

# MODELING, SIMULATION AND OPTIMIZATION ANALYSIS OF STEERING KNUCKLE COMPONENT FOR RACE CAR

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## Abstract

Light weight and low fuel consumption are the two main demands for a vehicle, particularly for a race car. Steering knuckle, as one of the critical components of a race car, is the main subject in the present study. A light weight and optimized design of steering knuckle is proposed to be used for an EDMARace race car: a small high performance formula-style car, with suitable material selection as well as finite element analysis and optimization studies. First part of this study involves modeling of steering knuckle and analysis of the stresses and displacement under actual load conditions. A CAD and FEA software: SolidWorks, is applied for modeling as well as for static analysis studies. Shape optimization is the second part of this study, utilizing solid thinking software from Altair Engineering packages. The improved design obtained had achieved 47.0% reduction of mass while meeting the strength requirements.

**Keywords:** Steering knuckle, FEA, Optimization, Race car.

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## 1. INTRODUCTION

Educational Innovative Motorsport and Automotive Race (EDMARace), that organized by Universiti Teknologi Malaysia (UTM) is an inter-universiti program that open to international and public higher education institutes, highlighting education through motorsports. Participating in this challenge inspires students to conceive, design, fabricate, and compete with small formula-style racing cars. The present study however will focus on development of one of the race car components: steering knuckle.

Steering knuckle is a part of vehicle suspension system which allows the steering arm to turn the front wheels and supports the vertical weight of the vehicle. Also known as spindle, upright, and hub, the steering knuckle is consists of wheel hub or spindle, and attached to the suspension components, lower and upper arm, and the rod. It basically is assembled with front tire and spindle that rotates in a stable plane of motion by a suspension assembly. Since it is subjected to time varying loads during its service life, design of the better steering knuckle is a crucial aspect in the product development cycle.

Steering knuckle is not a standard part of vehicle component. Thus the design may differ to its all sorts of applications and suspension types [1]. In the present study, design of a reliable and durable steering knuckle for a race-car being an ultimate aim to be achieved. Development of race car components is basically tied with the regulations

drawn by the organizer. Able to complete 15 laps within minimum time with only 5 liter of fuel are the prominent requirements. Therefore, the need of light weight components is vital. It is because the minimal weights will give substantial impact to fuel efficiency [2-5], efforts to reduce emissions and therefore, might save the environment [1]. In addition, particularly the steering knuckle, according to Hales et al. [4], the lighter steering knuckle may produce greater power and less vibrations, results from the low inertia. Besides need to be as light weight as possible, the component also must be very strong and rigid, due to harsh and high time varying loads for the race car driving conditions.

This paper is aimed to propose an improved design of a light-weight steering knuckle for an EDMARace car. The model developments are starting from modeling, material selection, finite element analysis (FEA) and finally optimization process.

## 2. METHODOLOGY

This study has been dealt with two parts. First part of this study involves modeling of steering knuckle and analysis of stresses and displacement under actual load conditions. CAD models of steering knuckle were developed in 3D modeling software, SolidWorks. The stress analysis and stiffness of the models were then obtained and compared using finite element analysis (FEA) via SolidWorks Simulation software. While the second part is shape

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