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Book Reviews

Global Positioning System: Signals, Measurements, and Performance

Pratap Misra and Per Enge, Ganga-Jamuna Press, distributed by Navtech, Alexandria, VA, 2001, 390 pp., $90.00

Applications of the global positioning system (GPS) have multiplied tremendously in recent years. GPS was initially developed in the 1960s and early 1970s to fulfill relatively limited military goals and was declared fully operational only as recently as 1995. As the size and cost of GPS receivers have decreased by several orders of magnitude, engineers have devised new ways of extracting position and time information from the signals and new uses for that information. In addition, a GPS modernization program is now underway that will inevitably lead to the development of even more applications. Therefore, it is surprising that there are so few texts devoted to GPS. This text by Misra and Enge is arguably the first book suitable to be used as a textbook for a senior-level undergraduate or early-graduate-level course. Each chapter includes a set of student exercises and a list of references. The book comes with a CD containing some GPS data sets and other supplementary material. It should also be noted that the emphasis is much more on civilian applications than on military applications.

The calculation of position from GPS pseudo range measurements is introduced in chapter 5. The linearization of nonlinear equations and least-squares solution are both very general techniques that have many applications of which one particular application is the estimation of position and time from GPS pseudo range measurements. The explanation given in the text may leave some students with the impression that these techniques are special tricks that apply only to GPS. This text has some very good intuitive explanations for many concepts, but some of the concepts should be tied into a larger theoretical framework to give students the tools necessary to tackle problems outside conventional GPS. An introductory chapter summarizing important results from matrix algebra, linear estimation, dynamic systems, and statistics would be very helpful.

The one serious omission is a discussion of Kalman filtering. Kalman filters are pervasive in all types of navigation systems from simple GPS-only receivers to integrated GPS and inertial systems. Perhaps the authors feel that Kalman filtering is too advanced for the intended audience, but I firmly believe that most of what a Kalman filter does is just common sense and can be taught at an elementary level. Certainly there is no need to derive the Kalman filter equations in an introductory GPS text, but the Kalman filter can at least be presented as an extension of least-squares estimation.

One of the strengths of this text is an entire chapter devoted to differential carrier phase positioning, including much material on integer ambiguity resolution. Many advanced applications require accurate relative positioning between two or more receivers rather than absolute positioning relative to a standard such as WGS-84. Carrier phase provides centimeter-level or better differential position and will become even more attractive when the new L5 civil frequency becomes available, a point the authors make extremely well at the end of the chapter.

Both time domain and frequency domain descriptions of the GPS signals are presented in chapter 7. This text contains one of the best elementary explanations of *m*-sequences and Gold codes in the literature. Coding theory can get very esoteric, and so many texts on GPS present Gold codes as if they are just magic. The authors present a very convincing intuitive explanation of how and why Gold codes work with concrete examples to illustrate the concepts.

Receiver technology is a subject that is difficult to teach at any level because there are many different options for receiver design, many different permutations of options are possible, and many of the details are proprietary. In addition, the task of finding and tracking the GPS signal is so fundamentally difficult that many students have difficulty believing that GPS works, even as they hold a GPS receiver in their hand. Even so, the chapter on GPS receivers could use more detail, particularly on signal acquisition, because the constraints imposed by signal acquisition or reacquisition are critical to many applications. The tradeoff between measurement accuracy and tolerance of dynamic stress is fundamental to receiver design but is not adequately emphasized in the text. Also, more detail on the signal processing techniques used to combat multipath errors and interference would give the chapter more depth. The preceding chapters use concrete examples very effectively; yet there are no receiver design examples in the last chapter.

New technology typically starts in journal papers that are understood by only a few experts in the field and then slowly filters down to graduate- and then undergraduate-level textbooks. In many ways this new text on GPS is the first of its kind; it is certainly the first GPS text that I would consider for a senior-level undergraduate course. As such, this book is an impressive achievement. Despite the criticism I have offered in the preceding paragraphs, I feel I personally benefited from reading the book for this review. I will probably use this textbook in my classes in the future, albeit with some supplementary material on Kalman filtering and receiver technology.

Eric Sutton
University of Florida

Analytical Fluid Dynamics, 2nd Edition

George Emanuel, CRC Press, Boca Raton, FL, 2000, 808 pp., $89.95

The second edition of George Emanuel's meticulous compilation of selected topics in analytical fluid dynamics represents a significant expansion of the first version published in 1994, almost doubling the total number of pages. However, the original emphasis of treating the subject material in rigorous depth rather than "bypassing crucial or difficult details," as the author states, is retained throughout the second edition. The author also discusses the assumptions and limitations applicable to each topic.

The new edition consists of five parts and 10 appendices, representing the addition of new topics and some reorganization of the preceding material. Each one of the 23 (up from 18) chapters also contains a list of pertinent references as well as sets of homework. The problems are planned to help the graduate student to understand the physical background of the general analytical treatment in the context of meaningful applications.

Part I, "Basic Concepts" (four chapters), includes mathematically uncompromising discussions of fundamental concepts (Eulerian and Lagrangian formulations, stress and deformation rate tensors, constitutive relations and the Reynolds transport theorem) and a chapter on conservation equations. The chapter on thermodynamics has been expanded into a detailed review of classical thermodynamics and its relationship to fluid dynamics, including a new approach using the Helmholtz potential function to facilitate coupling to computational solutions.

Part II is now entitled "Advanced Gas Dynamics" (eight chapters). In addition to the previous coverage of Euler equations, shock wave dynamics, the hodograph transformation, and the substitution principle, new chapters describe calorically imperfect basic flows, sweep in oblique shock waves and in Prandtl–Meyer flow, interaction of an expansion wave with a shock wave, and unsteady one-dimensional flow. The explicit analysis of sweep effects and the extensive coverage of unsteady shock phenomena in internal flow are relevant to current designs and test facilities in high-speed aerodynamics.

Part III, "Viscous/Inviscid Fluid Dynamics" (two chapters), is formally an addition in the new edition but does contain the previous chapter on coordinate systems and similarity parameters, with additional comments on bulk viscosity and on heat addition into a circular duct flow by a molecular beam device. The second chapter is an extensive addition entitled "Force and Moment Analysis," which contains specific applications from the author's experience, as well as an interesting elucidation of the relationship between supersonic wave drag and entropy generation.

Part IV, "Exact Solutions for a Viscous Flow" (three chapters), again presents the classical solutions for Rayleigh, Couette, and stagnation point flows, including effects of compressibility and heat conduction. Part V, "Laminar Boundary Layer Theory for Steady Two-Dimensional or Axisymmetric Flow" (six chapters), continues to provide an unusually extensive (more than 180 pages) and thorough coverage of incompressible and compressible laminar boundary layers, reflecting the author's longtime interest and personal contributions to this topic. The similarity transformations for two-dimensional and axisymmetric compressible boundary layers, with comprehensive tables of numerical solutions, are a valuable part of the existing database. The discussions of matched asymptotic expansions and of second-order boundary-layer theory are mandatory reading for any researcher who aspires to a complete understanding of the roles and mutual interaction of the viscosity- and inertia-dominated regions of a physical flowfield. The performance analysis of a scramjet propulsion nozzle, with an interesting conclusion, has been added to the chapter on "Supersonic Boundary Layer Examples."

The appendices (number increased from eight to 10) continue to provide comprehensive listings of equations from vector and tensor analysis, with the conservation equations specifically expressed in orthogonal curvilinear coordinates and in body-oriented coordinates. A thorough discussion of Jacobian theory has been added as a separate appendix. Formulas and tables related to shock waves now include a short appendix on the closed-form solution for an oblique shock wave angle discovered within the past half-century independently by several authors, including the present one. The method of characteristics, equations for similar compressible boundary layers, and second-order equations for supersonic, rotational flat plate boundary layers are presented.

This book provides a unique source of topics for specialized graduate courses and an indispensable collection of background material for practitioners of modern fluid dynamics. The value of the second edition is clearly enhanced by the changes and additions, although some of them are quite specialized, reflecting the author's personal interests. The reviewer agrees wholeheartedly with the author's comment about the value of analytical solutions as initial estimates or verification cases for computational fluid dynamics (CFD) calculations. In fact, in many cases neither CFD nor experimental fluid dynamics (EFD), where increasingly sophisticated instrumentation is used to study increasingly complex flow phenomena, will be able to simulate all aspects of the pertinent physical processes, and the achievement of practical solutions by balanced engineering judgment may well benefit from guidance by analytical fluid dynamics, or AFD, as designated by the author.

The author states, also quite appropriately, that fluid dynamics is "very much alive and growing," and future research will also be needed in the specialties not covered in this book. The reviewer would like to add the observation that, although much of present-day advanced fluid dynamics has evolved in the primary context of aeronautical

applications, significant progress is already being achieved in the integration of AFD, CFD, and EFD into interdisciplinary research with other scientific and engineering disciplines. This book will not only remain a valuable source of scientific background for aerospace research but will also provide guidance for the forthcoming interdisciplinary advances in fluid dynamics.

Raimo J. Hakkinen
Washington University in St. Louis