Spacecraft Attitude And Orbit Control Textbook Princeton

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.

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. .

The primary function of a spacecraft attitude control subsystem is the attitude determination and, more generally, the state estimation (attitude of the main body, appendages and flexible modes). The so-called optical-inertial concept is first described with application to a number of modern spacecraft; an example of implementation using space-qualified microprocessors is given in detail; the state estimation of a flexible spacecraft is then considered, a technique which can be readily implemented on existing hardware. The extension of this concept to autonomous orbit control of an orbiting spacecraft is then considered for future development. (Author).

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

This volume contains select papers presented during the 1st International Conference on Small Satellites, discussing the latest research and developments relating to small satellite technology. The papers cover various issues relating to design and engineering, ranging from the control, mechanical and thermal systems to the sensors, antennas and RF systems used. The volume will be of interest to scientists and engineers working on or utilizing satellite and space technologies.

This book describes recent studies on modern control systems using various control techniques. The control systems cover large complex systems such as train operation systems to micro systems in nanotechnology. Various control trends and techniques are

discussed from practically modern approaches such as Internet of Things, artificial neural networks, machine learning to theoretical approaches such as zero-placement, bang-bang, optimal control, predictive control, and fuzzy approach.
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.
The torque developed by the interaction of current-carrying coils with the earth's magnetic field can be used as a means of attitude control. The degree to which the attitude of a vehicle can be maintained utilizing this torque depends on the fluctuations of the magnetic field at the satellite as the satellite orbits about the earth. Due to the nature of the torque developed only two vehicle axes can be c ntinuously controlled simultaneously. With the principle described, either a two- or three-coil system can be used to control vehicle attitude about two axes. Intermittent control about three axes can be obtained. (Author).
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.
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.

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.

"An important feature of this book is that fundamentals of classical control are presented and developed in the context of spacecraft attitude control"--

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.

This book explores CubeSat technology, and develops a nonlinear mathematical model of a spacecraft with the assumption that the satellite is a rigid body. It places emphasis on the CubeSat subsystem, orbit dynamics and perturbations, the satellite attitude dynamic and modeling, and components of attitude determination and the control subsystem. The book focuses on the attitude stabilization methods of spacecraft, and presents gravity gradient stabilization, aerodynamic stabilization, and permanent magnets stabilization as passive stabilization methods, and spin stabilization and three axis stabilization as active stabilization methods. It also discusses the need to develop a control system design, and describes the design of three controller configurations, namely the Proportional–Integral–Derivative Controller (PID), the Linear Quadratic Regulator (LQR), and the Fuzzy Logic Controller (FLC) and how they can be used to design the attitude control of CubeSat three-axis stabilization. Furthermore, it presents the design of a suitable attitude stabilization system by combining gravity gradient stabilization with magnetic torquing, and the design of magnetic coils which can be added in order to improve the accuracy of attitude stabilization. The book then investigates, simulates, and compares possible controller configurations that can be used to control the currents of magnetic coils when magnetic coils behave as the actuator of the system.

This book collects selected papers from the 7th Conference on Signal and Information Processing, Networking and

Computers held in Rizhao, China, on September, 2020. The 7th International Conference on Signal and Information Processing, Networking and Computers (ICSINC) was held in Rizhao, China, on September, 2020.

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.

Since the beginning of space flight, the collision hazard in Earth orbit has increased as the number of artificial objects orbiting the Earth has grown. Spacecraft performing communications, navigation, scientific, and other missions now share Earth orbit with spent rocket bodies, nonfunctional spacecraft, fragments from spacecraft breakups, and other debris created as a byproduct of space operations. Orbital Debris examines the methods we can use to characterize orbital debris, estimates the magnitude of the debris population, and assesses the hazard that this population poses to spacecraft. Potential methods to protect spacecraft are explored. The report also takes a close look at the projected future growth in the debris population and evaluates approaches to reducing that growth. Orbital Debris offers clear recommendations for targeted research on the debris population, for methods to improve the protection of spacecraft, on methods to reduce the creation of debris in the future, and much more.

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 discusions of coordinate systems, new discussion on perturbations and quarternions NEW: Increased coverage of attitude dynamics, including new Matlab algorithms and examples in chapter 10 New examples and homework problems

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.

Very Good,No Highlights or Markup,all pages are intact.

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.

Provides the basics of spacecraft orbital dynamics plusattitude dynamics and control, using vectrix notation Spacecraft Dynamics and Control: An Introductionpresents the fundamentals of classical control in the context ofspacecraft attitude control. This approach is particularlybeneficial for the training of students in both of the subjects ofclassical control as well as its application to spacecraft attitudecontrol. By using a physical system (a spacecraft) that the readercan visualize (rather than arbitrary transfer functions), it iseasier to grasp the motivation for why topics in control theory areimportant, as well as the theory behind them. The entiretreatment of both orbital and attitude dynamics makes use ofvectrix notation, which is a tool that allows the user to writedown any vector equation of motion without consideration of areference frame. This is particularly suited to the treatment ofmultiple reference frames. Vectrix notation also makes a very cleardistinction between a physical vector and its coordinaterepresentation in a reference frame. This is very important inspacecraft dynamics and control problems, where often multiplecoordinate representations are used (in different reference frames)for the same physical vector. Provides an accessible, practical aid for teaching andself-study with a layout enabling a fundamental understanding ofthe subject Fills a gap in the existing literature by providing ananalytical toolbox offering the reader a lasting, rigorousmethodology for approaching vector mechanics, a key element vitalto new graduates and practicing engineers alike Delivers an outstanding resource for aerospace engineeringstudents, and all those involved in the technical aspects of designand engineering in the space sector Contains numerous illustrations to accompany the written text.Problems are included to apply and extend the material in eachchapter Essential reading for graduate level aerospace engineeringstudents, aerospace professionals, researchers and engineers.

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.

Automatic Control in Space is a compendium of papers presented on the Eighth IFAC Symposium that took place in Oxford, England in July 1979.

Comprehensive coverage includes environmental torques, energy dissipation, motion equations for four archetypical systems, orientation parameters, illustrations of key concepts with on-orbit flight data, and typical engineering hardware. 1986 edition.

Roger D. Werking Head, Attitude Determination and Control Section National Aeronautics and Space Administration/ Goddard Space Flight Center Extensiye 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 stu dents and professionals starting in this field; an information source for experimen ters 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.

"Space Vehicle Dynamics and Control provides a solid foundation in dynamic modeling, analysis, and control of space vehicles. More than 200 figures, photographs, and tables are featured in detailed sections covering the fundamentals of controlling orbital, attitude, and structural motions of space vehicles. The textbook highlights a range of orbital maneuvering and control problems: orbital transfer, rendezvous, and halo orbit determination and control. Rotational maneuvering and attitude control problems of space vehicles under the influence of reaction jet firings, internal energy dissipation, or momentum transfer via reaction wheels and control moment gyros are treated in detail. The textbook also highlights the analysis and design of attitude control systems in the presence of structural flexibility and/or propellant sloshing. At the end of each chapter, Dr. Wie includes a helpful list of references for graduate students and working professionals studying spacecraft dynamics and control. A bibliography of more than 350 additional references in the field of spacecraft guidance, control, and dynamics is also provided at the end of the book. This text requires a thorough knowledge of vector and matrix algebra, calculus, ordinary differential equations, engineering mechanics,

and linear system dynamics and control. The first two chapters provide a summary of such necessary background material. Since some problems may require the use of software for the analysis, control design, and numerical simulation, readers should have access to computational software (i.e., MATLAB) on a personal computer.

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.

This comprehensive handbook provides an overview of space technology and a holistic understanding of the system-of-systems that is a modern spacecraft. With a foreword by Elon Musk, CEO and CTO of SpaceX, and contributions from globally leading agency experts from NASA, ESA, JAXA, and CNES, as well as European and North American academics and industrialists, this handbook, as well as giving an interdisciplinary overview, offers, through individual self-contained chapters, more detailed understanding of specific fields, ranging through: · Launch systems, structures, power, thermal, communications, propulsion, and software, to · entry, descent and landing, ground segment, robotics, and data systems, to · technology management, legal and regulatory issues, and project management. This handbook is an equally invaluable asset to those on a career path towards the space industry as it is to those already within the industry.

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.

This book de-emphasizes the formal mathematical description of spacecraft on-board attitude and orbit applications in favor of a more qualitative, concept-oriented presentation of these topics. The information presented in this book was originally given as a set of lectures in

1999 and 2000 instigated by a NASA Flight Software Branch Chief at Goddard Space Flight Center. The Branch Chief later suggested this book. It provides an approachable insight into the area and is not intended as an essential reference work. ACS Without an Attitude is intended for programmers and testers new to the field who are seeking a commonsense understanding of the subject matter they are coding and testing in the hope that they will reduce their risk of introducing or missing the key software bug that causes an abrupt termination in their spacecraft's mission. In addition, the book will provide managers and others working with spacecraft with a basic understanding of this subject.

This volume is designed as an introductory text and reference book for graduate students, researchers and practitioners in the fields of astronomy, astrodynamics, satellite systems, space sciences and astrophysics. The purpose of the book is to emphasize the similarities between celestial mechanics and astrodynamics, and to present recent advances in these two fields so that the reader can understand the inter-relations and mutual influences. The juxtaposition of celestial mechanics and astrodynamics is a unique approach that is expected to be a refreshing attempt to discuss both the mechanics of space flight and the dynamics of celestial objects. "Celestial Mechanics and Astrodynamics: Theory and Practice" also presents the main challenges and future prospects for the two fields in an elaborate, comprehensive and rigorous manner. The book presents homogenous and fluent discussions of the key problems, rendering a portrayal of recent advances in the field together with some basic concepts and essential infrastructure in orbital mechanics. The text contains introductory material followed by a gradual development of ideas interweaved to yield a coherent presentation of advanced topics. Spacecraft Modeling, Attitude Determination, and ControlQuaternion-Based ApproachCRC Press

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