STUDY OF REAR WHEEL TURNING MOVEMENT FOR HEAVY VEHICLES

Report submitted to the SASTRA Deemed to be University

as the requirement for the course

MEC300 MINI PROJECT

Submitted by

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Bonafide Certificate

This is to certify that the report titled "**STUDY OF REAR WHEEL TURNING MOVEMENT FOR HEAVY VEHICLES**" submitted as a requirement for the course, **MEC 300 Mini-project** for B.Tech. Mechanical Engineering programme, is a bonafide record of the work done by **Mr. DHANVARSHAN. G (Reg. No.-124009032), Mr. GOGUL. S (Reg. No.-124009187), Mr. SANJAY.S (Reg. No.-124009164)** during the academic year 2022-23, in the Mechanical Engineering, under my supervision.

Signature of Project Supervisor :

Name with Affiliation : Dr. A. P. Mohan Raj, Senior Assistant Professor

Date : 18/05/2023

Mini-project Viva-voce held on ________________

Examiner 1 **Examiner 2**

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Declaration

We declare that the report titled "**STUDY OF REAR WHEEL TURNING MOVEMENT FOR HEAVY VEHICLES**" submitted by us is an original work done by us under the guidance of **Dr. A. P. Mohan Raj, Senior Assistant Professor, School of Mechanical Engineering, SASTRA Deemed to be University** during the even semester of the academic year 2022-23, in the **School of Mechanical Engineering**. The work is original and wherever we have used materials from other sources, we have given due credit and cited them in the text of the report. This report has not formed the basis for the award of any degree, diploma, associate-ship, fellowship or other similar title to any candidate of any University.

Signature of the candidate(s) :

Name of the candidates : DHANVARSHAN. G, GOGUL. S, SANJAY.S

Date : 18/05/2023

Acknowledgements

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First, we express our gratitude with great admiration and respect to Dr S. Vaidhyasubramaniam, Vice Chancellor, SASTRA Deemed University, who provided all facilities and necessary encouragement during the course of our study. We extend our sincere gratitude to Dr R. Chandramouli, The Registrar, SASTRA Deemed University for providing the opportunity to pursue this project. It is our privilege to express our sincerest regards to Dr S. Pugazhenthi, The Dean, School of Mechanical Engineering, SASTRA Deemed University. We owe a debt of deepest gratitude to our project guide Dr A. P. Mohan Raj, Senior Assistant Professor, School of Mechanical Engineering for his valuable guidance and advice on the topic “Study Of Rear Wheel Turning Movement For Heavy Vehicles” by providing us with essential information, whole-hearted cooperation, and encouragement throughout the duration of our project. . Finally, we would like to extend our sincere thanks to our family members, friends and the non-teaching faulty members of School of Mechanical Engineering, SASTRA Deemed to be University for supporting us such an opportunity to enrich our knowledge.

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NOMENCLATURE

n	Number of variables in the problem
m	Number of fundamental dimensions (e.g., length [L], mass [M], time [T])
$x_1, x_2, ..., x_n$	Variables in the problem
[L], [M], [T]	Symbols representing the fundamental dimensions (e.g., length, mass, time)
$a_1, a_2, ..., a_n$	Exponents associated with the length dimension for each variable
$b_1, b_2, ..., b_n$	Exponents associated with the mass dimension for each variable
$c_1, c_2, ..., c_n$	Exponents associated with the time dimension for each variable
x_r	Reference variable used for forming dimensionless ratios
$\pi_1, \pi_2, ..., \pi_{n-m}$	Dimensionless ratios or π terms
$e_1, e_2, ..., e_{n-m}$	Exponents associated with the length dimension for each π term
$f_1, f_2, ..., f_{n-m}$	Exponents associated with the mass dimension for each π term
$g_1, g_2, ..., g_{n-m}$	Exponents associated with the time dimension for each π term
$F(\pi_1, \pi_2, ..., \pi_{n-m})$	Function representing the relationships between the π terms
W	Wheelbase
Θ	Steering angle
T	Track width
R	Turning radius
μs	Coefficient of static friction .
g	Acceleration due to gravity
R	Radius of the circular path

Abstract

Register No: 124009032

Name: Dhanvarshan. G

This project mainly focusses on the reduction of turning radius of the vehicle by turning its rear wheel with the front wheel. We believe that our project helps in the development of the performance of the heavy vehicles, because in our day-to-day life we see many large and heavy vehicles getting struck in the roads while turning or while making the U turn. The dimensions of the rear truck are taken into consideration and the study has been made on it. The original dimensions have been scaled down. The turning angle of the rear wheel is limited to 14 $^{\circ}$and the turning radius have been calculated. This idea can be more useful in the automobile field because the reduction of drag, friction and less force are required to turn the vehicle are seen.

Specific Contribution

- Calculated the π using Buckingham pi theorem.
- Designing the vehicle model.
- Design and turning radius ideas.

Specific Learning

- About Buckingham pi theorem, turning angle and turning radius.
- Auto Cad and Solid works software.

Technical Limitations & Ethical Challenges faced

- Designing the model, Scaling the vehicle.
- Simulation ideas for calculating turning radius.

Abstract

Register No:	**Name:**
124009187	Gogul. S

This project focuses on improving the performance of heavy vehicles by examining the turning movement of their rear wheels. Using a scaled-down truck model, the study aims to reduce the turning radius by coordinating the rotation of the front and rear wheels. Specifically, the rear wheel is limited to a turning angle of 14 degrees and is turned 2 degrees for every 5 degrees of front wheel rotation. This approach can significantly reduce drag, friction, and force required to turn the vehicle. Overall, this concept has great potential in the automotive industry to reduce road congestion caused by heavy vehicles struggling to make turns or U-turns.

Specific Contribution

- Calculated the turning angle
- Designing the vehicle model in 2D
- Design of chassis.

Specific Learning

- About the weight distribution and turning angle.
- About turning angle and turning radius.
- Solid works software and how to sketch

Technical Limitations & Ethical Challenges faced

- Designing the model.
- Scaling from real life vehicle.

Abstract

Register No: **Name:**

124009164 Sanjay. S

This study is all about the turning of rear wheel of the vehicle. A truck is taken as a reference for the model and scaled down. The turning radius is being reduced to a large ratio when compared to turning only the front wheel. The turning angle of the rear wheel is limited to 14^{o}.The rear wheel is eventually turned 2^{o} for every 5^{o} of front wheel. Most automobile company use this method in order to reduce the risk of turning the vehicles in narrow turns. Companiesuse different methods like using bevel gears, electric motors, differential to turn the vehicle. This idea can be implemented in the vehicles to reduce the drag, friction, force of the vehicle acting on the road.

Specific Contribution

- Calculation of turning radius, 2D simulation, Rear wheel turning angle ideas.

Specific Learning

- About turning radius, about turning angle, Auto TURN software.

Technical Limitations & Ethical Challenges faced

- Designing the model, simulation ideas, scaling the vehicle.

CHAPTER 1
INTRODUCTION

In our day-to-day life we face many problems while turning or while making U turns in traffic or congested roads. For our small vehicles itself it's a huge task to turn. Let's us now consider the large, heavy and long vehicles. They suffer a lot while turning and even to make a small turn they suffer a lot. And if it comes to U turn or any sharp turn, then it done. It makes a great traffic jam and it also make all the people travelling in that road to get suffered and also consumes more time therefore more time is wasted.

In order to overcome all this problem, we need a solution or some improvement in the field of automobile sector. Therefore, taking this as the core problem of our project we came to a solution that, we strongly believe that if the turning radius of the vehicle is reduced, then all the things will get sorted out. We also come with many more ideas. But at the end considering all the idea, we concluded that only in the reduction of turning radius only we can achieve our goal. So, we started to work on the reduction of turning radius.

In general, the turning radius of the vehicle can be reduced by increasing the turning of the wheels of the particular vehicle. That is, we know that turning radius of the vehicle is inversely proportional to the turning of the vehicle. To say in detail if the turning radius of the vehicle is low then the turning radius of the vehicle will be high.

While making the next step in the project we were in the position to consider the main factors like friction and load of the vehicle. Because if we know that if a vehicle is running in the road, it is clear that it will be subjected to some friction. If the vehicle is running without friction means it will lead the vehicle to slip and therefore it may cause serious damage to the vehicle, the driver and to the public also. Sometimes if the vehicle loss its friction control it leads to serious accidents. So, the consideration of friction is one of the greatest factors that are to be considered mainly while doing the project.

Next another important factor is the load of the vehicle or the weight of the vehicle and also if the vehicle with load in the loaded condition. Here in the project, we considered the load as the vehicles own weight and we made all our calculation and all works based on it. The term load is more important because it only help us to calculate the centre of gravity and also the moment of inertia or the vehicle.

In the continuation with load the term rollover also comes into effect. Because if the load is not distributed properly it may lead to the cause of rollover. So, the rollover also plays an important factor in the design of the vehicle.

By taking into account of all the terms, we made a design by keeping the reference of a real time vehicle. By scaling down the values of the real time with proper scaling ratio, we obtained the dimension values of our vehicle which we have designed. We taken the scaling ratio in such a way that it may be used as a miniature model or even for simulation purpose. We also taken our scaling ratio in such a way that, it suits well for a design to accommodate all the necessary things that design needed while testing.

With the design we have made, we done the simulation of our vehicle and we obtained the turning radius and turning angle values. We have also made a 2D simulation of our vehicle which shows how better the turning radius is reduced. We also calculated the values on hands-on and also checked the theoretical values with the practical(simulation) values.

FIGURE 1.1: A real time example of a long truck getting struck while making a turn

1.1 Literature survey

Jemioł, Leszek, Zbigniew Wołczyński, Alfredas Rimkus, Ruslans Smigins, Milena Górska, and Mateusz Purtak. "The programmable steering machine for the electric lightweight vehicle." *Journal of civil engineering and transport* 5 (2023).

In this paper the design of the lightweight electric vehicle and the PSM made by the Student Research Group "Turbodoładowani" has been presented. In particular, the performance of the PSM was assessed within of the maneuver's tests carried out for selected turning angles i.e.: 45, 90, 180 and 360-degree. The results confirmed that the PSM meets the design assumptions. However, a minor improvement in the future works is still necessary.

Rahmaan, Mohammad Ubaid Ur, Mohd Jaber, Abdul Rahman, and Attalique Rabbani. "360 Degree Wheel Rotation Vehicle." (2020).

A prototype for the proposed approach was developed by introducing steering and servo motor to wheel rotate 360 degrees. Thus, it is concluded that vehicle can be allowed to guide vehicle in all direction. 360 degree of rotating automobiles and also, we can guide in parallel direction. In recent time the advancement is made in automobiles. So, it has been modified in such a way that it can save time and also easily work with many problems. This can give fast response and less space is required.

Scholar, B. E., and M. P. Bhopal. "Design and Analysis of 360 Degree Turning Vehicle".

A vehicle featuring low cost and user-friendly steering mechanism has been introduced. This paper focused on a steering mechanism which offers feasible solutions to a number of current maneuvering limitations. A prototype for the proposed approach was developed by introducing separate mechanism for normal steering purpose and 360 steering purposes.

Kumar, K. Saravana. "FABRICATION OF 360 DEGREE ROTATING WHEEL IN ELECTRIC VEHICLE." (2019).

This project is made with pre planning, that it provides flexibility in operation. This innovation has made the more desirable and Economical. This project "fabrication of 360-degree rotating wheel in vehicle" is designed with the hope that it is very much economical and help full to vehicles for parking and other purpose.

N.Dinesh , V. Ashok Kumar ,A. Arul Christon ,B. Dharshan, M. Muthu Kumar, 1-Assistant.Professor, 2-UG scholar Department of Mechanical Engineering, Hindustan Institute of Technology, Coimbatore.

This project vehicle is to guide in all directions rotating 360 degree and also, we can guide in parallel direction. In recent time the advancement is made in automobiles. So, we have modified in such a way that it can save time and also easily work with many problems.

CHAPTER 2

OBJECTIVE AND MOTIVATION

To minimize the turning radius of the vehicles. Because we believe that turning radius plays a major role in turning of the vehicle. We also have the motivation to study the rear wheel turning movement of the vehicle so that it will help us to reduce the turning radius of the vehicle. This study of turning movement will also help us to calculate the theoretical values for the project and also help us to check the values that are obtained from the simulations.

We also have the motive to increase the degree of rear wheel rotation so that it helps us to reduce the turning radius of the vehicle. With all this we strongly believe that our project will surely help in the turning of heavy and long vehicle and help in automobile field.

CHAPTER 3
METHODOLOGY

3.1 Buckingham PI theorem

In this chapter we studied the Buckingham pi theorem and we made the calculation for our design. That is from the original value of our reference vehicles dimension we scaled and calculated the dimension values for our design and with that we also calculated the moment of inertia and centre of gravity from the X, Y, and Z axis. We also calculated the relationship value that is the π value. This π gives the relationship between our design to the original design. This is a dimension less term and we use it for calculating the moment of inertia.

The Buckingham Pi theorem is a principle in dimensional analysis that helps us analyse and understand the relationships between variables in a physical problem. It states that if a problem involves n variables and m fundamental dimensions, then the problem can be expressed in terms of n - m dimensionless π terms.

Let's start with a problem that involves n variables: $x_1, x_2, x_3, ..., x_n$, and m fundamental dimensions: [L], [M], [T], etc. Each variable can be expressed in terms of these fundamental dimensions as follows:

$x_1 = [L]^{a_1} [M]^{b_1} [T]^{c_1} ...$

$x_2 = [L]^{a_2} [M]^{b_2} [T]^{c_2} ...$

...

$x_n = [L]^{a_n} [M]^{b_n} [T]^{c_n} ...$

We can rearrange these equations as:

$x_1 = [L]^{a_1} [M]^{b_1} [T]^{c_1} ... \Rightarrow [L]^{a_1} [M]^{b_1} [T]^{c_1} ... x_1^{-a_1} x_2^{-b_1} x_3^{-c_1} ... = 1$

where the exponents in the rightmost expression are negative. Similarly, we can express the other variables in a similar manner.

Now, we form dimensionless ratios by dividing each variable by a reference variable or by each other:

$\pi_1 = (x_1 / x_r) = ([L]^{a_1} [M]^{b_1} [T]^{c_1} ... x_1^{-a_1} x_2^{-b_1} x_3^{-c_1} ... / x_r)$

$\pi_2 = (x_2 / x_r) = ([L]^{a_2} [M]^{b_2} [T]^{c_2} \ldots x_1^{-a_2} x_2^{-b_2} x_3^{-c_2} \ldots / x_r)$

...

$\pi_n = (x_n / x_r) = ([L]^{a_n} [M]^{b_n} [T]^{c_n} \ldots x_1^{-a_n} x_2^{-b_n} x_3^{-c_n} \ldots / x_r)$

where x_r is the reference variable.

Now, let's express these π terms in terms of their dimensions:

$[\pi_1] = [L]^{e_1} [M]^{f_1} [T]^{g_1} \ldots$

$[\pi_2] = [L]^{e_2} [M]^{f_2} [T]^{g_2} \ldots$

...

$[\pi_n] = [L]^{e_n} [M]^{f_n} [T]^{g_n} \ldots$

where [π] denotes the dimensions of the π terms.

According to the Buckingham Pi theorem, since there are m fundamental dimensions and n variables, there must be (n - m) independent π terms.

Hence, we can choose (n - m) independent π terms, say $\pi_1, \pi_2, \ldots, \pi_{n-m}$, such that they involve all the variables and eliminate the fundamental dimensions. These π terms are known as the dimensionless groups or dimensionless parameters.

Thus, the relationships among the variables can be expressed in terms of these dimensionless π terms:

$F(\pi_1, \pi_2, \ldots, \pi_{n-m}) = 0$

where F is a function representing the relationships between the π terms.

By using the Buckingham Pi theorem, we can simplify and analyse the problem, reducing the number of variables to be considered and expressing their relationships in terms of dimensionless π terms.

We use this theorem to calculate the dimension values of our design and also to know the moment of inertia, centre of gravity on the X, Y, Z axis and also to know where the rollover of the vehicle occurs that is at which point the rollover of the vehicle happens.

3.2 APPROACH:

- We took the real vehicle as a reference. The real time vehicle model name is TATA LPT 2518
- We scaled the vehicle to the ratio of 1:10/3 as it is the common scaling ratio
- By using Buckingham pi theorem with its reference values, we made a design and we calculated the $\pi\ values$
- From the design, we obtained the mass properties:
    - Moment of Inertia
    - Principal Axes and Moment of Inertia
    - Center of Mass
    - Mass of the Design
    - We have also done the analysis in solid works for checking geometry correction and also for various factors of design such as mass, moment etc.

TATA LPT 2518

Scale – 1:10/3 = 1:3.33

Overall Width =>	2440 mm =	732.7 mm
Wheel Base =>	6750 mm =	2027 mm
Front Overhang =>	1260 mm =	378.3 mm
Overall Length =>	12000mm =	3603.6 mm
Gross Vehicle Weight =>	25000 kg=	139kg(from design)

$\pi_1 = a/l$

$\pi_2 = b/l$

$\pi_3 = \cos l / mU^2$

$\pi_4 = \cos rl / mU^2$

$\pi_5 = I_2 / ml^2$

$\pi_1 = 1423.5/6750$

$= 0.210$

$a = \pi_1 \text{ x } l$

$= 0.210 \text{ x } 2027$

$= 425.67$

b = Wheel base – a

$= 2027 – 425.67$

= 1601.33 mm

Distance of centre of gravity from front axle = 1801.8 – 378.3 = 1423.5 mm

Distance of centre of gravity from rear axle = 1801.8 – 378.3 = 1423.5 mm

Height of centre of gravity from ground = 1013.5 mm

$\pi_5 = I_{xx} / ml^2$

$= 1388.1/25000 \text{ x} 12^2$

$= 3.85 \text{ x } 10^{-4}$

$I_{xx} = \pi_5 \text{ m } l^2$

$= 3.85\text{x } 10^{-4} \text{ x } 139.8 \text{ x } 36.03^2$

$= 69.87 \text{ kg m}^2$

$\pi_5 = I_{yy} / ml^2$

$= 7433.3/25000 \text{ x} 12^2$

$= 2.06 \text{ x } 10^{-4}$

$I_{yy} = \pi_5 \text{ m } l^2$

$= 2.06 \text{ x } 10^{-4} \text{ x } 139.8 \text{ x } 36.03^2$

$= 373.85 \text{ kg m}^2$

$\pi_5 = I_{zz} / ml^2$

$= 2467.9/25000 \text{ x} 12^2$

$= 6.85 \text{ x } 10^{-4}$

$I_{zz} = \pi_5 \text{ m } l^2$

$= 6.85 \text{ x } 10^{-4} \text{ x } 139.8 \text{ x } 36.03^2$

$= 124.31 \text{ kg m}^2$

3.3 Scaling:

Dimensional parameters	**Original model**	**Scaled model**
Overall width	2440 mm	732.7 mm
Wheel base	6750 mm	2027 mm
Front overhang	1260 mm	378.3 mm
Overall length	12000 mm	3603.6 mm
Vehicle weight	25000 kg	139.8 kg
CG from front axle		1423.5 mm
CG from back axle		1423.5 mm
CG from ground		1013.5 mm
Ixx	1388.1 kgm^2	69.87 kgm^2
Iyy	7433.8 kgm^2	373.85 kgm^2
Izz	2467.9 kgm^2	124.31 kgm^2

TABLE 3.1: Scaling table

CALCULATED π VALUES:

Dimensional parameters	**Original model**	**Scaled model**	π *values*
Overall width	2440 mm	732.7 mm	
Wheel base	6750 mm	2027 mm	
Front overhang	1260 mm	378.3 mm	
Overall length	12000 mm	3603.6 mm	
Vehicle weight	25000 kg	139.8 kg	
CG from front axle		1423.5 mm	π1=0.210
CG from back axle		1423.5 mm	π1=0.210
CG from ground		1013.5 mm	
Ixx	1388.1 kgm^2	69.87 kgm^2	π5=0.000385
Iyy	7433.8 kgm^2	373.85 kgm^2	π5=0.000206
Izz	2467.9 kgm^2	124.31 kgm^2	π5=0.000685

TABLE 3.2 : π values

CHAPTER 4

DESIGN

TOP VIEW OF OUR DESIGN

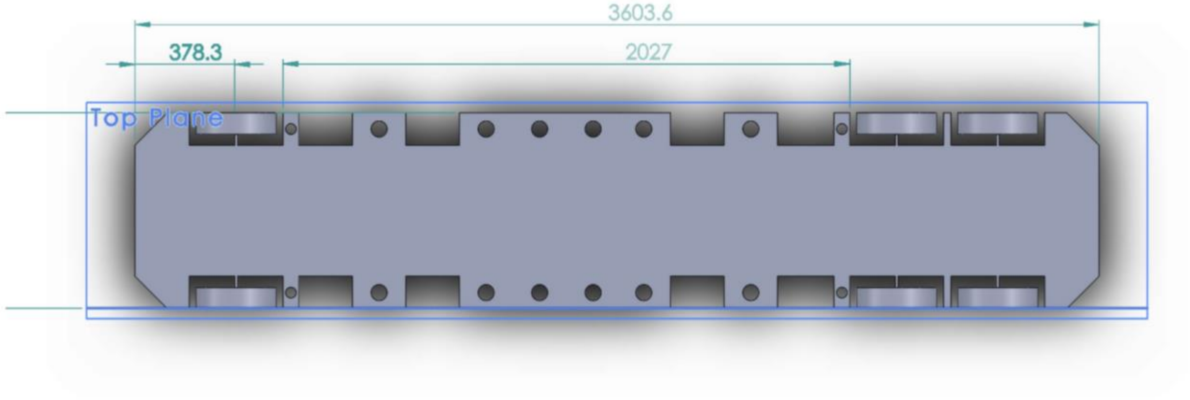


FIGURE 4.1: Top view

Total length: 3603.6 mm

Length between front and back wheel: 2027mm

Front overhang length: 378.3mm

SIDE VIEW OF OUR DESIGN

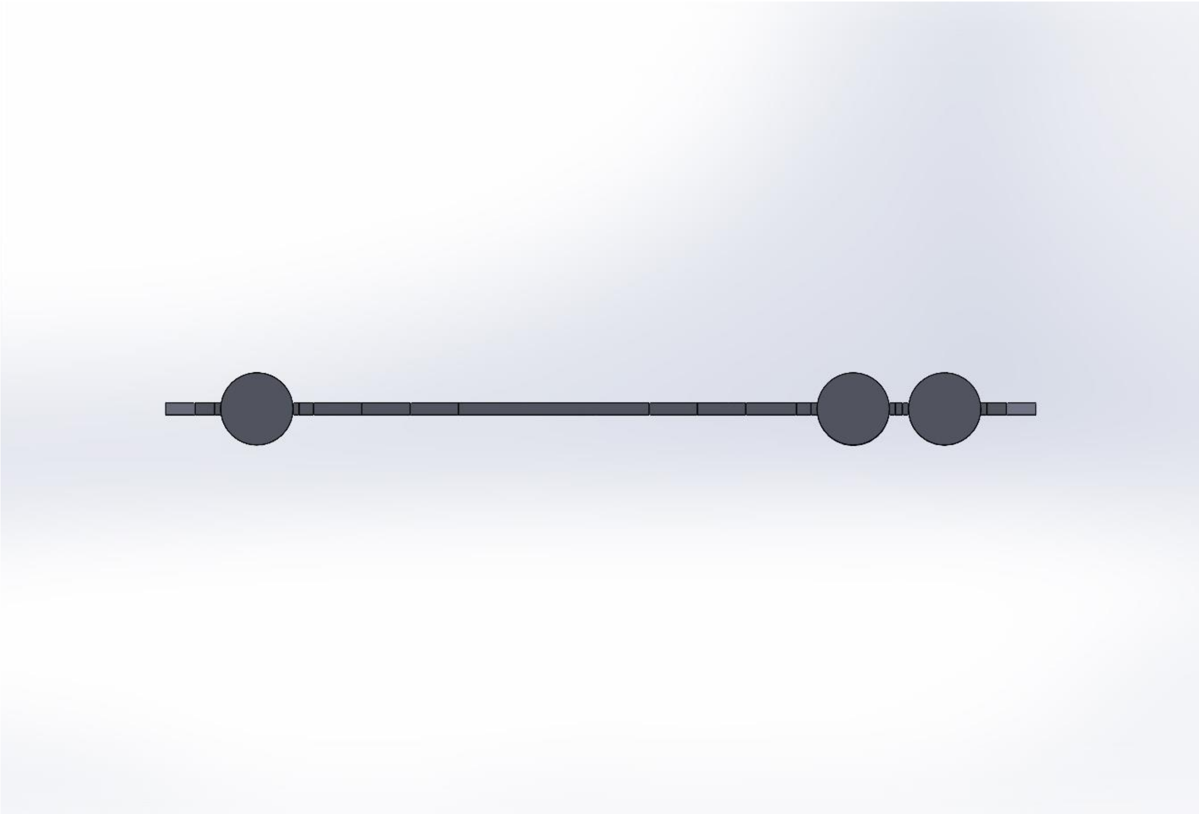


FIGURE 4.2: Side View

Side view of our truck. With this we can know the place where the tyres have been placed and how much is the distance between each tyre. We also know the front overhang and back overhang length form his view.

3D VIEW

FIGURE 4.3: 3D view

The above picture gives the 3D view of the design of our truck. Here the overall design can be seen clearly and it can be easy understood how the chases of the truck is been designed and how is sides is defined for the chases.

CHAPTER 5

CALCULATIONS

5.1 Turning angle and turning radius for front wheel turning

Turning Radius (R) = Wheel base / Tan θ

Maximum speed = $\sqrt{\mu_s g R}$ (m/s)

μ_s = 0.75 (Co-efficient of friction)

g = 9.8 m/s

R = Turning radius (m/s)

Turning angle	**Turning radius**
5	23168.71 mm
10	11495.68 mm
15	7564.36 mm
20	5569.13 mm
25	4346.91 mm
30	3510.86 mm
35	2894.35 mm
40	2415.68 mm
45	2027.00 mm

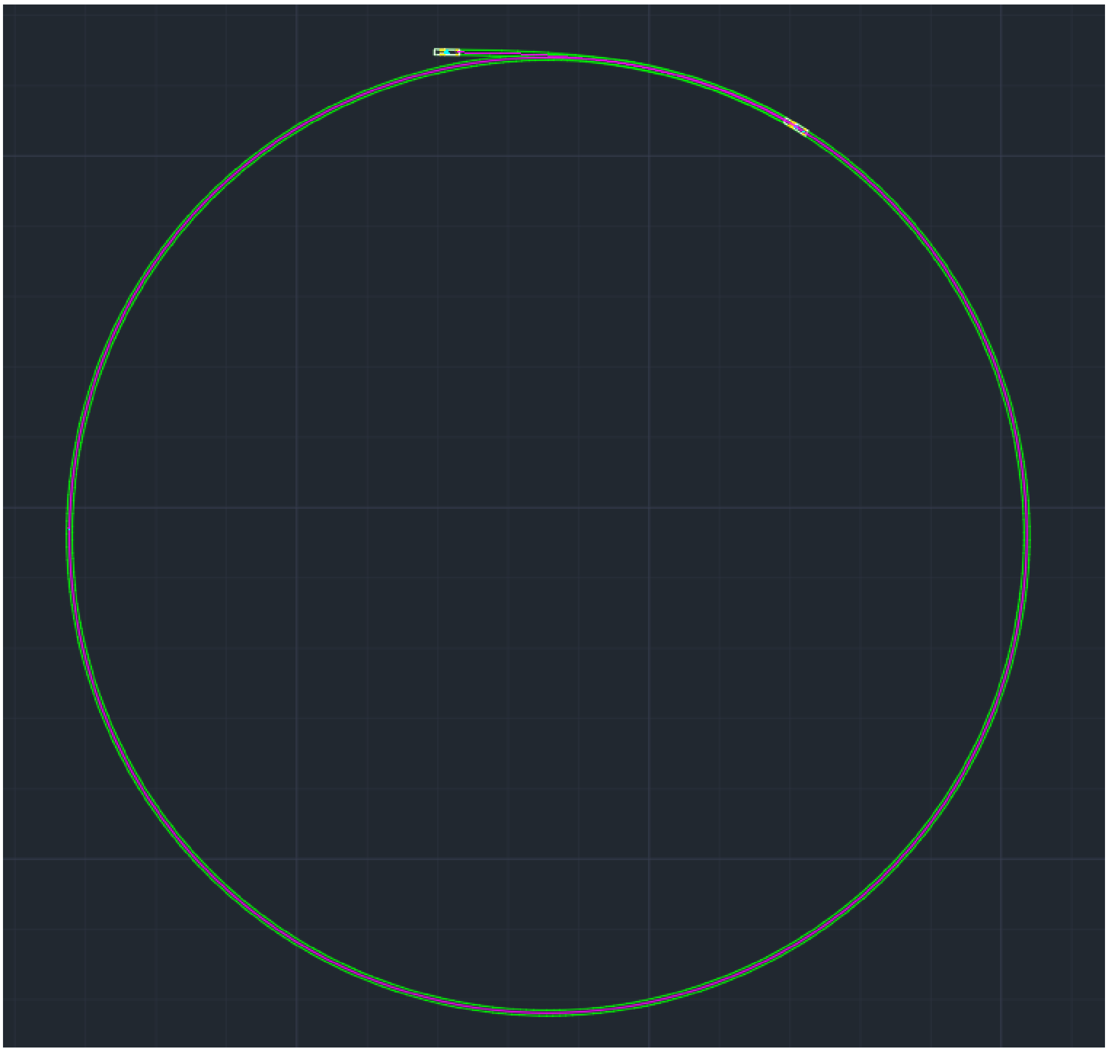
TABLE 5.1: Front wheel turning radius

Turning angle θ = 5^0

Turning Radius = 2027 / Tan 5^0

= 23168.71 mm

= 23.16871 m



Maximum speed = $\sqrt{0.75 \text{ X } 9.8 \text{ X } 23.16471}$

= 13.04 m/s

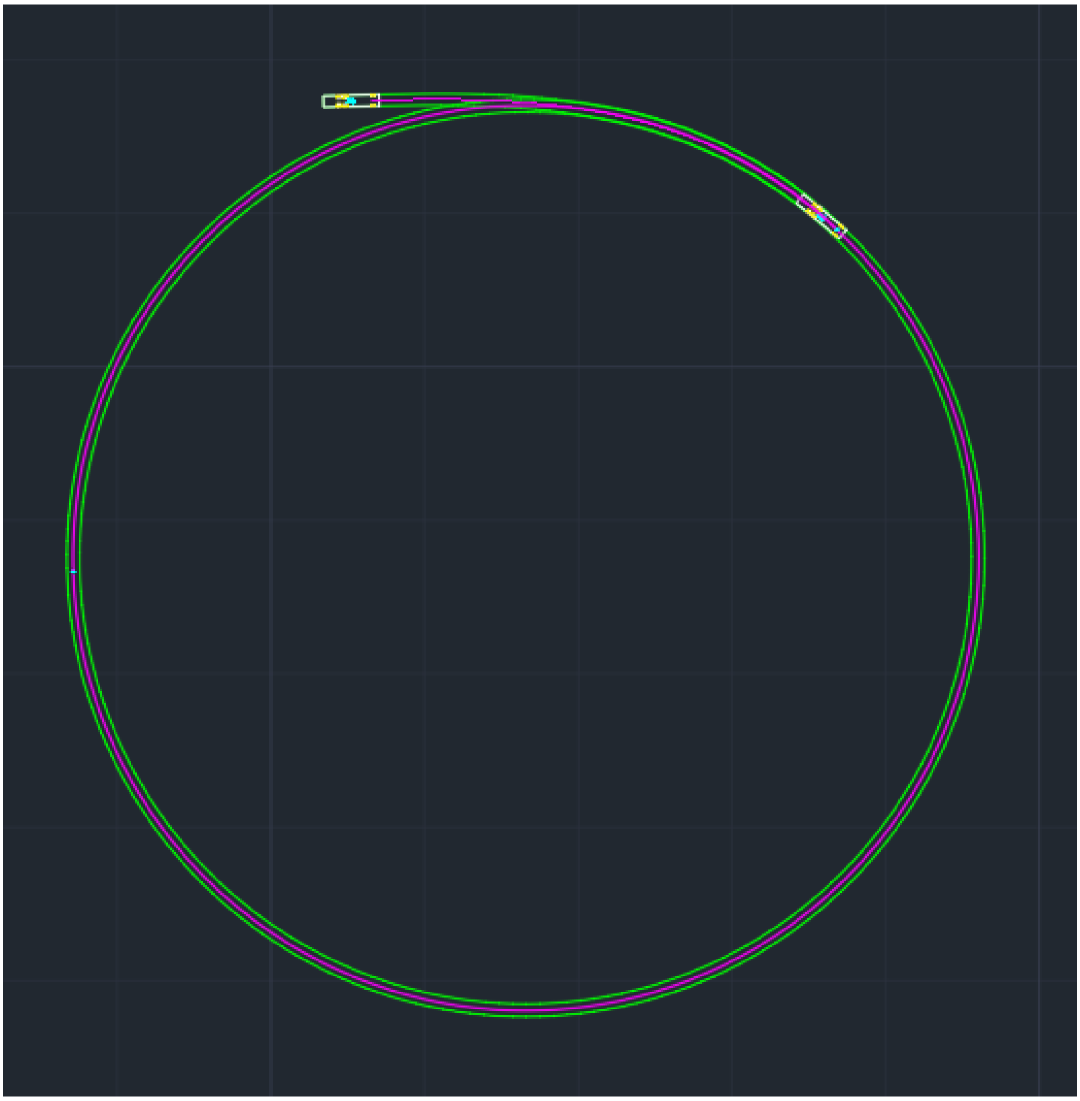
= 46.944 km/h

Turning angle θ = 10^0

Turning Radius = 2027 / Tan 10^0

= 11495.68 mm

= 11.49568 m



Maximum speed = $\sqrt{0.75 \text{ X } 9.8 \text{ X } 11.49568}$

= 9.19 m/s

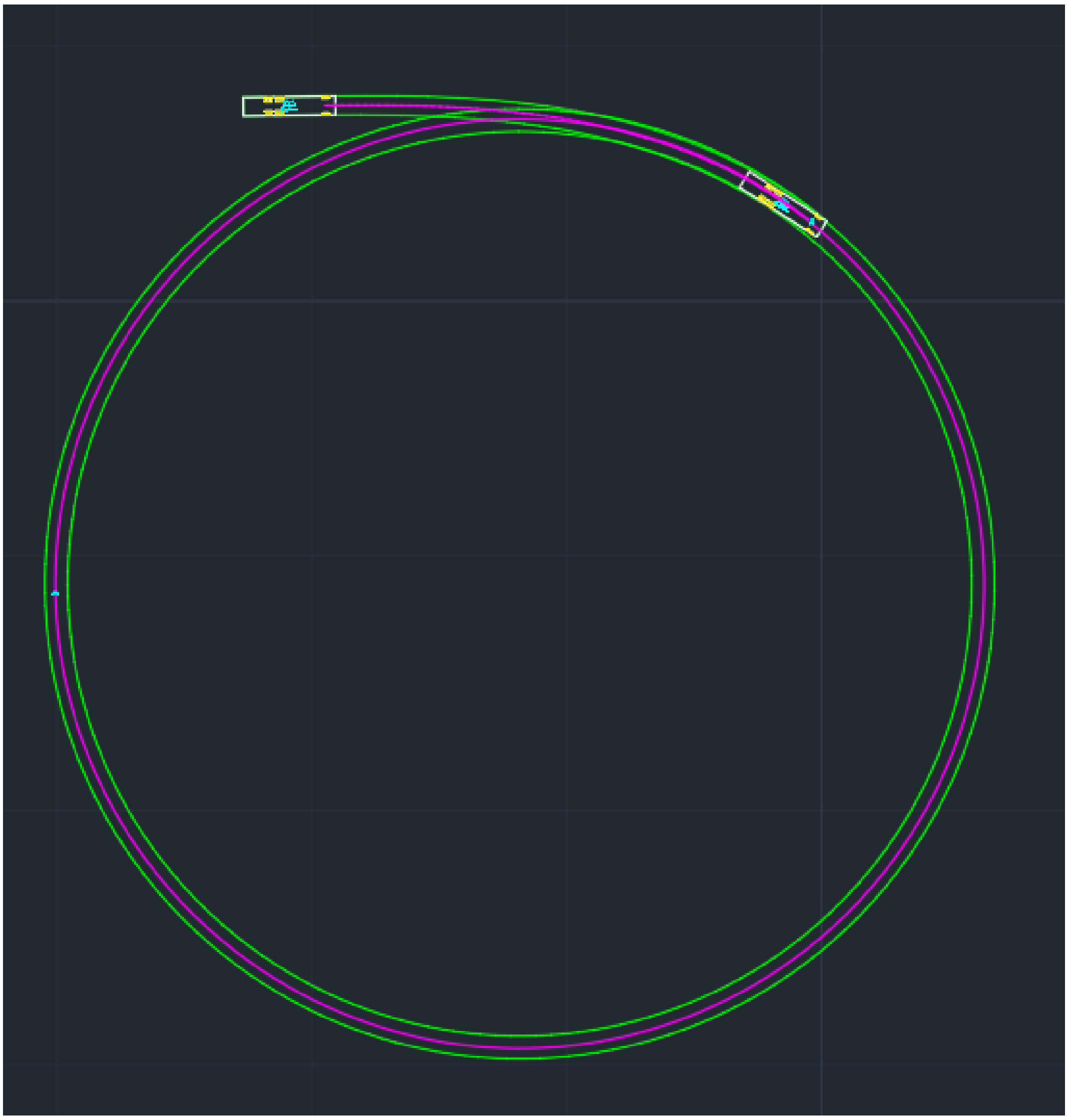
= 33.084 km/h

Turning angle θ = 15^0

Turning Radius = 2027 / Tan 15^0

= 7564.36 mm

= 7.56436 m



Maximum speed = √0.75 X 9.8 X 7.56436

= 7.45 m/s

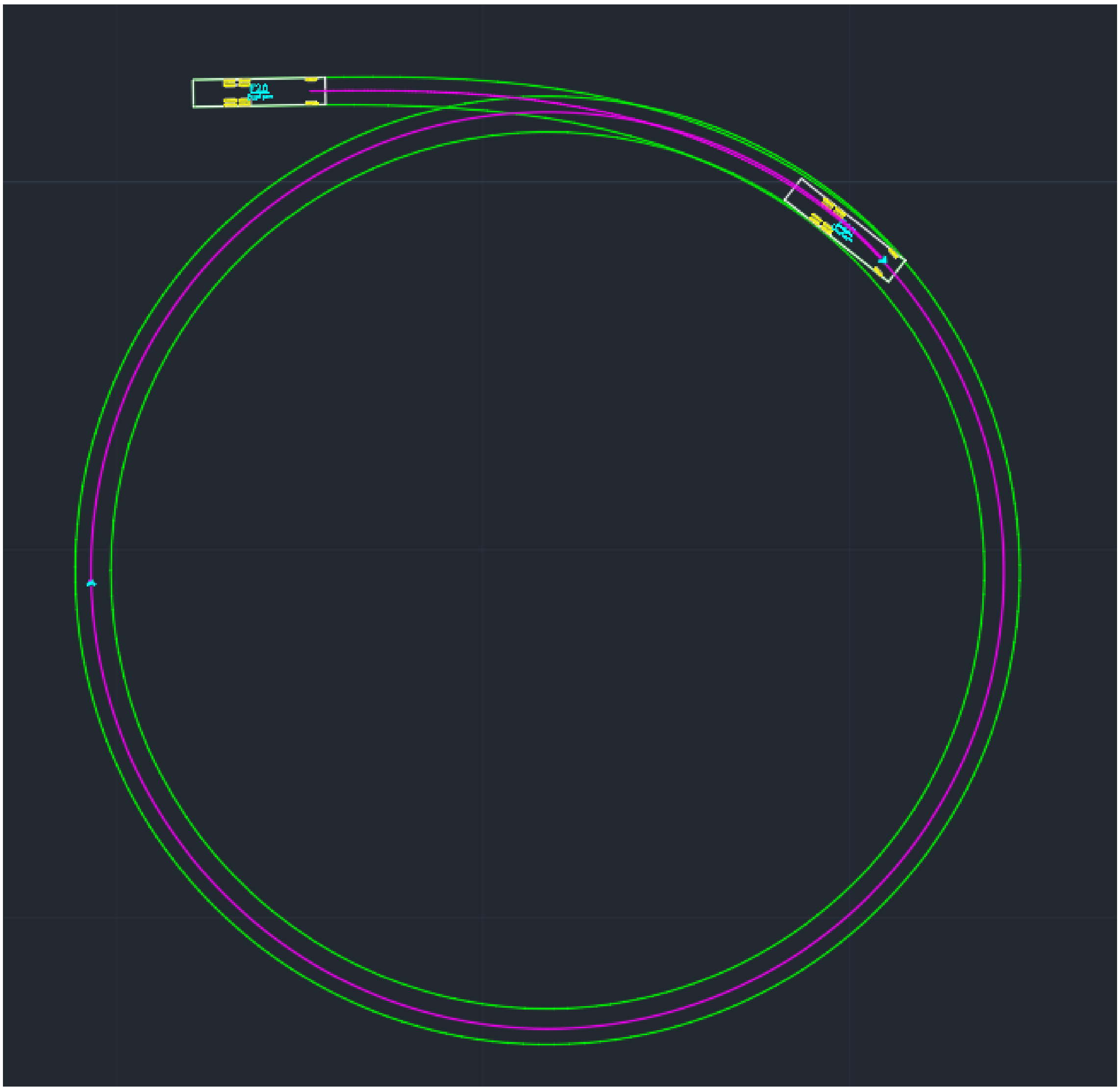
= 26.82 km/h

Turning angle θ = 20^0

Turning Radius = 2027 / Tan 20^0

= 5569.13 mm

= 5.56913 m



Maximum speed = $\sqrt{0.75 \text{ X } 9.8 \text{ X } 5.56913}$

= 6.39 m/s

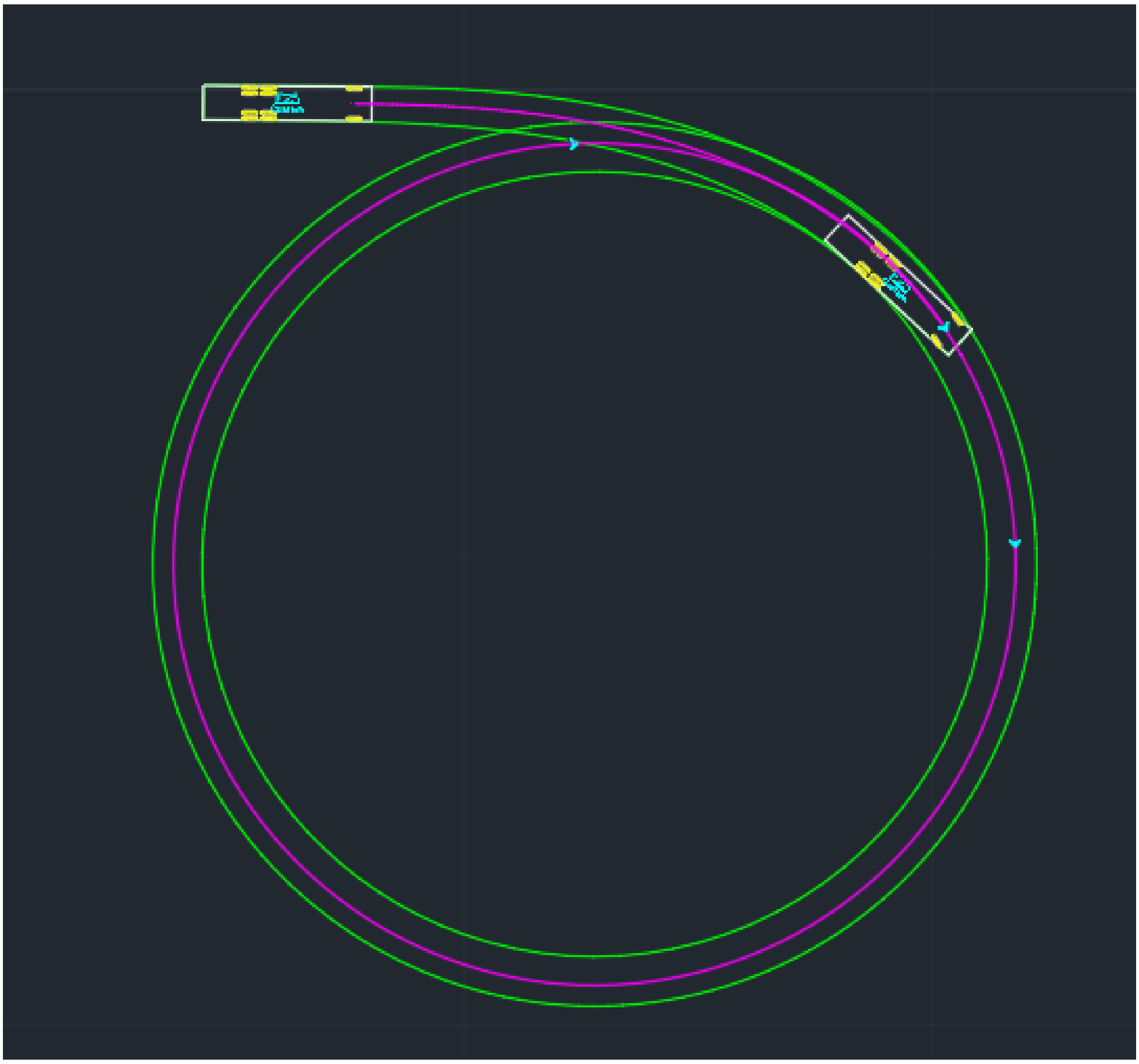
= 23.004 km/h

Turning angle θ = 25^0

Turning Radius = 2027 / Tan 25^0

= 4346.91 mm

= 4.34691 m



Maximum speed = $\sqrt{0.75 \times 9.8 \times 4.34691}$

= 5.65 m/s

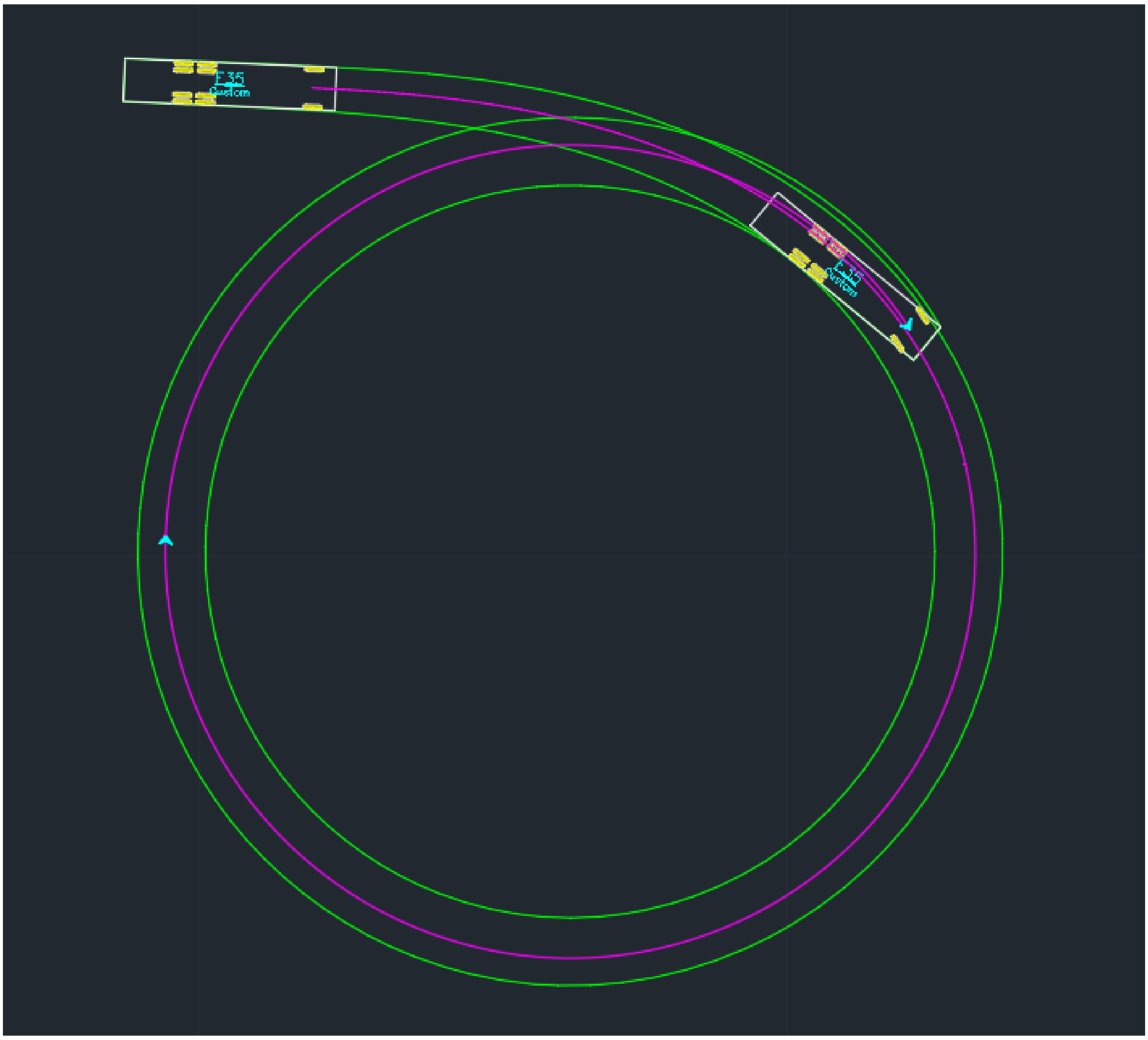
= 20.34 km/h

Turning angle θ = 30^0

Turning Radius = 2027 / Tan 30^0

= 3510.86 mm

= 3.51086 m



Maximum speed = √0.75 X 9.8 X 3.51086

= 5.07 m/s

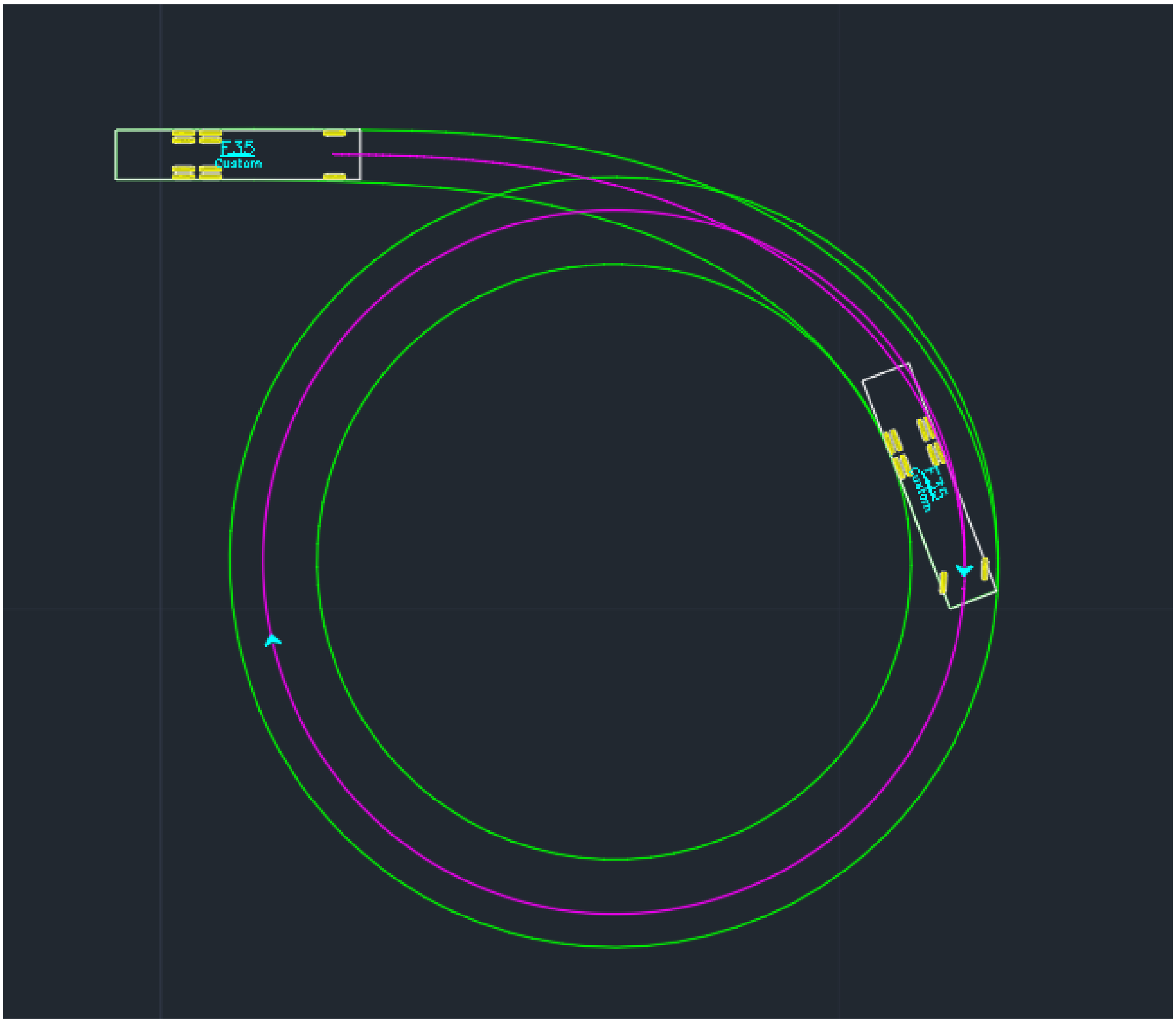
= 18.252 km/h

Turning angle $\theta = 35^0$

Turning Radius = 2027 / Tan 35^0

= 2894.35 mm

= 2.89435 m



Maximum speed = $\sqrt{0.75 \text{ X } 9.8 \text{ X } 2.89435}$

= 4.61 m/s

= 16.596 km/h

Failure Calculations:

Turning angle $\theta = 40^0$

Turning Radius = 2027 / Tan 5^0

= 2415.68 mm

Turning angle $\theta = 45^0$

Turning Radius = 2027 / Tan 5^0

= 2027.00 mm

As per our calculations the vehicle will be turning it front wheel about 35^0 only. So, 40^0 and 45^0 are failure calculations.

5.2 For front and rear wheel turning:

Front	**Rear**	**Turning radius**
5^0	2^0	16508.59 mm
10^0	4^0	8129.85 mm
15^0	6^0	5230.51 mm
20^0	8^0	3812.23 mm
25^0	10^0	2894.85 mm
30^0	12^0	2251.20 mm
35^0	14^0	1762.04 mm

TABLE 5.2: Front and rear wheel combined turning radius

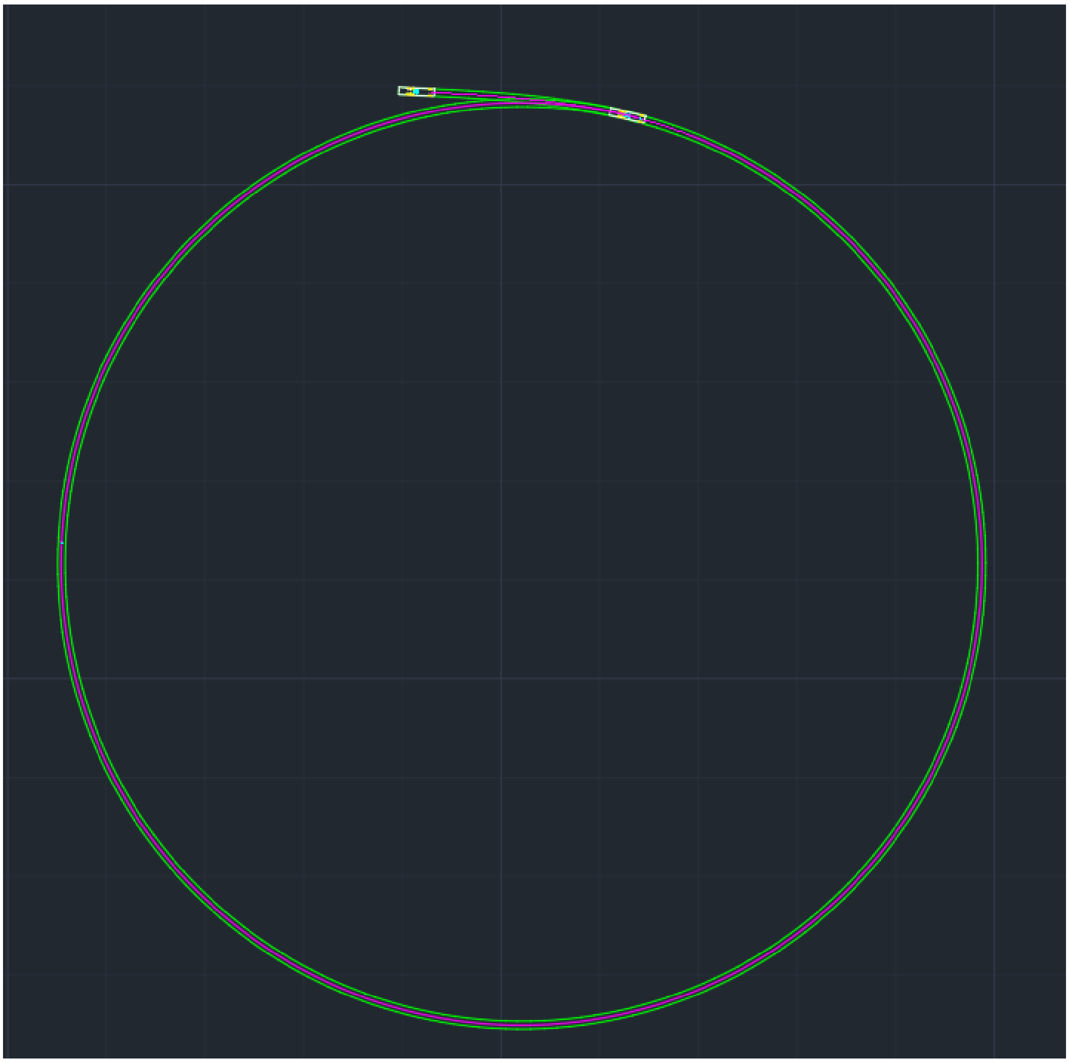
For every 5^0 turn of front wheel, the rear wheel eventually turns 2^0. The rear wheel is turned maximum 14^0 in order to avoid the roll over and shift of centre of mass and centre of gravity.

Turning angle θ = $5^0 + 2^0 = 7^0$

Turning Radius = 2027 / Tan 7^0

= 16508.59 mm

= 16.50859 m



Maximum speed = $\sqrt{0.75 \times 9.8 \times 16.50859}$

= 11.01 m/s

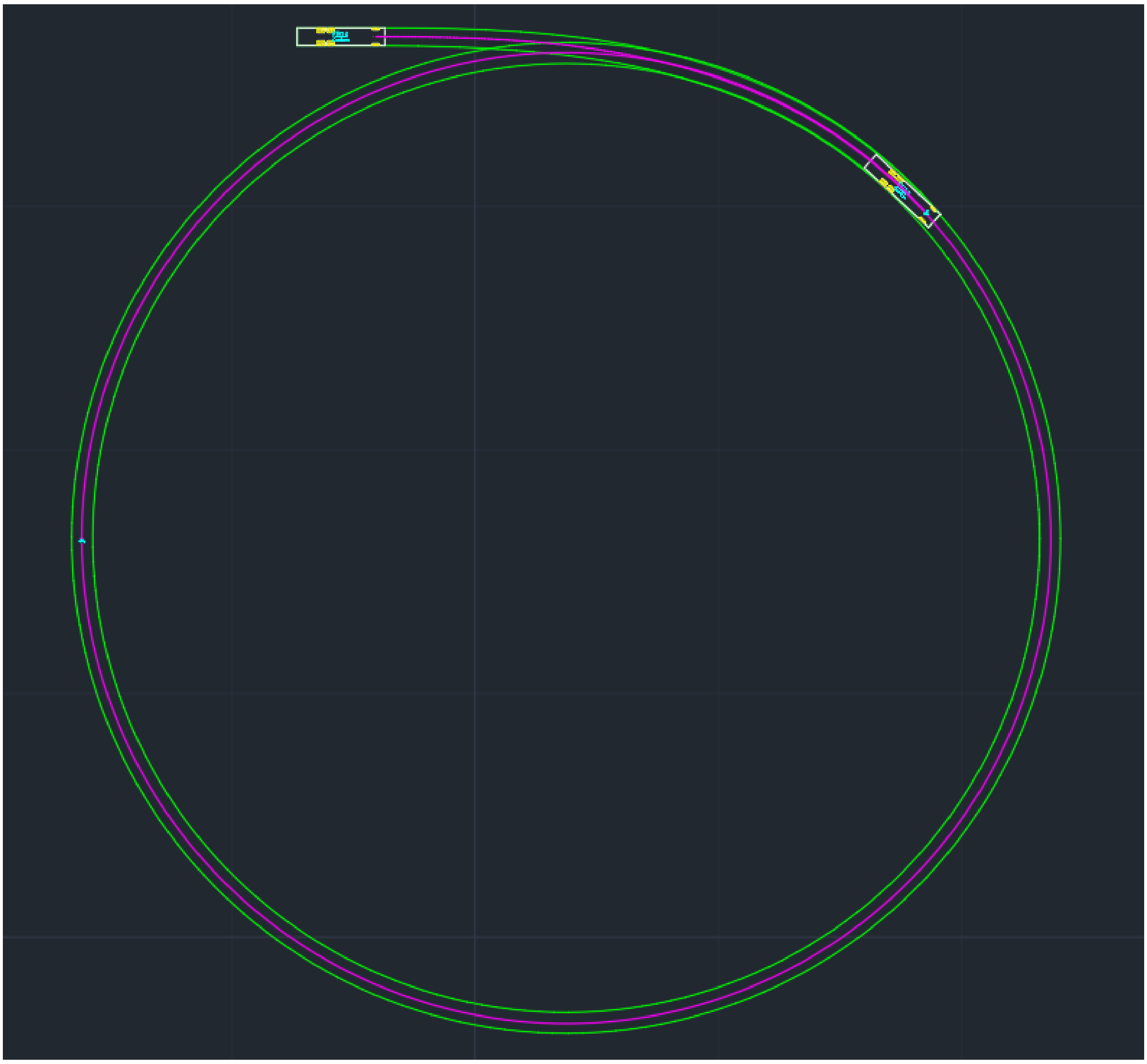
= 39.636 km/h

Turning angle θ = $10^0 + 4^0 = 14^0$

Turning Radius = 2027 / Tan 14^0

= 8129.85 mm

= 8.12985 m



Maximum speed = $\sqrt{0.75 \times 9.8 \times 8.12985}$

= 7.73 m/s

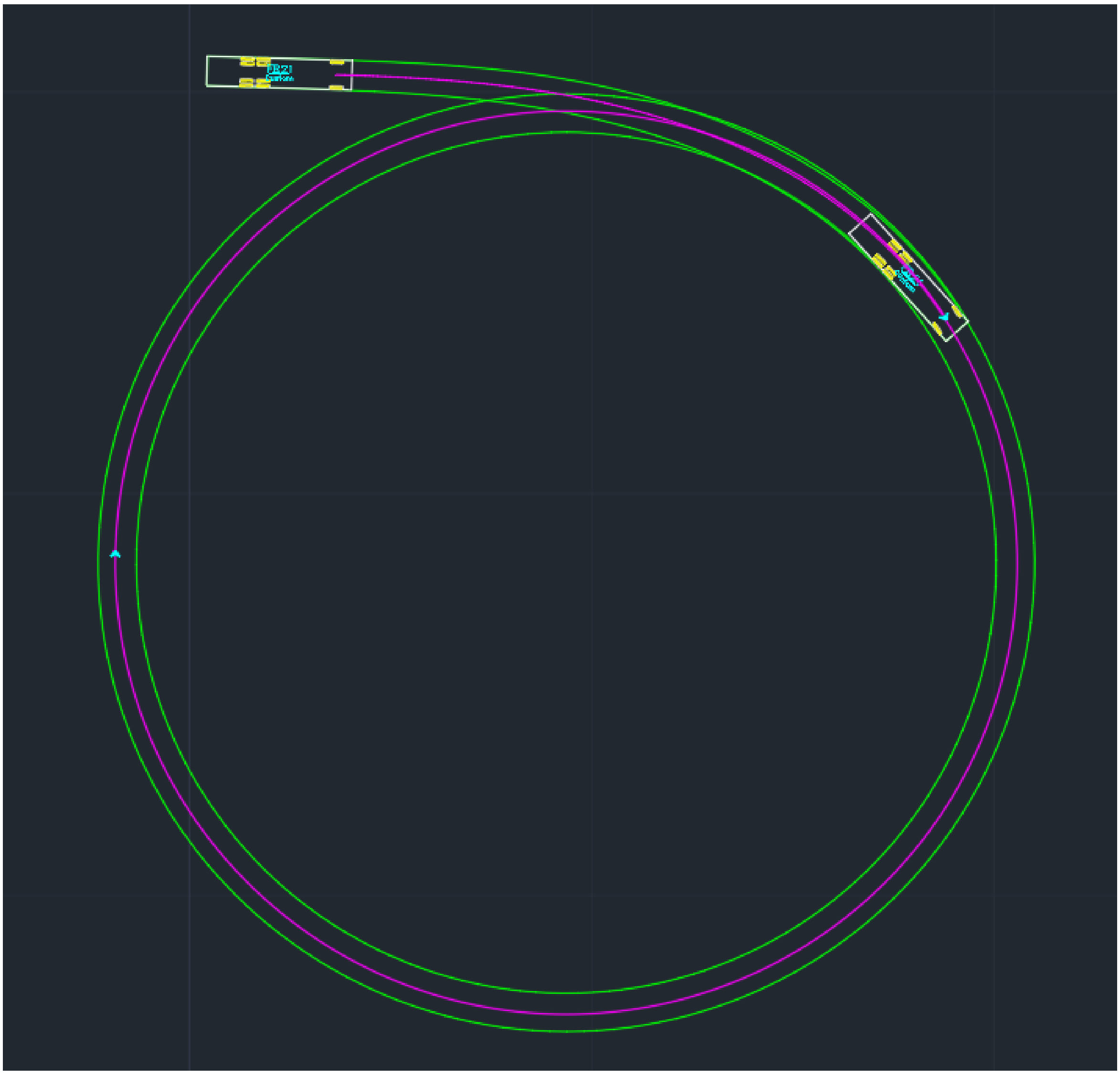
= 27.828 km/h

Turning angle $\theta = 15^0 + 6^0 = 21^0$

Turning Radius = 2027 / Tan 21^0

= 5230.51 mm

= 5.23051 m



Maximum speed = $\sqrt{0.75 \times 9.8 \times 5.23051}$

= 6.20 m/s

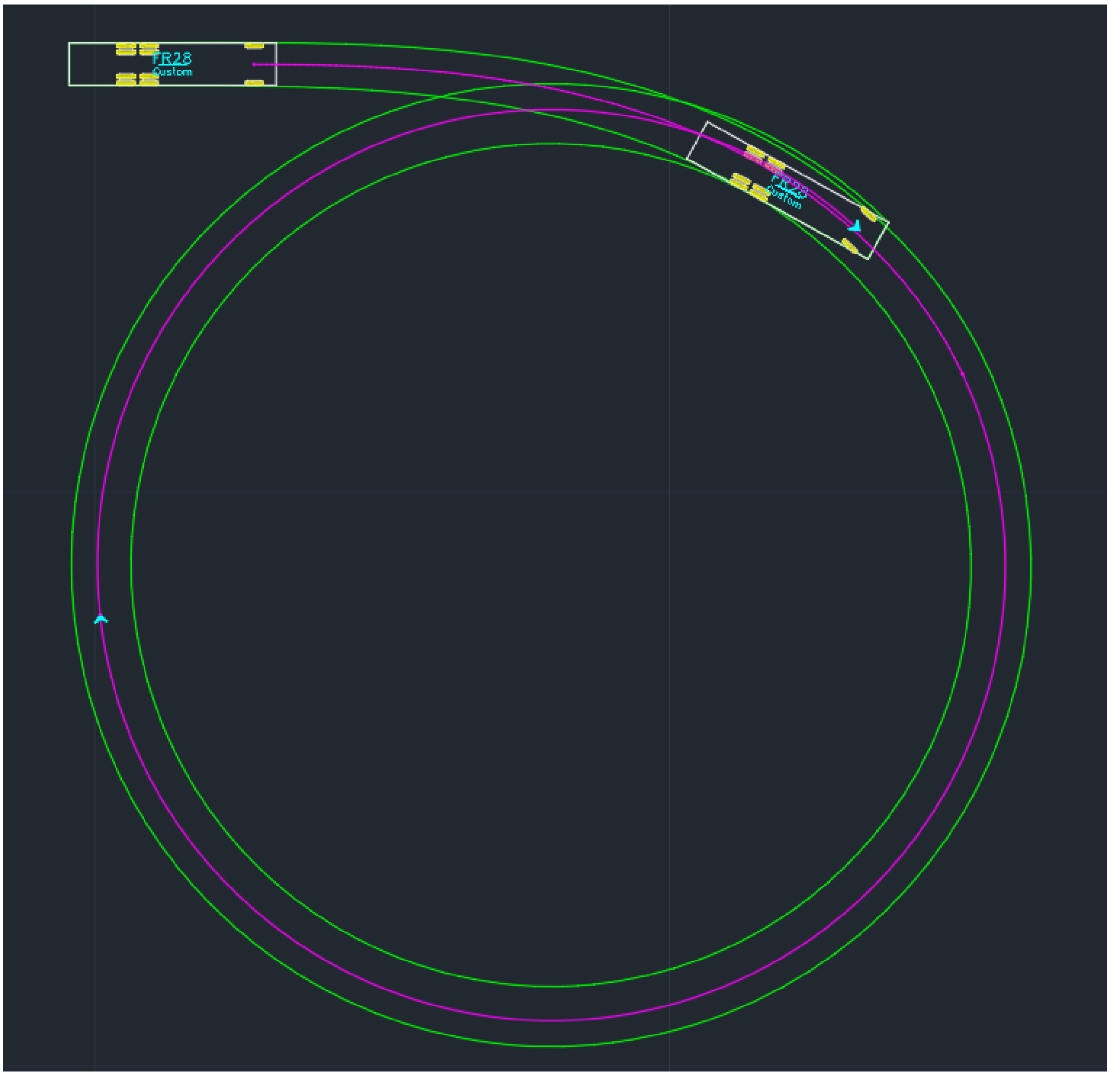
= 22.32 km/h

Turning angle $\theta = 20^0 + 8^0 = 28^0$

Turning Radius = 2027 / Tan 28^0

= 3812.23 mm

= 3.81223 m



Maximum speed = $\sqrt{0.75 \text{ X } 9.8 \text{ X } 3.81223}$

= 5.29 m/s

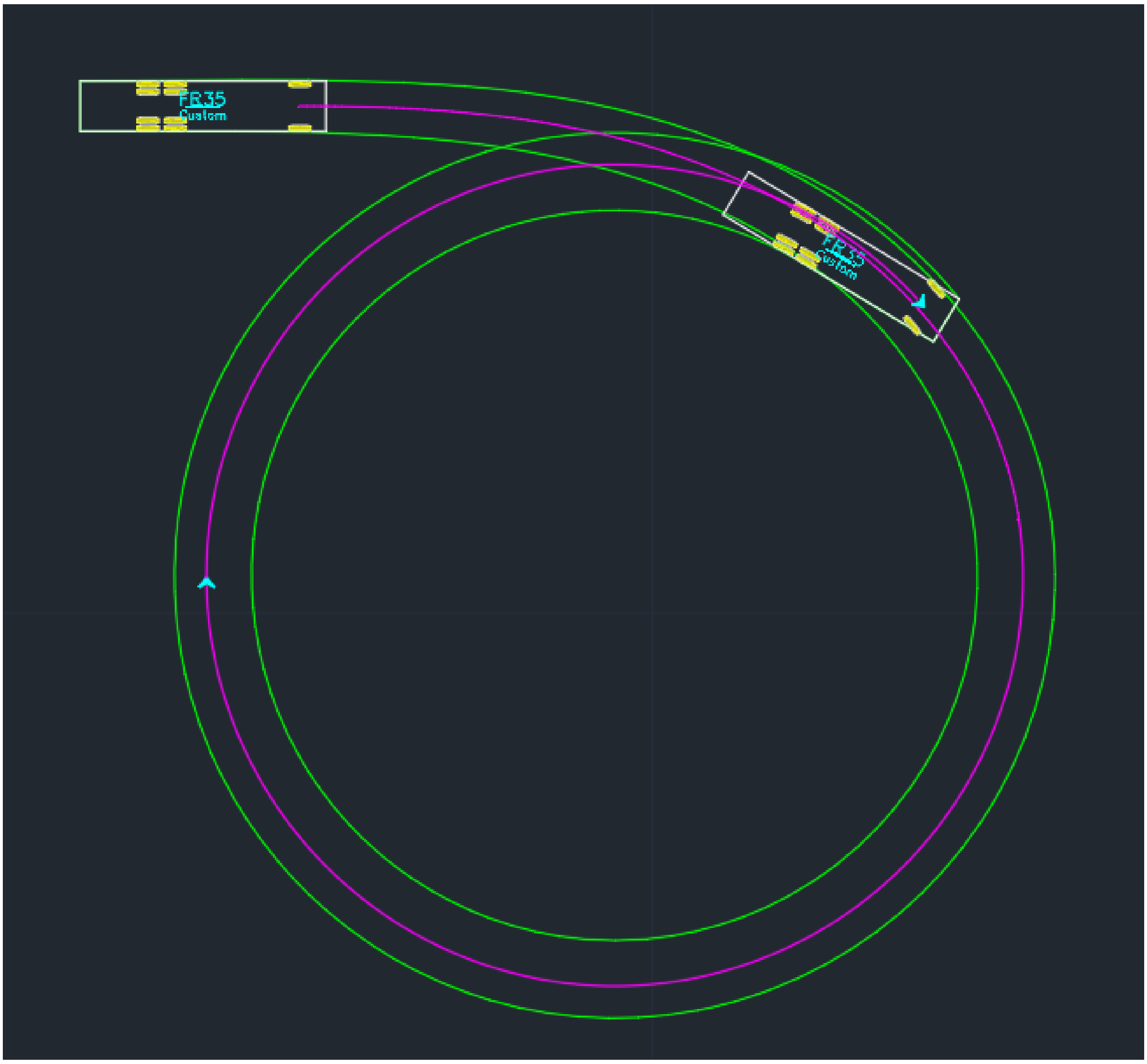
= 19.044 km/h

Turning angle θ = $25^0 + 10^0 = 35^0$

Turning Radius = 2027 / Tan 35^0

= 2894.85 mm

= 2.89485 m



Maximum speed = $\sqrt{0.75 \text{ X } 9.8 \text{ X } 2.89485}$

= 4.61 m/s

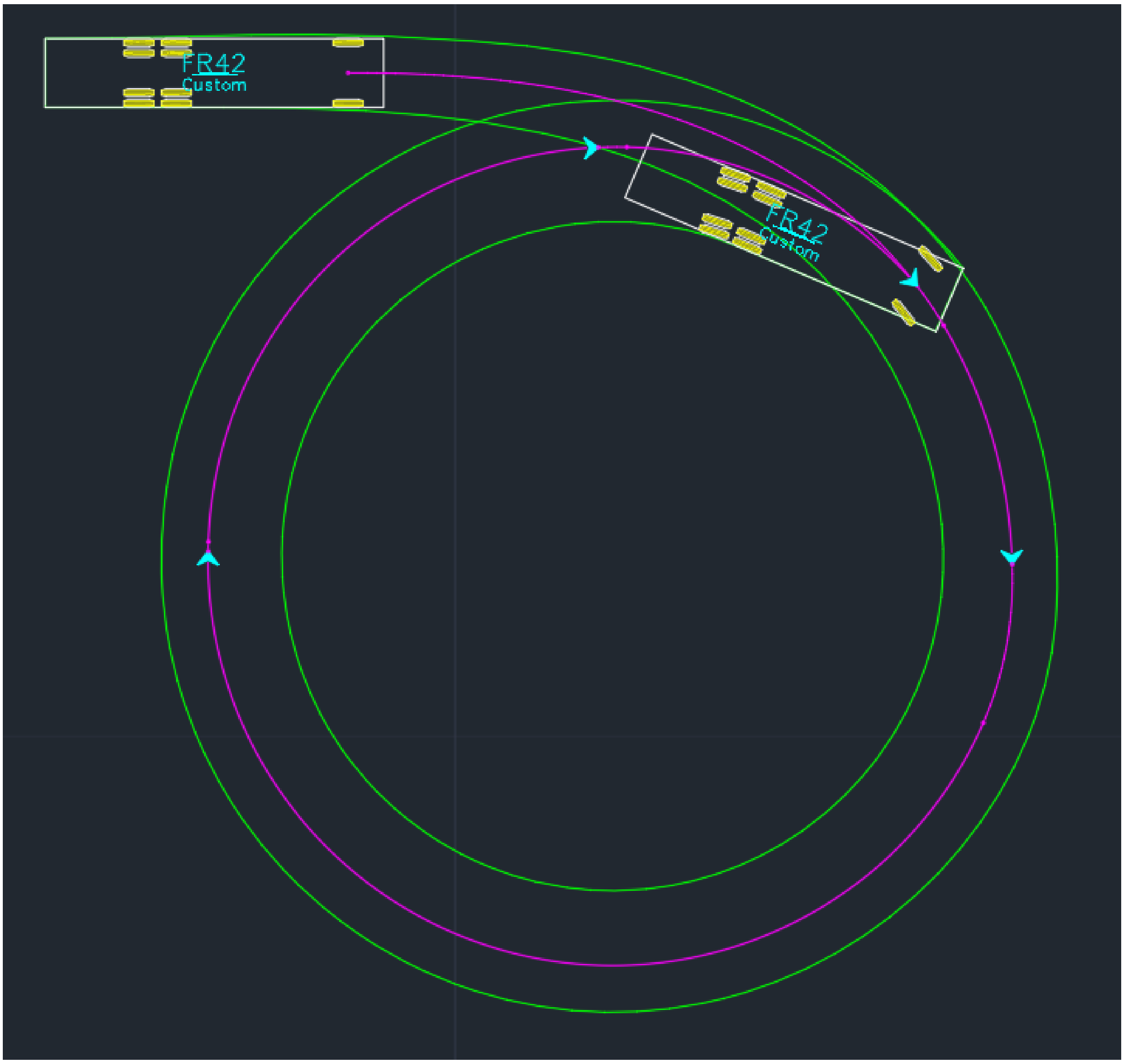
= 16.596 km/h

Turning angle θ = $30^0 + 12^0 = 42^0$

Turning Radius = 2027 / Tan 42^0

= 2251.20 mm

= 2.25120 m



Maximum speed = $\sqrt{0.75 \text{ X } 9.8 \text{ X } 2.25120}$

= 4.06 m/s

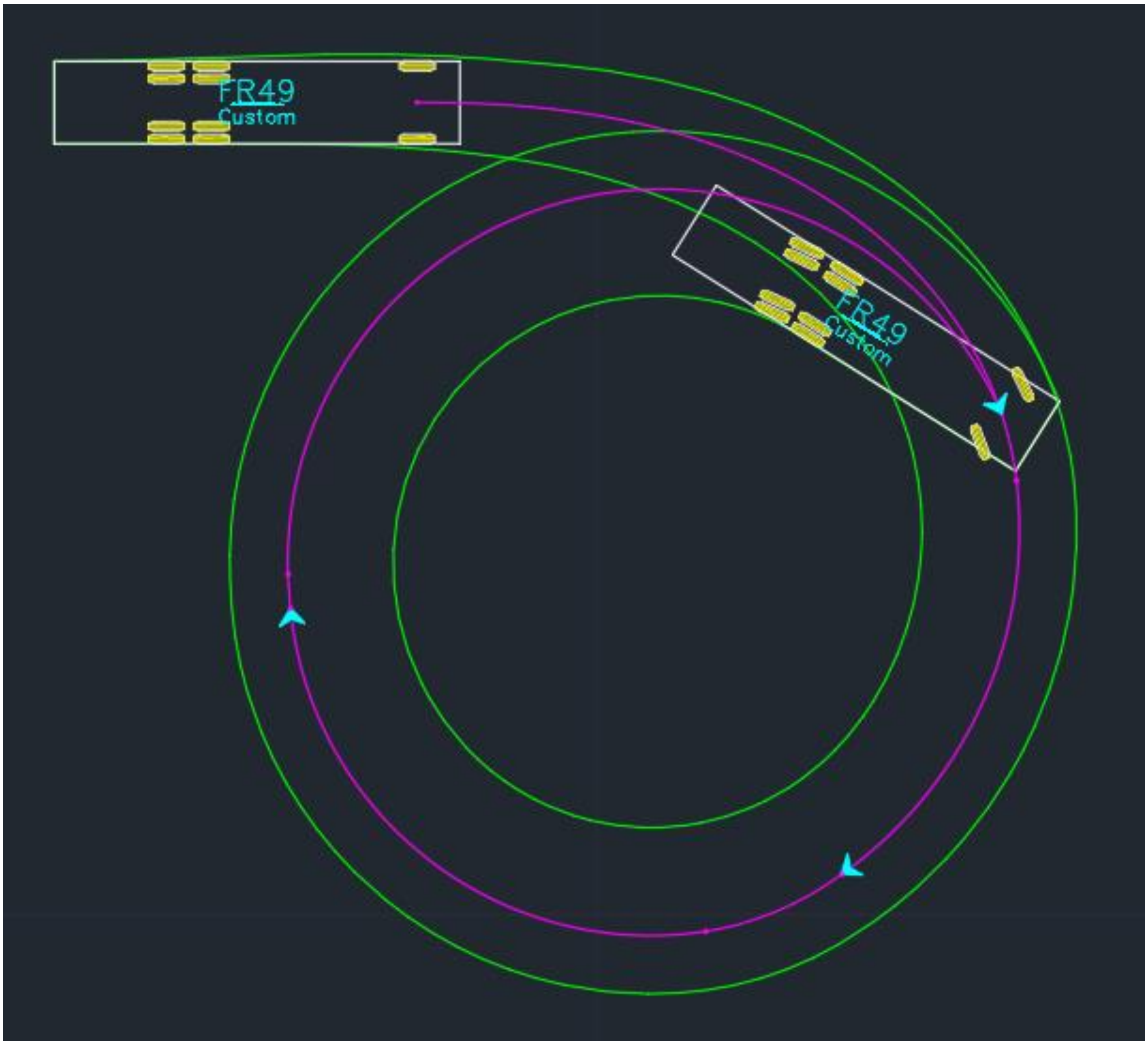
= 14.616 km/h

Turning angle $\theta = 35^0 + 14^0 = 49^0$

Turning Radius = 2027 / Tan 49^0

= 1762.04mm

= 1.76204 m



Maximum speed = $\sqrt{0.75 \text{ X } 9.8 \text{ X } 1.76204}$

= 3.59 m/s

= 12.924 km/h

CHAPTER 6

RESULTS AND DISCUSSION

Turning angle	Turning radius
5	23168.71 mm
10	11495.68 mm
15	7564.36 mm
20	5569.13 mm
25	4346.91 mm
30	3510.86 mm
35	2894.35 mm
40	2415.68 mm
45	2027.00 mm

TABLE 6.1: Turning angle and radius

The above table shows the turning angle of the wheel that we used in general. The values of the turning radius is also the approximate values in general irrespective of wheels selection and orientation.

Turning angle	Turning radius	Maximum Velocity
5	23168.71 mm	46.944 km/h
10	11495.68 mm	33.084 km/h
15	7564.36 mm	26.82 km/h
20	5569.13 mm	23.004 km/h
25	4346.91 mm	20.34 km/h
30	3510.86 mm	18.252 km/h
35	2894.35 mm	16.596 km/h
40	2415.68 mm	
45	2027.00 mm	

TABLE 6.2: Turning of front wheel

The above table gives the values of the turning radius of the front wheel. We made the wheel to turn for each 5 degrees, so that the values can be calculated more efficiently and accurately. We see that the maximum velocity is reduced as the turning radius decreases. Therefore it is said the maximum velocity and the turning radius are directly proportional to each other.

Front	Rear	Total degree	Turning radius	Maximum velocity
5	2	7	16508.59 mm	39.636 km/h
10	4	14	8129.85 mm	27.828 km/h
15	6	21	5230.51 mm	22.320 km/h
20	8	28	3812.23 mm	19.044 km/h
25	10	35	2894.85 mm	16.596 km/h
30	12	42	2251.20 mm	14.616 km/h
35	14	49	1762.04 mm	12.924 km/h

TABLE 6.3: Turning of both front and rear wheels

The above table gives the turning radius of each front and rear wheels. And the total turning degree is also seen. The front is wheel is turned to each of its 5 degrees and the rear wheel is turned to each of its 2 degrees. The both wheels are turned simultaneously and their respective turning radius is calculated. It is clearly seen that turning radius and the turning maximum velocity is getting reduced as the turning angle get higher. Therefore, it is seen that the turning angle is inversely proportional to the turning radius and maximum velocity.

Chapter 7

Conclusion

In this project the study of rear wheel turning movement of heavy vehicles is done. We calculated the values for design with the help of Buckingham pi theorem. With the values calculated we made our design with the help of solid works software. After design we calculated the values of moment of inertia, centre of gravity, turning radius of the vehicle. We also found the turning angle of their respective turning radius.

We strongly believe that our project will help in the reduction of turning radius of the long and heavy vehicles and make them turn easily. In turn it also reduces the traffic jam caused and also consumes less time to turn the vehicle and therefore people time will be saved. We also believe that out idea can be implemented on the large real time vehicle by giving them a proper steering system to turn.

We have also made the consideration of the rollover of the vehicle. Because in the turn process the rollover of the vehicle may occur and the vehicle may fall down or may cause accident. Roll over is caused by the operating the vehicle beyond its maximum velocity for turning. So, we have also calculated the maximum velocity at which the vehicle can travel so that it will be safe.

As per the calculations of the turning radius and maximum speed of the vehicle at that particular turning radius, if the vehicle is turned beyond the maximum speed, then rollover of the vehicle is possible.

We use AutoTURN software for our simulation. It is a software that is used to analyse the road, site design projects to pre plan the path. We use this software in order to trace the path of the vehicle to its maximum turning radius at a particular angle of the wheels. We used solid works for design. This is the software where all the design can be done and used for analyse the design.

We also believe that the friction and drag of the vehicle is reduced. Therefore, the wear and tear of the tyre is also reduced and it makes the user to be somewhat save money. This project can also be developed and further expanded in the future if needed. Thus, we conclude that our project helps in the real time process of automobile industry in the effective way.

CHAPTER 8

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STUDY OF REAR WHEEL TURNING MOVEMENT FOR HEAVY VEHICLES
Report submitted to the SASTRA Deemed to be University as the requirement for the course MEC300 MINI PROJECT Submitted by DHANVARSHAN G (Reg. No.:124009032) GOGUL S (Reg. No.:124009187) SANJAY S (Reg. No.:124009164)May 2023 SCHOOL OF MECHANICAL ENGINEERING THANJAVUR, TAMIL NADU, INDIA – 613 401 I

SCHOOL OF MECHANICAL ENGINEERING THANJAVUR, TAMIL NADU, INDIA – 613 401 Bonafide Certificate This is to

certify that the report titled "STUDY OF REAR WHEEL TURNING MOVEMENT FOR HEAVY VEHICLES" submitted as a requirement for the course, MEC 300 Mini-project for B.Tech. Mechanical Engineering programme, is a bonafide record of the work done by Mr. DHANVARSHAN. G (Reg. No.-124009032), Mr. GOGUL. S (Reg. No.-124009187), Mr. SANJAY.S

(Reg. No.-124009164) during the academic year 2022-23, in the Mechanical Engineering, under my supervision. Signature of Project Supervisor : Name with Affiliation : Dr. A. P. Mohan Raj, Senior Assistant Professor Date : 18/05/2023Mini-project Viva-voce held on ____Examiner 1 Examiner 2 II

SCHOOL OF MECHANICAL ENGINEERING THANJAVUR, TAMIL NADU, INDIA – 613 401 Declaration We declare that the

report titled "

STUDY OF REAR WHEEL TURNING MOVEMENT FOR HEAVY VEHICLES"

submitted by us is an original work done by us under the guidance of Dr.

A. P. Mohan Raj, Senior Assistant Professor, School of Mechanical Engineering,

SASTRA Deemed to be University during the even semester of the academic year 2022-23, in the School of Mechanical Engineering. The work is original and wherever we have used materials from other sources, we have given due credit andcited them in the text of the report.

This report has not formed the basis for the award of any degree, diploma,

associate-ship, fellowship or other similar title to any candidate of any University. Signature of the candidate(s) : Name of thecandidates : DHANVARSHAN. G, GOGUL. S, SANJAY.S Date : 18/05/2023 III

Peer Evaluation Form for Group Work

Name**: Dhanvarshan. G**

Write the name of each of your group members in a separate column. For each person, indicate the extent to which you agree with the statement on the left, using a scale of 1-4 (1=strongly disagree; 2=disagree; 3=agree; 4=strongly agree). Total the numbers in each column

Evaluation Criteria	Group member: Gogul. S	Group member: Sanjay. S
Attends group meetings regularly and arrives on time	4	4
Contributes meaningfully to group discussions.	4	4
Completes group assignments on time	4	4
Prepares work in a quality manner	4	4
Demonstrates a cooperative and supportive attitude	4	4
Contributes significantly to the success of the mini-project.	4	4
TOTAL	24	24

Feedback on team dynamics:

1.How effectively did your group work?

The group worked effectively throughout the project.

2. Were the behaviours of any of your team members particularly valuable or detrimental to the team? Explain.

N/A.

3. What did you learn about working in a group from this mini-project that you will carry into your next group experience?

Taking initiatives

Self Evaluation Form for Group Work

Name**:** Dhanvarshan. G

	Seldom	Sometimes	Often
Contributed good ideas			✓
Listened to and respected the ideas of others			✓
Compromised and cooperated			✓
Took initiative where needed			✓
Came to meetings prepared			✓
Communicated effectively with teammates			✓
Did my share of the work			✓

My greatest strengths as a team member are:

- Ability to listen and understand the work, finding ways to solve the errors or problems and taking initiatives
- A good team member and coordinates the team and listening to their words.
- I prioritized timely completion of my tasks and actively supported my teammates throughout

The group work skills I plan to work improve are

- Should plan for regular discussions frequently and make progress on a daily basis

Peer Evaluation Form for Group Work

Name**: Gogul. S**

Write the name of each of your group members in a separate column. For each person, indicate the extent to which you agree with the statement on the left, using a scale of 1-4 (1=strongly disagree; 2=disagree; 3=agree; 4=strongly agree). Total the numbers in each column

Evaluation Criteria	Group member: Dhanvarshan. G	Group member: Sanjay. S
Attends group meetings regularly and arrives on time	4	4
Contributes meaningfully to group discussions.	4	4
Completes group assignments on time	4	4
Prepares work in a quality manner	4	4
Demonstrates a cooperative and supportive attitude	4	4
Contributes significantly to the success of the mini-project.	4	4
TOTAL	24	24

Feedback on team dynamics:

1.How effectively did your group work?

The group worked effectively throughout the project.

2. Were the behaviours of any of your team members particularly valuable or detrimental to the team? Explain.

N/A.

3. What did you learn about working in a group from this mini-project that you will carry into your next group experience?

Taking initiatives

Self Evaluation Form for Group Work

Name: Gogul S

	Seldom	Sometimes	Often
Contributed good ideas			✓
Listened to and respected the ideas of others			✓
Compromised and cooperated			✓
Took initiative where needed			✓
Came to meetings prepared			✓
Communicated effectively with teammates			✓
Did my share of the work			✓

My greatest strengths as a team member are:

- Coordinating the team.
- Having some good knowledge in solid works.
- Helping with my ideas.
- Never give up attitude.

The group work skills I plan to work improve are:

- To be calm in pressure situations.
- Complete the work as early as possible.
- Learn more about new technology.
- Finishing the work in time.

Peer Evaluation Form for Group Work

Name**: Sanjay. S**

Write the name of each of your group members in a separate column. For each person, indicate the extent to which you agree with the statement on the left, using a scale of 1-4 (1=strongly disagree; 2=disagree; 3=agree; 4=strongly agree). Total the numbers in each column

Evaluation Criteria	Group member: Dhanvarshan. G	Group member: Gogul. S
Attends group meetings regularly and arrives on time	4	4
Contributes meaningfully to group discussions.	4	4
Completes group assignments on time	4	4
Prepares work in a quality manner	4	4
Demonstrates a cooperative and supportive attitude	4	4
Contributes significantly to the success of the mini-project.	4	4
TOTAL	24	24

Feedback on team dynamics:

1.How effectively did your group work?

The group worked effectively throughout the project.

2. Were the behaviours of any of your team members particularly valuable or detrimental to the team? Explain.

N/A.

3. What did you learn about working in a group from this mini-project that you will carry into your next group experience?

Taking initiatives

Self Evaluation Form for Group Work

Name**:** Sanjay S

	Seldom	Sometimes	Often
Contributed good ideas			✓
Listened to and respected the ideas of others			✓
Compromised and cooperated			✓
Took initiative where needed			✓
Came to meetings prepared			✓
Communicated effectively with teammates			✓
Did my share of the work			✓

My greatest strengths as a team member are:

- Coordinating the team.
- Motivating my team members.
- Helping with my ideas.
- Never give up attitude.

The group work skills I plan to work improve are:

- To be calm in pressure situations.
- Complete the work as early as possible.
- Learn more about new technology.
- Designing skills in solidworks.