

BOOKS

Handbook of Nonlinear Partial Differential Equations

Andrei D. Polyaniin and Valentin F. Zaitsev
Chapman and Hall/CRC,
Boca Raton, FL, 2004
814 pp., \$99.95 *hb*
ISBN 1-58488-355-3

Reviewed by Andrew Resnick

This book initially appears to be quite formidable, for it contains almost 800 densely packed pages of nonlinear partial differential equations and their solutions. The stated goal of this text is impressive: to present closed-form solutions to more than 1,600 nonlinear partial differential equations. The equations chosen appear in multiple physical and biological sciences problems, including heat and mass transfer, hydrodynamics, control theory, and chemical engineering. The authors are to be congratulated for somehow making this book so approachable. From the well-ordered table of contents to the clear index, this book promises to be one that will be used regularly, rather than gather dust on a shelf.

The first six chapters are concerned with parabolic, hyperbolic, and elliptic equations. They cover the bulk of equations found in the physical sciences. The next two chapters address mixed derivatives and general cases of second-order differential equations, while the last three chapters are concerned with third-, fourth-, and higher-order differential equations. Some examples, chosen at random, that illustrate the breadth of this book are the following: the Schrödinger (quantum mechanics) and Fitzhugh-Nagumo (signal propagation in nerve cells) equations are parabolic equations, the telegraph equation (transport in a conductive and diffusive medium) is a hyperbolic equation, the Monge-Ampère equation (gas dynamics and meteorology) contains mixed derivatives, the

hydrodynamic boundary-layer equations are third-order, and the Navier-Stokes equations are fourth-order in the stream function.

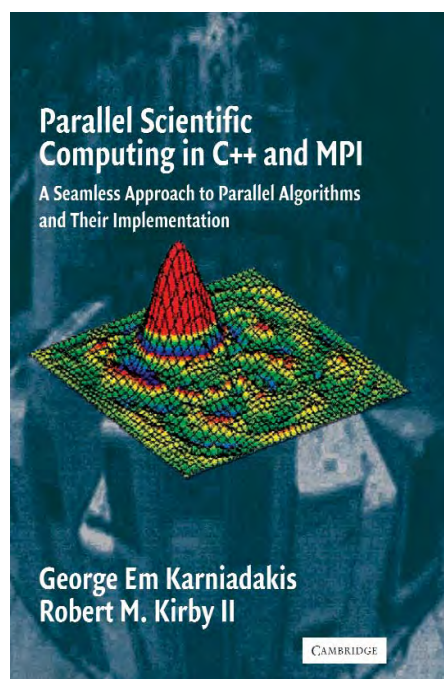
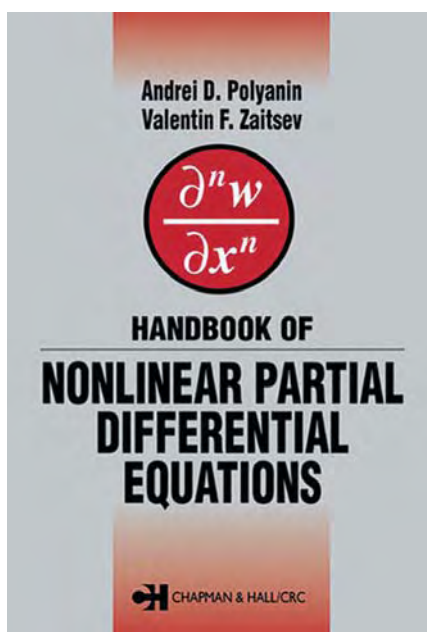
The 12 supplementary chapters contain a wealth of information on methods of classification, transformations, and constructing closed-form solutions of differential equations. It is difficult to summarize the supplements, but a few sections that are particularly interesting to this reviewer are those on similarity transforms, methods of functional and generalized separation of variables, and group analysis methods. I found these supplements to be clearly written, with the goal of providing a “recipe” that can be applied toward a solution. Although the topics are rather advanced, the notation is uniformly clear and easy to follow.

The authors clearly state in the preface that an overriding goal was to make the book useful to a wide audience with different mathematical backgrounds. Thus, they prefer schematic approaches to specialized topics rather than introducing detailed terminology. Without a doubt, this approach makes the book useful to those of us lacking advanced mathematical abilities. Books like this are presumably prone to errors, either typographical or otherwise. I checked approximately a dozen of the equa-

tions, chosen at random throughout the book, and found no errors.

Handbook of Nonlinear Partial Differential Equations is a total success from the standpoint of offering a complete, easy-to-use solution guide. The authors are to be congratulated on what surely must have been a monumental effort to bring this book to fruition. □

Andrew Resnick (andy.resnick@case.edu) is a postdoctoral fellow at the Case Western Reserve School of Medicine, Department of Physiology and Biophysics, in Cleveland, Ohio. His current research concerns how cells sense their fluid environment using a primary cilium.

**Parallel Scientific Computing in C++ and MPI: A Seamless Approach to Parallel Algorithms and Their Implementation**

George Em Karniadakis and
Robert M. Kirby II
Cambridge University Press,
New York, 2003

616 pp., \$150.00 *hb*, \$55.00 *pb* (both include CD-ROM)
ISBN 0-521-81754-4 *hb*, ISBN 0-521-52080-0 *pb*

Reviewed by Babak Makkinejad

New and challenging problems are being encountered in the areas of data mining, bioinformatics, and computational fluid dynamics that require a very large computational capacity. The availability of commodity hardware components such as motherboards and memory chips, together with free software such as Linux, the GNU compilers, and the Message-Passing Interface (in which message-passing is used to control the flow of the computation), has put massively parallel machines such as Beowulf clusters within reach of medium-sized companies and academic departments. As parallel computing continues to merge into the mainstream of computing, it is becoming important for students and professionals to understand the application and analysis of algorithmic paradigms to both the (traditional) sequential model of computing and various parallel models.

Parallel Scientific Computing in C++ and MPI, by George Em Karniadakis and Robert M. Kirby II, is a valiant effort to introduce

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parallel scientific computing to the student in a unified manner. The textbook offers the student with no previous background in computing three books in one. There is a textbook on the analysis of algorithms, a textbook on parallel programming using MPI 1.x, and an elementary book on programming using a subset of C++ as a better “C”.

Karniadakis is a professor of applied mathematics at Brown University, working on simulations of turbulence in complex geometries. Kirby is an assistant professor of computer science at the University of Utah, specializing in large-scale scientific computing. This textbook, largely based on Karniadakis’s courses at Princeton University, Brown University, and MIT over the past 15 years, is thus slanted toward computational fluid dynamics. It is strong as a traditional algorithms-based textbook for an introductory course in numerical analysis at the late-undergraduate or early-graduate level. It examines such core topics as dense and sparse matrix computations, linear systems, finite differences, and fast Fourier transforms. The text assumes a solid technical background including calculus, linear algebra, and differential equations.

The initial chapters explain how and why parallel computing began, present an overview of parallel architectures, and introduce MPI 1.x. The authors follow this by discussing the powerful divide-and-conquer paradigm and develop the basics of each topic, such as root finding and approximation with sequential and MPI-specific implementation details and much useful (but not optimal) C++ code. Chapters 3, 5, and 6 are the heart of the book, where approximation of functions, explicit and implicit discretization, and MPI are discussed in detail. The authors are very careful in establishing the foundation of each algorithm, and considerable care is taken in explaining and estimating the accuracy of each numerical technique, its stability, and its convergence with benchmarks. Each chapter also includes advice on common programming pitfalls, “gotchas,” and exercises. There are, in fact, 162 homework problems throughout the book.



The authors state the following: “Our book treats numerics, parallelism, and programming equally and simultaneously.” They do not achieve their stated purpose of treating these topics equally in their discussions of C++ and MPI 1.x. Readers looking for examples of how encapsulation, inheritance, exception handling, templates, and polymorphism can be used to control the complexity of developing, debugging, maintaining, and tuning parallel software using MPI will not find it in this book. For a more thorough discussion of MPI 1.x from a software development point of view using “C,” one might consult *Parallel Programming with MPI* by Peter S. Pacheco (Morgan Kaufmann Publishers, 1997). However, neither text treats MPI 2.0 features such as multithreading or C++ bindings for MPI.

In spite of falling short of its ambitious goals, this textbook is useful for those who would like to know how to write parallel programs using MPI or who wish to go beyond such cookbook texts as *Numerical Recipes in C++: The Art of Scientific Computing* by William H. Press, et al. (Cambridge University Press, 1988). 

Babak Makkinejad (babak.makkinejad@eds.com), a consultant with EDS, received his Ph.D. in theoretical physics from the University of Michigan in Ann Arbor. He has worked in the areas of computational physics, computer graphics, image processing, and enterprise software development.

The following books have been received in the offices of *The Industrial Physicist*. Comments and questions may be addressed to Cynthia Cummings, One Physics Ellipse, College Park, MD 20740-3843; tel. 301-209-3004; fax 301-209-0842; e-mail ccumming@aip.org.

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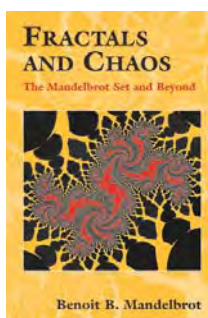
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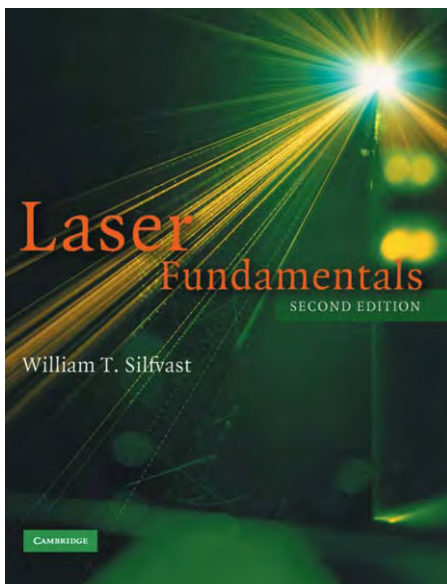
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