Between simplicity and accuracy: Effect of adding modeling details on quarter vehicle model accuracy

Ming Foong Soong, Rahizer Ramil, Ahmad Saifizul
Advanced Computational and Applied Mechanics (ACAM) Research Group, Department of Mechanical Engineering, Faculty of Engineering, University of Malaya, Kuala Lumpur, Malaysia

Abstract
Quarter vehicle model is the simplest representation of a vehicle that belongs to lumped-mass vehicle models. It is widely used in vehicle and suspension analyses, particularly those related to ride dynamics. However, as much as its common adoption, it is also commonly accepted without quantification that this model is not as accurate as many higher-degree-of-freedom models due to its simplicity and limited degrees of freedom. This study investigates the trade-off between simplicity and accuracy within the context of quarter vehicle model by determining the effect of adding various modeling details on model accuracy. In the study, road input detail, tire detail, suspension stiffness detail and suspension damping detail were factored in, and several enhanced models were compared to the base model to assess the significance of these details. The results clearly indicated that these details do have effect on simulated vehicle response, but to various extents. In particular, road input detail and suspension damping detail have the most significance and are worth being added to quarter vehicle model, as the inclusion of these details changed the response quite fundamentally. Overall, when it comes to lumped-mass vehicle modeling, it is reasonable to say that model accuracy depends not just on the number of degrees of freedom employed, but also on the contributions from various modeling details.

Introduction
It is probably known that virtual development has become an integral part in vehicle development process due to the shortening of product life cycle in the automotive industry. Be it in the development of conventional vehicles or even in the research of state-of-the-art vehicle technologies like electric vehicle and hybrid electric vehicle [1–3], virtual development through simulation is both time and cost effective compared to physical prototype testing as it allows fine-tuning and optimization of a vehicle to be performed efficiently. For example, an important phase of virtual vehicle development is the simulation of vehicle dynamics to achieve optimum ride and handling performances. Obviously, such simulation requires an accurate