



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**DESIGN AND ANALYSIS A LIGHTWEIGHT KNUCKLE FOR
IMPROVING THE FORMULA STUDENT RACING CAR**

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree in Mechanical Engineering Technology (Automotive Technology)(Hons.)

by

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Engineering Technology (Automotive Technology) (Hons.). The member of the supervisory is as follow:

.....

(Project Supervisor)

ABSTRAK

Matlamat utama untuk projek ini ialah untuk mereka bentuk dan menganalisis “steering knuckle” yang lebih ringan berbanding dengan “steering knuckle” yang telah digunakan pada kereta lumba formula pelajar. Pada tahun 2012, Fakulti Teknologi Kejuruteraan, UTeM telah menyertai Formula Varsity. Ketika perlumbaan, kereta lumba formula pelajar FTK mempunyai berat yang berlebihan berbanding dengan pesaing yang lain. Oleh kerana berat komponen pada kenderaan menyumbang kepada berat keseluruhan kenderaan, maka dengan mengurangkan salah satu berat “steering knuckle” akan membantu mengurangkan berat kenderaan. Di samping itu, ia juga dapat membantu meningkatkan prestasi kereta lumba formula pelajar. Di dalam projek ini, reka bentuk “steering knuckle” yang ringan akan dilakukan dan perbandingan keputusan analisa reka bentuk “steering knuckle” akan dilaksanakan kepada “steering knuckle” yang telah digunakan oleh kereta lumba formula pelajar FTK sebelum ini. Oleh sebab itu, banyak kajian yang telah dijalankan bagi mencapai objektif utama projek ini. Reka bentuk “steering knuckle” akan menggunakan perisian sistem pengaturcaraan berkomputer (CAD) dan menggunakan pengaturcaraan kejuruteraan berkomputer (CAE) bagi mengenal pasti berat dan kekuatan pada “steering knuckle” yang telah diringkaskan. Kadar pengurangan berat untuk rekabentuk “steering knuckle” yang baru akan dibandingkan dengan “steering knuckle” yang telah digunakan oleh kereta lumba formula oleh pelajar FTK sebelum ini. Di akhir projek ini, rekabentuk baru “steering knuckle” yang lebih ringan akan dihasilkan bagi menambah baik pada kereta lumba formula pelajar nanti.

ABSTRACT

The aim of this project are to design and analysis a lighter steering knuckle compare to the previous steering knuckle that have been use for Formula Student Racing Car. In 2012, Fakulti Teknologi Kejuruteraan, UTeM has joined the Formula Varsity. During the competition, FTK's student formula student racing car had an overweight car compared to the other competitors. Since the weight of the components are contributed to the total weight of the vehicle, so by reducing one of the weight part of steering knuckle will help to reduce the weight of the car. Besides that, it also can improves the performance of the formula student racing car. For this project, a design of a lightweight steering knuckle will be made and the analysis design of the steering knuckle result will be compared to the previous steering knuckle of FTK's student formula racing car. Therefore, a lot of research will be done in order to achieve the main objective of this project. To design a steering knuckle, it will use computer aided design (CAD) software, then analysis the design of the steering knuckle by using computer analysis engineering (CAE) to determine the weight and the strength of the lightweight steering knuckle. The weight reduction for a new design of lightweight steering knuckle will be compared to the previous steering knuckle for FTK's student formula student racing car. At the end of this project, a new design of a lightweight steering knuckle will be produce to improve the formula student racing car.

DEDICATION

I dedicated this thesis to my beloved parents Fatimah and Mohd. Saru, my siblings
and my dearest Nur Damia Sara.

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TABLE OF CONTENT

Abstrak	i
Abstract	ii
Dedication	iii
Acknowledgement	iv
Table of Content	v
List of Tables	vi
List of Figures	vii
List Abbreviations, Symbols and Nomenclatures	viii
CHAPTER 1: INTRODUCTION	1
1.1 General	1
1.2 Problem Statement	1
1.3 Objective	2
1.4 Scope of Study	2
CHAPTER 2: LITERATURE REVIEW	3
2.1 Introduction	3
2.2 UTeM Formula Varsity	3
2.2.1 Formula Varsity History	4
2.3 Steering Knuckle	5
2.3.1 Types of Steering Knuckle	9
2.3.2 Steering Knuckle Material Review	11
2.4 Factors That Influence Design	13
2.3.1 Types of Steering Knuckle	14
2.3.2 Steering Knuckle Material Review	16
2.5 Optimization Method	18
2.5.1 Shape Optimization	22
2.6 Static Analysis	28

2.7	Identification of Steering Knuckle Material	32
CHAPTER 3: METHODOLOGY		33
3.1	Introduction	33
3.2	Project Flow Chart	33
3.2.1	Defining Problem Statement	35
3.2.2	Literature Review	35
3.2.3	Develop Conceptual Design	35
3.2.4	Detail Design	37
3.2.5	Design Selection	39
3.2.6	Material Selection	39
3.2.7	Analysis	40
CHAPTER 4: RESULT AND DISCUSSION		41
4.1	Design Selection	41
4.2	Material Properties	42
4.3	Material Selection	43
4.4	Finite Element Analysis of Steering Knuckle	47
4.4.1	Meshing the Design	47
4.4.2	Applying Constraints and Force	50
4.4.2.1	Weight of the Formula Student Racing Car	50
4.4.2.2	The Force Act Each Tires	51
4.4.3	Force and Constraints Act On Steering Knuckle	51
4.4.4	Finite Element Analysis Result	53
4.4.4.1	Von Misses Stress	53
4.4.4.2	Displacement	60
4.5	Data Comparison	62
4.5.1	Weight	62
4.5.2	Stress and Displacement Result	63
4.5.3	Factor of Safety	64
4.6	Overall Discussion	65
CHAPTER 5: Conclusion & Future Work		66
5.1	Conclusion	66

5.2 Future Work 67

REFERENCES 68

APPENDICES

A List of Respondents

LIST OF TABLES

2.1	Chemical Properties of Aluminium 2011	11
2.2	Physical and Mechanical Properties of Aluminium 2011 T3 Alloy	11
2.3	Summary of Results	12
2.4	Summary of Mechanical Properties	13
2.5	Result Summary	27
2.6	Loading Conditions	29
4.1	Material Properties of Ductile Iron	41
4.2	Material Properties of Mild Steel	42
4.3	The Weight of the Steering Knuckle with Iron (A536)	44
4.4	Comparison of A536 80-55-06 and Mild Steel	45
4.5	Structure Computation for Design 1	48
4.6	Structure Computation for Design 2	48
4.7	Structure Computation for Design 3 with Mild Steel	49
4.8	Structure Computation for Design 3 with A536	49
4.9	Percentage of the Weight Reduction	62
4.10	Maximum Stress, Displacement and Yield Strength Result	62
4.11	Factor of Safety for Each Design	63

LIST OF FIGURES

2.1	Steering Knuckle with the Wheel Hub	5
2.2	Steering Knuckle Assembly	6
2.3	King Pin	6
2.4	Static Lateral and Longitudinal Input	7
2.5	Steering Knuckle Assembly Force reactions with Logitudinal input	8
2.6	Steering knuckle with Hub Assembly	9
2.7	Late Model front Axle Steering Knuckle Assembly Components	9
2.8	Automotives Steering Knuckle	10
2.9	Automotive Steering Knuckle	12
2.10	Solid Model of the Double Wishbone Suspension	14
2.11	Schematic of the Double Wishbone Suspension Mechanism	15
2.12	FKM, UTeM Formula Student Racing Car Suspension System	15
2.13	FTK, UTeM Formula Student Racing Car Suspension System	16
2.14	Original Figure of the Sports Car Uprights	17
2.15	Design After Optimizing	18
2.16	Topology Optimization using HyperShape/CATIA	19
2.17	Topology Optimization Result	20
2.18	Shape Optimization-Parameterization	20
2.19	Shape Optimization using CATIA/PEO	21
2.20	Shape optimization Result	21
2.21	Topology and Shape Optimization Summary	22
2.22	Baseline Superposed Over Optimized Steering Knuckle	23
2.23	Initial Shape of Model	24
2.24	Optimized Mode Shape	25
2.25	Stress Contour of Initial Model	25
2.26	Stress Contour of Optimized Model	26
2.27	Displacement Contour of Initial Model	26
2.28	Displacement contour of Optimized Model	27

2.29	Detail and Meshing of Model	28
2.30	Detail and Meshing of Model	29
2.31	Forces and Constrain	30
2.32	Deformation	31
2.33	Stress Produced	31
2.34	Comparison of micro structure with ASTMA536	32
3.1	Process Flow Chart	34
3.2	Concept Design For Steering Knuckle	35
3.3	Concept Design For Steering Knuckle	36
3.4	FKM Student Formula Racing Car Detail Design of Steering Knuckle	37
3.5	FTK Student Formula Racing Car Detail Design of Steering Knuckle	37
3.6	Detail Design One of Steering Knuckle	38
3.7	Detail Design Two of Steering Knuckle	38
4.1	Detail Design of The New Design	41
4.2	Weight of Design 1 Steering Knuckle	43
4.3	Weight of Design 2 Steering Knuckle	43
4.4	Weight of Design 3 with Iron	44
4.5	Weight of Design 3 with Mild Steel	45
4.6	Mesh Model of Design 1	46
4.7	Mesh Model of Design 2	47
4.8	Mesh Model of Design 3 with Mild Steel	47
4.9	Mesh Model of Design 3 with Iron	48
4.10	Design 1 Steering Knuckle Constraint and Force Apply	50
4.11	Design 2 Steering Knuckle Constraint and Force Apply	51
4.12	Design 3 (Mild Steel) of Steering Knuckle Constraint and Force Apply	51
4.13	Design 3 (Iron) of Steering Knuckle Constraint and Force Apply	52
4.14	Von Misses Stress of Design 1	53

4.15	Stress Contour of Design 1	53
4.16	Stress Contour of Design 1	54
4.17	Von Misses Stress of Design 2	54
4.18	Stress Contour of Design 2	55
4.19	Stress Contour of Design 2	55
4.20	Von Misses Stress of Design 3 with Mild Steel	56
4.21	Stress Contour of Design 3 with Mild Steel	57
4.22	Stress Contour of Design 3 with Mild Steel	57
4.23	Von Misses Stress of Design 3 with Iron	58
4.24	Stress Contour of Design 3 with Iron	58
4.25	Stress Contour of Design 3 with Iron	59
4.26	Translation Displacement of Design 1	59
4.27	Translation Displacement of Design 2	60
4.28	Translation Displacement of Design 3 with Mild Steel	60
4.29	Translation Displacement of Design 3 with Iron	61

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

kg	-	Kilogram
Si	-	Silicon
Fe	-	Iron
Cu	-	Copper
Pb	-	Lead
Bi	-	Bismuth
Zn	-	Zinc
Al	-	Aluminium
Pa	-	Pascal
m ³	-	Meter Cubic
G	-	Gravitational Force
N	-	Newton
ASTM	-	American Society for Testing and Materials
FEA	-	Finite Element Analysis
g	-	Gravity
FoS	-	Factor of Safety

CHAPTER 1

INTRODUCTION

1.1 General

Automobiles knuckle is a part of vehicle suspension system and it is an important component as it carries varies type of load such as longitudinal, vertical and torque load. It is connected to the part of suspension and steering systems . It is used for adjusting the direction of a rotation through its attachment to the wheel. The automobile knuckle has a direct impact on the performance of the vehicle ride, steer ability and durability since this part link to the steering and suspension systems of the vehicle.

1.2 Problem Statement

During last Formula Varsity competition in 2012, FTK's formula racing car had an overweight car compared to the other car. The regulation has set the minimum weight for the racing car is 200 kg (car plus driver without fuel). But the FTK's student racing car weight was 320 kg. So, it will affect the performance of car. Steering knuckle is a one of the component that contribute to the total weight of the car. Thus, in this research, it will concentrate on the design and analyse of the lightweight knuckle following the regulation set by rules and regulations of Formula Varsity competition.

1.3 Objective

The objectives of this project are to achieve the target as below:

- i. To design a lightweight steering knuckle for the Formula Student racing car.
- ii. To compare and analysis the design of steering knuckle with the FTK's and FKM's steering knuckle.

1.4 Scope of Study

The scopes of this project are:

- i. Re-design a steering knuckle for the Formula Student racing car.
- ii. Produce the detail design of a steering knuckle using CAD software.
- iii. Analyse the new design of steering knuckle using CATIA software to determine the weight and the strength of the lightweight steering knuckle.
- iv. Compare the weight reduction for a new design of lightweight steering knuckle with the previous FTK's and FKM's student formula steering knuckle.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

With references from the reference book, journal, previous thesis and the articles from the internet, literature review has been carry out to collect the information for the vehicle steering knuckle. The main purpose of this chapter is to give an overview how the lightweight steering knuckle is designed using a suitable method and software.

2.2 UTeM Formula Varsity

Formula Varsity is student formula race car event that tests the ability of engineering students to develop the formula-style racing cars. It also tests the student's analytical and technical skills. Formula Varsity also a field to develop student team working skills and student creative problem solving that give the students unique experience and knowledge. Since Formula Varsity covers all aspects of automotive industry such as research, design, analysis, prototype and test, manufacture, assembly, management and communications skills, it also a driving factor to improves student excellence in engineering technology fields.

2.2.1 UTeM Formula History

Formula Varsity was introduced by Faculty of Mechanical Engineering of Universiti Teknikal Malaysia Melaka in 2006. The first event was organised on September 2006 with participation from Universiti Tun Hussein Onn. The second event was in August 2008, with involvements from five Public Higher Education Institution (PHEI) teams which are Universiti Teknikal Malaysia Melaka (UTeM), University of Nottingham Malaysia (NU), Universiti Putra Malaysia (UPM), Politeknik Shah Alam (PSA) and Politeknik Kota Bharu (PKB).

Universiti Teknikal Malaysia Melaka continue to organised the third event of Formula Varsity in October 2010 and make a record by success to get 25 teams from various Higher Education Institutions (HEI) as well as nationwide polytechnics to participate in the race. In 2012, a new faculty (Fakulti Teknologi Kejuruteraan) from Universiti Teknikal Malaysia Melaka was joined in the race. This makes Universiti Teknikal Malaysia Melaka Formula Varsity as one of the scholarship tournaments that gets very favourable response from many Higher Education Institution (HEI).

The original concept of Formula Varsity program is from Formula SAE tournament in the Canada and United State of America. The student formula racing cars are considered as a mini Formula 1 at Public Higher Education Institution even the vehicles are develop in a mini sized. The Formula Varsity challenges the engineering students to design, build and race with the formula style race machines. It gives opportunities to the team from one institution to show and prove their engineering expertise with the other teams. Formula Varsity event also give the opportunity for the students because this event is an efficient platform to be recruit by automotive company to join them after they graduate from their study. (www.formulavarsity.utm.edu.my).

2.3 Steering Knuckle

The steering knuckle is a link between the axle housing, the tie rod and the stub axle. It connected to the tie rod and the other connection is to the axle housing by using the king pin. After that, by using the bearing, the wheel hub is fixed to the knuckle. The main function of the steering knuckle is to exchange linear motion of the tie rod into angular motion of the stub axle. The car will have a less vibration and produce a greater performance when the lighter steering knuckle is used because it will produce a less of the inertia. It is happen because of the steering knuckle brings the power thrust from the tie rod to the stub axle and hence the steering knuckle must be lighter as possible, stiffer and it must be very strong. Figure 2.1, shows the assembly of the steering knuckle system (B.Babu, 2014). Figure 2.2, shows the steering knuckle assembly (Patel Akash A., 2014) and Figure 2.3, shows the kingpin of the steering knuckle (www.motorera.com).

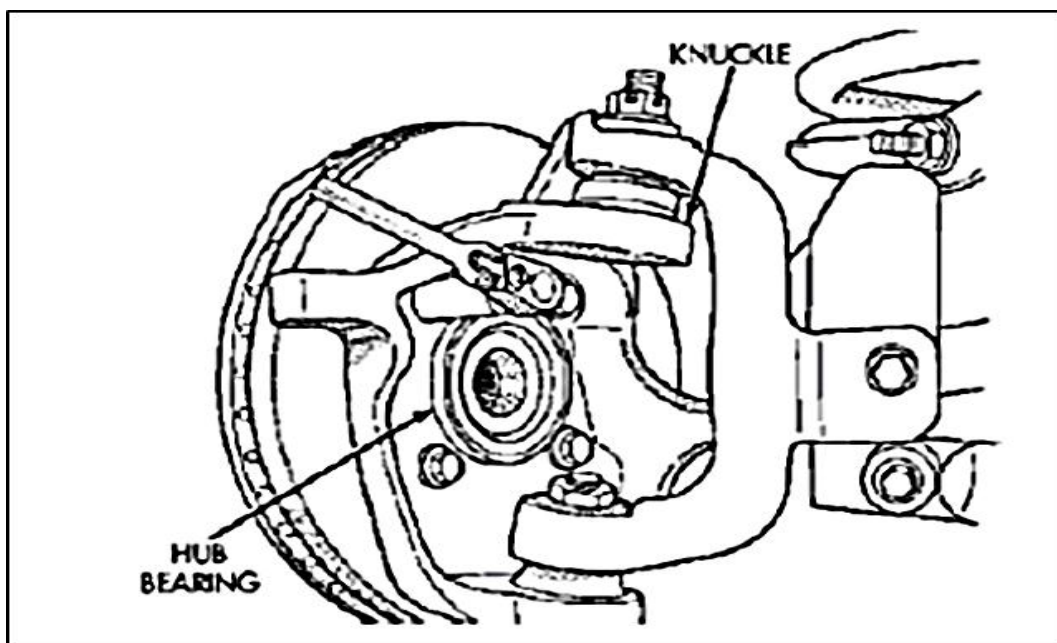


Figure 2.1 : Steering Knuckle with the Wheel Hub (B.Babu, 2014).

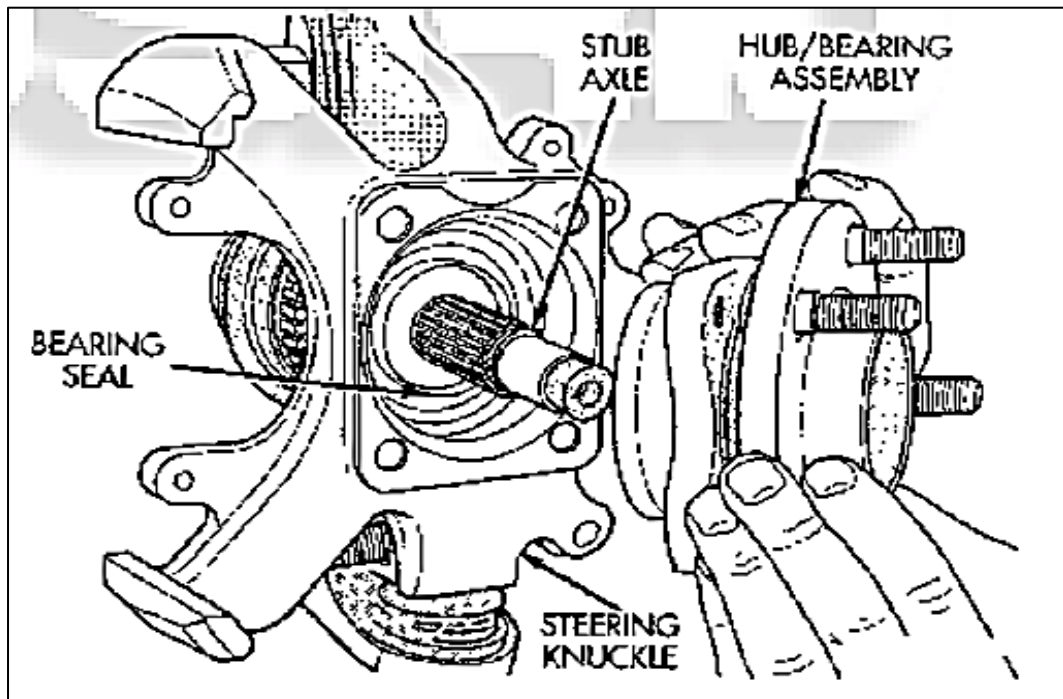


Figure 2.2 : Steering Knuckle Assembly (Patel Akash A., 2014).

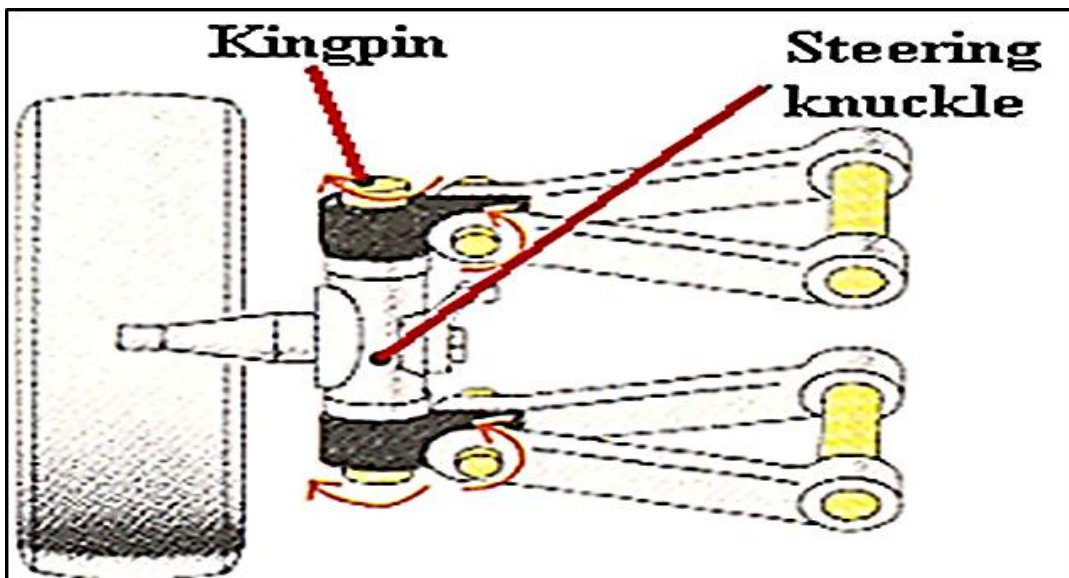


Figure 2.3 : King Pin (Source : www.motorera.com)

The steer motion of the vehicle suspension system and force are influence by many factors. Haeg,1997 state that, the axle still experienced the force even the axle are not steer in normal vehicle operation. Figure 2.4 shows a longitudinal static lateral force at the centre (right) of the tire and static lateral force at the centre of patch (left) (Haeg, 1997). At the lower and upper horizontal sanction, the primary lateral reactions path is through. It is only have a little force that react with the steering system when the line of the steer axis is crossed by the static lateral force input vectors. When the tires patch face a longitudinal load or resistance, it is resolved into a moment and force around the axis of rotational of the tire.

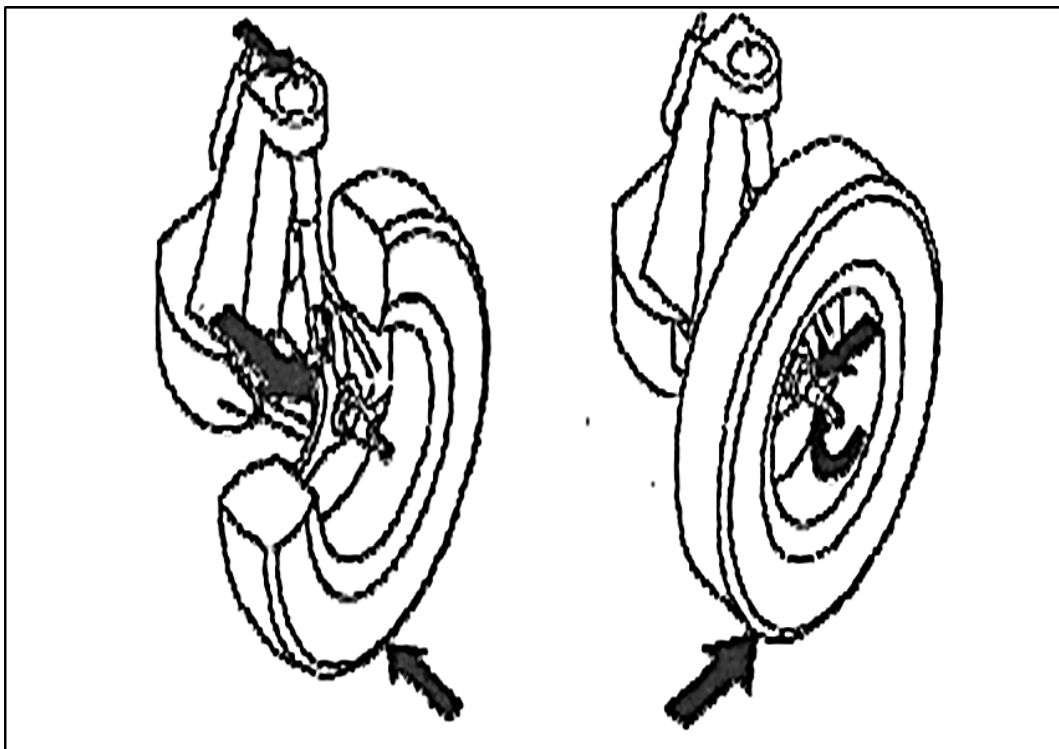


Figure 2.4: Static lateral input (left) and static longitudinal input (Haeg, 1997)

Figure 2.5 shows the response of steer moment through the opposing forces at the horizontal restrains and tie rod end. The forces from the tie rod reacted back through the steering gear and transfer to the frame or body. (Haeg, 1997).

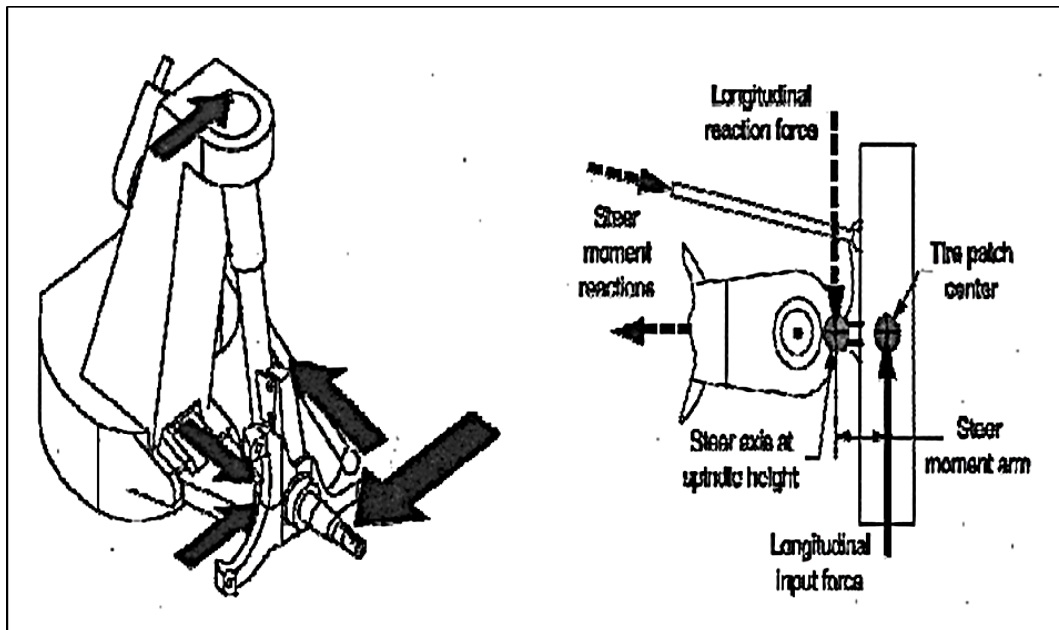


Figure 2.5: Steering knuckle assembly force reactions with longitudinal input
Isometric view (left) and plan view (Haeg, 1997)

2.3.1 Types of Steering Knuckle

Steering knuckle come in various shapes and sizes. The steering knuckle design is vary to fit all sorts of applications and suspension types. However, the steering knuckle can be separated into two main types as shown in Figure 2.6 and Figure 2.7