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# Book Reviews

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*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.*

## ***Engineering Analysis in Applied Mechanics***

John W. Brewer, Taylor & Francis, 2002, 472 pp., $75, ISBN 1-56032-932-7

Professor Brewer's intent, to teach students to derive and solve equations in the field of applied mechanics, is admirable. The intended audience of second-semester juniors would certainly benefit from a strong grounding in the fundamentals presented in this text, as would seniors and first-year graduate students. The author's view of the importance of this material is thoroughly explained in the prefatory remarks and persists throughout as he shares his enthusiasm with his readers. Professors could easily develop a solid course for third- through fifth-year students using this book, and graduate students will find it a useful study resource.

The text includes six chapters and two appendices. The first three chapters provide the mathematical foundation required for the mechanics applications in the remaining chapters, while the two appendices provide reviews of matrix algebra and real analysis. Several textbook references are provided at the end of each chapter. The chapters, which average about 70 pages in length, include numerous examples, review questions, exercises, and computer assignments. The worked examples support the text, and are especially effective when the author reuses previous examples to illustrate new material. The review questions typically are discussion topics, such as "What is a beam?" and "What are the primary differences between the vector mechanics and the analytical mechanics?" Questions such as these could be useful as in-class discussion topics, as essay questions, or as research paper assignment. The exercises, about 25–50 per chapter, provide standard homework fare and also lead the student in the development of important results excluded from the text. For example, the special cases of first integrals of the Euler–Lagrange equation are developed in exercises in Chapter 3. The computer assignments, 0–5 per chapter, introduce the MATLAB® programming environment as a tool for solving equations. These assignments are, of course, MATLAB-specific. However, they could easily be modified to use other programming languages, and most provide useful topics for semester projects.

Chapter 1, *The Theory of Equations*, uses several simple examples from mechanics to establish the concepts of existence and uniqueness in the solution of linear systems of equations and to develop the eigenvalue problem and its applications. The examples include structural equilibrium, hydraulic and electrical circuits, and vibrating systems. The chapter's exclusive focus on linear equations seems peculiar, especially in light of the author's comment on p. xx that he has doubts about whether "the linear approximation [is] a generally applicable tool." The 70 or so pages on linear equations in Chapter 1 imply that linear approximations are indeed generally applicable. One of the most important techniques for solving nonlinear systems of equations, Newton's method, is resigned to the brief *Review of Elementary Real Analysis* in Appendix B. Given the general applicability of Newton's method, the author could have easily integrated it into Chapter 1, along with some simple examples of nonlinear equations.

The omission of Newton's method and nonlinear problems from Chapter 1 continues into Chapter 2, *Theory of the Extreme Values of Functions*, where necessity and sufficiency join existence and uniqueness as important properties to establish when seeking solutions to mathematical problems. The basic results that arise in parameter optimization, with and without constraints, are developed here, and the examples, exercises, and computer assignments will provide a substantial education to the student who completes them all.

Although the topics in Chapters 1 and 2 are typically included in an undergraduate engineering curriculum, the topics of Chapter 3, *The Calculus of Variations*, are less commonly included. The author presents this relatively advanced material at an appropriate level for the intended audience, and the subject is certainly important to the topics in analytical mechanics developed in the remaining three chapters. However, subsequent chapters make scant reference to Chapter 3, so that Chapter 3 is not a prerequisite to an understanding of Chapters 4–6.

The choice and sequence of topics for the three chapters on mechanics applications is interesting. Chapter 4, *The Extremum Principles of Thermodynamics*, seems curiously out of place, preceding as it does the more typical topics presented in Chapter 5, *The Stationarity and Extremum Principles of Solid Mechanics*, and Chapter 6, *Equations of Motion and the Stationarity Principles of Lagrange and Hamilton*. Although the material in the latter two chapters is frequently included in undergraduate courses, the application of variational principles in thermodynamics is seldom included in courses at this level. For this reason, these three chapters would almost certainly be presented in the order of 5, 6, 4 or 6, 5, 4 in any course, with Chapter 4 likely to be omitted altogether in an undergraduate course. The author justifies the inclusion of Chapter 4 in the prefatory section, *To the Instructor*, stating that the chapter "provide[s] a logical completeness." However, the appearance of this material in the *first* of the three chapters devoted to applied mechanics remains an unexplained curiosity.

In any event, the text develops the material in these three chapters in a thorough and effective manner, from first principles to applications. All of the usual topics are included here and there are numerous extended examples. The treatment of rigid body motion in Chapter 6 takes the usual Eulerian approach, but also includes the Lagrangian development for axisymmetric bodies. Specifically, example 16 develops equations of motion and solutions for the axisymmetric football, where the author's experiences with controlling the initial conditions in an experimental setting are used to motivate further experimentation by students.

The principal distinction between this text and other applied mechanics texts is the emphasis on the mathematical foundations. The text combines a shortened version of a traditional engineering mathematics text with material from traditional applied mechanics texts, and does so in a reasonably effective manner. The book will be useful in the intended setting of an upper-level undergraduate course.

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## ***June 8, 2004: Venus in Transit***

Eli Maor, Princeton University Press, 2000, 186 pp., $29.95, ISBN 0-691-04874-6

Of the countless near commensurabilities that exist in the solar system, some are dramatic, such as the Saros cycle and lunar eclipses; some have deep dynamical significance, such as the great inequality between Jupiter and Saturn; and some are just mathematical and physical oddities. The transit cycle of Venus falls into this last category—an event that was unobservable prior to the astronomical prediction and observational techniques of the Renaissance and was of no apparent consequence. That is the current status of these transit events, occurring in pairs separated by eight years, with an overall period of 130 and 113 years between pairs. However, from the late 17th century through the 19th century, these transits assumed a lofty scientific status related to their use in the measurement of the astronomical unit. In fact, the possibility of measuring the scale of the solar system by accurately measuring transit times from widely separated points on the globe motivated some of the earliest "large scale" scientific measurement campaigns.

This book focuses exclusively on these Venus transits, from their discovery by Kepler in his preparation of ephemerides through their first observation in 1639 by Horrocks in England and the elevation of their status as a method by which to measure the fundamental unit of the solar system by Halley in 1716. Inspired by this practical application, Maor describes in detail the series of campaigns to make this measurement in 1761, 1769, 1874, and 1882. The excitement all ends, however, with the final realization that the heralded accuracy of this measurement technique fell far short of what was significant.

The next Venus transit occurs on June 8, 2004: an event which mobilized scientists around the world in its previous incarnations will instead mobilize amateur astronomers wishing to gaze upon an interesting moment in the evolving motion of the solar system. To support those interested, Maor gives great detail on the times and places from which the 2004 transit can be observed, making this an essential handbook for people planning to observe this event.

Maor has written many books relating the history and sociology of mathematics and science, and his adeptness as an author shows clearly. He has written an engaging book that takes us from Kepler through many of the major players at the dawn of science, following the one thread that ties the story together: the opportunity to predict and observe a transit of Venus, with the intention of using this rare event to measure the solar system. Overall the book is an enjoyable and quick read. (I was able to start and finish it during one flight from Detroit to Houston.)

Besides the general interest of *JGCD* readers in matters of scientific and astronomical significance, this book will be of interest for other reasons as well. First, Maor gives a correct and illuminating description of transit and eclipse cycles that, by itself, is worth the read. Second, the stories that Maor relates, with extensive footnotes and a complete bibliography, describe some of the earliest examples of large-scale, coordinated campaigns to carry out measurements of scientific interest. Anyone involved with a large space science mission can directly relate to these stories and would appreciate the detailed descriptions of how personal relationships and rivalries, government bureaucracies, and basic physics can drive the whole enterprise in unforseen ways.

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While well written and entertaining, the book does have some drawbacks. First, by the middle of the book we realize that the entire endeavor to use Venus transits to measure the astronomical unit was fundamentally flawed, so much so that during the last Venus transit in 1882 the scientific community gave little real effort or thought to carrying out the necessary measurements. As a striking moral for our own times, the governmental bureaucracies did not let this stop them from investing far more time and money into the final opportunity—widely perceived as no longer useful by the scientific community—than was ever invested in the earlier attempts at measurement while there was still a strong hope of success. This same historical fate, however, also dooms this book to an ultimate let-down and diminishes the relevance of this story for today, as anything other than a morality tale.

One cannot fault the author for this ending, but it seems as if Maor himself lost some of the enthusiasm for this book during the final stretch. Several items of real scientific interest related to the transit measurements and why they ultimately led to failure are not explained in the same depth and energy the author used to describe physical phenomenon at the start of the book. Further, the surprising lack of any discussion of the 2013 transit detracts strongly from this book. Surely the author had the information at hand and either he (or the editors) chose not to let us know when or from where the 2013 transit would be visible.

These drawbacks are minor, however, and the book is still worth the read.

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