جامعة الأمير محمد بن فهد

PRINCE MOHAMMAD BIN FAHD UNIVERSITY

College of Engineering

Department of Mechanical Engineering

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Senior Design Project Report

Design and Fabrication of Go-Kart

Team Members

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Chapter 1: Introduction

This chapter based on the four major sections, which are enumerated below:

1.1 Project Definition

The go-kart is a vehicle that is small, quick, light, and simple to drive. Since the go-kart is designed for flat-track racing, it has a very poor ground clearance relative to most cars, but it does not have suspension. Engine, steering, suspension, tires, and bumpers are the elements of a go-kart. A go-engine kart is either a two-stroke or a four-stroke engine. The word "eco-kart" refers to a car that uses electric motors instead of an engine. Go-karting is a form of open-wheel motorsport that involves lightweight, open-wheeled vehicles with four wheels. To feel the excitement, the chassis is independent of the suspension.

Because of its ease, low cost, and safer way of racing, go-karting is a perfect outlet for those involved in racing. It is possible to have an indoor or outdoor track. The go-kart tracks are much smoother than the F1 tracks. Go-karting experience will better introduce the driver to the actual racing environment, allowing them to participate as professional motor racer in various competitions.

This project is intended to design and fabricate a low-weight go-kart. To reduce the weight of this vehicle, the main effort in this project is to select material. Hence, by choosing an appropriate material for its fabrication, one can reduce the overall weight of this vehicle.

1.2 Project objectives

Following are the main objectives of this project:

1. Selection of a suitable material for designing.
2. Designing of Go-Kart on software.
3. Analysis of Vehicle on an analysis software
4. Fabrication of Go-Kart

1.3 Project Specifications

Material: 304 Stainless Steel

Mechanical Properties of grade 304 stainless steel

Property	Value
Elastic Modulus	200-210 GPa
Yield Strength	190 Mpa
Tensile Strength	500-700 Mpa
Elongation	35-45%

Chemical composition of grade 304 of Stainless Steel

Element	Percentage
C	0.07
Cr	19.5
Mn	2
Ni	10.5
Si	1

Engine: 110 CC

Chasis: Seamless Tube

Wheelbase: 1066.8 mm

The total length of the vehicle: 1779 mm

Engine Type: 110 cc

Ground Clearance: 2 inches from the bottom

1.4 Applications

Following are the applications of Go-kart:

1. It is used in racing.
2. Outdoor karts are also typically used for traditional kart racing, but these are more robust as mainly comprising of four-stroke engines.
3. Indoor karts are used in warehouses and factories, and typically, these are smaller in size than outdoor karts.

Chapter 2: Literature Review

2.1 Project Background

The Go-Kart is a simple, lightweight, compact, and simple-to-run car. Unlike other vehicles, the go-kart is specifically built for racing and has very little ground clearance. Engine, wheels, steering, tires, suspension, and frame are the most common components of a go-kart. Due to the go-poor kart's ground clearance, no suspension can be mounted. (CHAUHAN, 2016) Go-karts are primarily used in racing; that's why for the maximum acceleration of these vehicles, it is mandatory to reduce its weight—the cars have low acceleration and high torque. But in the case of racing, the driver always needs a less-weight vehicle so that it will cause an increase in speed. Because of its ease, low cost, and safer way of driving, go-karts are a perfect choice for those involved in racing. The go-kart track is similar to an F1 racecourse. Go-karts can be approved for use on public roads in certain countries. A go-kart on the street in the European Union, for example, must have headlights (high/low beam), taillights, a whistle, markers, and a limit of 20 horsepower.

2.2 Previous Work

MRF launched go-karts to India in 2003, with a 125cc four-stroke engine that produces 15 bhp and costs about three lakhs. Go-kart is also available from Indus Motors for 1 lakh to 3 lakhs. Go-karting racing circuits can be found in Nagpur, which is regarded as India's go-kart capital. The race attracts a large number of participants and is becoming increasingly successful. Go-karts in other countries do even better than Indian go-karts. A single-engine 160cc 4-stroke kart with a top speed of about 40 mph and a twin-engine 320cc 4-stroke kart used outdoors with a top speed of 70 mph are two styles. There are hundreds of karting tracks in the United States, and they are much more professional than those in India. (Quazi, 2018)

Taking part in a run Over the last 50 years, go-kart racing has developed into one of the most competitive forms of motor racing in the United States. Kart racing has acted as a turning stone for many drivers seeking careers in NASCAR and Formula One; all began their careers in this less costly but high-octane style of motorsports racing. Karting can cater to almost everyone as a leisure sport. From 5 to 75, people of all ages have taken to driving Go-Karts worldwide in search of an exciting way to have fun. In reality, several amusement parks have introduced concession Karts, which are rented racing Go Karts with detuned four-stroke engines for a slighter experience. Most karting historians credit Californian Art Ingels for being the first to build a racing go-kart, also known as a go-kart. It didn't take long for this craze to catch on, and go-kart tracks began to emerge all over the United States. By the late 1950s, an American company had adapted a two-stroke chain saw engine to produce the McCullochMC-10, the first motor designed exclusively for go-kart racing. (D. Raghunandan, 2016)

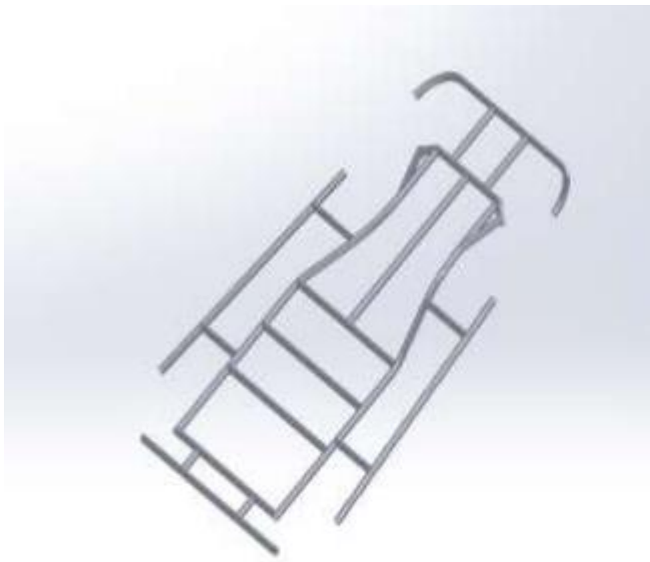


Figure 1: Design of chassis in Solidworks (D.Raghunandan, 2016)

According to Larry (Hui, 2011), karting began as a recreational sport for airmen in the 1950s in America following World War II. When the practice was shared among the commons, it gained attention. Art Ingels, also known as the "Father of Karting," invented the first go-kart in 1956 in California, America.

The kart was created in its most simplistic shape, consisting of only the most essential parts that could meet the basic requirements for a miniature race car. The frame, engine, and tires are among these elements. According to the International Recreational Go-Kart Association's report on the history of go-karts, no suspension was planned for that go-kart due to economic and weight considerations.

2.3 Comparative Study

In this section, we did a targeted study to study all those projects that have consideration regarding weight reduction. Following are the relevant studies of go-kart:

This project aimed to build a go-kart based on a conceptual design that was optimized to improve the vehicle's stability. The definition is based on a CIK-FIA-affiliated rule book. The Go-design kart's and fabrication focuses on creating a simple, lightweight, and easy-handle vehicle. The architecture requirements included ergonomics, safety, and reliability considerations. Both significant components were evaluated to enhance vehicle performance, improve strength and rigidity, and reduce complexity and manufacturing costs. (Thatavarthy.Rasmi1, 2019)

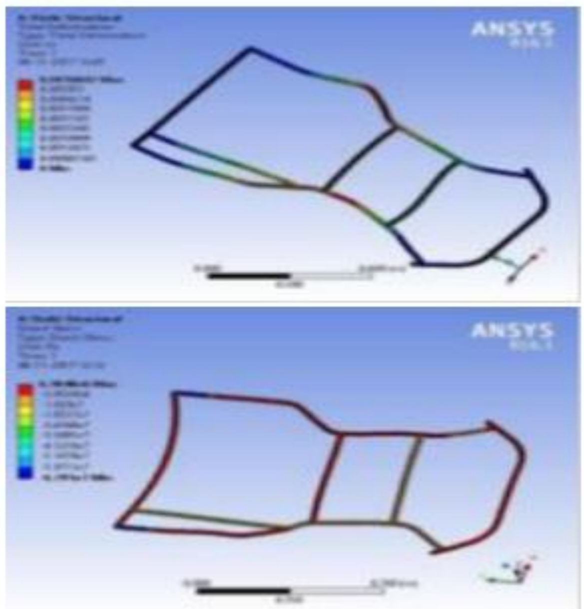


Figure 2: Go-kart analysis on Ansys (Thatavarthy.Rasmi1, 2019)

Different forms of fiberglass have other properties and use. Different prototypes for the fiberglass-made go-kart chassis were developed, and each design was simulated to obtain valuable details about the plan. Different wall thicknesses of the chassis, different types of reinforcements used, and additional structural factors are all examples of design variants. When a go-kart chassis is filled with 70 kg or roughly 687 N, the bending deflection is estimated to be about 5.229 mm. The simulation data was compared to the desired value, and a good design was chosen. The decision was taken not only based on the performance but also on factors such as component assembly ease, fabrication ease, and comfort level. Finally, the concept model was designed, and experiments were conducted to ensure that the configuration suited what had been simulated. (Hui, 2011)

Figure 3: Plywood molding of Go-Kart (Hui, 2011)

This paper aims to simplify the overall design of a go-kart to make it easy and light in weight without causing premature failure or a drop in speed since vehicle efficiency is determined mainly by the optimal design of its various components. The optimal Go-kart concept was developed, evaluated, and recast using the Finite Element Analysis (FEM) technique to achieve its goal. In addition to CAD tools, Go-Kart components were developed and evaluated using other approaches. Finally, the serviceability, protection, power, expense, standardization, ergonomics, and aesthetics of a proposed design will be considered. (BRAR, 2020)

After a comprehensive study of all the projects as mentioned earlier, where keeping the go-kart light-weighted was one of the consideration, I get to know that in all above explained projects, the researchers have reduced the weight of go-kart by using plywood molding and incorporating fiberglass into structures, or optimizing the design of chassis or by many other different ways. While what we did was to select a suitable material of grade of 304 stainless steel, which was having all the required properties of yield strength, tensile strength, and elastic modulus in the proper range. By selecting this material, we ensured the reduction in the vehicle's weight without changing or optimizing the design of the car.

Chapter 3: System Design

3.1 Design Constraints

Following are the design constraints in the design of go-kart:

1. **Weight Considerations**

   In the design of go-karts, the weight has always remained an integral element because increased weight is directly linked to a decrease in acceleration of these go-karts, mainly used as racing cars.

2. **Compact Design**

   The next most daunting challenge is designing a go-kart in a very compact and user-friendly manner.

3. **Ergonomics**

   This factor is very significant in designing as here; the designer is concerned about the driver's comfort. It will be easy and simple for the driver to drive and have a comfortable environment while traveling. But it is very difficult to induce a comfortable environment for the driver in designing go-karts while remaining within the range of allowable weight.

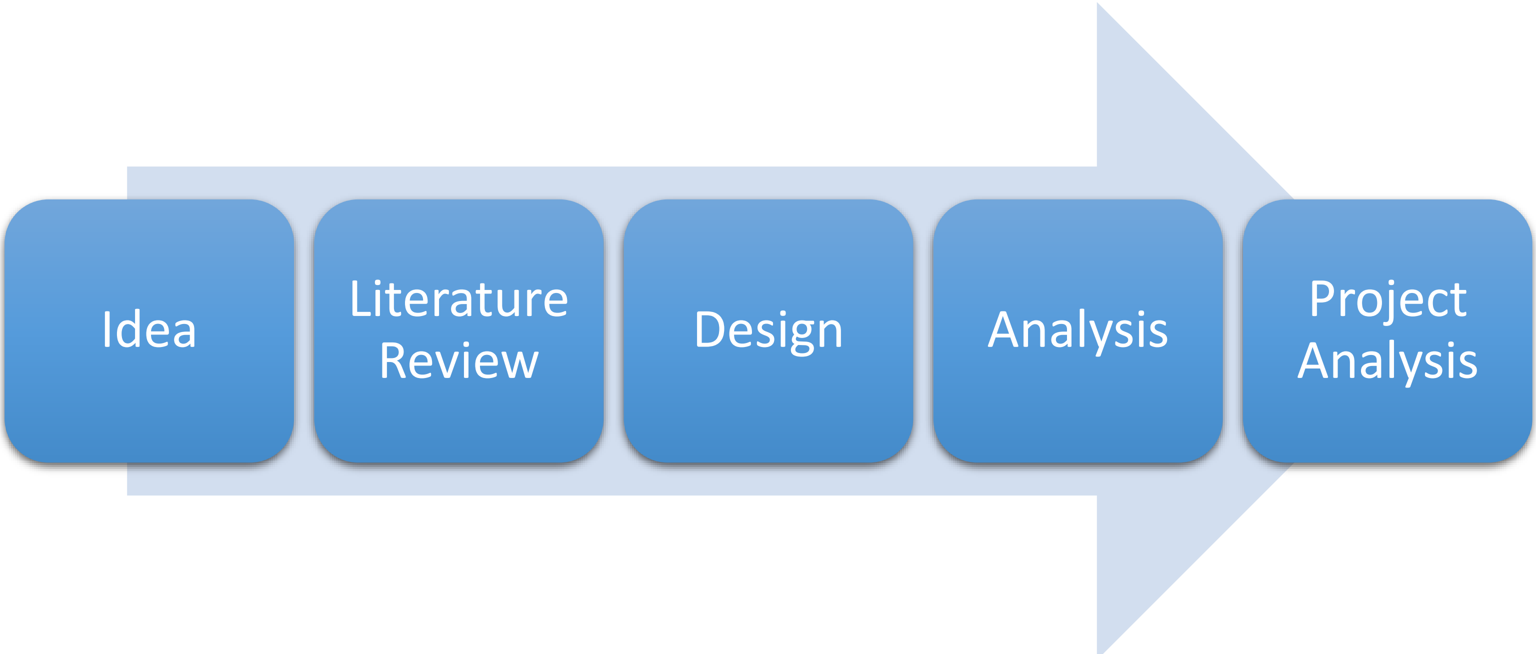
4. **Environmental Considerations**

   Here the main concern is to avoid the negative impact on the environment, and for this use of high-quality fuel and proper combustion in the engine is to be managed while designing the go-kart.

3.2 Design Methodology

The design methodology is often perceived as the flow of work in a project means that how the idea is executed in the form of product in the end. This is usually shown as a flow chart to get an idea in the form of pictorial representation. This flow chart shows how the project is initiated with an idea and how it is executed. This is the efficient design methodology that differentiates the project in the end.

Figure 4: Flow chart showing design methodology of go-kart



- ✓ Idea: The Idea is to design a lightweight vehicle, and for that, we analyzed different options to reduce the weight of the go-kart.
- ✓ Literature review: In this section of methodology, we have gone through the previous projects where different techniques have been adopted to reduce the weight of the vehicle, but in the end, we went with a selection of a material that is lightweight.
- ✓ Design: In this section, we selected the material of grade 304 of stainless steel, which is lightweight. The rest of the project is designed as per the usual designs of the go-kart. The only difference here is the material of this product.
- ✓ Analysis: In this part of the project, we will analyze and test prototype one. We will be done with designing a go-kart with our selected material.
- ✓ Project Analysis: In the end, we will do the cost analysis of the project that how different costs are being managed in the designing of this project.

3.3 Project subsystems and components

Following are the subsystems and components of a go-kart that are to be designed on software before entering into the area of fabrication:

Chassis: The skeleton structure of a go-kart is made up of pipes and other components with different cross-sections. Since there is no suspension, the go-kart frame must have stability, torsional rigidity, and a comparatively high degree of flexibility. It also has enough power to withstand the weight of the operator and other accessories. The chassis was created with the operator's comfort and protection in mind. The frame was designed to have a stable journey, and the load is added without jeopardizing the structural integrity.

Seat: This kart's seat is also built to be lightweight; it's made of simple plastic and is only connected to the frame by four points. The seat's backrest angle is 13 degrees, which is a decent spot for the driver's body rest from an ergonomics standpoint, and it is almost parallel to the firewall. The seat in our go-kart has a good ride.

Steering: The lines drawn through each of the four-wheel axes would converge at the instantaneous center to actual roll for a four-wheeled vehicle driving on a curved track. Since the front wheel angular locations are alternated to correct the steered vehicle's direction, the exact location of the instantaneous center is continually shifting. The instantaneous centers lie somewhere in an imaginary stretched line traced through the axis of the rear axle when all rear wheels are mounted on the same axis, but the front wheel axles are independent of each other. The Ackermann theory is based on the pivoting of the two front-steered wheels at the axle-beam ends.

Transmission System: In an automobile, a transmission system is a device that transfers the power provided by the engine to the wheels. The power supplied by the engine in a go-kart is transferred to the rear two wheels through the cord. According to John, a traditional go-kart has no differential and can be classified as a non-shifting direct drive kart. This means that the motor drives the rear axle directly through the chain. In reality, compared to the shifter kart, the direct drive kart is still the most popular in the industry because the mechanical configuration is much simpler, and the cost is lower.

Tires: The tires used on a go-kart are often determined by the track conditions. When the weather is muddy, wet tires are used, and when the weather is dry, slippery tires are used. Although some of the karts would use intermediate tires with a reasonable degree of grooves to deal with conditions that are in between rainy and dry, some would use wet/dry tires. The complete tread patterns on both the wet and intermediate tires were designed to remove water trapped between the road surface and the tires.

3.4 Implementation

In this section of system design, we have designed the go-kart on a modeling software that is Solid Works by using the software. As per the idea of the project, we only changed the material of the go-kart that is 304 Stainless Steel; otherwise, all the design of the project remained as per the design of a typical go-kart. There are some pictures of the model below to have a practical insight into the project:

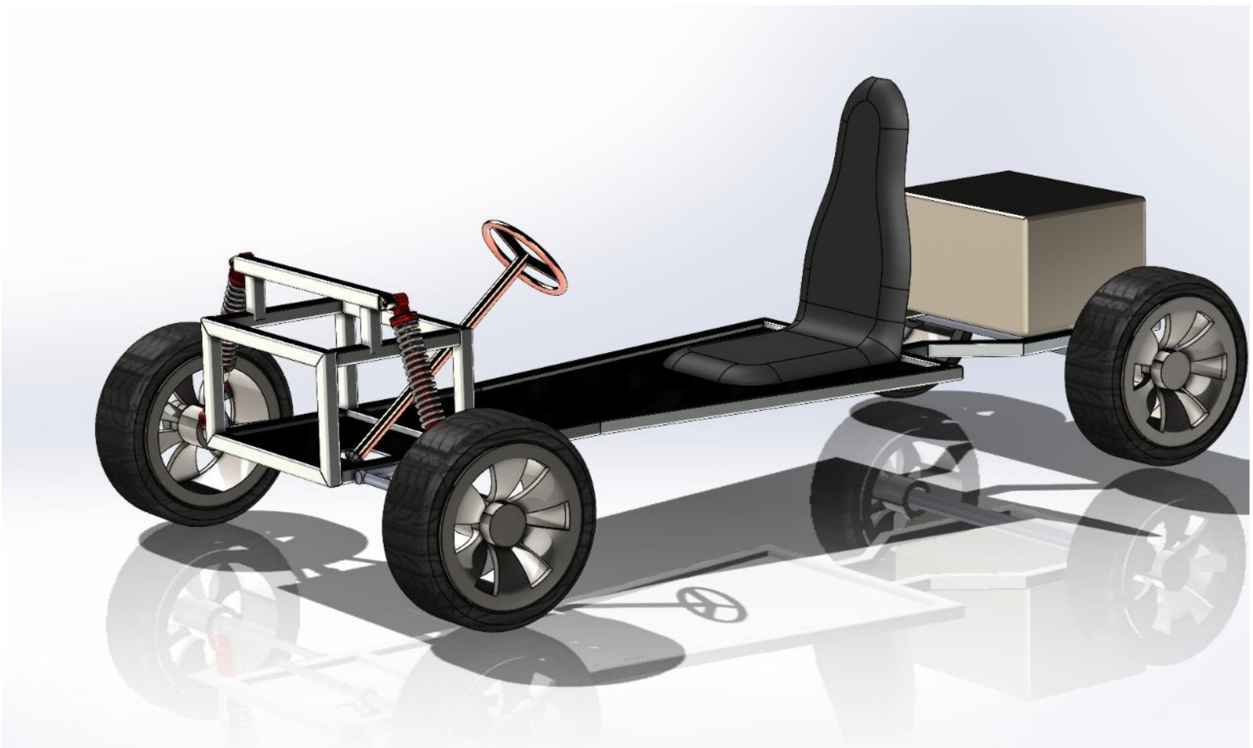


Figure 5: Model of Go-Kart

The use of a mechanical arrangement is expected. This steering system was chosen due to its basic operating mechanism and a steering ratio of 1:1, so we used mechanical type linkage to keep it simple. Our steering geometry is 99 percent Ackerman and provides a 60-degree lock-to-lock steering wheel switch, which is ideal for the race track because it allows for fast turns with limited feedback while still being more accurate. We also reach a 2.37-meter perspective turning radius.

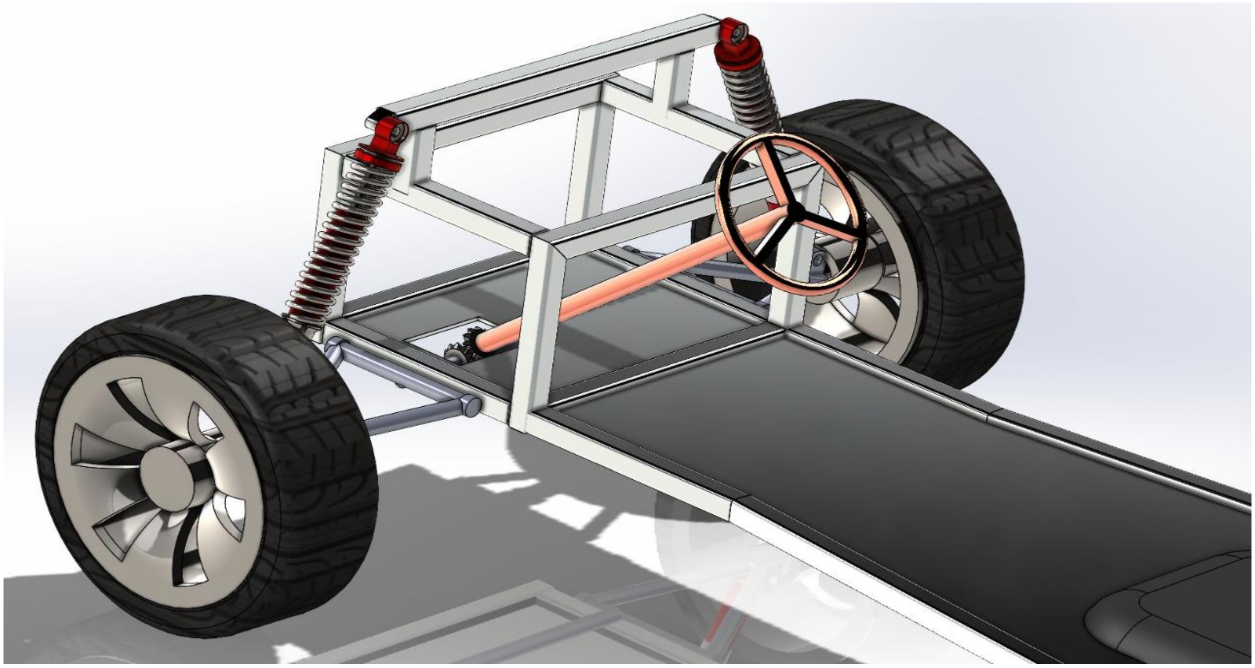


Figure 6: Steering mechanism of Go-Kart

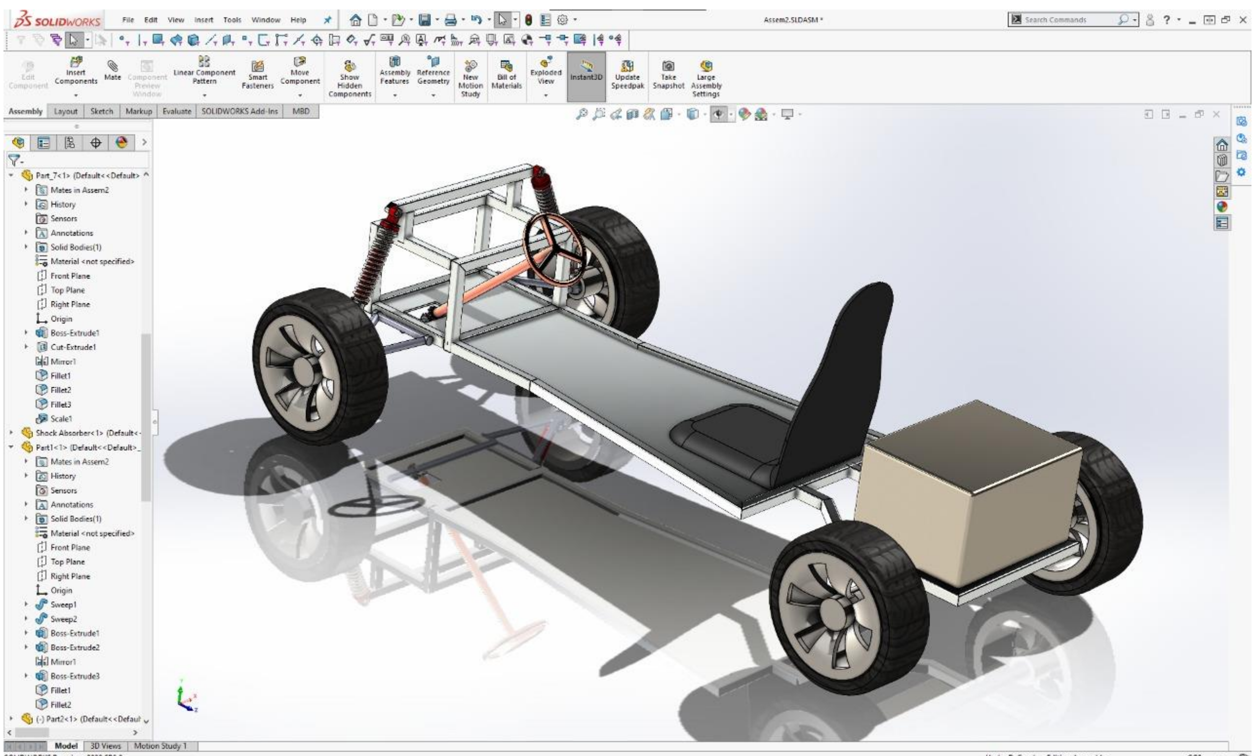


Figure 7: Side View of Go-Kart in Solid Works

After modeling of project, we went for its fabrication.

Chapter 4: System Testing and Analysis

4.1 Subsystem 1

The first major subcomponent is chassis which has been tested in impact tests in Ansys in all three ways, be it a front-impact test, side-impact test, and rear impact test.

The mass of a car with a driver is estimated to be 200 kg for the front impact test, and the vehicle is balanced with the impact force at a speed of 60 km/h for a second in the front portion of the frame. The effect of applied impact load is investigated for various load values of 4g, 6g, 8g, 10g, and 16g, which vary in driver protection.

The factor of safety is also calculated by:

$F.O.S. = Yield\ Strength / (Von - Mises\ stress)$

It is also shown in the result where the design is safe or fail.

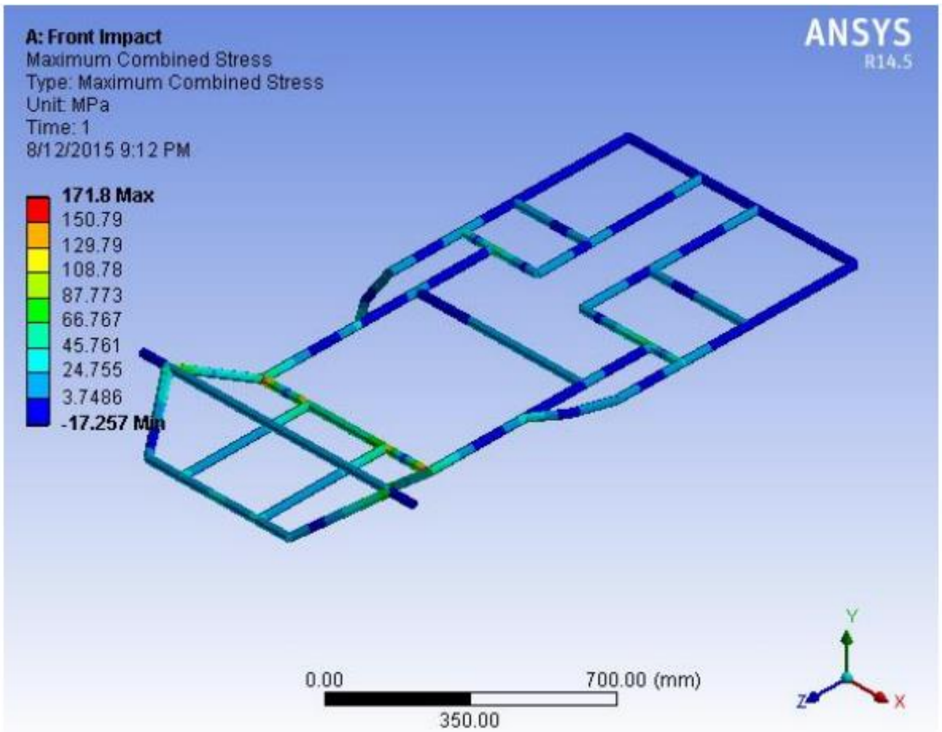


Figure 8: Front Impact test of chassis in Ansys work Bench

The mass of a car with a driver is estimated to be 200 kg for the rear impact test, and the body is countered with the impact force at a speed of 60 km/h for a second in the rear portion of the frame. The effect of applied impact load is investigated for various load values of 4g, 6g, 8g, 10g, and 16g, which vary in driver protection.

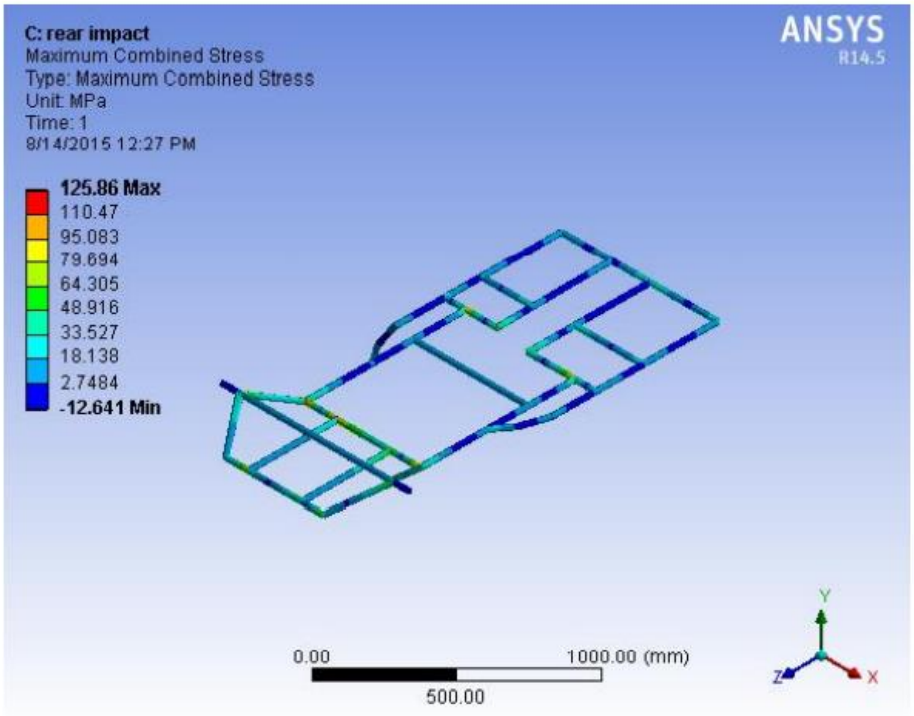


Figure 9: Rear Impact Test of chassis in Ansys workbench

The mass of a car with a driver is estimated to be 200 kg for the side impact test, and the vehicle is countered with the impact force at a speed of 60 km/h for a second in the side section of the frame. For driver safety, the effect of applied impact load is investigated at 3g and 5g.

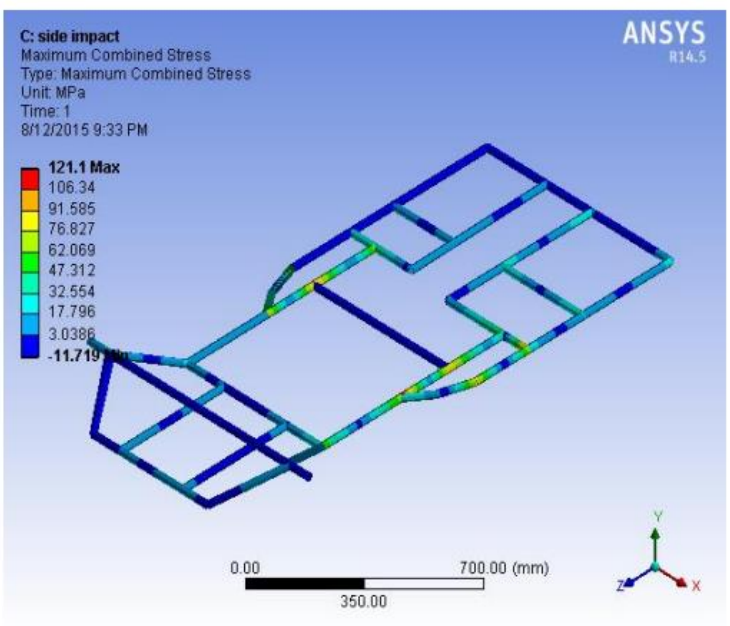


Figure 10: Side impact test of chassis in Ansys workbench

4.2 Subsystem 2

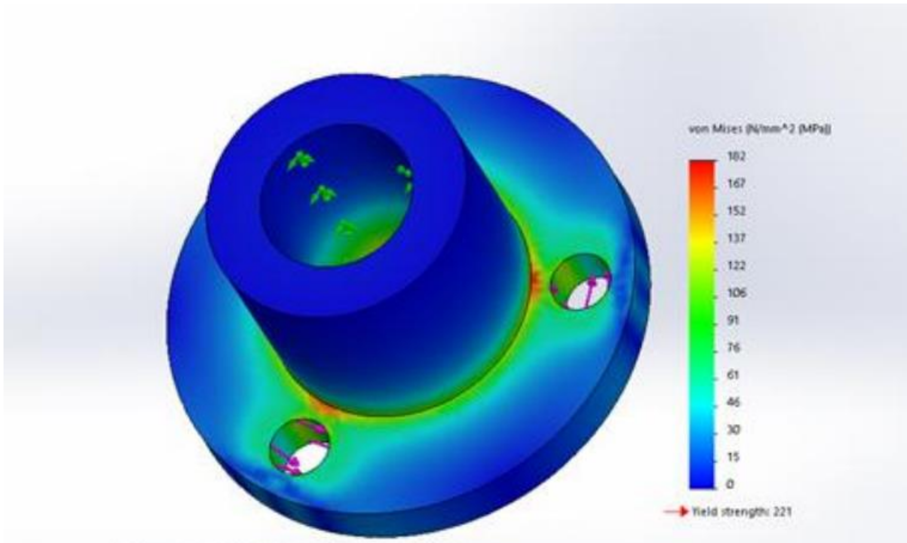


Figure 11: Analysis of wheel hub in Ansys workbench

4.3 Results and Discussions

1. According to the current investigation, no substance withstands the 10g, 16g loading requirement in the front-impact test for a designed chassis. 304 Stainless Steel is a more effective material as it provides a protected outcome for 4g, 6g, and 8g loading criteria.
2. According to the current inquiry, no substance withstands the 16g loading threshold in a rear impact test for a designed chassis. 304 stainless steel is a more effective material because it produces safer results for the 4g, 6g, 8g, and 10g loading criteria.
3. For side-impact testing, all materials provide a safe design, but 304 Stainless Steel is the most efficient material.

Hence, for all the tests, the safety factor is above 1 for the material of 304 stainless steel, which shows that's our choice of this material for meeting the weight considerations is right.

Chapter 5: Project Management

5.1 Project Plan

In our project, there are many tasks included. Each task is assigned to one or more members. The details about the division of the whole work are being presented below:

#	Tasks	Assigned Members	Start - End
1	Chapter 1: Introduction	✓ All	28th February – 1st March
2	Chapter 2: Literature Review	✓ Mohammed Al-Garni	2nd March – 10th March
3	Chapter 3: System Design	✓ Abdulaziz Aljamea selected the parameter based on which we reduced the weight of the kart.	11th March – 15th March
4	Chapter 4: System Testing and Analysis	✓ Mohammed Al-Garni performed testing and analysis of the project.	16th March – 25th March
5	Chapter 5: Project Management	✓ Abdulaziz Aljamea is assigned to perform project management, including the preparation of bills of materials and budget.	25th March – 31st March
6	Chapter 6: Project Analysis	✓ Hamad Alnaim is assigned to perform the project analysis of its impacts on the environment and which issues this project will address.	1st April – 5th April
7	Chapter 7: Conclusion and Recommendation	✓ All	6th April – 8th April
8	Design of Prototype	✓ Hamad Alnaim designed the kart on software.	9th April – 12th April
9	Parts Purchase	✓ Abdulhadi alqahtani purchases the selected material for fabrication.	13th April – 15th April
10	Manufacturing	✓ Abdulhadi alqahtani is required to supervise the whole fabrication process.	16th April – 22nd April

11	Completing Report	✓ Sultan Bujlai is required to complete the whole report as per the instructions provided by the supervisor.	23rd April – 25th April

Table 1: Plan of Work

5.2 Contribution of Team Members

The tasks were assigned to all the team members as per the project plan enunciated above. The contributions of team members to those tasks are given below:

#	Tasks	Assigned Members	Start - End	Contribution
1	Chapter 1: Introduction	✓ All	28th February – 1st March	100%
2	Chapter 2: Literature Review	✓ Mohammed Al-Garni	2nd March – 10th March	100%
3	Chapter 3: System Design	✓ Abdulaziz Aljamea selected the parameter based on which we reduced the weight of the kart.	11th March – 15th March	80%
4	Chapter 4: System Testing and Analysis	✓ Mohammed Al-Garni performed testing and analysis of the project.	16th March – 25th March	100%
5	Chapter 5: Project Management	✓ Abdulaziz Aljamea is assigned to perform project management, including the preparation of bills of materials and budget.	25th March – 31st March	80%
6	Chapter 6: Project Analysis	✓ Hamad Alnaim is assigned to perform the project analysis of its impacts on the environment and which issues this project will address.	1st April – 5th April	100%
7	Chapter 7: Conclusion and Recommendation	✓ All	6th April – 8th April	100%

8	Design of Prototype	✓ Hamad Alnaim designed the kart on software.	9th April – 12th April	100%
9	Parts Purchase	✓ Abdulhadi alqahtani purchases the selected material for fabrication.	13th April – 15th April	100%
10	Manufacturing	✓ Abdulhadi alqahtani is required to supervise the whole fabrication process.	16th April – 22nd April	100%
11	Completing Report	✓ Sultan Bujlai is required to complete the whole report as per the instructions provided by the supervisor.	23rd April – 25th April	100%

Table 2: Contribution of Team Members

5.3 Project Execution Monitoring

During our project, regular meetings and sittings were arranged to ensure continuous monitoring and meeting deadlines to accomplish goals. Following is the list of events and meetings being conducted during this whole period of project formulation:

Time/ Date	Activities/ Events
One time a week	Assessment class
Biweekly	Meeting with supervisor
Weekly	Meeting with group members
25th March 2021	First Evaluation by the group leader
10th April 2021	2nd Evaluation by the group leader
22nd April 2021	Final Test of Kart
25th April 2021	Final Evaluation by the group leader

Table 3: List of activities being performed from 28th February to 25th April

5.4 Challenges and Decision Making

Following are the issues and challenges being encountered during the execution of the project:

1. Issues in equipment:

   In the fabrication of the project, a selected engine where the weight to power ratio was high resulted in losing the kart's traction. That's why to balance the weight to power ratio, and I selected 110 CC engine. Firstly, we decided to install an electrical power steering. Still, as the car's power is high compared to the weight because there was a high risk that the car would lose its control with a little movement, we went for the stiff hydraulic steering, which will help us maintain the kart's stability.

2. Testing and Safety Concerns:

   In the testing phase of the project, we monitored the speed of the kart by attaching speedometers. As the required speed was not achieved in the first attempt, we further reduced the weight of the kart by optimizing the design kart. In this way, by keeping security concerns in mind, we finally achieved the desired speed of the kart. First, we added normal cushion seats, but then it was a bit dangerous, so we had to compromise our comfort for safety by installing bucket seats which are way safer than the ordinary seats.

3. Design Problems:

   We faced challenges in matting parts during the fabrication and assembling of kart because of the wrong tolerances we maintained in the first attempt. Then we redesigned shafts to meet the close tolerances to ensure a close fit during assembly. Moreover, we faced problems in designing complex parts like chassis, etc. But later on, things get smooth when we were successfully done with the testing of the kart.

5.5 Project Bill of Materials and Budget

The table below is showing the cost of parts that we purchased and the ones we designed. Moreover, it also illustrates the cost of the material for which we designed this kart.

Components	Costs (SR)
Shock Absorbers	100
Steering Wheel	100
Brake Pads	90
Exhaust Pipe	90

Arms	130
Engine	150
Tie Rods	100
Differential	130
Spark Plugs	30

Overall costs are as follows:

Total Cost	5000 SAR
Manufacturing Cost	2500 SAR
Laborers Cost	500 SAR
Material Cost	1300 SAR
Sand Cost	200 SAR
Galvanization Cost	500 SAR

Table 4: Overall cost of project analysis

Chapter 6: Project Analysis

6.1 Life-long Learning

When we worked on our project, we gained diverse knowledge about different things: software skills, hardware skills, time management skills, and project management skills. By working as a team, we learned how to manage tasks by ensuring time management and good communication skills with the team members. This part will explain the number of skills we gained since we worked on this project.

6.1.1 Software Skills

We gained hands-on experience working on software like MS Word, MS Powerpoint, and Solidworks in this project. For designing kart, we used the software of Solidworks, which helped us polishing our skills in this designing software. In addition to this, we learned about using word and PowerPoint while writing the report and making the presentation.

6.1.2 Hardware Skills

During our project, we learned about assembling the designed parts to fabricate the kart. We also have hands-on experience of the skill of welding. Moreover, I also learned about doing sound calculations before moving towards the fabrication part of the project. A small difference in calculations can result in a huge difference during the fabrication of the project.

6.1.3 Management Skills

During project work, we learned about time management that how deadlines can be met efficiently during the execution of the project. Moreover, there are many skills like distribution of work, teamwork, and leading the team in the right direction that I learned during the completion of the project.

6.2 Impact of Engineering Solutions

Following are the social, economic, and environmental impacts of our project:

6.2.1 Social Impacts of project

Our project has positive social impacts as it necessitates the kart to be light-weighted. So, a lightweight kart will be in the interest of its users.

6.2.2 Economic Impacts of project

As our kart is of less weight so it will be fuel-efficient. This reduction in weight leads to an increase in the speed of the kart. More accelerated kart will be in buyers' interest and would earn a large revenue for the country.

6.2.3 Environmental Impacts of project

As its engine is of small size: 110 ccs so its emissions will be of less amount. Moreover, we installed a catalytic converter to ensure zero emissions from the kart.

6.3 Contemporary Issues Addressed

The foremost issue we faced was high levels of pollution. The first strategy was to install a small engine with a catalytic converter, while the second solution was to lower the vehicle's weight to make it more fuel economical. This saving can then be utilized in using fuel of high octane number. The next issue was noise pollution. For that, we went on using silencers to prevent the production of large noise. The next issue was poor aerodynamics of kart because of maintaining a low weight of kart and for that we installed a fiber spoiler at the back of kart which resulted in the better fuel economy of the go-kart.

Chapter 7: Conclusions and Future Recommendations

7.1 Conclusion

This project aimed to build a go-kart based on a conceptual design that was optimized to improve the vehicle's stability. The Go-design kart's and fabrication focuses on creating a simple, lightweight, and easy-to-operate vehicle. The design specifications included ergonomics, safety, and reliability considerations. All major components were analyzed to improve vehicle performance, improve strength and rigidity, and reduce complexity and manufacturing costs.

The Go-kart design has been as per usual calculations of go-kart, but to reduce the weight of this vehicle, we used the option of choosing lighter material of 304 grade of stainless steel. Moreover, the engine used in this project is 110 cc that is light enough to design a light-weighted vehicle.

7.2 Future Recommendations

Various ideas can improve the project. Following are the ideas that can be used to facilitate this project further:

1. Manufacturers should shift to the use of fibers to fabricate go-karts as these fibers are lightest in weight and comparatively have high strength to rely upon.
2. The second idea is the optimization of the go-kart design so that the extra material can be removed and it can be made further lighter in weight.
3. The third idea is to lower its bottom and keep its ground clearance as low as possible to improve its grip.

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