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Book Reviews

Incompressible Flow and the Finite Element Method

P. M. Gresho and R. L. Sani (in collaboration with M. S. Engelman), Wiley, New York, 1998, 1021 pp., $295.00

This substantial publication (over 1000 pages) is asserted to be volume 1 in a proposed two-volume series. The literary scope is to expose in exhaustive detail the mathematical, theoretical, and practical aspects of finite element methods applied to solution of the incompressible Navier–Stokes equations.

This first volume contains four chapters and three appendices. The third chapter, which addresses the laminar, isothermal, and mainly two-dimensional Navier–Stokes equations, is almost 500 pages in length. The preceding chapter of several hundred pages addresses the scalar advection–diffusion equation in one to three dimensions. The Navier–Stokes chapter also contains a number of comparisons to finite volume and finite difference methods for laminar incompressible isothermal flows.

This monograph represents a monumental undertaking by the authors, documenting their thorough knowledge of the discipline and the associated literature generated over the past 30 years. The individual knowledge the authors have about the field led them to present their subject in an exhaustive manner, full of parenthetical comments, paraphrases, vignettes, remarks, and digressions. Because of this treatment, the volume reads rather "autobiographically" in the sense that these caveats are meant to be informative as well as, in several cases, humorous and historical in flavor.

However, it is precisely this writing style, carried to an extreme (in this reviewer's opinion), that makes keeping the thread of the discourse unnecessarily difficult. Certainly the reader with experience in the field and knowledge of the literature benefits from these numerous digressions. However, the neophyte (i.e., student), at the beginning of learning about the finite element method for the problem class, is likely to be severely distracted by this style.

The topical organization of this book indicates that it was conceived as a monograph intended for the knowledgeable reader. In no other instance would one write the fundamental Navier–Stokes (and Stokes) material into a single chapter of 500 pages. This is particularly poignant when considering adaptation for support of the education of novices. The clear compartmentalizing of facts, notions, and concepts into palatable, lecture-size subsections of chapters is accepted as the norm for books intended for instruction.

For the novice reader, an additional detraction is the intermingling of very detailed mathematical discourses, complete with numerous caveats, with the practical material. Having this mathematical detail regularly precede the practical issues is fine for the mathematically inclined. However, for the world of engineers, the significantly larger audience, this approach is in inverse order from the norm for such books.

Another detraction to the widespread assimilation of this material is the dearth of significant computational results and examples. A broad range of well-accepted verification and benchmark-type problems exists for Navier–Stokes algorithms, and I am sure the authors have detailed numerical experience with them. It would have made this monograph significantly more attractive had significant benchmark problem results been included to support the theoretical contentions of superior mathematical performance, or the potential thereof.

This criticism extends to the lack of practical problem analyses and data up to the Reynolds number limit for turbulent flow transition. An exhaustive theory exists and is exposed for the Stokes limit (*Re* approaching zero), but most of the engineer's real world exists at the opposite end of the Reynolds number range! Herein, convection dominates diffusion by orders of magnitude, injecting the range of computational fluid dynamics (CFD) algorithm pathologies well known to the profession. The associated theoretical and practical issues of stabilizing an algorithm immediately take critical importance, but they are addressed only casually in this monograph. Thereby, the practical applicable scope of the published material is really quite limited.

In summary, the present monograph constitutes thorough documentation of the very extensive archival finite element literature that exists on a very limited problem class particular to the incompressible Navier–Stokes equations. I commend the authors on the thoroughness of what they have prepared. The run-on literary style is a distraction to the casual reader and a minor impediment to the student of the field. It would be quite difficult to use this book as a textbook to teach CFD, but it is fine as support for a seminar class focusing on material pertinent to Ph.D.-level research. As such, it belongs on the shelves of the libraries of academics whose field is finite elements and CFD.

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Experimentation and Uncertainty Analysis for Engineers, 2nd Edition

Hugh W. Coleman and W. Glenn Steele, Wiley, New York, 1999, 275 pp., $69.95

The second edition of *Experimentation and Uncertainty Analysis for Engineers* by Hugh W. Coleman and W. Glenn Steele is a welcome sequel to the first edition, published in 1989. The book addresses the recent major developments in the field of experimental uncertainty analysis since the publication in 1993 of the present standard, *Guide to the Expression of Uncertainty in Measurement* by the International Organization for Standardization (ISO). The authors were active participants in the international organizations that produced the new standard and have offered numerous short courses on the topic. In this edition, they explain how the new standard compares with the popular but supplanted U_{RSS} and U_{ADD} methods. For example, they show that, in the large-sample limit, the uncertainty estimates provided by the U_{RSS} method and the new standard are identical.

The format of the new edition is quite similar to that of the earlier version, now with seven chapters and three appendices. Chapters 1 and 2 introduce basic definitions and concepts and requisite statistical methods. Chapter 3 describes general uncertainty analysis from the perspective of planning an experiment. Here, the overall uncertainty is considered and not the details of the precision and bias components. Chapter 4 considers separately how precision and bias errors propagate into an experimental result within the context of designing an experiment. Chapter 5 addresses additional considerations in uncertainty analysis, including asymmetric systematic uncertainties, comparative testing, code validation, Monte Carlo simulations, digital data acquisition, and dynamic response of instrumentation. Chapter 6 discusses the debugging and execution of experiments, and Chapter 7 examines data analysis, including regression, and the reporting of results. Appendix A tabulates useful statistical information, and Appendix B compares the current standard for analyzing uncertainty propagation with previous popular methods. Appendix C uses Monte Carlo simulations to establish the validity of the large-sample uncertainty model.

Significant new material has been added to this edition, including improved methods that account for the effects of correlated bias errors and asymmetric systematic uncertainties. A discussion of correlated random errors is a pleasant supplement. Useful information is also provided on uncertainties associated with comparing data with predictions, as well as a straightforward method that properly accounts for both random and systematic uncertainties in regression analysis. The material in this book is appropriate for an advanced undergraduate or beginning graduate course, with or without an accompanying laboratory. In addition, an experimentalist, as well as a computational or modeling analyst, will likely find the material in this book useful.

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