

# Planar Multibody Dynamics Solutions Manual

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Integrated Product and Process Development John M. Usher  
1998-03-13 The phenomenal success of integrated product and process development (IPPD) at such companies as Boeing, Motorola, and Hewlett-Packard has led many manufacturers to place renewed emphasis on this critical aspect of concurrent engineering. If you are among those charged with the daunting task of implementing,

upgrading, or maintaining IPPD, you need a single reference/handbook that covers all of the tools, technologies, and applications that support IPPD. You need Integrated Product and Process Development. Emphasizing applications, this extremely user-friendly guide covers everything from basic principles to cutting-edge research. It addresses ideas and methods in product design as well as issues related to

process design and manufacturing. Case studies illustrate the application of various tools and techniques of IPPD in manufacturing for the defense industry, making the most of product planning, applications of quality function deployment (QFD), the effective use of design optimization, and integrating design and process planning. Other topics covered include: Identifying customer needs using QFD. Issues and constraints in time-driven product development. Enhancing automated design systems with functional design. Rapid prototyping. Case-based process planning systems

**XXI Congreso Nacional de Ingeniería Mecánica** Emilio Velasco Sánchez 2016-11-09 Congreso Nacional de Ingeniería Mecánica se realiza bianualmente promovido por la Asociación Española de Ingeniería Mecánica, AEIM. En su XXI edición, este Congreso está organizado por el Grupo de Ingeniería Mecánica Aplicada (AME) del Departamento de Ingeniería

Mecánica y Energía de la Universidad Miguel Hernández. Y se ha celebrado en la ciudad de Elche (Alicante-España). El Congreso Nacional de Ingeniería Mecánica es el principal lugar de encuentro para el intercambio de conocimiento científico y técnico, de experiencias profesionales y de proyectos competitivos en el campo de la Ingeniería Mecánica a nivel nacional. Los artículos presentados se organizan en 18 áreas temáticas. El libro está organizado por tanto en capítulos por áreas temáticas. Se han presentado 224 comunicaciones científicas de gran nivel que muestran el buen hacer de los investigadores en Ingeniería Mecánica.

Intermediate Dynamics Edward J. Haug 1992

**Rigid Body Dynamics Algorithms** Roy Featherstone 2014-11-10 Rigid Body Dynamics Algorithms presents the subject of computational rigid-body dynamics through the medium of spatial 6D vector notation. It explains how

to model a rigid-body system and how to analyze it, and it presents the most comprehensive collection of the best rigid-body dynamics algorithms to be found in a single source. The use of spatial vector notation greatly reduces the volume of algebra which allows systems to be described using fewer equations and fewer quantities. It also allows problems to be solved in fewer steps, and solutions to be expressed more succinctly. In addition algorithms are explained simply and clearly, and are expressed in a compact form. The use of spatial vector notation facilitates the implementation of dynamics algorithms on a computer: shorter, simpler code that is easier to write, understand and debug, with no loss of efficiency.

### **Advanced Multibody System Dynamics**

Werner Schiehlen  
 2013-04-17 The German Research Council (DFG) decided 1987 to establish a nationwide five year research project devoted to dynamics of

multibody systems. In this project universities and research centers cooperated with the goal to develop a general purpose multibody system software package. This concept provides the opportunity to use a modular structure of the software, i.e. different multibody formalisms may be combined with different simulation programmes via standardized interfaces. For the DFG project the database RSYST was chosen using standard FORTRAN 77 and an object oriented multibody system datamodel was defined. The project included

- research on the fundamentals of the method of multibody systems,
- concepts for new formalisms of dynamical analysis,
- development of efficient numerical algorithms and
- realization of a powerful software package of multibody systems.

These goals required an interdisciplinary cooperation between mathematics, computer science, mechanics, and control theory. ix X After a

rigorous reviewing process the following research institutions participated in the project (under the responsibility of leading scientists): Technical University of Aachen (Prof. G. Sedlacek) Technical University of Darmstadt (Prof. P. Hagedorn) University of Duisburg M. Hiller) (Prof. Monthly Catalog of United States Government Publications 1996 *Technology for Large Space Systems* 1989 Large Space Structures & Systems in the Space Station Era 1991 *Advances in Mechanism and Machine Science* Tadeusz Uhl 2019-06-13 This book gathers the proceedings of the 15th IFToMM World Congress, which was held in Krakow, Poland, from June 30 to July 4, 2019. Having been organized every four years since 1965, the Congress represents the world's largest scientific event on mechanism and machine science (MMS). The contributions cover an extremely diverse range of topics, including biomechanical

engineering, computational kinematics, design methodologies, dynamics of machinery, multibody dynamics, gearing and transmissions, history of MMS, linkage and mechanical controls, robotics and mechatronics, micro-mechanisms, reliability of machines and mechanisms, rotor dynamics, standardization of terminology, sustainable energy systems, transportation machinery, tribology and vibration. Selected by means of a rigorous international peer-review process, they highlight numerous exciting advances and ideas that will spur novel research directions and foster new multidisciplinary collaborations.

### **Kinematic Chains and Machine Components**

**Design** Dan B. Marghitu 2010-08-03 Kinematic Chains and Machine Components Design covers a broad spectrum of critical machine design topics and helps the reader understand the fundamentals and apply the

technologies necessary for successful mechanical design and execution. The inclusion of examples and instructive problems present the reader with a teachable computer-oriented text. Useful analytical techniques provide the practitioner and student with powerful tools for the design of kinematic chains and machine components. Kinematic Chains and Machine Components Design serves as a on-volume reference for engineers and students in mechanical engineering with applications for all engineers working in the fields of machine design and robotics. The book contains the fundamental laws and theories of science basic to mechanical engineering including mechanisms, robots and machine components to provide the reader with a thorough understanding of mechanical design. Combines theories of kinematics and behavior of mechanisms with the practical design of robots, machine parts, and machine systems into one comprehensive mechanical

design book Offers the method of contour equations for the kinematic analysis of mechanical systems and dynamic force analysis Mathematica programs and packages for the analysis of mechanical systems

**Spacecraft Dynamics** Thomas R. Kane 1983 Good, No Highlights, No Markup, all pages are intact, Slight Shelfwear, may have the corners slightly dented, may have slight color changes/slightly damaged spine.

*Dynamics, Theory and Applications* Thomas R. Kane 1985-01-01

**Analytical Dynamics** Haim Baruh 1999 This book presents a fair and balanced description of dynamics problems and formulations. From the classical methods to the newer techniques used in today's complex and multibody environments, this text shows how those approaches complement each other. The text begins by introducing the reader to the basic concepts in mechanics. These concepts are

introduced at the particle mechanics level. The text then extends these concepts to systems of particles, rigid bodies (plane motion and 3D), and lightly flexible bodies. The cornerstone variational principles of mechanics are developed and they are applied to particles, rigid bodies, and deformable bodies. The text emphasizes both the derivation of the describing equations and the response. The describing equations are developed using force and moment balances, as well as variational principles. Different approaches of obtaining equations of motion are discussed and compared. The response is analyzed qualitatively and quantitatively. Applied Dynamics Francis C. Moon 2008-10-20 For almost a decade now, this textbook had been at the forefront in using modern analytical and computational codes and in addressing novel developments. Already used by numerous institutions for their courses, this second edition has been substantially revised, with new sections on

biomechanics and micro- and nanotechnology. There is also more coverage of robotics, multibody simulations and celestial mechanics. Numerous examples have been added and problems, partly using MATLAB, have been included. \* Free solutions manual available for lecturers at [www.wiley-vch.de/supplements/](http://www.wiley-vch.de/supplements/) *Planar Multibody Dynamics* Parviz E. Nikravesh 2008 Written by Parviz Nikravesh, one of the world's best known experts in multibody dynamics, *Planar Multibody Dynamics: Formulation, Programming, and Applications* enhances the quality and ease of design education with extensive use of the latest computerized design tools combined with coverage of classical design and dynamics of machinery principles. Using language that is clear, concise, and to the point, the textbook introduces fundamental theories, computational methods, and program development for analyzing simple to complex planar mechanical systems.

The author chose MATLAB® as the programming language, and since students may not be skilled programmers, the examples and exercises provide a tutorial for learning MATLAB. The examples begin with basic commands before introducing students to more advanced programming techniques. The routines developed in each chapter eventually come together to form complete programs for different types of analysis. Pedagogical highlights Contains homework problems at the end of each chapter, some requiring standard pencil-and-paper solution in order to understand the concept and others requiring either programming or the use of existing programs. Electronic highlights All the programs that are listed in the book, and some additional programs, will be available for download and will be updated periodically by the author. Additional materials for instructors, such as a solutions manual and other teaching aids, will also be available on the website. The author

organizes the analytical and computational subjects around practical application examples. He uses several examples repeatedly, in various chapters, providing students with a basis for comparison between different formulations. The final chapter describes more extensive modeling and simulation projects. Designed specifically for undergraduates, the book is suitable as a primary text for a course on mechanisms or a supplementary text for a course on dynamics.

*International Aerospace Abstracts* 1998

**Modern Robotics** Kevin M. Lynch 2017-05-25 A modern and unified treatment of the mechanics, planning, and control of robots, suitable for a first course in robotics.

*Symbolic Methods in Control System Analysis and Design* N. Munro 1999 Fifteen

contributions provide an up-to-date treatment of issues in system modeling, system analysis, design and synthesis methods, and nonlinear systems. Coverage includes the

application of multidimensional Laplace transforms to the modeling of nonlinear elements, a survey of customized computer algebra modeling programs for multibody dynamical systems, robust control of linear systems using a new linear programming approach, the development and testing of a new branch-and-bound algorithm for global optimization using symbolic algebra techniques, and dynamic sliding mode control design using symbolic algebra tools.

Traditional and Innovative Approaches in Seismic Design

Linda Giresini 2018-03-19 This book is a printed edition of the Special Issue "Traditional and Innovative Approaches in Seismic Design" that was published in Buildings

**Planar Multibody Dynamics**

Parviz E. Nikravesh 2018  
Planar Multibody Dynamics: Formulation, Programming with MATLAB(R), and Applications, Second Edition provides methodologies for analyzing dynamics of

mechanical systems and machines, with coverage of classical and modern principles. MATLAB examples with basic commands are first used, before introducing students to advanced programming techniques.

*Computational Dynamics*

Ahmed A. Shabana 2001-06-25

A practical approach to the computational methods used to solve real-world dynamics problems Computational dynamics has grown rapidly in recent years with the advent of high-speed digital computers and the need to develop simulation and analysis computational capabilities for mechanical and aerospace systems that consist of interconnected bodies.

Computational Dynamics, Second Edition offers a full introduction to the concepts, definitions, and techniques used in multibody dynamics and presents essential topics concerning kinematics and dynamics of motion in two and three dimensions. Skillfully organized into eight chapters that mirror the standard



learning sequence of computational dynamics courses, this Second Edition begins with a discussion of classical techniques that review some of the fundamental concepts and formulations in the general field of dynamics. Next, it builds on these concepts in order to demonstrate the use of the methods as the foundation for the study of computational dynamics. Finally, the book presents different computational methodologies used in the computer-aided analysis of mechanical and aerospace systems. Each chapter features simple examples that show the main ideas and procedures, as well as straightforward problem sets that facilitate learning and help readers build problem-solving skills. Clearly written and ready to apply, *Computational Dynamics, Second Edition* is a valuable reference for both aspiring and practicing mechanical and aerospace engineers.

*Applied Mechanics Reviews*  
1988

**Multibody Dynamics** Ronald L. Huston 1990 This book develops the fundamentals of multibody dynamics from the principles of elementary mechanics. It is written in a tutorial style with numerous examples and an emphasis upon computational methods. This book should be accessible to anyone with a basic knowledge of elementary mechanics and analysis. *Multibody Dynamics* examines the behavior of systems of bodies subjected to forces or constraints. The bodies may be securely or loosely connected, and flexible or rigid. Such generality allows the use of multibody systems to model an increasing number of physical systems ranging from robots, biosystems (human body models), satellite booms, large structures, chains and cables. Until recently, analyses of such systems were virtually intractable. With the availability of high-speed digital computers, however, and with corresponding advances in analysis methods, multibody dynamics analyses

are not only feasible, they are also practical, and applicable, to these important physical systems.

### **Finite Element Analysis Concepts**

J. E. Akin 2010  
Young engineers are often required to utilize commercial finite element software without having had a course on finite element theory. That can lead to computer-aided design errors. This book outlines the basic theory, with a minimum of mathematics, and how its phases are structured within a typical software. The importance of estimating a solution, or verifying the results, by other means is emphasized and illustrated. The book also demonstrates the common processes for utilizing the typical graphical icon interfaces in commercial codes. In particular, the book uses and covers the widely utilized SolidWorks solid modeling and simulation system to demonstrate applications in heat transfer, stress analysis, vibrations, buckling, and other fields. The book, with its detailed

applications, will appeal to upper-level undergraduates as well as engineers new to industry.

Romansy 14 Giovanni Bianchi 2014-05-04 Mechanics, Motion Control, Sensing and Programming, Synthesis and Design, Legged Locomotion and Biomechanical Aspects of Robots and Manipulators - world view of the state of the art. Characterization: This volume presents the latest contribution to the theory and practice of modern robotics given by the world recognized scientists from Australia, Canada, Europe, Japan, Mexico, Singapore and USA.

### **Computer Aided Kinematics and Dynamics of Mechanical Systems: Basic methods**

Edward J. Haug 1989  
*Vehicle Dynamics* Reza N. Jazar 2013-11-19 This textbook is appropriate for senior undergraduate and first year graduate students in mechanical and automotive engineering. The contents in this book are presented at a theoretical-practical level. It explains vehicle dynamics

concepts in detail, concentrating on their practical use. Related theorems and formal proofs are provided, as are real-life applications. Students, researchers and practicing engineers alike will appreciate the user-friendly presentation of a wealth of topics, most notably steering, handling, ride, and related components. This book also: Illustrates all key concepts with examples Includes exercises for each chapter Covers front, rear, and four wheel steering systems, as well as the advantages and disadvantages of different steering schemes Includes an emphasis on design throughout the text, which provides a practical, hands-on approach

**Scientific and Technical Aerospace Reports** 1995

**Digital Human Modeling** Vincent G. Duffy 2011-06-24

This book constitutes the refereed proceedings of the Third International Conference on Digital Human Modeling, ICDHM 2011, held in Orlando, FL, USA in July 2011. The 58 revised papers presented were

carefully reviewed and selected from numerous submissions. The papers accepted for presentation thoroughly cover the thematic area of anthropometry applications, posture and motion modeling, digital human modeling and design, cognitive modeling, and driver modeling.

**Mechanics of Machines**

Viswanatha Ramamurti 2005

"Emphasizes the industrial relevance of the subject matter, dispenses with conventional inaccurate graphical methods used in Kinematics of plane mechanisms, cams and balancing. Instead presents general vector approach for both plane and space mechanisms."--BOOK JACKET.

**A Mathematical**

**Introduction to Robotic Manipulation** Richard M. Murray 2017-12-14 A

Mathematical Introduction to Robotic Manipulation presents a mathematical formulation of the kinematics, dynamics, and control of robot manipulators. It uses an elegant set of mathematical tools that

emphasizes the geometry of robot motion and allows a large class of robotic manipulation problems to be analyzed within a unified framework. The foundation of the book is a derivation of robot kinematics using the product of the exponentials formula. The authors explore the kinematics of open-chain manipulators and multifingered robot hands, present an analysis of the dynamics and control of robot systems, discuss the specification and control of internal forces and internal motions, and address the implications of the nonholonomic nature of rolling contact are addressed, as well. The wealth of information, numerous examples, and exercises make *A Mathematical Introduction to Robotic Manipulation* valuable as both a reference for robotics researchers and a text for students in advanced robotics courses.

**Solution Manual for  
Mechanics and Control of  
Robots** Krishna C. Gupta

1997-04-24 Intended as an

introduction to robot mechanics for students of mechanical, industrial, electrical, and bio-mechanical engineering, this graduate text presents a wide range of approaches and topics. It avoids formalism and proofs but nonetheless discusses advanced concepts and contemporary applications. It will thus also be of interest to practicing engineers. The book begins with kinematics, emphasizing an approach based on rigid-body displacements instead of coordinate transformations; it then turns to inverse kinematic analysis, presenting the widely used Pieper-Roth and zero-reference-position methods. This is followed by a discussion of workplace characterization and determination. One focus of the discussion is the motion made possible by spherical and other novel wrist designs. The text concludes with a brief discussion of dynamics and control. An extensive bibliography provides access to the current literature.

*Kinematics and Dynamics of*

Multibody Systems with Imperfect Joints Paulo Flores  
2008-01-10 This book presents suitable methodologies for the dynamic analysis of multibody mechanical systems with joints. It contains studies and case studies of real and imperfect joints. The book is intended for researchers, engineers, and graduate students in applied and computational mechanics.

*Generalized Principal Component Analysis* René Vidal  
2016-04-11 This book provides a comprehensive introduction to the latest advances in the mathematical theory and computational tools for modeling high-dimensional data drawn from one or multiple low-dimensional subspaces (or manifolds) and potentially corrupted by noise, gross errors, or outliers. This challenging task requires the development of new algebraic, geometric, statistical, and computational methods for efficient and robust estimation and segmentation of one or multiple subspaces. The book also presents interesting real-world applications of these new

methods in image processing, image and video segmentation, face recognition and clustering, and hybrid system identification etc. This book is intended to serve as a textbook for graduate students and beginning researchers in data science, machine learning, computer vision, image and signal processing, and systems theory. It contains ample illustrations, examples, and exercises and is made largely self-contained with three Appendices which survey basic concepts and principles from statistics, optimization, and algebraic-geometry used in this book. René Vidal is a Professor of Biomedical Engineering and Director of the Vision Dynamics and Learning Lab at The Johns Hopkins University. Yi Ma is Executive Dean and Professor at the School of Information Science and Technology at ShanghaiTech University. S. Shankar Sastry is Dean of the College of Engineering, Professor of Electrical Engineering and Computer Science and Professor of Bioengineering at

the University of California, Berkeley.

**Algorithmic Foundations of Robotics XII** Ken Goldberg

2020-05-06 This book presents the outcomes of the 12th International Workshop on the Algorithmic Foundations of Robotics (WAFR 2016). WAFR is a prestigious, single-track, biennial international meeting devoted to recent advances in algorithmic problems in robotics. Robot algorithms are an important building block of robotic systems and are used to process inputs from users and sensors, perceive and build models of the environment, plan low-level motions and high-level tasks, control robotic actuators, and coordinate actions across multiple systems. However, developing and analyzing these algorithms raises complex challenges, both theoretical and practical. Advances in the algorithmic foundations of robotics have applications to manufacturing, medicine, distributed robotics, human-robot interaction, intelligent prosthetics, computer animation,

computational biology, and many other areas. The 2016 edition of WAFR went back to its roots and was held in San Francisco, California - the city where the very first WAFR was held in 1994. Organized by Pieter Abbeel, Kostas Bekris, Ken Goldberg, and Lauren Miller, WAFR 2016 featured keynote talks by John Canny on "A Guided Tour of Computer Vision, Robotics, Algebra, and HCI," Erik Demaine on "Replicators, Transformers, and Robot Swarms: Science Fiction through Geometric Algorithms," Dan Halperin on "From Piano Movers to Piano Printers: Computing and Using Minkowski Sums," and by Lydia Kavraki on "20 Years of Sampling Robot Motion." Furthermore, it included an Open Problems Session organized by Ron Alterovitz, Florian Pokorny, and Jur van den Berg. There were 58 paper presentations during the three-day event. The organizers would like to thank the authors for their work and contributions, the reviewers for ensuring the high quality of the

meeting, the WAFR Steering Committee led by Nancy Amato as well as WAFR's fiscal sponsor, the International Federation of Robotics Research (IFRR), led by Oussama Khatib and Henrik Christensen. WAFR 2016 was an enjoyable and memorable event.

Virtual Nonlinear Multibody Systems Werner Schiehlen  
2012-12-06 This book contains an edited versIOn of lectures presented at the NATO ADVANCED STUDY INSTITUTE on VIRTUAL NONLINEAR MUL TIBODY SYSTEMS which was held in Prague, Czech Republic, from 23 June to 3 July 2002. It was organized by the Department of Mechanics, Faculty of Mechanical Engineering, Czech Technical University in Prague, in cooperation with the Institute B of Mechanics, University of Stuttgart, Germany. The ADVANCED STUDY INSTITUTE addressed the state of the art in multibody dynamics placing special emphasis on nonlinear systems, virtual reality, and control

design as required in mechatronics and its corresponding applications. Eighty-six participants from twenty-two countries representing academia, industry, government and research institutions attended the meeting. The high qualification of the participants contributed greatly to the success of the ADVANCED STUDY INSTITUTE in that it promoted the exchange of experience between leading scientists and young scholars, and encouraged discussions to generate new ideas and to define directions of research and future developments. The full program of the ADVANCED STUDY INSTITUTE included also contributed presentations made by participants where different topics were explored, among them: Such topics include: nonholonomic systems; flexible multibody systems; contact, impact and collision; numerical methods of differential-algebraical equations; simulation approaches; virtual modelling; mechatronic design; control;

biomechanics; space structures and vehicle dynamics. These presentations have been reviewed and a selection will be published in this volume, and in special issues of the journals *Multibody System Dynamics* and *Mechanics of Structures and Machines*.

### **Engineering Dynamics N.**

Jeremy Kasdin 2011-02-22 This textbook introduces undergraduate students to engineering dynamics using an innovative approach that is at once accessible and comprehensive. Combining the strengths of both beginner and advanced dynamics texts, this book has students solving dynamics problems from the very start and gradually guides them from the basics to increasingly more challenging topics without ever sacrificing rigor. *Engineering Dynamics* spans the full range of mechanics problems, from one-dimensional particle kinematics to three-dimensional rigid-body dynamics, including an introduction to Lagrange's and Kane's methods. It skillfully blends an easy-to-read,

conversational style with careful attention to the physics and mathematics of engineering dynamics, and emphasizes the formal systematic notation students need to solve problems correctly and succeed in more advanced courses. This richly illustrated textbook features numerous real-world examples and problems, incorporating a wide range of difficulty; ample use of MATLAB for solving problems; helpful tutorials; suggestions for further reading; and detailed appendixes. Provides an accessible yet rigorous introduction to engineering dynamics Uses an explicit vector-based notation to facilitate understanding  
Professors: A supplementary Instructor's Manual is available for this book. It is restricted to teachers using the text in courses. For information on how to obtain a copy, refer to: [http://press.princeton.edu/class\\_use/solutions.html](http://press.princeton.edu/class_use/solutions.html)  
*Control Design and Analysis for Underactuated Robotic Systems* Xin Xin 2014-01-03



The last two decades have witnessed considerable progress in the study of underactuated robotic systems (URs). Control Design and Analysis for Underactuated Robotic Systems presents a unified treatment of control design and analysis for a class of URs, which include systems with multiple-degree-of-freedom and/or with underactuation degree two. It presents novel notions, features, design techniques and strictly global motion analysis results for these systems. These new materials are shown to be vital in studying the control design and stability analysis of URs. Control Design and Analysis for Underactuated Robotic Systems includes the modelling, control design and analysis presented in a systematic way particularly for the following examples: 1 directly and remotely driven Acrobots 1 Pendubot 1 rotational pendulum 1 counter-weighted Acrobot 2-link underactuated robot with flexible elbow joint 1 variable-

length pendulum 1 3-link gymnastic robot with passive first joint 1 n-link planar robot with passive first joint 1 n-link planar robot with passive single joint double, or two parallel pendulums on a cart 1 3-link planar robots with underactuation degree two 2-link free flying robot The theoretical developments are validated by experimental results for the remotely driven Acrobot and the rotational pendulum. Control Design and Analysis for Underactuated Robotic Systems is intended for advanced undergraduate and graduate students and researchers in the area of control systems, mechanical and robotics systems, nonlinear systems and oscillation. This text will not only enable the reader to gain a better understanding of the power and fundamental limitations of linear and nonlinear control theory for the control design and analysis for these URs, but also inspire the reader to address the challenges of more complex URs.

*Large Space Structures &*

*Systems in the Space Station  
Era 1992*

**Global Formulations of  
Lagrangian and  
Hamiltonian Dynamics on  
Manifolds** Taeyoung Lee

2017-08-14 This book provides an accessible introduction to the variational formulation of Lagrangian and Hamiltonian mechanics, with a novel emphasis on global descriptions of the dynamics, which is a significant conceptual departure from more traditional approaches based on the use of local coordinates on the configuration manifold. In particular, we introduce a general methodology for obtaining globally valid equations of motion on configuration manifolds that are Lie groups, homogeneous spaces, and embedded manifolds, thereby avoiding the difficulties associated with coordinate singularities. The

material is presented in an approachable fashion by considering concrete configuration manifolds of increasing complexity, which then motivates and naturally leads to the more general formulation that follows. Understanding of the material is enhanced by numerous in-depth examples throughout the book, culminating in non-trivial applications involving multi-body systems. This book is written for a general audience of mathematicians, engineers, and physicists with a basic knowledge of mechanics. Some basic background in differential geometry is helpful, but not essential, as the relevant concepts are introduced in the book, thereby making the material accessible to a broad audience, and suitable for either self-study or as the basis for a graduate course in applied mathematics, engineering, or physics.