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Dynamics and Control of Autonomous Space Vehicles and Robotics This is a long-overdue volume devoted to space trajectory optimization. Interest in the subject has grown, as space missions of increasing levels of sophistication, complexity, and scientific return — hardly imaginable in the 1960s — have been designed and flown. Although the basic tools of optimal control theory remain as accepted today, there has been a revolution in the manner in which they are applied and in the development of numerical optimization. This volume purports to include a variety of both analytical and numerical approaches to trajectory optimization. The choice of authors has been guided by the editor's intention to assemble the best experts and active researchers in the various specialties presented. The authors were given considerable freedom to choose their subjects, and although this may yield a somewhat eclectic volume, it also yields chapters written with palpable enthusiasm and relevance to contemporary problems.


Orbital Mechanics and Astrodynamics A simple family of indirect-transfer trajectories between circular orbits is used to evaluate the mass ratio required to complete round-trip interplanetary missions using low-thrust propulsion systems. These trajectories allow for optimal utilization of the fuel resources, which results in substantial reductions in fuel consumption, heliocentric specific weight (ΔV/Δm) of 10 pounds per kilogram of jet power, trip time were reduced from 1200 to 600 days, for a typical mission, with an initial weight increase of a factor of two. Comparison with a nuclear rocket with 1000-second specific impulse indicates that the electric propulsion system requires less initial weight for trip times as low as 550 days with (ΔV/Δm) of 10 and as low as 400 days with (ΔV/Δm) of 5 pounds per kilogram. Further weight reductions would be expected with even more practical optimization.

Some Methods for Establishing Interplanetary Orbit Transfers, Second Edition, provides a detailed introduction to the basic concepts of space mechanics. These include vector kinematics and the Newton's laws of motion and gravitation relative motion, the vector-based solution of the classical two-body problem, derivation of Kepler's equations of motion in three dimensions, preliminary orbit determination, and orbital maneuvers. The book also covers the relative motion of two bodies, the principal rendezvous problem; interplanetary mission design using patched conics, rigid-body dynamics used to characterize the attitude of a spacecraft, satellite attitude dynamics, and the characteristics and design of manipulators and control systems. The book contains a wealth of key concepts and examples, including all the important equations and algorithms used in the modern design and analysis of space flight programs. The Encyclopedia of Planetary Sciences is superbly illustrated throughout with over 450 line drawings, 180 black and white photographs, and 63 color illustrations. It will be a key reference source for planetary scientists, astronomers, and engineers.

Space Flight Dynamics Some methods for establishing heliocentric interplanetary transfer orbits. The four basic methods and their variations can be used to establish orbits: having specified transfer angles, transfer times, hypersonic excess velocities, or heliocentric departure velocities. Each method consists of a step-by-step procedure which utilizes the equations of two-body motion and appropriate trigonometric relations to establish the desired transfer orbit. Each method is illustrated in section "Example exercises". The book provides a simple but powerful method for establishing heliocentric interplanetary transfer orbits. The book is very well illustrated using a large-scale digital computer. In this way numerous orbits can be established and the orbit which is optimum for some specific requirement can be selected. None of the methods permits a direct analytical determination of an optimum orbit. (author).

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topic include the practical results obtained from using these methods, navigation problems, near-to-planet orbits, and an overview of proves and new flight schemes.

Analytical Solutions for Extreme Space Trajectories

NASA Technical Notes and reports with abstracts for aerospace-related reports obtained from world-wide sources and announce documents that have recently been entered into the NASA Scientific and Technical Information Database.

Orbital Debris This book provides readers with a clear description of the types of lunar and interplanetary transfers, and how they influence satellite-system design. The description follows an engineering rather than a mathematical approach and includes many examples of space trajectories, based on real missions. It helps readers gain an understanding of the driving subsystems of interplanetary and lunar satellites. The tables and graphs showing features of trajectories make the book easy to understand.

Scientific and Technical Aerospace Reports

Orbital Mechanics An unclassified analytical trajectory design, performance, and mission study was done for the 1992 to 1994 Joint National Aeronautics and Space Administration (NASA—United States Air Force (USAF) Shuttle/Centaur 6 stage upper stage development program to send performance-demanding payloads to high orbits such as Molniya using an unconventional orbit transfer. This optimized three orbiter burn to Molniya orbit was compared to the then-baselined two burn transfer. The results of the three dimensional trajectory optimization performed include powered phase steering data and coast phase orbital element data. Time derivatives of the orbital elements as functions of thrust components were evaluated and used to obtain the optimization’s solution. Vehicle performance as a function of parking orbit inclination was given. Performance and orbital element data was provided for launch windows as functions of launch time. Ground track data was given for all burns and coast phases. A summary of the commonalities was found that showed launch low Earth parking orbit to achieve Molniya orbit with compatible performance to the baseline launch transfer which started from a 57 deg inclined orbit; 9,543 versus 9,752 lb of separated spacecraft weight, respectively. There was a significant reduction in the need for propellant launch time reserve for 1 hr window: only 74 lb for the three burn transfer versus 322 lb for the two burn transfer. Conversely, this also meant that launch launch windows were more orbital revolutions could be done for the same amount of propellant reserve. There was no practical difference in ground tracking station or airborne assets needed to secure telemetry data, even though the geographic locations of the former varied considerably. There was a significant adverse increase in total mission elapsed time for the three versus two burn transfer (11 vs. 1-1/4 hr), but could be accommodated by modest modifications to current systems. Future applications was found to be viable, arguably preferable, to the two burn transfer. Williams, Kyle D. and Belbruno E. "Minotaur I/Minotaur III: Optimal Launch Inclination and Vehicle Configuration Options for Near-Earth and Interplanetary Transfers." ARSS-96-0213. January 1997.


Fly Me to the Moon Studies in Astronautics, Volume 1: Optimal Space Trajectories focuses on the concept of optimal transfer and the problem of optimal space trajectories. It examines the relative performances of the various propulsion systems (classical and electrical propulsions) and their optimization (optimal mass breakdown), along with parametric and functional optimizations and optimal transfers in an arbitrary, uniform, and central gravitational field. Organized into 13 chapters, this volume begins with an overview of optimal transfer and the modeling of propulsion systems. It then discusses the invariant, the Weiler and Milne bi-elliptical transfer, and the definitions of parametric optimization. The book explains the classical high-thrust and low-thrust propulsion systems model and their optimization. Fly Me to the Moon is written primarily for engineers who specialize in aerospace mechanics and want to pursue a career in the space industry or space research. It also introduces students to the different aspects of the problem of optimal space trajectories.

Optimal Space Trajectories

Fly Me to the Moon is a memoir and adventure story of American astronaut Eugene Cernan as he was sent to the surface of the moon and back on the Apollo 10 mission. Along with his fellow crewmen, Cernan tells the story of their journey, the difficulties they faced, and the excitement of being part of one of the greatest adventures in human history. The book is written in an engaging and informative style, making it a must-read for anyone interested in the history of space exploration.

Captured Dynamic and Chaotic Motions in Celestial Mechanics

Celestial Mechanics and Dynamical Systems

Scientific and Technical Aerospace Reports

Optimal Space Trajectories

Analysed solutions for extreme space trajectories...
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NASA Thesaurus Celestial Mechanics and Astrodynamics

Orbital Mechanics for Engineering Students This book describes a revolutionary new approach to determining low energy routes for spacecraft and comets by exploiting regions in space where motion is very sensitive (or chaotic). It also represents an ideal introductory text to celestial mechanics, dynamical systems, and dynamical astronomy. Bringing together wide-ranging research by others with his own original work, much of it new or previously unpublished, Edward Belbruno argues that regions supporting chaotic motions, termed weak stability boundaries, can be exploited. Although controversial until quite recently, this method was in fact first applied in 1991, when Belbruno used a new route developed from this theory to get a stray Japanese satellite back on course to the moon. This application provided a major verification of his theory, representing the first application of chaos to space travel. Since that time, the theory has been used in other space missions, and NASA is implementing new applications under Belbruno’s direction. The use of invariant manifolds to find low energy orbits in another method here addressed. Recent work on estimating weak stability boundaries and related regions has also given mathematical insight into chaotic motion in the three-body problem. Belbruno further considers different capture and escape mechanisms, and resonance transitions. Providing a rigorous theoretical framework that incorporates both recent developments such as Aubrey-Mather theory and established fundamentals like Kolmogorov-Arnold-Moser theory, this book represents an indispensable resource for graduate students and researchers in the disciplines concerned as well as practitioners in fields such as aerospace engineering.

Modern Spacecraft Dynamics and Control Analytical Solutions for Extremal Space Trajectories presents an overall treatment of the general optimal control problem, in particular, the Rayleigh’s variational problem, with necessary and sufficient conditions of optimality. It also provides a detailed derivation of the analytical solutions of these problems for thrust arcs for the Newtonian, linear central and uniform gravitational fields. These solutions are then used to analytically synthesize the extremal and optimal trajectories for the design of various orbital transfer and powered descent and landing maneuvers. Many numerical examples utilizing the proposed analytical synthesis of the space trajectories and comparison analyses with numerically integrated solutions are provided. This book will be helpful for engineers and researchers of industrial and government organizations, and it is also a great resource for university faculty and graduate and undergraduate students working, specializing or majoring in the field of aerospace engineering, applied celestial mechanics, and guidance, navigation and control technologies, applied mathematics and analytical dynamics, and avionics software design and development. Features an analysis of Frenet-Serret extremal and/or Frenet-Serret minima in the context of space trajectory design presents the general methodology of an analytical synthesis of the extremal and optimal trajectories for the design of various orbital transfer and powered descent and landing maneuvers. Assists in developing the optimal control theory for applications in aerospace technology and space mission design.

Fast Interplanetary Missions with Low-thrust Propulsion Systems

Space Flight Dynamics

Three Orbital Burns to Molniya Orbit via Shuttle_Centaur & Upper Stage Thorough coverage of space flight topics with self-contained chapters serving a variety of courses in orbital mechanics, spacecraft dynamics, and astrodynamics. 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 dynamics). 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 dynamics, 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.

An Introduction to the Mathematics and Methods of Astrodynamics The present inputs to drive down the overall cost of space missions is leading to ever-increasing demands for more efficient design techniques over a wide range of interplanetary missions, and the methods are now being utilized to do this are described in the timely and authoritative work. Spacecraft Trajectory Optimization Solar sailing – using the sun as a propellant – offers the possibility of low-cost long-distance missions that are impossible with conventional spacecraft. This first comprehensive book on this propulsion method provides a detailed account of solar sailing, at a high technical level, but in a way accessible to the scientifically informed layperson. Solar sail orbital dynamics and solar radiation pressure form the foundations of the book, but the engineering design of solar sails is also considered, along with potential mission applications.

U.S. Government Research & Development Reports Presents the established principles underlying 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.

Multiple Gravity Assist Interplanetary Trajectories 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-relationships and social influences. The presentation 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 interwoven to yield a coherent presentation of advanced topics.

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