Re Entry Vehicle Dynamics

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Space Vehicle Design - Michael Douglas Griffin 2004

Dynamics of Atmospheric Re-Entry - Frank J. Regan 1993

Spacecraft Attitude Dynamics - Peter C. Hughes 2012-05-23 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.

Investigation of Ablation Effects on Hypersonic Dynamic Stability of a 10 Cone - Dave R. Moore 1967

An experimental program has been conducted in the LTV Hypervelocity Wind Tunnel at M = 17 to investigate the effects of ablation product characteristics and thermal lags on re-entry vehicle dynamic stability. The free oscillation method of dynamic stability measurement was used and the ablation processes were simulated by the controlled mass injection through four sections of the porous model skin. The flow rates through the top and bottom quadrants were oscillated at the same frequency and at an amplitude proportional to the model motion. The thermal lag effect was investigated with nitrogen injection into nitrogen tunnel flow at several different mass flow rates and phase angles between the oscillating mass flow and the body motion. The ablation product study was conducted by injecting gases other than nitrogen with specific heat ratio and molecular weight being the test parameters in addition to mass flow rate. The

results obtained from these tests indicate significant effect on dynamic stability with both injection phase angle and some characteristics of the injected gas. The effects of model frequency, Reynolds number and mass injection distribution were also investigated and some static pressure measurements were made near the aft of the model. Appendices to the report contain tabulations of the pertinent data and discussions of supporting analytical studies and data analysis.

Radiation Gas Dynamics - Shih-I. Pai 2012-12-06

When the temperature of a gas is not too high and the density of a gas is not too low, the transfer of heat by radiation is usually negligibly small in comparison with that by conduction and convection. However, in the hypersonic flow of space flight, particularly in the re-entry of a space vehicle, and in the flow problem involving nuclear reaction such as in the blast wave of nuclear bomb or in the peaceful use of the controlled fusion reaction, the temperature of the gas may be very high and the density of the gas may be very low. As a result, thermal radiation becomes a very important mode of heat transfer. A complete analysis of such high temperature flow fields should

be based upon a study of the gasdynamic field and the radiation field simultaneously. Hence during the last few years, considerable efforts have been made to study such interaction problems between gasdynamic field and radiation field and a new title, Radiation Gasdynamics, has been suggested for this subject. Even though radiative transfer has been studied for a long time by astro physicists, the interaction between the radiation field and the gadsynamic field has been only extensively studied recently.

Atmospheric Re-Entry Vehicle Mechanics - Patrick Gallais 2007-10-19

Based on a long engineering experience, this book offers a comprehensive and state-of-the-art analysis of aerodynamic and flight mechanic entry topics. This updated edition had new chapters on Re-entry on Mars mission, flight quality, rarefied aerodynamics and re-entry accuracy. In addition, it provides a large set of application exercises and solutions.

The Second Nuclear Age - Colin S. Gray 1999

The author takes issue with the complacent belief that a happy mixture of deterrence, arms control and luck will enable humanity to cope adequately with weapons of mass destruction, arguing that the

risks are ever more serious.

Hypersonic Vehicles - Giuseppe Pezzella 2019-10-02

In the aviation field there is great interest in high-speed vehicle design. Hypersonic vehicles represent the next frontier of passenger transportation to and from space. However, several design issues must be addressed, including vehicle aerodynamics and aerothermodynamics, aeroshape design optimization, aerodynamic heating, boundary layer transition, and so on. This book contains valuable contributions focusing on hypervelocity aircraft design. Topics covered include hypersonic aircraft aerodynamic and aerothermodynamic design, especially aeroshape design optimization, computational fluid dynamics, and scramjet propulsion. The book also discusses high-speed flow issues and the challenges to achieving the dream of affordable hypersonic travel. It is hoped that the information contained herein will allow for the development of safe and efficient hypersonic vehicles.

Technical Abstract Bulletin -

Scientific and Technical Aerospace Reports - 1994

Re-Entry Aerodynamics - Wilbur L. Hankey 1988

Integrated Design for Space Transportation System - B.N. Suresh 2015-11-20

The book addresses the overall integrated design aspects of a space transportation system involving several disciplines like propulsion, vehicle structures, aerodynamics, flight mechanics, navigation, guidance and control systems, stage auxiliary systems, thermal systems etc. and discusses the system approach for design, trade off analysis, system life cycle considerations, important aspects in mission management, the risk assessment, etc. There are several books authored to describe the design aspects of various areas, viz., propulsion, aerodynamics, structures, control, etc., but there is no book which presents space transportation system (STS) design in an integrated manner. This book attempts to fill this gap by addressing systems approach for STS design, highlighting the integrated design aspects, interactions between various subsystems and interdependencies. The main focus is towards the complex integrated design to arrive at an optimum, robust and cost effective space transportation system. The orbital mechanics of satellites including different coordinate frames, orbital perturbations

and orbital transfers are explained. For launching the satellites to meet specific mission requirements, viz., payload/orbit, design considerations, giving step by step procedure are briefed. The selection methodology for launch vehicle configuration, its optimum staging and the factors which influence the vehicle performance are summarized. The influence of external, internal and dynamic operating environments experienced by the vehicle subsystems and the remedial measures needed are highlighted. The mission design strategies and their influence on the vehicle design process are elaborated. The various critical aspects of STS subsystems like flight mechanics, propulsion, structures and materials, thermal systems, stage auxiliary systems, navigation, guidance and control and the interdependencies and interactions between them are covered. The design guidelines, complexity of the flight environment and the reentry dynamics for the reentry missions are included. The book is not targeted as a design tool for any particular discipline or subsystem. Some of the design related equations or expressions are not attempted to derive from the first principle as this is beyond the scope of this book. However, the

important analytical expressions, graphs and sketches which are essential to provide in-depth understanding for the design process as well as to understand the interactions between different subsystems are appropriately included.

Modeling and Simulation of Aerospace Vehicle Dynamics - Peter H. Zipfel 2000

A textbook for an advanced undergraduate course in which Zipfel (aerospace engineering, U. of Florida) introduces the fundamentals of an approach to, or step in, design that has become a field in and of itself. The first part assumes an introductory course in dynamics, and the second some specialized knowledge in subsystem technologies. Practicing engineers in the aerospace industry, he suggests, should be able to cover the material without a tutor. Rather than include a disk, he has made supplementary material available on the Internet. Annotation copyrighted by Book News, Inc., Portland, OR

Optimal Trajectories in Atmospheric Flight - Nguyen Vinh 2012-12-02

Optimal Trajectories in Atmospheric Flight deals with the optimization of trajectories in atmospheric flight. The book begins with a simple treatment

of functional optimization followed by a discussion of switching theory. It then presents the derivation of the general equations of motion along with the basic knowledge in aerodynamics and propulsion necessary for the analysis of atmospheric flight trajectories. It goes on to the study of optimal trajectories by providing the general properties of the optimal aerodynamic controls and the integrals of motion. This is followed by discussions of high subsonic and supersonic flight, and approximation techniques to reduce the order of the problem for a fast computation of the optimal trajectory. The final chapters present analyses of optimal reentry trajectories and orbital maneuvers. This book is intended as a reference text for scientists and engineers wanting to get into the subject of optimal trajectories in atmospheric flight. If used for teaching purposes, the book is written in a self-contained way so that a selective use of the material is at the discretion of the lecturer. The first 11 chapters are sufficient for a one-semester course with emphasis on optimal maneuvers of high performance aircraft.

Hypersonic and High Temperature Gas Dynamics - John David Anderson 2000

This book is a self-contained text for those students and readers interested in learning hypersonic flow and high-temperature gas dynamics. It assumes no prior familiarity with either subject on the part of the reader. If you have never studied hypersonic and/or high-temperature gas dynamics before, and if you have never worked extensively in the area, then this book is for you. On the other hand, if you have worked and/or are working in these areas, and you want a cohesive presentation of the fundamentals, a development of important theory and techniques, a discussion of the salient results with emphasis on the physical aspects, and a presentation of modern thinking in these areas, then this book is also for you. In other words, this book is designed for two roles: 1) as an effective classroom text that can be used with ease by the instructor, and understood with ease by the student; and 2) as a viable, professional working tool for engineers, scientists, and managers who have any contact in their jobs with hypersonic and/or high-temperature flow.

Launch-vehicle Dynamics - Harry L. Runyan 1961

Space Flight Dynamics - Craig A. Kluever 2018-03-12

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.

Introduction to Aircraft Flight Mechanics - Thomas R. Yechout 2003

Based on a 15-year successful approach to teaching aircraft flight mechanics at the US Air Force Academy, this text explains the concepts and derivations of equations for aircraft flight mechanics. It covers aircraft performance, static stability, aircraft dynamics stability and feedback control.

Coming Home - Roger D. Launius 2012

NOTE; NO FURTHER DISCOUNT ON THIS PRINT PRODUCT-- OVERSTOCK SALE -- Signficantly reduced list price The technologies for the reentry and recovery from space might change over time, but the challenge remains one of the most important and vexing in the rigorous efforts to bring spacecraft and their crews and cargo home successfully. Returning to Earth after a flight into space is a fundamental challenge, and contributions from the NASA Aeronautics Research Mission Directorate in aerodynamics, thermal

protection, guidance and control, stability, propulsion, and landing systems have proven critical to the success of the human space flight and other space programs. Without this base of fundamental and applied research, the capability to fly into space would not exist. Other related products: NASA Historical Data Book, V. 7: NASA Launch Systems, Space Transportation/Human Spaceflight, and Space Science can be found here: https://bookstore.gpo.gov/products/sku/033-000-01309-4 Revolutionary Atmosphere: The Story of the Altitude Wind Tunnel and the Space Power Chambers can be found here: https://bookstore.gpo.gov/products/sku/033-000-01342-6 Spinoff: Innovative Partnerships Program 2009 can be found here: https://bookstore.gpo.gov/products/sku/033-000-01331-1 Spinoff 2010: NASA Technologies Benefit Society can be found here: https://bookstore.gpo.gov/products/sku/033-000-01343-4 Spinoff 2015: Technology Transfer Program can be found here: https://bookstore.gpo.gov/products/sku/033-000-01372-8 Aerospace, Astronomy & Space Exploration resources collection can be found here: https:

//bookstore.gpo.gov/catalog/science-technology/aerospace-astronomy... Other products produced by the U.S. National Aeronautics and Space Administration (NASA) can be found here: https://bookstore.gpo.gov/agency/550 "

Atmospheric and Space Flight Dynamics - Ashish Tewari 2007-05-08

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.

The Legacy of the White Oak Laboratory - 2000

Rigid Body Dynamics for Space Applications - Vladimir S Aslanov 2017-04-22

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

Selected Aerothermodynamic Design Problems of Hypersonic Flight Vehicles - Ernst Heinrich Hirschel 2009-11-26

In this book selected aerothermodynamic design problems in hypersonic vehicles are treated. Where applicable, it emphasizes the fact that outer surfaces of hypersonic vehicles primarily are radiation-cooled, an interdisciplinary topic with many implications.

Investigation of Ablation Effects on Hypersonic Dynamic Stability of a 100 Cone - Dave R. Moore 1967

Performance Evaluation and Design of Flight Vehicle Control Systems - Eric T. Falangas 2015-12-03

The purpose of this book is to assist analysts, engineers, and students toward developing dynamic models, and analyzing the control of flight vehicles with various blended features comprising aircraft, launch vehicles, reentry vehicles, missiles and aircraft. Graphical methods for analysing vehicle performance Methods for trimming deflections of a vehicle that has multiple types of effectors Presents a parameters used for speedily evaluating the performance, stability, and controllability of a new flight vehicle concept along a trajectory or with fixed flight

conditions

Spacecraft Dynamics and Control - Anton H. de Ruiter 2012-12-05

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.

Atmospheric Re-Entry Vehicle Mechanics - Patrick Gallais 2007-09-23

Based on a long engineering experience, this book offers a comprehensive and state-of-the-art analysis of aerodynamic and flight mechanic entry topics. This updated edition had new chapters on Re-entry on Mars

mission, flight quality, rarefied aerodynamics and re-entry accuracy. In addition, it provides a large set of application exercises and solutions.

Reentry Vehicle Flight Controls Design Guidelines - National Aeronautics and Space Administration (NASA) 2018-06-13

This report addresses issues in developing a flight control design for vehicles operating across a broad flight regime and with highly nonlinear physical descriptions of motion. Specifically it addresses the need for reentry vehicles that could operate through reentry from space to controlled touchdown on Earth. The latter part of controlled descent is achieved by parachute or paraglider - or by all automatic or a human-controlled landing similar to that of the Orbiter. Since this report addresses the specific needs of human-carrying (not necessarily piloted) reentry vehicles, it deals with highly nonlinear equations of motion, and then-generated control systems must be robust across a very wide range of physics. Thus, this report deals almost exclusively with some form of dynamic inversion (DI). Two vital aspects of control theory - noninteracting control laws and the transformation of nonlinear systems into equivalent linear systems - are

embodied in DI. Though there is no doubt that the mathematical tools and underlying theory are widely available, there are open issues as to the practicality of using DI as the only or primary design approach for reentry articles. This report provides a set of guidelines that can be used to determine the practical usefulness of the technique. Ito, Daigoro and Georgie, Jennifer and Valasek, John and Ward, Donald T. Johnson Space Center

Advanced UAV Aerodynamics, Flight Stability and Control - Pascual Marqués 2017-04-19

Comprehensively covers emerging aerospace technologies Advanced UAV aerodynamics, flight stability and control: Novel concepts, theory and applications presents emerging aerospace technologies in the rapidly growing field of unmanned aircraft engineering. Leading scientists, researchers and inventors describe the findings and innovations accomplished in current research programs and industry applications throughout the world. Topics included cover a wide range of new aerodynamics concepts and their applications for real world fixed-wing (airplanes), rotary wing (helicopter) and quad-rotor aircraft. The book begins with two introductory chapters that address

fundamental principles of aerodynamics and flight stability and form a knowledge base for the student of Aerospace Engineering. The book then covers aerodynamics of fixed wing, rotary wing and hybrid unmanned aircraft, before introducing aspects of aircraft flight stability and control. Key features: Sound technical level and inclusion of high-quality experimental and numerical data. Direct application of the aerodynamic technologies and flight stability and control principles described in the book in the development of real-world novel unmanned aircraft concepts. Written by world-class academics, engineers, researchers and inventors from prestigious institutions and industry. The book provides up-to-date information in the field of Aerospace Engineering for university students and lecturers, aerodynamics researchers, aerospace engineers, aircraft designers and manufacturers.

Atmospheric and Space Flight Dynamics - Ashish Tewari 2007-11-15

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.

Space Shuttle Hypersonic Aerodynamic and Aerothermodynamic Flight Research and the Comparison to Ground Test Results - Kenneth W. Iliff 1993

Intermediate Reader of Modern Chinese - Robert F. Stengel 2022-11-01

An updated and expanded new edition of an authoritative book on flight dynamics and control system design for all types of current and future fixed-wing aircraft Since it was first published, Flight Dynamics has offered a new approach to the science and mathematics of aircraft flight, unifying principles of aeronautics with contemporary systems analysis. Now updated and expanded, this authoritative book by award-winning aeronautics engineer Robert Stengel presents traditional material in the context of modern

computational tools and multivariable methods. Special attention is devoted to models and techniques for analysis, simulation, evaluation of flying qualities, and robust control system design. Using common notation and not assuming a strong background in aeronautics, Flight Dynamics will engage a wide variety of readers, including aircraft designers, flight test engineers, researchers, instructors, and students. It introduces principles, derivations, and equations of flight dynamics as well as methods of flight control design with frequent reference to MATLAB functions and examples. Topics include aerodynamics, propulsion, structures, flying qualities, flight control, and the atmospheric and gravitational environment. The second edition of Flight Dynamics features up-to-date examples; a new chapter on control law design for digital fly-by-wire systems; new material on propulsion, aerodynamics of control surfaces, and aeroelastic control; many more illustrations; and text boxes that introduce general mathematical concepts. Features a fluid, progressive presentation that aids informal and self-directed study Provides a clear, consistent notation that supports understanding, from elementary to complicated

concepts Offers a comprehensive blend of aerodynamics, dynamics, and control Presents a unified introduction of control system design, from basics to complex methods Includes links to online MATLAB software written by the author that supports the material covered in the book

Orbital Mechanics for Engineering Students - Howard D Curtis 2009-10-26

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

Occupational Outlook Handbook - United States. Bureau of Labor Statistics 1976

Basics of Aerothermodynamics - Ernst Heinrich Hirschel 2004-09-30

The last two decades have brought two important developments for aeroth-modynamics. One is that airbreathing hypersonic flight became the topic of technology programmes and extended system studies. The other is the emergence and maturing of the discrete numerical methods of aerodyn-ics/aerothermodynamics complementary to the ground-

simulation facilities, with the parallel enormous growth of computer power. Airbreathing hypersonic flight vehicles are, in contrast to aeroassisted re-entry vehicles, drag sensitive. They have, further, highly integrated lift and propulsion systems. This means that viscous eflFects, like boundary-layer development, laminar-turbulent transition, to a certain degree also strong interaction phenomena, are much more important for such vehicles than for re-entry vehicles. This holds also for the thermal state of the surface and thermal surface effects, concerning viscous and thermo-chemical phenomena (more important for re-entry vehicles) at and near the wall. The discrete numerical methods of aerodynamics/aerothermodyna mics permit now - what was twenty years ago not imaginable - the simulation of high speed flows past real flight vehicle configurations with thermo-chemical and viscous effects, the description of the latter being still handicapped by in sufficient flow-physics models. The benefits of numerical simulation for flight vehicle design are enormous: much improved aerodynamic shape definition and optimization, provision of accurate and reliable aerodynamic data, and highly

accurate determination of thermal and mechanical loads. Truly mul- disciplinary design and optimization methods regarding the layout of thermal protection systems, all kinds of aero-servoelasticity problems of the airframe, et cetera, begin now to emerge.

U.S. Government Research Reports - 1962

Seize the High Ground - James A. Walker 2003

"[Seize the high ground is a] narrative history of the Army's aerospace experience from the 1950s to the present. The focus is on ballistic missile defense, from the early NIKE-HERCULES missile program through the SAFEGUARD acquisition site allowed by the 1972 ABM Treaty to the more advanced 'Star Wars' concepts studies toward the end of the century. [What is] covered is not only the technological response to the threat but the organizational and tactical development of the commands and units responsible for the defense mission"--CMH website.

Wingless Flight - R. Dale Reed 2021-10-21

Most lifting bodies, or "flying bathtubs" as they were called, were so ugly only an engineer could love them, and yet, what an elegant way to keep wings from burning off in supersonic

flight between earth and orbit. Working in their spare time (because they couldn't initially get official permission), Dale Reed and his team of engineers demonstrated the potential of the design that led to the Space Shuttle. Wingless Flight takes us behind the scenes with just the right blend of technical information and fascinating detail (the crash of M2-F2 found new life as the opening credit for TV's "The Six Million Dollar Man"). The flying bathtub, itself, is finding new life as the proposed escape-pod for the Space Station.

Re-entry Vehicle Dynamics - Frank J. Regan 1984

Re-entry Vehicle Dynamics - Frank J. Regan 1984