

Spacecraft Dynamics And Control An Introduction

Roger D. Werking Head, Attitude Determination and Control Section National Aeronautics and Space Administration/ Goddard Space Flight Center Extensive work has been done for many years in the areas of attitude determination, attitude prediction, and attitude control. During this time, it has been difficult to obtain reference material that provided a comprehensive overview of attitude support activities. This lack of reference material has made it difficult for those not intimately involved in attitude functions to become acquainted with the ideas and activities which are essential to understanding the various aspects of spacecraft attitude support. As a result, I felt the need for a document which could be used by a variety of persons to obtain an understanding of the work which has been done in support of spacecraft attitude objectives. It is believed that this book, prepared by the Computer Sciences Corporation under the able direction of Dr. James Wertz, provides this type of reference. This book can serve as a reference for individuals involved in mission planning, attitude determination, and attitude dynamics; an introductory textbook for students and professionals starting in this field; an information source for experimenters or others involved in spacecraft-related work who need information on spacecraft orientation and how it is determined, but who have neither the time nor the resources to pursue the varied literature on this subject; and a tool for encouraging those who could expand this discipline to do so, because much remains to be done to satisfy future needs.

Robotic technology offers two potential benefits for future space exploration. One benefit is minimizing the risk that astronauts face. The other benefit is increasing their productivity. Realizing the benefits of robotic technology in space will require solving several problems which are unique and now becoming active research topics. One of the most important research areas is dynamics, control, motion and planning for space robots by considering the dynamic interaction between the robot and the base (space station, space shuttle, or satellite). Any inefficiency in the planning and control can considerably risk by success of the space mission. Space Robotics: Dynamics and Control presents a collection of papers concerning fundamental problems in dynamics and control of space robots, focussing on issues relevant to dynamic base/robot interaction. The authors are all pioneers in theoretical analysis and experimental systems development of space robot technology. The chapters are organized within three problem areas: dynamics problems, nonholonomic nature problems, and control problems. This collection provides a solid reference for researchers in robotics, mechanics, control, and astronomical science.

This book presents the dynamic modeling and attitude control of flexible spacecraft with time-varying parameters. The dynamic characteristics, vibration control methods and attitude stabilization methods for spacecraft are systematically studied in respects of the theoretical modeling, numerical simulation and the ground experiment. Three active control theories in complex mode space are presented for flexible space structures. Optimal slew strategies based on variable amplitudes input shaping methods and coupling control methods are proposed for stabilization of flexible spacecraft. The research provides an important way to solve the problem of high-precision attitude control of flexible spacecraft with time-varying parameters. This book is appropriate for the researchers who focus on the multi-body dynamics, attitude and vibration control of flexible spacecraft.

Comprehensive, classic introduction to space-flight engineering for advanced undergraduate and graduate students provides basic tools for quantitative analysis of the motions of satellites and other vehicles in space.

Space Robotics: Dynamics and Control

Spacecraft Dynamics

Space Flight Dynamics

Rigid Body, Multibody, and Aerospace Applications

*An extensive text reference includes around an asteroid – a new and important topic
Covers the most updated contents in spacecraft dynamics and control, both in theory
and application Introduces the application to motion around asteroids – a new and
important topic Written by a very experienced researcher in this area*

*Orbital Mechanics for Engineering Students, Second Edition, provides an introduction
to the basic concepts of space mechanics. These include vector kinematics in three
dimensions; Newton's laws of motion and gravitation; relative motion; the vector-
based solution of the classical two-body problem; derivation of Kepler's equations;
orbits in three dimensions; preliminary orbit determination; and orbital maneuvers.
The book also covers relative motion and the two-impulse rendezvous problem;
interplanetary mission design using patched conics; rigid-body dynamics used to
characterize the attitude of a space vehicle; satellite attitude dynamics; and the
characteristics and design of multi-stage launch vehicles. Each chapter begins with an
outline of key concepts and concludes with problems that are based on the material
covered. This text is written for undergraduates who are studying orbital mechanics for
the first time and have completed courses in physics, dynamics, and mathematics,
including differential equations and applied linear algebra. Graduate students,
researchers, and experienced practitioners will also find useful review materials in the
book. NEW: Reorganized and improved discussions of coordinate systems, new
discussion on perturbations and quaternions NEW: Increased coverage of attitude
dynamics, including new Matlab algorithms and examples in chapter 10 New examples
and homework problems*

*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.*

*Space agencies are now realizing that much of what has previously been achieved
using hugely complex and costly single platform projects—large unmanned and
manned satellites (including the present International Space Station)—can be replaced
by a number of smaller satellites networked together. The key challenge of this
approach, namely ensuring the proper formation flying of multiple craft, is the topic of
this second volume in Elsevier's Astrodynamics Series, Spacecraft Formation Flying:
Dynamics, control and navigation. In this unique text, authors Alfrend et al. provide a
coherent discussion of spacecraft relative motion, both in the unperturbed and
perturbed settings, explain the main control approaches for regulating relative satellite
dynamics, using both impulsive and continuous maneuvers, and present the main
constituents required for relative navigation. The early chapters provide a foundation
upon which later discussions are built, making this a complete, standalone offering.
Intended for graduate students, professors and academic researchers in the fields of
aerospace and mechanical engineering, mathematics, astronomy and astrophysics,
Spacecraft Formation Flying is a technical yet accessible, forward-thinking guide to
this critical area of astrodynamics. The first book dedicated to spacecraft formation
flying, written by leading researchers and professors in the field Develops the theory
from an astrodynamical viewpoint, emphasizing modeling, control and navigation of*

formation flying satellites on Earth orbits Examples used to illustrate the main developments, with a sample simulation of a formation flying mission included to illustrate high fidelity modeling, control and relative navigation

Analytical Mechanics of Space Systems

Fundamental Spacecraft Dynamics and Control

Introduction to Space Dynamics

Spacecraft Dynamics and Control

Control of Spacecraft and Aircraft

An introduction to orbital mechanics and spacecraft attitude dynamics Foundations of Space Dynamics offers an authoritative text that combines a comprehensive review of both orbital mechanics and dynamics. The author a noted expert in the field covers up-to-date topics including: orbital perturbations, Lambert's transfer, formation flying, and gravity-gradient stabilization. The text provides an introduction to space dynamics in its entirety, including important analytical derivations and practical space flight examples. Written in an accessible and concise style, Foundations of Space Dynamics highlights analytical development and rigor, rather than numerical solutions via ready-made computer codes. To enhance learning, the book is filled with helpful tables, figures, exercises, and solved examples. This important book: Covers space dynamics with a systematic and comprehensive approach Is designed to be a practical text filled with real-world examples Contains information on the most current applications Includes up-to-date topics from orbital perturbations to gravity- gradient stabilization Offers a deep understanding of space dynamics often lacking in other textbooks Written for undergraduate and graduate students and professionals in aerospace engineering, Foundations of Space Dynamics offers an introduction to the most current information on orbital mechanics and dynamics.

Spacecraft attitude maneuvers comply with Euler's moment equations, a set of three nonlinear, coupled differential equations. Nonlinearities complicate the mathematical treatment of the seemingly simple action of rotating, and these complications lead to a robust lineage of research. This book is meant for basic scientifically inclined readers, and commences with a chapter on the basics of spaceflight and leverages this remediation to reveal very advanced topics to new spaceflight enthusiasts. The topics learned from reading this text will prepare students and faculties to investigate interesting spaceflight problems in an era where cube satellites have made such investigations attainable by even small universities. It is the fondest hope of the editor and authors that readers enjoy this book.

Provides the basics of spacecraft orbital dynamics plus attitude dynamics and control, using vector notation Spacecraft Dynamics and Control: An Introduction presents the fundamentals of classical control in the context of spacecraft attitude control. This approach is particularly beneficial for the training of students in both of the subjects of classical control as well as its application to spacecraft attitude control. By using a physical system (a spacecraft) that the reader can visualize (rather than arbitrary transfer functions), it is easier to grasp the motivation for why topics in control theory are important, as well as the theory behind them. The entire treatment of both orbital and attitude dynamics makes use of vector notation, which is a tool that allows the user to write down any vector equation of motion without consideration of a reference frame. This is particularly suited to the treatment of multiple reference frames. Vector notation also makes a very clear distinction between a physical vector and its coordinate representation in a reference frame. This is very important in spacecraft dynamics and control problems, where often multiple coordinate representations are

used (in different reference frames) for the same physical vector. Provides an accessible, practical aid for teaching and self-study with a layout enabling a fundamental understanding of the subject. Fills a gap in the existing literature by providing an analytical toolbox offering the reader a lasting, rigorous methodology for approaching vector mechanics, a key element vital to new graduates and practicing engineers alike. Delivers an outstanding resource for aerospace engineering students, and all those involved in the technical aspects of design and engineering in the space sector. Contains numerous illustrations to accompany the written text. Problems are included to apply and extend the material in each chapter. Essential reading for graduate level aerospace engineering students, aerospace professionals, researchers and engineers.

A textbook that incorporates the latest methods used for the analysis of spacecraft orbital, attitude, and structural dynamics and control. Spacecraft dynamics is treated as a dynamic system with emphasis on practical applications, typical examples of which are the analysis and redesign of the pointing control system of the Hubble Space Telescope and the analysis of an active vibrations control for the COFS (Control of Flexible Structures) Mast Flight System. In addition to the three subjects mentioned above, dynamic systems modeling, analysis, and control are also discussed.

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Advances in Spacecraft Attitude Control

Spacecraft Attitude Dynamics and Control

Rigid-Flexible Coupling Dynamics and Control of Flexible Spacecraft with Time-Varying Parameters

An Introduction

Foundations of Space Dynamics

Topics include orbital and attitude maneuvers, orbit establishment and orbit transfer, plane rotation, interplanetary transfer and hyperbolic passage, lunar transfer, reorientation with constant momentum, attitude determination, more. Answers to selected exercises. 1976 edition.

This book is an up-to-date compendium on spacecraft attitude and orbit control (AOC) that offers a systematic and complete treatment of the subject with the aim of imparting the theoretical and practical knowledge that is required by designers, engineers, and researchers. After an introduction on the kinematics of the flexible and agile space vehicles, the modern architecture and functions of an AOC system are described and the main AOC modes reviewed with possible design solutions and examples. The dynamics of the flexible body in space are then considered using an original Lagrangian approach suitable for the control applications of large space flexible structures. Subsequent chapters address optimal control theory, attitude control methods, and orbit control applications, including the optimal orbital transfer with finite and infinite thrust. The theory is integrated

with a description of current propulsion systems, with the focus especially on the new electric propulsion systems and state of the art sensors and actuators.

Rigid Body Dynamics for Space Applications explores the modern problems of spaceflight mechanics, such as attitude dynamics of re-entry and space debris in Earth's atmosphere; dynamics and control of coaxial satellite gyrostats; deployment, dynamics, and control of a tether-assisted return mission of a re-entry capsule; and removal of large space debris by a tether tow. Most space systems can be considered as a system of rigid bodies, with additional elastic and viscoelastic elements and fuel residuals in some cases. This guide shows the nature of the phenomena and explains the behavior of space objects. Researchers working on spacecraft attitude dynamics or space debris removal as well as those in the fields of mechanics, aerospace engineering, and aerospace science will benefit from this book. Provides a complete treatise of modeling attitude for a range of novel and modern attitude control problems of spaceflight mechanics Features chapters on the application of rigid body dynamics to atmospheric re-entries, tethered assisted re-entry, and tethered space debris removal Shows relatively simple ways of constructing mathematical models and analytical solutions describing the behavior of very complex material systems Uses modern methods of regular and chaotic dynamics to obtain results

This book offers a unified presentation that does not discriminate between atmospheric and space flight. It demonstrates that the two disciplines have evolved from the same set of physical principles and introduces a broad range of critical concepts in an accessible, yet mathematically rigorous presentation. The book presents many MATLAB and Simulink-based numerical examples and real-world simulations. Replete with illustrations, end-of-chapter exercises, and selected solutions, the work is primarily useful as a textbook for advanced undergraduate and beginning graduate-level students.

Motion Control Systems

Modern Spacecraft Dynamics and Control

Quaternion-Based Approach

The Embedded Model Control Approach

Spacecraft Modeling, Attitude Determination, and Control

Spacecraft Dynamics and Control An Introduction John Wiley & Sons

Flight Vehicle Dynamics and Control Rama K. Yedavalli, The Ohio State University, USA A comprehensive textbook which presents flight vehicle dynamics and control in a unified framework Flight Vehicle Dynamics and Control presents the dynamics and control of various flight vehicles, including aircraft, spacecraft, helicopter, missiles, etc, in a unified framework. It covers the fundamental topics in the dynamics and control of these flight vehicles, highlighting shared points as well as differences in dynamics and control issues, making use of the 'systems level' viewpoint. The book begins with the derivation of the equations of motion for a general rigid body and then delineates the differences between the dynamics of various flight vehicles in a fundamental way. It then focuses on the dynamic equations with application to these various flight vehicles, concentrating more on aircraft and spacecraft cases. Then the control systems analysis and design is carried out both from transfer function, classical control, as well as modern, state space control points of view. Illustrative examples of application to atmospheric and space vehicles are presented, emphasizing the 'systems level' viewpoint of control design. Key features: Provides a comprehensive treatment of dynamics and control of various flight vehicles in a single volume. Contains worked out examples (including MATLAB examples) and end of chapter homework problems. Suitable as a single textbook for a sequence of undergraduate courses on flight vehicle dynamics and control. Accompanied by a website that includes additional problems and a solutions manual. The book is essential reading for undergraduate students in mechanical and aerospace engineering, engineers working on flight vehicle control, and researchers from other engineering backgrounds working on related topics.

Written for aerospace engineering courses of senior undergraduate or graduate level, this work presents basic concepts, methods and mathematical developments in spacecraft attitude dynamics and control. Topics covered include rigid body dynamics, environmental effects and linear control theory.

Spacecraft Attitude Control: A Linear Matrix Inequality Approach solves problems for spacecraft attitude control systems using convex optimization, and more specifically, through a linear matrix inequalities approach (LMI). High-precision pointing and improved robustness in the face of external disturbances and other uncertainties are requirements for the current generation of spacecraft. The title develops an LMI approach to spacecraft attitude control and shows that all uncertainties in the maneuvering process can be solved numerically. The book develops a wide variety of novel and robust controllers, applicable both to spacecraft attitude control and easily extendible to second-order systems. This title introduces spacecraft attitude control and robust systems, giving an extensive survey of current research and helping researchers improve robust control performance. Considers the control requirements of modern spacecraft Presents rigid and flexible spacecraft control systems with inherent mathematic uncertainties that lead to a model-like state-

space Develops a variety of novel and robust controllers directly applicable to spacecraft control and extendable to other second-order systems Includes a systematic survey of recent research in spacecraft attitude control

Modeling and Simulation with MATLAB® and Simulink®

Advanced Control of Aircraft, Spacecraft and Rockets

Spacecraft Attitude Determination and Control

Advanced Dynamics

Fault-Tolerant Attitude Control of Spacecraft

Presents the established principles underpinning space robotics with a thorough and modern approach. This text is perfect for professionals in the field looking to gain an understanding of real-life applications of manipulators on satellites, and of the dynamics of satellites carrying robotic manipulators and of planetary rovers.

This book discusses all spacecraft attitude control-related topics: spacecraft (including attitude measurements, actuator, and disturbance torques), modeling, spacecraft attitude determination and estimation, and spacecraft attitude controls. Unlike other books addressing these topics, this book focuses on quaternion-based methods because of its many merits. The book lays a brief, but necessary background on rotation sequence representations and frequently used reference frames that form the foundation of spacecraft attitude description. It then discusses the fundamentals of attitude determination using vector measurements, various efficient (including very recently developed) attitude determination algorithms, and the instruments and methods of popular vector measurements. With available attitude measurements, attitude control designs for inertial point and nadir pointing are presented in terms of required torques which are independent of actuators in use. Given the required control torques, some actuators are not able to generate the accurate control torques, therefore, spacecraft attitude control design methods with achievable torques for these actuators (for example, magnetic torque bars and control moment gyros) are provided. Some rigorous controllability results are provided. The book also includes attitude control in some special maneuvers, such as orbital-raising, docking and rendezvous, that are normally not discussed in similar books. Almost all design methods are based on state-spaced modern control approaches, such as linear quadratic optimal control, robust pole assignment control, model predictive control, and gain scheduling control. Applications of these methods to spacecraft attitude control problems are provided. Appendices are provided for readers who are not familiar with these topics.

This book explores topics that are central to the field of spacecraft attitude determination and control. The authors provide rigorous theoretical derivations of significant algorithms accompanied by a generous amount of qualitative discussions of the subject matter. The book documents the development of the important concepts and methods in a manner accessible to practicing engineers, graduate-level engineering students and applied mathematicians. It includes detailed examples from actual mission designs to help ease the transition from theory to practice and also provides prototype algorithms that are readily available on the author's website. Subject matter includes both theoretical derivations and practical implementation of spacecraft attitude determination and control systems. It provides detailed derivations for attitude kinematics and dynamics and provides detailed description of the most widely used attitude parameterization, the quaternion. This title also provides a thorough treatise of attitude dynamics including Jacobian elliptical functions. It is the first known book to provide detailed derivations and explanations of state attitude determination and gives readers real-world examples from actual working spacecraft missions. The subject matter is chosen to fill the void of existing textbooks and treatises, especially in state and dynamics attitude determination. MATLAB code of all examples will

be provided through an external website.

Spacecraft Dynamics and Control: The Embedded Model Control Approach provides a uniform and systematic way of approaching space engineering control problems from the standpoint of model-based control, using state-space equations as the key paradigm for simulation, design and implementation. The book introduces the Embedded Model Control methodology for the design and implementation of attitude and orbit control systems. The logic architecture is organized around the embedded model of the spacecraft and its surrounding environment. The model is compelled to include disturbance dynamics as a repository of the uncertainty that the control law must reject to meet attitude and orbit requirements within the uncertainty class. The source of the real-time uncertainty estimation/prediction is the model error signal, as it encodes the residual discrepancies between spacecraft measurements and model output. The embedded model and the uncertainty estimation feedback (noise estimator in the book) constitute the state predictor feeding the control law. Asymptotic pole placement (exploiting the asymptotes of closed-loop transfer functions) is the way to design and tune feedback loops around the embedded model (state predictor, control law, reference generator). The design versus the uncertainty class is driven by analytic stability and performance inequalities. The method is applied to several attitude and orbit control problems. The book begins with an extensive introduction to attitude geometry and algebra and ends with the core themes: state-space dynamics and Embedded Model Control. Fundamentals of orbit, attitude and environment dynamics are treated giving emphasis to state-space formulation, disturbance dynamics, state feedback and prediction, closed-loop stability. Sensors and actuators are treated giving emphasis to their dynamics and modelling of measurement errors. Numerical tables are included and their data employed for numerical simulations. Orbit and attitude control problems of the European GOCE mission are the inspiration of numerical exercises and simulations. The suite of the attitude control modes of a GOCE-like mission is designed and simulated around the so-called mission state predictor. Solved and unsolved exercises are included within the text - and not separated at the end of chapters - for better understanding, training and application. Simulated results and their graphical plots are developed through MATLAB/Simulink code.

Spacecraft Formation Flying

Spacecraft Attitude Control

A Linear Matrix Inequality Approach

Spacecraft Momentum Control Systems

Flight Dynamics and Control of Aero and Space Vehicles

Fault-Tolerant Attitude Control of Spacecraft presents the fundamentals of spacecraft fault-tolerant attitude control systems, along with the most recent research and advanced, nonlinear control techniques. This book gives researchers a self-contained guide to the complex tasks of envisaging, designing, implementing and experimenting by presenting designs for integrated modeling, dynamics, fault-tolerant attitude control, and fault reconstruction for spacecraft. Specifically, the book gives a full literature review and presents preliminaries and mathematical models, robust fault-tolerant attitude control, fault-tolerant attitude control with actuator saturation, velocity-free fault tolerant attitude control, finite-time fault-tolerant attitude tracking control, and active fault-tolerant attitude control. Finally, the book looks at the future of this interesting topic, offering readers a one-stop solution for those working on fault-tolerant attitude control for spacecraft. Presents the fundamentals of fault-tolerant attitude control systems for spacecraft in one practical solution Gives the latest research and thinking on nonlinear attitude control, fault tolerant control, and reliable attitude control Brings together concepts in fault control theory, fault diagnosis, and attitude control for

spacecraft Covers advances in theory, technological aspects, and applications in spacecraft Presents detailed numerical and simulation results to assist engineers Offers a clear, systematic reference on fault-tolerant control and attitude control for spacecraft Here a leading researcher provides a comprehensive treatment of the design of automatic control logic for spacecraft and aircraft. In this book Arthur Bryson describes the linear-quadratic-regulator (LQR) method of feedback control synthesis, which coordinates multiple controls, producing graceful maneuvers comparable to those of an expert pilot. The first half of the work is about attitude control of rigid and flexible spacecraft using momentum wheels, spin, fixed thrusters, and gimballed engines. Guidance for nearly circular orbits is discussed. The second half is about aircraft attitude and flight path control. This section discusses autopilot designs for cruise, climb-descent, coordinated turns, and automatic landing. One chapter deals with controlling helicopters near hover, and another offers an introduction to the stabilization of aeroelastic instabilities. Throughout the book there is a strong emphasis on the mathematical modeling necessary for designing a good feedback control system. The appendixes summarize analysis of linear dynamic systems, synthesis of analog and digital feedback control, simulation, and modeling of flexible vehicles.

A thorough understanding of rigid body dynamics as it relates to modern mechanical and aerospace systems requires engineers to be well versed in a variety of disciplines. This book offers an all-encompassing view by interconnecting a multitude of key areas in the study of rigid body dynamics, including classical mechanics, spacecraft dynamics, and multibody dynamics. In a clear, straightforward style ideal for learners at any level, *Advanced Dynamics* builds a solid fundamental base by first providing an in-depth review of kinematics and basic dynamics before ultimately moving forward to tackle advanced subject areas such as rigid body and Lagrangian dynamics. In addition, *Advanced Dynamics*: Is the only book that bridges the gap between rigid body, multibody, and spacecraft dynamics for graduate students and specialists in mechanical and aerospace engineering Contains coverage of special applications that highlight the different aspects of dynamics and enhances understanding of advanced systems across all related disciplines Presents material using the author's own theory of differentiation in different coordinate frames, which allows for better understanding and application by students and professionals Both a refresher and a professional resource, *Advanced Dynamics* leads readers on a rewarding educational journey that will allow them to expand the scope of their engineering acumen as they apply a wide range of applications across many different engineering disciplines.

Satellites are used increasingly in telecommunications, scientific research, surveillance, and meteorology, and these satellites rely heavily on the effectiveness of complex onboard control systems. This 1997 book explains the basic theory of spacecraft dynamics and control and the practical aspects of controlling a satellite. The emphasis throughout is on analyzing and solving real-world engineering problems. For example, the author discusses orbital and rotational dynamics of spacecraft under a variety of environmental conditions, along with the realistic constraints imposed by available hardware. Among the topics covered are orbital dynamics, attitude dynamics, gravity gradient stabilization, single and dual spin stabilization, attitude maneuvers, attitude stabilization, and structural dynamics and liquid sloshing.

Technologies by Giovanni Campolo

Celestial Mechanics and Astrodynamics

Spacecraft Dynamics and Control and Intro

Dynamics and Control of Autonomous Space Vehicles and Robotics

Flexible Spacecraft Dynamics, Control and Guidance

This book presents up-to-date concepts and design methods relating to space dynamics and control, including spacecraft attitude control, orbit control, and guidance, navigation, and control (GNC), summarizing the research advances in control theory and methods and engineering practice from Beijing Institute of Control Engineering over the years. The control schemes and systems based on these achievements have been successfully applied to remote sensing satellites, communication satellites, navigation satellites, new technology test satellites, Shenzhou manned spacecraft, Tianzhou freight spacecraft, Tiangong 1/2 space laboratories, Chang'e lunar explorers, and many other missions. Further, the research serves as a guide for follow-up engineering developments in manned lunar engineering, deep space exploration, and on-orbit service missions.

This modern textbook guides the reader through the theory and practice of the motion and attitude control of space vehicles. It first presents the fundamental principles of spaceflight mechanics and then addresses more complex concepts and applications of perturbation theory, orbit determination and refinement, space propulsion, orbital maneuvers, interplanetary trajectories, gyroscope dynamics, attitude control, and rocket performance. Many algorithms used in the modern practice of trajectory computation are also provided. The numerical treatment of the equations of motion, the related methods, and the tables needed to use them receive particular emphasis. A large collection of bibliographical references (including books, articles, and items from the "gray literature") is provided at the end of each chapter, and attention is drawn to many internet resources available to the reader. The book will be of particular value to undergraduate and graduate students in aerospace engineering.

Motion Control Systems is concerned with design methods that support the never-ending requirements for faster and more accurate control of mechanical motion. The book presents material that is fundamental, yet at the same time discusses the solution of complex problems in motion control systems. Methods presented in the book are based on the authors' original research results. Mathematical complexities are kept to a required minimum so that practicing engineers as well as students with a limited background in control may use the book. It is unique in presenting know-how accumulated through work on very diverse problems into a comprehensive unified approach suitable for application in high demanding, high-tech products. Major issues covered include motion control ranging from simple trajectory tracking and force control, to topics related to

haptics, bilateral control with and without delay in measurement and control channels, as well as control of nonredundant and redundant multibody systems. Provides a consistent unified theoretical framework for motion control design Offers graduated increase in complexity and reinforcement throughout the book Gives detailed explanation of underlying similarities and specifics in motion control Unified treatment of single degree-of-freedom and multibody systems Explains the fundamentals through implementation examples Based on classroom-tested materials and the authors' original research work Written by the leading researchers in sliding mode control (SMC) and disturbance observer (DOB) Accompanying lecture notes for instructors Simulink and MATLAB® codes available for readers to download Motion Control Systems is an ideal textbook for a course on motion control or as a reference for post-graduates and researchers in robotics and mechatronics. Researchers and practicing engineers will also find the techniques helpful in designing mechanical motion systems.

Thorough coverage of space flight topics with self-contained chapters serving a variety of courses in orbital mechanics, spacecraft dynamics, and astronautics This concise yet comprehensive book on space flight dynamics addresses all phases of a space mission: getting to space (launch trajectories), satellite motion in space (orbital motion, orbit transfers, attitude dynamics), and returning from space (entry flight mechanics). It focuses on orbital mechanics with emphasis on two-body motion, orbit determination, and orbital maneuvers with applications in Earth-centered missions and interplanetary missions. Space Flight Dynamics presents wide-ranging information on a host of topics not always covered in competing books. It discusses relative motion, entry flight mechanics, low-thrust transfers, rocket propulsion fundamentals, attitude dynamics, and attitude control. The book is filled with illustrated concepts and real-world examples drawn from the space industry. Additionally, the book includes a "computational toolbox" composed of MATLAB M-files for performing space mission analysis. Key features: Provides practical, real-world examples illustrating key concepts throughout the book Accompanied by a website containing MATLAB M-files for conducting space mission analysis Presents numerous space flight topics absent in competing titles Space Flight Dynamics is a welcome addition to the field, ideally suited for upper-level undergraduate and graduate students studying aerospace engineering.

Spacecraft Dynamics and Control China Edition
Automated Rendezvous and Docking of Spacecraft
Practical Astrodynamics

Atmospheric and Space Flight Dynamics

Space Vehicle Dynamics and Control

Advanced Control of Aircraft, Spacecraft and Rockets introduces the reader to the concepts of modern control theory applied to the design and analysis of general flight control systems in a concise and mathematically rigorous style. It presents a comprehensive treatment of both atmospheric and space flight control systems including aircraft, rockets (missiles and launch vehicles), entry vehicles and spacecraft (both orbital and attitude control). The broad coverage of topics emphasizes the synergies among the various flight control systems and attempts to show their evolution from the same set of physical principles as well as their design and analysis by similar mathematical tools. In addition, this book presents state-of-art control system design methods - including multivariable, optimal, robust, digital and nonlinear strategies - as applied to modern flight control systems. Advanced Control of Aircraft, Spacecraft and Rockets features worked examples and problems at the end of each chapter as well as a number of MATLAB / Simulink examples housed on an accompanying website at <http://home.iitk.ac.in/~ashtew> that are realistic and representative of the state-of-the-art in flight control.

The goal of this book is to serve both as a practical technical reference and a resource for gaining a fuller understanding of the state of the art of spacecraft momentum control systems, specifically looking at control moment gyroscopes (CMGs). As a result, the subject matter includes theory, technology, and systems engineering. The authors combine material on system-level architecture of spacecraft that feature momentum-control systems with material about the momentum-control hardware and software. This also encompasses material on the theoretical and algorithmic approaches to the control of space vehicles with CMGs. In essence, CMGs are the attitude-control actuators that make contemporary highly agile spacecraft possible. The rise of commercial Earth imaging, the advances in privately built spacecraft (including small satellites), and the growing popularity of the subject matter in academic circles over the past decade argues that now is the time for an in-depth treatment of the topic. CMGs are augmented by reaction wheels and related algorithms for steering all such actuators, which together comprise the field of spacecraft momentum control systems. The material is presented at a level suitable for practicing engineers and those with an undergraduate degree in mechanical, electrical, and/or aerospace engineering.

Celestial Mechanics and Astrodynamics

The definitive reference for space engineers on rendezvous and docking/berthing (RVD/B) related issues, this book answers key questions such as: How does the docking vehicle accurately approach the target spacecraft? What technology is needed aboard the spacecraft to perform automatic rendezvous and docking, and what systems are required by ground control to supervise this process? How can the proper functioning of all rendezvous-related equipment, systems and operations be verified before launch? The book provides an overview of the major issues governing approach and mating strategies, and system concepts for rendezvous and docking/berthing. These issues are described and explained such that aerospace engineers, students and even newcomers to the field can acquire a basic understanding of RVD/B. The author would like to extend his thanks to Dr Shufan Wu, GNC specialist and translator of the book's Chinese edition, for his help in the compilation of

these important errata.

Rigid Body Dynamics for Space Applications

Orbital Mechanics for Engineering Students

Spacecraft Collision Avoidance Technology

A Practical Engineering Approach

Fundamentals of Spacecraft Attitude Determination and Control

Spacecraft Collision Avoidance Technology presents the theory and practice of space collision avoidance. The title gives models of time and space environment, their impact on high-precision orbit prediction, considers optimal orbit determination methods and models in different warning stages, and establishes basic models for warning and avoidance. Chapters present an outline of spacecraft collision warning strategy, elaborate on the basics of orbital calculation for collision avoidance, consider space object detection technology, detail space environment and object orbit, give a method for spacecraft collision warning orbit calculation, and finally, demonstrate a strategy for spacecraft collision warning and avoidance. Presents strategies, methods and real-world examples relating to space collision avoidance Considers time and space environment models in orbit prediction Gives optimal orbit determination methods and models for various warning stages Establishes and elaborates basic models for warning and avoidance Takes note of the current space environment for object detection and collision avoidance
Dynamics, Control and Navigation