Book review

Wave Propagation in Fluids: Models and Numerical Techniques. Second Edition by Vincent Guinot. September 2010. ISTE Ltd and John Wiley & Sons, London/Hoboken. 560 pages. Hardback ISBN: 978-1-84821-213-8, £130/€156/$195

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Professor Vincent Guinot has done a great service to the discipline of computational hydraulics and fluid mechanics in the first and second editions of this book. This book belongs in the library of all engineers and scientists engaged in the analysis, development and application of computational hydraulics and fluid dynamics.

As commercial simulation codes have matured and become ubiquitous, they have come into common use in engineering analysis and design by those who may have little education or experience in the essential numerical methodologies employed – and the relation of these methodologies to the physical wave phenomena being simulated. Yet as professional engineers, the users of such codes are responsible for the effects of their analyses and designs on the public health, safety, and welfare. Professor Guinot's book provides valuable insight into the strengths and weaknesses of both traditional and evolving numerical techniques, and ultimately into the ability of such techniques to capture, and be faithful to, the essential physical processes on which engineering design and analysis are based.

As Professor Guinot states explicitly, his text is directed primarily at students in professional and research masters and doctoral programs; and at engineers and professionals involved in the development and use of simulation codes in hydraulics and fluid mechanics. However, the book is essentially a mathematical work, exploring the design and behavior of a range of numerical schemes from the point of view of their emulation of the properties of the underlying mathematical formulations. The introduction states that the book deals with both the physics and mathematics of wave propagation, but the physics gets rather short shrift compared to the mathematics (waterhammer phenomena being a notable exception). The book is a complement to classical texts such as Stoker's 1957 treatise *Water Waves*, Garabedian's definitive 1964 work *Partial Differential Equations*, and to more practically-oriented works such as Cunge, Holly, and Verwey's 1980 *Practical Aspects of Computational Hydraulics*. The reader of Professor Guinot's book should expect to approach it as an essentially mathematical text.

This second edition complements the first edition with four new chapters on the finite-element method, treatment of source terms (especially those generated from variations in geometry), the mathematical basis for sensitivity analyses, and guidance on model use in practice.

The complete table of contents is as follows: Introduction; Scalar Hyperbolic Conservation Laws in One Dimension of Space; Hyperbolic Systems of Conservation Laws in One Dimension of Space; Weak Solutions and their Properties; The Riemann Problem; Multidimensional Hyperbolic Systems; Finite Difference Methods for Hyperbolic Systems; Finite Volume Methods for Hyperbolic Systems; Finite Element Methods for Hyperbolic Systems; Treatment of Source Terms; Sensitivity Equations for Hyperbolic Systems; Modeling in Practice; and appendices on Linear Algebra; Numerical Analysis; Approximate Riemann Solvers; and Summary of the Formulae. An extensive bibliography and topical index are included.

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As can be seen from the above list of chapters and appendices, the book is focused on hyperbolic systems for various physical processes, as expressed in the Euler, Burger, shallow-water wave, and waterhammer equations. A number of practical examples are taken from various areas of fluid mechanics and hydraulics, such as contaminant transport, the motion of immiscible hydrocarbons in aquifers, river flow, pipe transients and gas dynamics. Finite difference, finite volume, finite element, and characteristics methods are applied in a general framework of possible mixed and transcritical flow regime, and issues of continuous and discontinuous flows underlie most presentations and discussions. Although most examples are one-dimensional in space, multi-dimensional hyperbolic problems are addressed as well.

A welcome feature at the end of the first eight chapters is a short section on 'what you should remember', though this emphasis is somewhat diffused in a general summary section in the last three chapters of the second edition. The first eight chapters also include suggested exercises with links to online solutions, though these suggestions do not appear in the source-term and sensitivity-equation that are somewhat more research-oriented. The last chapter is a particularly valuable guide to quality assurance and an overview of 'what can go wrong' in numerical simulation of physical flow processes, from the standpoint of the formal numerical methods. New users of simulation packages will find the section 'getting started with a simulation package' to be particularly helpful. The final appendix provides a very useful and thoughtfully presented summary of basic equations for the various processes and their formulations in conservative, non-conservative and characteristic forms.

The importance of this book is perhaps best summarized by Professor Guinot's own closing sentences:

> *Modeling only provides an approximation of reality and numerical techniques are essentially inaccurate. For this reason, the modeler's critical judgment remains an essential feature of the modeling process. If one piece of advice should be given to a newcomer in the world of modeling, it may be the following: the model is and must remain a tool. Use it, never let it use you.*