AIAA JOURNAL
Vol. 50, No. 4, April 2012

# 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.*

## *Theoretical and Computational Aeroelasticity*

Edited by William P. Rodden, 2011, 814 pp., $250

DOI: 10.2514/1.J051738



Within the last 30 years, there has been a revival of interest in the field of aeroelasticity as evidenced by the publication of several books: Dowell [1–4], now in its fourth edition; Hodges and Pierce [5,6], now in its second; Wright and Cooper [7], and, now, the subject book by Rodden. Collectively, these are successors to the decades-old works of Fung [8], Bisplinghoff et al. [9], and Bisplinghoff and Ashley [10].

The newer books serve very different purposes from one another. The most different of all the newer books is the one by Hodges and Pierce, which has the distinction of being aimed primarily at undergraduate students. Thus, it treats only the most elementary points of structural dynamics and aeroelasticity along with exercises. The other books are significantly more advanced.

The fourth edition of the book by Dowell and his collaborators has 746 pages and shows the amazing breadth of the field, providing researchers with a panoramic view of aeroelasticity and applications, ranging from linear to nonlinear, from fixed- and rotary-wing to turbomachinery, from buildings to bridges, etc. On the other end of the spectrum are the two newest books, one by Wright and Cooper [7] and the other by Rodden, both of which focus on fixed-wing aeroelasticity. Like the book by Dowell, they are both lengthy treatments. Wright and Cooper [7] has 559 pages, whereas Rodden has 814. Rather than breadth, however, they focus on depth, offering extensive details, particularly concerning both technical and historical matters. Rodden's book is further distinguishable from all the others in that it provides what reads at times like an insider's description of the unfolding history of the field, along with a (sometimes quite colorful) glimpse into the author's career. This book is evidently intended both as a resource for advanced students and as a reference for practicing aerospace engineers.

What follows is a brief synopsis of the book's contents. Chapter 1 is called "Introduction to Aeroelasticity" and provides an overview of the field's scope, its uses, its terminology, and the standard coordinate systems used in the book. Chapter 2 is "A Brief History of Aeroelasticity" and provides one of the most detailed treatments of the history of the field in print. In treatments of a technical nature, it is not uncommon for aeroelasticity to be presented as an extension of structural dynamics. In the minds of some, aeroelasticity has been reduced to determining generalized forces (i.e., the excitation terms on the right-hand side of the equations of motion). On the other hand, Rodden starts his book's technical discussions with Chapter 3, which is titled "Aerodynamics: Steady and Unsteady Theory." In so doing, the author affirms up front the vital foundation provided by aerodynamics in aeroelasticity. Indeed, the theory of aeroelasticity is interdisciplinary, and one must not relegate it to anything less. Structural analysis, dealt with in Chapter 4 ("Structures: Deflection Theory"), and dynamics and vibration, which are dealt with in Chapter 5 ("Vibrations: Frequencies and Modes"), together with steady and unsteady aerodynamics, are essential subdisciplines that collectively make up the field of aeroelasticity. In fact, without a full-orbed treatment of all three of these subdisciplines, one cannot do justice to a discussion of aeroelasticity. Chapters 3–5, then, comprise the fundamentals of the subject matter and seem to be about the right length (250 pages) and depth for a one or two semester course in aeroelasticity. Therein, the instructor would have the liberty of pursuing applications found in Chapter 6 ("Quasistatic Aeroelasticity: Maneuvering Flight"), Chapter 7 ("Flutter: The Dynamic Aeroelastic Instability"), and Chapter 8 ("Transient Response: Landing and Gust Loads"). Additional theoretical material follows in Chapter 9, which is titled "Random Response: Atmospheric Turbulence and Runway Roughness." The book concludes with three chapters that expand the envelope of aeroelasticity to include controls in Chapter 10 ("Aeroservoelasticity: Control System Interaction"), thermal effects in Chapter 11 ("Aerothermoelasticity: High Speed Atmospheric Flight"), and optimization methodology in Chapter 12 ("Aeroelastic Design: Optimization").

The book has a rather extensive set of appendices containing important background material: Appendix A: "Matrix Algebra," Appendix B: "Laplace and Fourier Transforms," Appendix C: "Probability and Its Distributions," Appendix D: "The Development of the Doublet-Lattice Method" (a reprinted paper), Appendix E: "Flight Mechanics of a Rigid Vehicle" (a reprinted paper), Appendix F: "Some Correspondence with the Federal Aviation Administration" (a set of letters between the author and the FAA), and Appendix G: "Galerkin: The Man and the Method" (a translation of the original paper by Galerkin in which his methodology was introduced).

These are followed by the author's autobiography in Appendix H. (All who know Rodden know his sense of humor, which is well-reflected in this appendix.) Finally, the subject and author indices are quite extensive, and there are nearly 40 pages of references.

The book should meet the needs of researchers ranging from first-year graduate students all the way to those who long ago left school but are interested in doing research in aeroelasticity. The author mentions its use in graduate courses, and this reviewer concurs that it is suitable for such a purpose. However, it has a shortcoming, which is indeed the shortcoming of most advanced treatments of aeroelasticity ranging from 1955 until the present: it does not contain exercises for students. The Hodges and Pierce books [5,6] are not advanced; instead, they are intentionally targeted toward senior-level undergraduates. Only the second edition is presently available, and because it contains exercises for students, it has been used as a text for a senior-year undergraduate course. Of the advanced books, however, only the Wright and Cooper book [7] has exercises (termed "examples"). So, will the lack of problems cause Rodden's book to be relegated only to the researcher's library? The reviewer does not think so, though he finds the notion of having to make up problems, in addition to preparing lectures and all else that academics must do, a drawback and a cost to count before adopting the text. This book has many strengths. It is chock-full of theoretical information, details of developing analyses, and historical insight from an insider of the field as it developed. Consequently, this reviewer highly recommends it for serious researchers. The author's sense of humor, which is sprinkled in various parts (such as Appendices F and H), is an added bonus.

## References

[1] Dowell, E. H., *A Modern Course in Aeroelasticity,*, Sijthoff & Noordhoff, Alphen aan den Rijn, The Netherlands, 1978.
[2] Dowell, E. H., *A Modern Course in Aeroelasticity*, 2nd ed., Kluwer Academic, Dordrecht, The Netherlands, 1989.
[3] Dowell, E. H., *A Modern Course in Aeroelasticity*, 3rd ed., Kluwer Academic, Dordrecht, The Netherlands, 1995.
[4] Dowell, E. H., *A Modern Course in Aeroelasticity*, 4th ed., Kluwer Academic, Dordrecht, The Netherlands, 2004.
[5] Hodges, D. H., and Pierce, G. A., *Introduction to Structural Dynamics and Aeroelasticity*, 1st ed., Cambridge Univ. Press, Cambridge, England, U. K., 2002.
[6] Hodges, D. H., and Pierce, G. A., *Introduction to Structural Dynamics and Aeroelasticity*, 2nd ed., Cambridge Univ. Press, Cambridge, England, U. K., 2011.
[7] Wright, J. R., and Cooper, J. E., Introduction to Aircraft Aeroelasticity and Loads, Wiley, Hoboken, NJ, 2007.
[8] Fung, Y. C., *An Introduction to the Theory of Aeroelasticity*, Wiley, New York, 1955.
[9] Bisplinghoff, R. L., Ashley, H., and Halfman, R. L., *Aeroelasticity*, Addison Wesley Publishing, Reading, MA, 1955.
[10] Bisplinghoff, R. L., and Ashley, H., *Principles of Aeroelasticity*, Wiley, New York, 1962.

Dewey H. Hodges
Georgia Institute of Technology