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Book Reviews

An Introduction to Turbulent Flow

Jean Mathieu and Julian Scott, Cambridge University Press, New York, 2000, 384 pp., $90.00

Turbulence is the last great unsolved problem of classical physics. Or so it goes in a quote variously attributed to one of the great modern physicists, Albert Einstein, Richard Feynman, Werner Heisenberg, and Arnold Sommerfeld. According to John Lumley, the closest sentiments to this quote that could be traced are due to the classical physicist Horace Lamb (1895), who actually wrote, starting with the second edition of his celebrated book *Hydrodynamics*, under the heading of Turbulent Motion: "It remains to call attention to the chief outstanding difficulty of our subject." Despite the subject's importance, complexity, and prevalence, the number of specialized books on turbulence remained relatively small during most of the second half of the 20th century: for example, Batchelor (1953), Townsend (1956), Hinze (1959), Monin and Yaglom (1971; 1975), and Tennekes and Lumley (1972). But starting in the 1990s, for reasons that elude this reviewer, a deluge of books on turbulence appeared on the scene. The field is crowded, and I presume readers can afford to be more discerning.

The present book is largely modeled after that of Tennekes and Lumley, with three important differences. It does contain a brief chapter on numerical simulations of turbulent flows; it does not provide any exercises; and it does not satisfactorily ease the reader into the art of approximation, dimensional analysis, and order-of-magnitude arguments. This third difference is perhaps Tennekes and Lumley's greatest strength as a textbook and the reason for its continued popularity in the classroom after nearly 30 years.

The present book is intended as an introduction to the subject to be followed by a more advanced second volume covering such topics as probabilistic and stochastic methods, scalar mixing, and small-scale intermittency. The first volume is organized into eight chapters: Introduction; Statistical Tools; Space and Time Scales; Basic Theory and Examples; Jets, Wakes, and Boundary Layers; Spectral Analysis of Homogenous Tubulence; Kolmogorov and Related Theories; and Numerical Simulations. Each chapter ends with its own list of references, and a list of "general" references follows the Preface and Roadmap. Both the chapter on shear-flow turbulence and the one on numerical simulations are disappointingly terse.

The book is well written by the two distinguished authors and superbly copyedited by Cambridge University Press. The prose is concise for the most part, and the technical arguments are precise, reflecting the long cumulative experience of the authors. The book is quite readable by graduate students beginning their research career in fluid mechanics and particularly in turbulence. Physical insight is emphasized throughout, and the mathematics is at a level approachable by most readers.

Unlike the now-classical books on the subject, the present book does not contain much in the way of original ideas. In other words, the authors merely describe what is out there, do not try to push their own thoughts, and do not provide experienced readers with much material that such readers do not already know. The authors appear to be trying hard to weave through the concept of chaos, but depth is clearly lacking in such discussion. Coherent structures are mentioned but do not get the coverage they surely warrant in a modern treatment of turbulence. How can knowledge of coherent structures help the modeling? The numerical simulations? Eventual control of turbulence?

Comparing the present book to two other recent books, also published by Cambridge, Holmes et al.'s *Turbulence, Coherent Structures, Dynamical Systems, and Symmetry* (1996) and Pope's *Turbulent Flows* (2000), I find the present book wanting. Holmes et al. discuss turbulence from the modern perspective of dynamical systems theory and offer the reader a blueprint for using a novel and useful tool. Pope's book is a modern text suited for the classroom—exercises and all—and contains an extensive discussion of modeling and numerical simulations of turbulent flows.

In summary, my views of the present book are somewhat mixed. There is nothing wrong with what is here, but several other books offer superior coverage, some of them better suited for graduate students and others for the more experienced researchers. The present book is not optimized for either group. Readers of *AIAA Journal* should perhaps urge their libraries to acquire the present book, but a personal copy may not be worth the price.

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Dynamic Optimization

Arthur E. Bryson Jr., Addison Wesley Longman, Menlo Park, CA, 1999, 434 pp., $95.00

This book is an expanded version of parts of the older book, *Applied Optimal Control*, by A. E. Bryson and Y.-C. Ho, which was first published in 1969. A large number of examples have been added, taken mostly from aerospace applications and such diverse fields as structural optimization, robotics, etc. MATLAB® has been extensively integrated into the body of the text. MATLAB script files are to be found throughout the text. A CD-ROM containing many of the programs used to generate the solutions to example problems is included. This book is a welcome addition to the list of textbooks available in the area of system optimization and is especially well suited for use in a first-level graduate course.

There are 10 chapters. The first chapter treats the concepts of static optimization and introduces the first-order gradient method and Newton–Raphson methods. The next chapter treats dynamic optimization of discrete and continuous systems and numerical solution techniques using the gradient method as well as the shooting method. Then comes a chapter on dynamic optimization of systems with terminal constraints and free final time. Two chapters are devoted to the linear-quadratic problems. Both the state transition matrix and the Riccati equation approaches are treated with numerous examples. A chapter on dynamic programming and the Hamilton–Jacobi–Bellman equation is included. The last three chapters contain advanced topics, such as neighboring optimal control, inequality constraints, and singular optimal control problems. The connection between the second variation and the linear-quadratic problem is established. Second-order necessary conditions and convexity issues are treated with many illustrative examples and figures.

At the end of the book is an appendix on the history of dynamic optimization from 1950 to 1985. It is worth reading, both for the sequence of historical developments and for inspirational value. Of special interest to students is the history behind the development and testing of the minimum-time-to-climb path for the F-4 aircraft. It is exhilarating to read that the theory and computations presented were actually verified in flight, as early as 1962, within a year after the work was done. The minimum time predicted for climb to 20 km, Mach 1, was 332 s, and that achieved was 338 s. Such examples are very few and hard to come by.

Missing from this book is a treatment of system model discontinuities, intermediate-point constraints, and the associated jump conditions. Newer advances in the computational aspects of dynamic optimization have not been addressed. However, the method of differential inclusions is mentioned as a form of optimization using the inverse dynamic approach. This approach has gained popularity in the past decade as a means for computing optimal trajectories in real time or close to it. Readers familiar with the subject matter will also find it rather strange that the shooting method is classified here as a direct method. The algorithms for the various methods are summarized at the end of the chapters, but the MATLAB script files are included in the main parts of the chapters. This does not make for easy reading. I personally do not find reading someone else's code easy, no matter how many comment cards are used. This is an unnecessary distraction. All of the script files would be better placed in an appendix. Some parts of the script files may need modifications as newer versions of MATLAB are released. As it stands now, the book seems more focused on solving example problems, and the theoretical aspects have been forced into the background. The book is full of acronyms, which is another possible source of distraction for the casual reader. I would urge the author to do away with these as much as possible in the next edition of the book.

All in all, I am thrilled that there now exists a textbook on dynamic optimization that can be used for a one-semester graduate course in an aerospace engineering curriculum. The book is quite self-contained, and ideally students will learn the subject matter better by doing many of the example problems themselves.

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