

**AUTOMOTIVE** SERIES

# **VEHICLE DYNAMICS**

**MARTIN MEYWERK**



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# VEHICLE DYNAMICS

## **Automotive Series**

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# VEHICLE DYNAMICS

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



# Contents

<b>Foreword</b>	<b>xi</b>
<b>Series Preface</b>	<b>xiii</b>
<b>Preface</b>	<b>xv</b>
<b>List of Abbreviations and Symbols</b>	<b>xvii</b>
<b>1 Introduction</b>	<b>1</b>
1.1 Introductory Remarks	3
1.2 Motion of the Vehicle	4
1.3 Questions and Exercises	8
<b>2 The Wheel</b>	<b>11</b>
2.1 Equations of Motion of the Wheel	11
2.2 Wheel Resistances	14
2.2.1 <i>Rolling Resistance</i>	14
2.2.2 <i>Aquaplaning</i>	18
2.2.3 <i>Bearing Resistance</i>	19
2.2.4 <i>Toe-In/Toe-Out Resistance</i>	19
2.3 Tyre Longitudinal Force Coefficient, Slip	20
2.4 Questions and Exercises	24
<b>3 Driving Resistances, Power Requirement</b>	<b>27</b>
3.1 Aerodynamic Drag	27
3.2 Gradient Resistance	29
3.3 Acceleration Resistance	29
3.4 Equation of Motion for the Entire Vehicle	32
3.5 Performance	34
3.6 Questions and Exercises	39

<b>4</b>	<b>Converters</b>	<b>43</b>
4.1	Clutch, Rotational Speed Converter	45
4.2	Transmission, Torque Converter	48
4.3	Questions and Exercises	54
<b>5</b>	<b>Driving Performance Diagrams, Fuel Consumption</b>	<b>57</b>
5.1	Maximum Speed without Gradient	60
5.2	Gradeability	61
5.3	Acceleration Capability	61
5.4	Fuel Consumption	63
5.5	Fuel Consumption Test Procedures	68
5.6	Questions and Exercises	70
<b>6</b>	<b>Driving Limits</b>	<b>73</b>
6.1	Equations of Motion	74
6.2	Braking Process	79
6.3	Braking Rate	84
6.4	Questions and Exercises	91
<b>7</b>	<b>Hybrid Powertrains</b>	<b>93</b>
7.1	Principal Functionalities	93
7.2	Topologies of Hybrid Powertrains	99
7.3	Regenerative Braking and Charging	101
7.4	Questions and Exercises	106
<b>8</b>	<b>Adaptive Cruise Control</b>	<b>107</b>
8.1	Components and Control Algorithm	107
8.2	Measurement of Distances and Relative Velocities	112
8.3	Approach Ability	117
8.4	Questions and Exercises	118
<b>9</b>	<b>Ride Dynamics</b>	<b>121</b>
9.1	Vibration Caused by Uneven Roads	124
9.1.1	<i>Damped Harmonic Oscillator</i>	124
9.1.2	<i>Assessment Criteria</i>	128
9.1.3	<i>Stochastic Irregularities</i>	130
9.1.4	<i>Conflict between Safety and Comfort</i>	132
9.2	Oscillations of Powertrains	144
9.2.1	<i>Torsional Oscillators</i>	144
9.2.2	<i>Centrifugal Pendulum Vibration Absorbers</i>	147
9.3	Examples	151
9.4	Questions and Exercises	152

<b>10</b>	<b>Vehicle Substitute Models</b>	<b>155</b>
10.1	Two-mass Substitute System	155
10.2	Two-axle Vehicle, Single-track Excitation	158
10.3	Non-linear Characteristic Curves	165
10.4	Questions and Exercises	167
<b>11</b>	<b>Single-track Model, Tyre Slip Angle, Steering</b>	<b>169</b>
11.1	Equations of Motion of the Single-track Model	169
11.2	Slip Angle	177
11.3	Steering	181
11.4	Linearized Equations of Motion of the Single-track Model	185
11.5	Relationship between Longitudinal Forces and Lateral Forces in the Contact Patch	188
11.6	Effect of Differentials when Cornering	189
11.7	Questions and Exercises	191
<b>12</b>	<b>Circular Driving at a Constant Speed</b>	<b>193</b>
12.1	Equations	193
12.2	Solution of the Equations	195
12.3	Geometric Aspects	197
12.4	Oversteering and Understeering	201
12.5	Questions and Exercises	205
<b>13</b>	<b>Dynamic Behaviour</b>	<b>207</b>
13.1	Stability of Steady-state Driving Conditions	207
13.2	Steering Behaviour	210
13.3	Crosswind Behaviour	213
13.4	Questions and Exercises	216
<b>14</b>	<b>Influence of Wheel Load Transfer</b>	<b>217</b>
14.1	Wheel Load Transfer without Considering Vehicle Roll	217
14.2	Wheel Load Transfer Considering Vehicle Roll	221
14.3	Questions and Exercises	228
<b>15</b>	<b>Toe-in/Toe-out, Camber and Self-steering Coefficient</b>	<b>229</b>
15.1	Toe-in/Toe-out, Camber	229
15.2	Questions and Exercises	233
<b>16</b>	<b>Suspension Systems</b>	<b>235</b>
16.1	Questions and Exercises	245
<b>17</b>	<b>Torque and Speed Converters</b>	<b>247</b>
17.1	Speed Converters, Clutches	247

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17.2	Transmission	252
17.3	Questions and Exercises	258
<b>18</b>	<b>Shock Absorbers, Springs and Brakes</b>	<b>259</b>
18.1	Shock Absorbers	259
18.2	Ideal Active Suspension and Skyhook Damping	264
	18.2.1 <i>Ideal Active Suspension</i>	264
	18.2.2 <i>Skyhook Dampers</i>	267
18.3	Suspension Springs	269
18.4	Brake Systems	277
18.5	Questions and Exercises	281
<b>19</b>	<b>Active Longitudinal and Lateral Systems</b>	<b>283</b>
19.1	Main Components of ABS	283
19.2	ABS Operations	287
19.3	Build-up Delay of Yaw Moment	290
19.4	Traction Control System	293
19.5	Lateral Stability Systems	294
19.6	Hydraulic Units for ABS and ESP	296
19.7	Active Steering System	297
19.8	Questions and Exercises	298
<b>20</b>	<b>Multi-body Systems</b>	<b>301</b>
20.1	Kinematics of Rigid Bodies	302
20.2	Kinetic Energy of a Rigid Body	305
20.3	Components of Multi-body Systems	309
20.4	Orientation of Rigid Bodies	312
20.5	Derivation and Solution of the Equations	315
	20.5.1 <i>Derivation of the Equations</i>	315
	20.5.2 <i>Solution of Equations</i>	316
20.6	Applications of MBS	317
20.7	Questions and Exercises	322
	<b>Glossary</b>	<b>323</b>
	<b>References</b>	<b>329</b>
	<b>Index</b>	<b>331</b>

# 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 power-train 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