JOURNAL OF GUIDANCE, CONTROL, AND DYNAMICS
Vol. 21, No. 4, July–August 1998

Book Review

Publishers are invited to send two copies of new books for review to Dr. I. Michael Ross, Code: AA/Ro, Department of Aeronautics and Astronautics, U.S. Naval Postgraduate School, 699 Dyer Road, Monterey, CA 93943.

Fundamentals of Astrodynamics and Applications

David A. Vallado, with technical contributions by Wayne D. McClain, McGraw–Hill, New York, 1997, 922 pp., $61.88/$34.95, ISBN 0-07-066829-9 (hardback); 0-07-066834-5 (paperback)

No other book encompasses the breadth of topics in astrodynamics contained here. True to its title, this book includes both fundamental analysis and many realistic applications, with the dominant emphasis on Earth-bound satellites. Although not encyclopedic, the book does succeed in giving at least an introduction to many subjects and detailed treatment of many others, emphasizing practice and practicalities. In this regard, it follows the form of other books in the Space Technology Series, for example, Larson and Wertz's *Space Mission Analysis and Design*.[1]

The chapters are organized into 1) geometry of conic sections, geodesy, geopotential modeling, coordinate systems and transformations, time systems, and Earth precession and nutation; 2) the two-body problem, Kepler's laws, the restricted three-body problem, integrals in the n-body problem, and orbital elements (including extensive examples of conversions between position and velocity information and the orbital elements); 3) conversions among various time systems and among several coordinate systems with example applications for sun, moon, and planetary positions; 4) the different forms of Kepler's equation for the conic sections and illustrations of solution techniques (including a universal variable formulation) and their application to the problem of generating satellite groundtracks; 5) coplanar and noncoplanar orbital maneuvering, rendezvous between circular and nearly circular orbits, continuous low-level thrusting, and relative motion between neighboring orbits; 6) the initial orbit determination problem (including the standard methods based on various types of measurements) and Lambert's problem, including several methods of solution with an example application involving intercept and rendezvous; 7) special perturbation techniques (including Encke's and Cowell's methods) along with discussions of numerical methods, their practical implementations, and various physical perturbations; 8) general perturbation techniques (including variation of parameters), linearized perturbations, Kozai's and Brouwer's methods, and the Draper Semianalytic Satellite Theory; 9) statistical orbit determination (with significant attention to sensor systems), linear and nonlinear least squares, differential correction, sequential-batch least squares, and the basics of Kalman filtering; and 10) practices and technologies for station keeping, geometries for surveillance and reconnaissance, sun-synchronous, molniya, and frozen orbits, the Global Positioning System, determination of satellite look angles, close approaches, and rise/set times and angles.

Each chapter includes some historical background, analytical developments, useful examples, and problems for the reader. At times the writing takes an informal, conversational tone that, for some, will detract from the utility of the book as a reference; on the other hand, this style has an effective tutorial character. Given the advanced nature of some topics, a greater reliance on mathematical expression might have allowed for more complete coverage without sacrificing the overall readability of the book. For example, a brief analytical development of Lagrange multipliers in a simple constrained optimization problem as a lead-in to optimal control theory (similar to that in Prussing and Conway[2]) could have replaced the general narrative description of that theory. The book's one great strength is the inclusion of 67 algorithms that range in complexity from calculation of the Julian date to determination of rise/set times and angles for a given satellite and ground station. The author has included some useful hints about implementation (for example, a reminder about resolving quadrant ambiguities). A liberal use of his own high-quality illustrations is also quite effective. Vallado has succeeded in arranging this extensive body of material into modular form with ample cross-referencing, a comprehensive index and bibliography, and four appendices (dictionary of symbols and acronyms, atmospheric modeling, mathematical fundamentals, and constants and expansions). The problems posed at the end of each chapter span a useful range of difficulty, appropriate for use in a senior- or graduate-level course. Given the book's organization and content, I would recommend it for use as a textbook or a reference.

References

[1]Larson, W. J., and Wertz, J. R. (eds.), *Space Mission Analysis and Design*, 2nd ed., Microcosm, Torrance, CA, and Kluwer Academic, Norwell, MA, 1992.

[2]Prussing, J. E., and Conway, B. A., *Orbital Mechanics*, Oxford Univ. Press, Oxford, England, UK, 1993, pp. 24, 93.

Robert G. Melton
Pennsylvania State University