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Book review

Fundamentals of Engineering Numerical Analysis, P. Moin. Cambridge University Press, Cambridge

This rather small book (209 pages including Appendix and Index) is an outgrowth of lecture notes for a graduate course at Stanford University. The lecture notes background of the book seems to provide both its merits and deficiencies.

The presentation is succinct, straightforward and supported by short and pertinent examples. Overall, the book conveys a great deal of information and the serious reader/student is bound to gain useful knowledge on the more practical sides of important topics in numerical methods.

On the other hand, course lectures do not necessarily present a balanced and thorough coverage of the topics and, in engineering departments, usually cannot afford the rigor, formalism and connectivity required for a good introduction to this applied-mathematical discipline. Indeed, the present book does not contain any formal theorems and proofs, perhaps an outcome of the "engineering" flavor emphasized in the title.

The chapters are: (1) Interpolation; (2) Numerical differentiation—finite differences; (3) Numerical integration; (4) Numerical solution of ODE's; (5) Numerical solution of PDE's; (6) Discrete transform methods. The appendix contains a short review of linear algebra. It is clear from the beginning that the traditional subjects of error analysis, solution of nonlinear equations and systems of linear equations are not directly addressed. Still, it is a very difficult task to cover so many topics in so few pages. Indeed, Chapters 1 and 3 are rather sketchy, and quite decoupled from the rest of the material. For example, polynomial interpolation and Gauss quadrature are discussed without the error term; the use of least squares is recommended for some cases of curve fitting, but the method is not presented. Actually, the book seems to be mainly an introduction to the solution of ODEs and PDEs by finite difference and spectral methods, and will have to compete mostly in this niche with other available textbooks.

Chapters 2 and 4–6 are more developed and provide a fair introduction to the topics concerned. However, there are some gaps. For example, in Chapter 4 Euler and Runge–Kutta methods are discussed in detail, but not the predictor–corrector methods. Chapter 5, which occupies about one third of the text, presents the classical equation cases and the stability analysis, but the method of characteristics and propagation of discontinuities are not treated. Moreover, only simple domains and rectangular geometries are considered. Again, a stronger theoretical support could be useful, in particular in Chapter 6, where the connection between orthogonality (of Fourier and Chebyshev series) and mean-square error is not formulated, and it is not clarified why the derivatives of the series and function are expected to be close; nice convergence features are illustrated in examples, but deeper statements or theorems (e.g., Parseval's), could improve the presentation.

Are the more subtle and formal points of numerical analysis important to engineering students? Yes, they are; without them, essential messages of the discipline are missed and, moreover, the intrinsic beauty of the subject is lost. Learning, especially in top universities, is also concerned with the added values of knowledge. Is it really possible to cover all these topics in a course? Certainly not, but a good book is not expected to mirror the lectures, rather to go beyond them. A serious student/reader should be exposed to the error formula of the polynomial approximation, the minimax property of Chebyshev polynomials, Lax's theorem, norms, etc., even if this material is not directly taught in the class—and a simple way to this awareness is to encourage him to use a book which neatly combines his practical needs with the additional material. A good book is also expected to allow the teacher a certain flexibility concerning both topics and depth. From this aspect the present book is disappointing.

There are many illuminating examples and exercises. Some rely on the use of specific programs from Numerical Recipes by Press et al., which is basically a fine combination, but also an obvious restriction. A list of books for further reading is supplied at the end of each chapter, but without clear pointers from within the text. The index is detailed, but the arrangement is not always straightforward (e.g., Adams–Bashforth method is not entered under letter A, but as a sub-key of "initial value problems").

In general, the text is well edited, but some misprints and careless formulations remain. We read, p. 133, that convergence of an iterative solution method for a linear system will happen if the spectral radius $\rho \leqslant 1$ (why not if and only if $\rho < 1$?). Example 2.1, p. 16, illustrates the truncation errors for various difference schemes as functions of the grid-spacing h, but does not emphasize that double-precision calculations are necessary to avoid the dominance of cancellation errors for $h < 10^{-2}$ in the particular case; otherwise, the numerically evaluated error vs. h, displayed in Fig. 2.1, will look different.

The price of the paperback, \$34.95 (a remarkable accuracy of four significant digits!) is not very attractive, and one should keep in mind that Numerical Recipes is also needed for the completion of many examples and exercises. Well-to-do libraries and individuals need not worry, because the hardback is also available, at the more exclusive price \$95.00.

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