

Ground Vehicle Dynamics

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Ground Vehicle Dynamics

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 Springer

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To our wives
Gitty Popp
Christine Schiehlen
Melanie Kröger
and to
Kristina von Scheidt

Preface

The book *Ground Vehicle Dynamics* is the revised English edition of the book *Fahrzeugdynamik* originally published in German back in 1993. During the preparation of this English edition the first author Karl Popp passed away far too early. In his spirit, and for his memories, two members of Karl Popp's research group at the Leibniz University Hanover, Matthias Kröger and Lars Panning, agreed to contribute to the ongoing work on this edition of the book. However, it took more time than originally planned and Matthias Kröger moved to the Technical University Bergakademie Freiberg as head of the Institute of Machine Elements, Design and Manufacturing.

Vehicle dynamics deals with the mechanical modeling as well as the mathematical description and analysis of vehicle systems. The aim of this book is a methodologically based introduction to the dynamics of ground vehicle systems. The different kinds of vehicles like automobiles, rail cars or magnetically levitated vehicles are not considered one by one but the dynamically common problems of all these vehicle systems are treated from a uniform point of view. This is achieved by a system oriented approach. The evaluation of meaningful mathematical models allows simulations of motion and parameter studies well in advance of setting up a first prototype. The trend to shorter periods for the development and to larger numbers of vehicle versions demands from the engineer comprehensive computations, the fundamentals of which are presented in this book.

The fundamental concept of this book is based on a modularization into vehicle subsystems with standardized interfaces. In the first vital part the models of vehicles, guidance and suspension systems as well as guideway systems are presented, they are mathematically described in detail and they are assembled to complete vehicle-guideway systems. The second methodologically oriented part is devoted to the performance criteria driving stability, driving safety and durability. Then, it follows a review on the computational methods for linear and nonlinear vehicle systems. The sophisticated theoretical methods related to the demanding problems in vehicle dynamics are applied in the third part to longitudinally, laterally and vertically

decoupled motions providing the basics of vehicle dynamics. An appendix with some results from the theory of optimal multivariable control systems presents methods for the control design of mechatronic vehicle components. The many problems included in the book show mainly simple applications of the theory presented, and their solutions will support the reader in better understanding the theory and the fundamentals of railway and road vehicles.

The book is devoted on the one hand to students of applied mechanics and system theory as well as mechanical engineering and automotive engineering. The book will support lectures on vehicle systems and provide a view on the general behavior of ground vehicles. On the other hand the book illustrates to engineers joining or working with a vehicle company, or one of their suppliers, advanced methods which are the basis of software tools widely used today in industry. Thus, the book may contribute to continuing education. Moreover, the systematic methodologically based approach is a good example for many divisions of mechanical engineering and mechatronics.

Compared to the successful German edition which has been out of print for some years, the English edition has been only slightly revised. New references are added throughout the book, in Chapter 2 the recursive formalisms for multibody dynamics are discussed, in Chapter 6 the revised ISO Standard 2631 is considered, in Chapter 7 the standard time integration codes provided by Matlab are evaluated and in Chapter 10 a planar half-car model has been included to fill the gap between the quarter-car model and the complex vehicle model. Since the book is now written in English, some German keywords are added in the appendix. This may help the German reader to identify more easily the technical terms for subjects in which she or he is interested.

The authors and contributors of the book acknowledge the continuous support of the Institute of Engineering and Computational Mechanics at the University of Stuttgart headed by Peter Eberhard. We thank our co-workers from Hanover and the many students from Stuttgart, for typing formulas, tables and text as well as for drawing the figures. Moreover, thanks are due to members of the Institute of Engineering and Computational Mechanics for proofreading the manuscript. In particular, Daniel García Vallejo, a post-doc from the University of Seville, Spain contributed to the final editorial work on the book during his stay at the Institute. Finally it has to be pointed out that the cooperation with Petra Jantzen, Dieter Merkle and Christoph Baumann from Springer-Verlag was excellent.

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Matthias Kröger
Lars Panning
Werner Schiehlen

Preface to the German Edition

Das vorliegende Buch entstand durch die bereits einige Zeit zurückliegende Anregung unseres verehrten Lehrers, Herrn Prof. Dr. Dr. - Ing. E.h. K. Magnus. Berücksichtigung fanden die Ergebnisse zahlreicher neuerer, zum Teil gemeinsamer Forschungsarbeiten. Vor allem aber ist die mehr als zehnjährige Lehrerfahrung der Verfasser aus Vorlesungen über Fahrzeugdynamik an der Technischen Universität München, der Universität Hannover und der Universität Stuttgart eingeflossen. Hilfreich zur Aufbereitung des umfangreichen Stoffes waren ferner die bei der Durchführung des Kurses "Dynamics of High-Speed Vehicles" am Internationalen Zentrum für Mechanik (CISM) in Udine gesammelten Erfahrungen.

Die Fahrzeugdynamik befaßt sich mit der mechanischen Modellierung sowie der mathematischen Beschreibung und Analyse von Fahrzeugsystemen. Ziel dieses Buches ist es, eine methodenorientierte Einführung in die Dynamik landgestützter Fahrzeugsysteme zu geben. Dabei werden nicht die einzelnen Fahrzeugarten wie Kraftfahrzeuge, Schienenfahrzeuge oder Magnetschwebebahnen nebeneinander betrachtet, sondern die allen Fahrzeugsystemen gemeinsamen dynamischen Probleme unter einheitlichen Gesichtspunkten behandelt. Dies ist durch eine systemtheoretische Betrachtungsweise möglich. Die Bereitstellung aussagekräftiger mathematischer Modelle erlaubt Bewegungssimulationen und Parameterstudien lange bevor der erste Prototyp gebaut wird. Der Trend zu kürzeren Entwicklungszeiten und eine große Variantenvielfalt verlangen heute vom Ingenieur umfassende Berechnungen, für die dieses Buch die Grundlagen vermitteln soll.

Das Grundkonzept des vorliegenden Buches beruht auf einer Modularisierung der Fahrzeugteilsysteme mit standardisierten Schnittstellen. Im ersten zentralen Teil werden die Modelle für Fahrzeuge, Trag- und Führsysteme sowie Fahrwege im einzelnen begründet, mathematisch ausführlich beschrieben und zu Gesamtmodellen für Fahrzeug-Fahrweg-Systeme zusammengefaßt. Der zweite, methodenorientierte Teil wird durch die Beurteilungskriterien Fahrstabilität, Fahrsicherheit, Fahrkomfort und Bauteil-Lebensdauer eingeleitet. Anschließend folgt die Darstellung der Berechnungsmethoden für lineare und nichtlineare Fahrzeugsysteme. Die der anspruchsvollen Aufgabenstellung entsprechenden theoretischen Verfahren werden im dritten Teil am Beispiel einfacher Longitudinal-, Lateral- und Vertikalbewegungen verdeutlicht. Ein Anhang mit Ergebnissen aus der Theorie optimaler Mehrgrößenregelsysteme trägt dem Trend zu aktiven Fahrzeugkomponenten Rechnung. Eine Vielzahl aufeinander abgestimmter und in die einzelnen Kapitel eingestreuter Beispiele mit ausführlichen Lösungen sollen das Verständnis der Theorie erleichtern und die Anschauung fördern.

Das Buch wendet sich einerseits an die Studierenden der Angewandten Mechanik und Systemtheorie sowie der Fahrzeugtechnik. Es soll insbesondere Vorlesungen über spezielle Fahrzeugsysteme unterstützen und den Blick für allgemeine Zusammenhänge schärfen. Andererseits zeigt es dem in der

Praxis stehenden Ingenieur die Fortschritte bei der Untersuchung komplexer Fahrzeugmodelle auf und dient so der Weiterbildung. Darüber hinaus ist das systematische Vorgehen beispielhaft für viele Bereiche des Maschinenbaus. Die Verfasser danken Herrn Dipl.-Ing. R. Austermann und Herrn Dipl.-Ing. P. Eberhard für die sorgfältige Durchsicht der Druckfahnen sowie Herrn W. Pietsch für die Erstellung der Reinzeichnungen und Bilder. Dank gebührt ferner den vielen Helfern beim Schreiben des Manuskripts. Schließlich gilt unser Dank dem Verlag B. G. Teubner für die erwiesene Geduld und die stets erfreuliche Zusammenarbeit.

Hannover
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Sommer 1992

K. Popp
W. Schiehlen

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