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VEHICLE DYNAMICS

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Automotive Series

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For my wife Annette
and my children Sophia, Aljoscha, Indira and Felicia

Contents

Foreword

This book is an extract of lectures on vehicle dynamics and mechatronic systems in vehicles held at the Helmut-Schmidt-University, University of the Federal Armed Forces, Hamburg, Germany. The lectures have been held since 2002 (Vehicle Dynamics) and 2009 (Vehicle Mechatronics). The book is an introduction to the field of vehicle dynamics and most parts of the book should be comprehensible to undergraduate students with a knowledge of basic mathematics and engineering mechanics at the end of their Bachelor studies in mechanical engineering. However, some parts require advanced methods which are taught in graduate studies (Master programme in mechanical engineering).

I wish to thank Mrs Martina Gerds for converting the pictures to Corel Draw with LaTeX labels and for typing Chapter 9. My thanks go to Mr Darrel Fernandes, B.Sc., for the pre-translation of my German scripts. I especially wish to thank Mr Colin Hawkins for checking and correcting the final version of the book with respect to the English language. My scientific assistants, especially Dr Winfried Tomaske and Dipl.-Ing. Tobias Hellberg, I thank for proofreading, especially with regard to the technical aspects. Special thanks for assistance in preparing a number of Solid Works constructions for pictures of suspensions and transmissions as well for help in preparing some MATLAB diagrams go to Mr Hellberg. Last but not the least, my thanks go to my family, my wife, Dr Annette Nicolay, and my children, Sophia, Aljoscha, Indira and Felicia, for their patience and for giving me a lot of time to prepare this book.

Series Preface

The automobile is a critical element of any society, and the dynamic performance of the vehicle is a key aspect regarding its value proposition. Furthermore, vehicle dynamics have been studied for many years, and provide a plethora of opportunities for the instructor to teach her students a wide variety of concepts. Not only are these dynamics fundamental to the transportation sector, they are quite elegant in nature linking various aspects of kinematics, dynamics and physics, and form the basis of some of the most impressive machines that have ever been engineered.

Vehicle Dynamics is a comprehensive text of the dynamics, modeling and control of not only the entire vehicle system, but also key elements of the vehicle such as transmissions, and hybrid systems integration. The text provides a comprehensive overview of key classical elements of the vehicle, as well as modern twenty-first century concepts that have only recently been implemented on the most modern commercial vehicles. The topics covered in this text range from basic vehicle rigid body kinematics and wheel dynamic analysis, to advanced concepts in cruise control, hybrid powertrain design and analysis and multi-body systems. This text is part of the *Automotive Series* whose primary goal is to publish practical and topical books for researchers and practitioners in industry, and post-graduate/advanced undergraduates in automotive engineering. The series addresses new and emerging technologies in automotive engineering supporting the development of next generation transportation systems. The series covers a wide range of topics, including design, modelling and manufacturing, and it provides a source of relevant information that will be of interest and benefit to people working in the field of automotive engineering.

Vehicle Dynamics presents a number of different designs, analysis and implementation considerations related to automobiles including power requirements, converters, performance, fuel consumption and vehicle dynamic models. The text is written from a very pragmatic perspective, based on the author's extensive experience. The book is written such that it is useful for both undergraduate and post-graduate courses, and