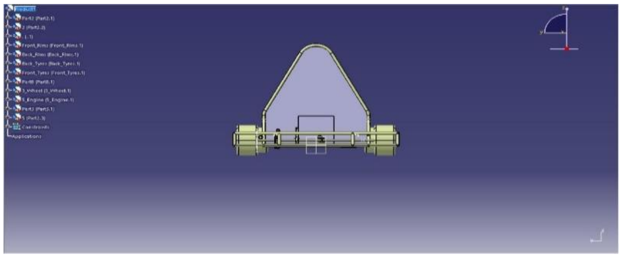

Fig. 2. Rear View of the go-kart

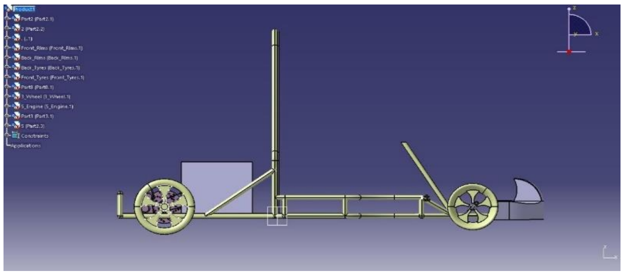

Fig. 3. Side View of the go-kart

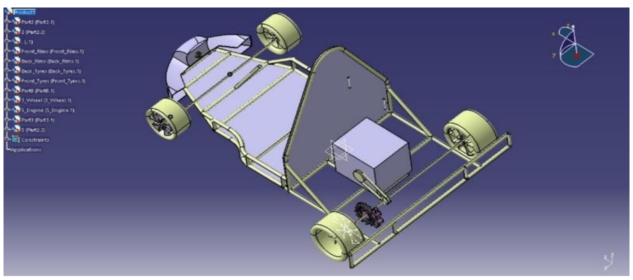

Fig. 4. Rear Isometric View of the go-kart

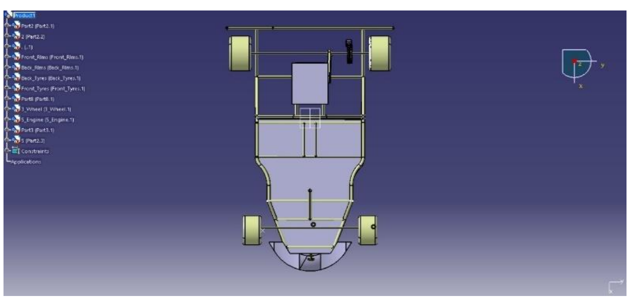

Fig. 5. Top View of the go-kart

C. FEA analysis for frame safety

Apart from deciding the bare minimal material requirement in the discussion between team members, the standard value of the frame is compared to the analysis outcomes to reinforce the kart frame strength as a whole. At the given critical points in the wireframe model, has theoretically derived loads that are set up to emulate the utmost force that the frame can withstand considering the self-weight and thereby the driver's weight in an unfortunate event. The frame's analysis was undertaken in the CATIA platform. During the meshing, the element count was found to be 36064 with 70568 nodes. Two or more differently constrained load cases are examined to check discrepancies in safety related issues of the design. Three cases that were utilised for the analysis were the frontal impact, rear impact and side-impact. The impact test conducted on the frame was made to be consistent with European safety standards. As per the safety norms, the linear Velocity of the vehicle stands at 64 km/hr for front impact, 50 km/hr for the rear impact and 48 km/hr for side-impacts

The final frame analysis is calculated as follows:

1) Front impact analysis

Front Impact test is undertaken using the following calculations:

Vehicle Mass = 165 kg (estimated)

Velocity V = 64 km/hr = 17.8 m/s

From equation of mass moment of inertia,

Front Impact Force F = P x ΔT

Where, ΔT = time duration = 1.1sec, P = momentum

P = M x V

= 165 x17.8

= 2937 kg-m/s

F = PxΔT

= 2937 x_1.1

= 3230.7 N

Now putting constrains at key points and applying calculated force to the necessary points in CATIA. The pictures below show the results of deformation, Von-Mises stress, and stress tensor distribution respectively. FOS for front impact is found to be 3.77.

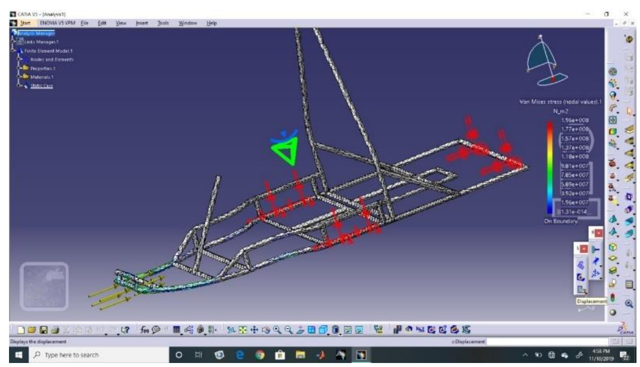

Fig. 6. Stress (Von-Mises type)

Maximum stress after analysis is 39.2 MPa. It is a safer value.

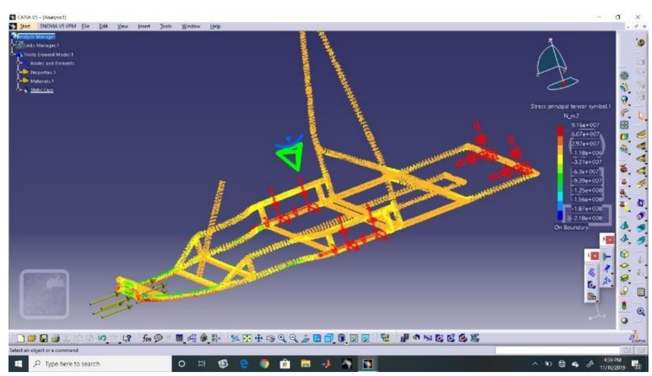

Fig. 7. Stress Tensor Distribution

Maximum stress is found to be 91.6 MPa which is minimal.

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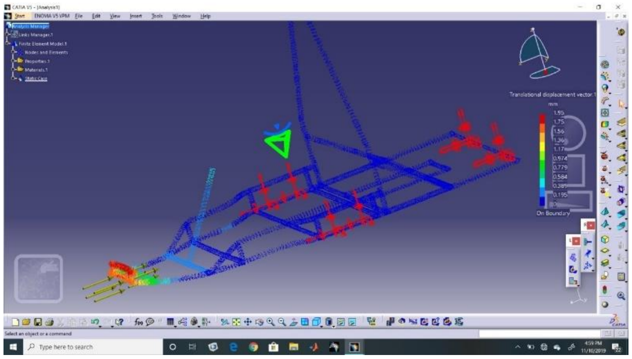

Fig. 8. Total Deformation

Maximum Deformation is 1.75 mm which is minimal.

2) Side impact analysis

Similarly, Side Impact Force

F = PxΔT

= 2194.5 x 1.1

= 2413.95 N

Now putting constrains at key points and applying calculated force to the necessary points in CATIA. The pictures below show the results of deformation, Von-Mises stress and stress tensor distribution. FOS for side impact found to be 5.061 which is safe.

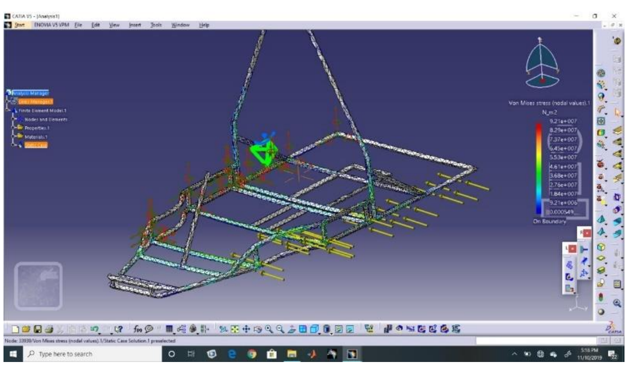

Fig. 9. Von Mises stress distribution

Maximum stress induced is 18.4 MPa which is safe.

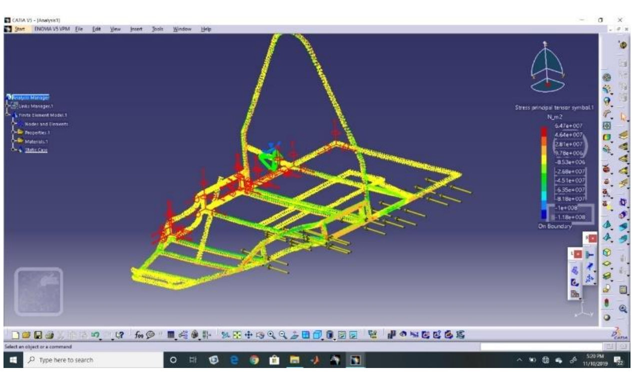

Fig. 10. Stress Tensor Distribution

Maximum stress is found to be 9.78 MPa which is minimal.

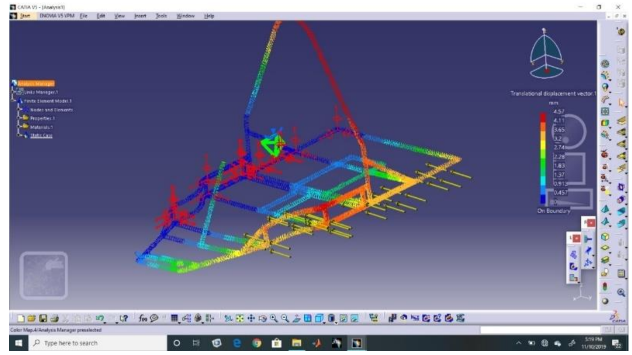

Fig. 11. Total Deformation

Maximum Deformation is 4.11 mm which is minimal.

3) Rear impact analysis

Similarly, Rear Impact Force

F = PxΔT

= 2277 x 1.1

= 2504.7 N

Now putting constrains at key points and applying calculated force to the necessary points in CATIA. Images below shows the outcomes of the analysis like Von-Mises stress, deformation and stress tensor distribution. FOS for rear impact found to be 7.64 which is safe.

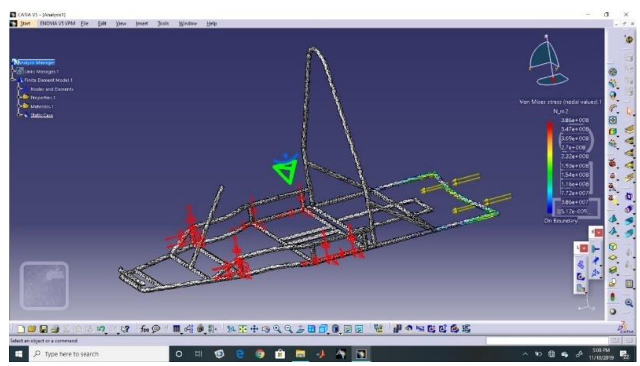

Fig. 12. Von Mises stress distribution

Maximum stress induced is 77.2 MPa which is safe.

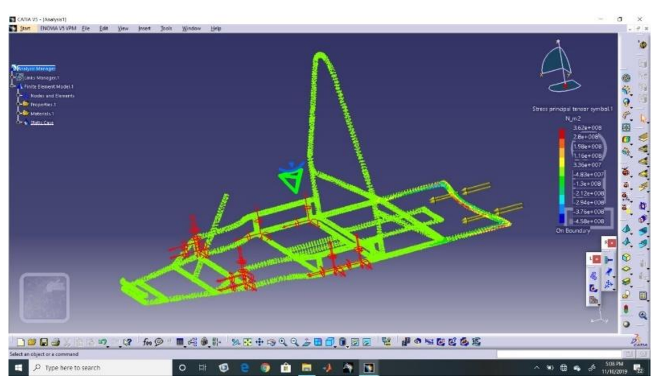

Fig. 13. Stress Tensor Distribution

Maximum stress is found to be 33.6 MPa which is minimal.

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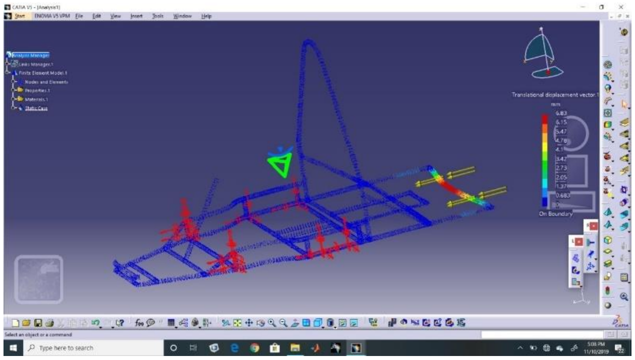
Fig. 14. Total Deformation

Maximum Deformation is 5.47 mm which is minimal.

D. Conclusion

The various crucial safety parameters have been drawn out from the CATIA analysis have been tabulated below.

Table 3
CATIA analysis

Parameter	Front	Rear	Side
Force (Impact Type)	3230.7 N	2504.7 N	2413.95 N
Stress Generated	39.2 N/mm²	77.2 N/m²	9.78 N/mm²
Total De-formation	1.75 mm	5.47mm	4.11 mm
Safety factor	3.77		

3. Steering System

Steering mechanism serves a very key importance for the drivability of any vehicle. The most purpose of this system is to supply control of direction. An ideal steering system should be lightweight, compact and easy to use while giving precise control over the directional stability to the vehicle.

Our Steering mechanism is meant to supply easy maneuvering with fast response upon input from driver and it follows the Ackermann Design.

A. Calculation

- Turning Radius, R = 2000 mm (assumed)
- Wheel Base, L = 1559 mm
- Track Width, T = 1000mm = d

1. Inner Wheel Angle = tan A = $\frac{L}{R-\frac{d}{2}} = \frac{1559}{2000-\frac{1000}{2}}$

   A = 46.104°.

2. Outer Wheel Angle = tan B = $\frac{L}{R+\frac{d}{2}} = \frac{1559}{2000+\frac{1000}{2}}$

   B = 31.9477°.

3. Actual Turning Radius,

$$R_1 = \frac{T}{2} + L\,cosec\left(\frac{A}{2}+\frac{B}{2}\right)$$
$$= \frac{1000}{2} + 1559\,cosec\left(\frac{46.104}{2}+\frac{31{\cdot}9477}{2}\right)$$
$$= 2975.8479 \text{ mm}$$

4. Ackermann Angle = $tan\,\varphi = \frac{L}{\frac{L}{tan\,B}-d}$

$$= \frac{1559}{\frac{1559}{0{\cdot}6236}-1000}$$ i.e. φ = 46.164°.

5. Ackermann Percentage = $\frac{46{\cdot}164}{46.164} \times 100$

   = 100 %

6. Steering Angle = $tan\,\alpha = \frac{L}{R_1}$

   α = 27.6493°

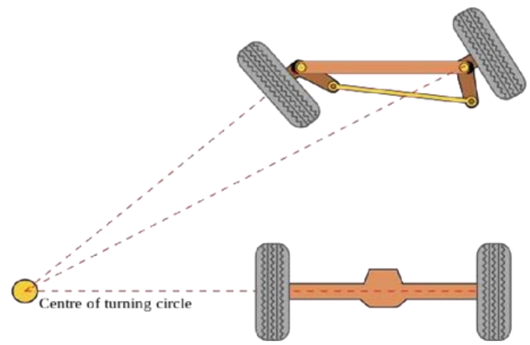

Fig. 15. Steering system

B. Results

Table 4
Results

Turning Radius (R)	2000mm
Wheel base (L)	1559mm
Track width (T)	1000mm
Inner wheel angle (A)	46.1049º
Outer wheel angle (B)	31.9477º
Actual turning radius (R_1)	2975.8479mm
Ackerman angle (φ)	46.1049º
Ackerman percentage	100%
Steering angle (α)	27.6493º

4. Power Transmission Shaft Calculation

Material of shaft = ASTMA 106
Yield strength = 330MPa
F.O.S = 3
Tensile Stress = 330/3 = 110 MPa
Shear stress = 0.6 × Tensile strength
=0.6 × 110 = 66 MPa   i.e. d = 24 mm
Note: -
From DDHB (Design Data Handbook Volume I),
Standard diameter = 25 mm diameter
Based on strength,
Bending stress = $\frac{32M}{\pi d_0^3(1-k^4)}$

$$= \frac{32\times180\times10^3}{3.142\times25^3} = 117.34 \text{ N/mm}^2$$

The induced stress is less than assumed stress.
Hence design is safe.

5. Power Train

In this go-kart, we will be using a Honda GX 160cc single cylinder 4-stroke petrol engine, which produces about 4.8HP at 3600rpm.

Its Specifications are given below:

Table 5
Specifications

Engine	Single cylinder petrol engine (4 stroke type)
Sleeve Material	Cast iron shaft
Bore × Stroke	68×45_mm
Compression ratio	9:1
Net power	3.6kW/3600rpm
Displacement	163 cm
Max. net torque	10.3N-m(1.05 kgfm)/2500rpm
Cont. rated power	2.5_kW(3.4HP)/3000rpm 2.9 kW(3.9HP)/3600RPM
Starter	Recoil (el start optional)
Ignition system	Transistorised
Fuel consumption at constant rated power	1.4 L/h-3600rpm
Fuel tank capacity	3 litres
Engine oil capacity	0.6 litre
Dimension (L×W×H)	312×362×346 mm
Dry weight	15.1kg

6. Wheels

Wheels permit a vehicle to manoeuvre easily over a surface. They reduce friction and provide leverage by rotating on the surface.

Wheel base:1559mm

Track width: 1000mm

Wheel Section	140mm
Tire Diameter	240mm

7. Innovation Regenerative Braking System

A. Components

- Electrochemical Battery
- Transmission Extension from Engine Flywheel
- Electric Motor
- Heat Sensors

B. Working

- Every time brakes are applied in a car; energy is wasted in the form of heat. Physics tells us that energy cannot be destroyed nor be created. So, when you use brakes, the K.E that was making your vehicle gain momentum goes wasted. Most of it simply dissipates as heat and becomes useless. This wasted energy can be somehow used to generate additional power for the vehicle.
- When the driver uses the brakes of an electric or hybrid vehicle, the regenerative types of brakes makes the vehicle's electric motor into reverse mode, because of which motor braking takes place by reversing the current direction in the motor, thus slowing the car speed. While running backward, the motor converts into an electric generator due to the opposite polarity, producing electricity that is further stored into the vehicle's battery. These brakes work better for a given speed range which further enhances their usability in go-karts as the go-karts usually are used within that speed range. In fact, they are considered to be most effective in stop-and-go driving situations and also reduce the power burden on the engine.

C. Advantages

- In case of an engine failure or some malfunctioning in the engine, the motor can still propel the go-kart to some safe distance reducing the risk of accidents in a track and making it a standalone system.
- Reduced fuel consumption and emissions as it is a hybrid system.
- Less chances of engine failures as the battery will ease load from the engine partially to accelerate the vehicle.
- Reduced human effort.
- Can be moved in reverse direction also by changing polarity of the motor.
- Less maintenance and use of simple electronics make it easy to be repaired without making a hole in the pocket and can be said to be a carefree system.
- Longevity of the friction brake is assured.

8. Kill Switch

Three kill switches are used, two will mounted on the either side of roll hope for easy external access and one is placed in such a way that the driver can access it easily. It is of push to off type and bright red in colour.

Table 6
Overall dimensions

Overall Length	1.904 m
Overall width	1.361 m
Track width (Front)	1 m
Wheel Base	1.559 m
Ground Clearance	1.5 inches
Engine Specification Rated power	4.6 BHP
Rated Torque	9.4 Nm at 2500 rpm
Type	4 stroke, single cylinder, Over Head Valves
Transmission Type	Chain Drive with motor coupled
Driver Sprocket	190 mm
Driven Sprocket	48 mm
Front tire diameter	10 inches
Rear tire diameter	11 inches
Rim Size	5 inches

9. Bodywork and Adjustable Seat

Bodywork part such as the front bumper is fabricated in moulding workshops as per the design. Go-kart seat which is adjustable gives extra safety and comfort to the person behind the wheels and a better position to drive in comparison to the traditional seats. Bodyworks give an aesthetically attractive look and also sometimes support better ergonomics.

10. Conclusion

In order to meet the standards, set by competitive karts, the team ran countless tests on CATIA and ANSYS in order to properly evaluate, create and modify the vehicle to the best it could be. The major aim of this was the creation of a Go Kart which could incorporate the regenerative braking model of larger vehicles such as trains while still maintaining competitive efficiency. The final result was the realization of such a vehicle maintaining the conditions listed above.

Acknowledgement

With deep sense of gratitude, I first and foremost express my profound thanks to Dr. Mahesh Shetty, Assistant Professor, Department of Mechanical Engineering for guiding me and giving us a lot of advice on this topic.

We also want to thank our project coordinator, Mr. Sunil Kumar for his valuable input throughout the preparation of this report.

Lastly, I would also like to express my gratitude towards Dr. Sudheer Reddy, HOD of Mechanical Engineering who gave us permission to use the various software available in the lab which was an invaluable boon as it allowed us to perform various virtual checks on our design.

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