Book Reviews

BOOK REVIEWS published in this section reflect the opinions of their individual authors. They are not necessarily the opinions of the Editors of this journal or of AIAA.

Publishers are invited to send two copies of new books for review to Dr. Christopher D. Hall, Mail Code 0203, Department of Aerospace and Ocean Engineering, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0203.

Analytical Mechanics of Space Systems

H. Schaub and J. L. Junkins, AIAA, Reston, VA, 2003, xix+711pp., $105.95, ISBN 1-56347-563-4

Analytical Mechanics of Space Systems is one of the books in the AIAA Education Series and is meant to be used as a textbook in at least two courses. Both authors, and especially J. L. Junkins, are well known for their research contributions to the general areas covered in the book.

The book consists of two parts, "Basic Mechanics" and "Celestial Mechanics." The first part is composed of eight chapters and contains material suitable for a graduate course on analytical dynamics. The second part consists of six chapters and can be used for a first graduate course on celestial mechanics/astrodynamics.

The first two chapters cover particle kinematics and Newtonian mechanics, respectively, and present fairly basic material that gives completeness to the book. Chapter 3 discusses rigid-body kinematics and is one of the strengths of the book. The material is presented in a thorough and rigorous, yet clear, manner. Students often find this topic difficult, but the chapter covers it in a very student-friendly way. It contains a description of different types of attitude parameters used in rigid-body kinematics, as well as the direction cosine matrices and kinematic differential equations associated with them. The discussion is fairly exhaustive and includes information about parameter sets such as modified and higher-order Rodrigues parameters and (w, z) coordinates, which are usually not covered in other textbooks. A disk containing Matlab M-files dealing with rigid-body kinematics comes with the textbook, which will be useful for both professors and students.

Chapter 4 on Eulerian mechanics covers the fundamentals of rigid-body dynamics as well as some topics from spacecraft attitude dynamics, namely, gravity gradient stabilization of satellites and control moment gyros. The chapter is well written, but probably it would have been better to separate the material on spacecraft attitude dynamics from the general treatment of rigid-body dynamics. The former could have been combined with the last two sections of Chapter 8 to form a separate chapter on spacecraft attitude dynamics and control. Chapters 5–7 present classical analytical dynamics, i.e., Lagrangian dynamics, variational methods, Hamilton's equations, and canonical transformations. Although the material is classical, the presentation style is contemporary. The examples given include particles and rigid bodies, as well as distributed parameter systems.

Although the title of Chapter 8 is "Nonlinear Spacecraft Stability and Control," most of the material is more general in nature, and only the last two sections are specific to spacecraft. The chapter is a welcome addition; topics included are normally not found in textbooks on analytical dynamics or spacecraft dynamics.

Part 2 on celestial mechanics presents two-body and restricted three-body problems in Chapters 9 and 10, respectively. The treatment is fairly classical. Chapters 11 and 12 discuss gravitational potential field models and orbital perturbations. Although the exposition of the theory is very good, the book is short on applications. For example, it would have helped the students a lot if the effects of J_2, and how they can lead to sun-synchronous orbits, were discussed in these chapters. This omission is difficult to understand, because there is a detailed discussion of the effects of J_2 on relative motion between satellites in the last chapter of the book on spacecraft formation flying. Similarly, the effects of atmospheric drag are barely touched on.

Chapter 13 covers Lambert's problem, geometric orbital transfer, and interplanetary transfers, as well as gravity assist. The topics are covered clearly from a student's point of view, but some interesting items are missing. For example, it would have been good to present the analytical solution for Lambert's problem.

The last chapter of the book discusses spacecraft formation flying. This book is unique as a textbook to contain such a chapter. It presents an up-to-date summary of the research work on this topic. In addition to presenting the relative motion equations and solutions in the Hill reference frame, the book derives the state transition matrix applicable to orbit element differences. A very useful portion of the book, from a practical point of view, is the section on J_2-invariant relative orbits. The section presents an analysis of relative orbit design that eliminates relative drift caused by J_2 whenever possible and minimizes it for near-polar orbits. The last section of this chapter contains an excellent discussion on relative orbit control methods by using both the mean orbit element formulation and the Cartesian Hill coordinates formulation. Both continuous feedback control and impulsive feedback control are considered.

There are many worked-out examples in the book. There is also a problem set at the end of each chapter, with more problems in the first part than the second.

I recommend with enthusiasm the use of the first part of the book for a graduate course on analytical dynamics or spacecraft attitude dynamics. The second part is slightly less successful but is likely to be adopted by many as a text, mainly because of the chapter on formation flying.

Arun Misra
McGill University