Preface to the Third Edition

More than a decade has elapsed since the publication of the first edition of this book. During this period the response from readers the world over has been overwhelming, from students and academics to senior researchers. This decade has also witnessed a significant increase in the use of numerical methods, not only in the traditional areas such as physics and industrial processes, but also in biology, economics, social sciences and in inter–disciplinary research areas. We also observe a new trend in mathematical modelling and numerical simulation. Numerical methods are steadily moving from being a simulation tool for engineering design in technology, to being an indispensable instrument in science, for studying and understanding phenomena of the most varied kind. The expectation is that a simulation will represent the solution of the actual mathematical model. Such expectation implies the need for more and more high–quality research on new and more accurate numerical methods and the need for better training of scientists at the undergraduate and post–graduate levels at universities and higher education institutions. I expect that this new edition of the book will continue to play a role in such endeavours.

In this edition I have included three new chapters, chapters 18 to 20. Chapter 18 is about a multi–dimensional extension of the centred FORCE flux studied in Chapter 7, for one–dimensional systems; in a sense, this new chapter is a response to the increasing role of the so–called centred methods. These have the advantage of avoiding the direct solution of the classical Riemann problem, in the conventional manner. As a result, the applicability of these centred schemes is more general than that of conventional upwind methods; this feature is specially useful when having to solve complicated systems, for which the solution of the Riemann problem may be difficult or impossible to obtain. The new FORCE scheme applies to two and three space dimensions on general structured and unstructured meshes and can be extended to high order of accuracy in space and time in the frameworks of finite volume and discontinuous Galerkin finite element methods. The second new addition, chapter 19, is about the high–order, or generalized, Riemann problem, the

Cauchy problem for hyperbolic balance laws whose initial conditions are two smooth vectors separated by a discontinuity at the origin. The solution of the generalized Riemann problem serves as the building block for constructing fully discrete, one–step Godunov–type schemes of arbitrary order of accuracy in both space and time. This chapter is effectively a generalization of the material of this book studied in previous chapters and responds to the general trend of improving the accuracy, in space and time, of numerical methods for solving evolutionary partial differential equations. These high–order numerical schemes can be constructed in the frameworks of finite volume and discontinuous Galerkin finite element methods. The third new chapter, chapter 20, contains an introduction to these high–order methods in the framework of finite volumes.

This edition of the book contains a substantially revised version of the HLLC Riemann solver of chapter 10. This responds to many communications received from readers and to new developments of the technique and its use for very ambitious scientific and technological applications. Some modifications to chapter 21 have also been carried out, as well general corrections to errors pointed out by readers.

This book, in spite of being introductory in nature, continues to be a book used mainly by researchers, and is perhaps too advanced for teaching undergraduate students. As a result, a new more elementary book is being written in collaboration with Enrico Bertolazzi and Gianluca Vignoli. This new book, to be published by Springer in 2009, is specifically designed for teaching undergraduate students in Science and Engineering, with plenty of exercises, case studies and miniprojects. On the other hand, in order to respond to research needs for better and more sophisticated numerical methods, we are currently preparing a new book, in collaboration with Claus–Dieter Munz, Vladimir Titarev and Michael Dumbser. This book will deal with advanced, high–order, finite volume and discontinuous Galerkin numerical methods for structured and unstructured meshes in multiple space dimensions, to be published by Springer in 2009.

I gratefully acknowledge the contribution of some collaborators to the preparation of this third edition. In particular I thank two of my former PhD students, Dr. Vladimir Titarev, now at Cranfield University, UK and Dr. Cristóbal Castro, now at the Technical University of Munich, Germany. I also thank two former post–doctoral fellows, Dr. Martin Käser, now at the Technical University of Munich, Germany and Dr. Michael Dumbser, now a colleague in my group at Trento University, Italy. Thanks are also due to colleague Enrico Bertolazzi and to visiting scholars María Nofuentes (Universidad de Córdoba, Spain) and Arturo Hidalgo (Universidad Politécnica de Madrid, Spain), who kindly helped in various ways in the preparation of the material.

I find it also appropriate to recall that the initial stages in the preparation of the first edition of this book took place at Cranfield University, formerly Cranfield Institute of Techology, United Kingdom. During the late 80s and early 90s, a very dynamic and stimulating group of scientists from various backgrounds, existed in the Aerodynamics Department, within the School of Aerospace Sciences. Those years at Cranfield greatly influenced the contents and scope of this book, for which I thank former senior and junior colleagues and students, John Clarke (FRS), Phil Roe, Jack Pike, Smadar Karni, James Quirk, Nikos Nikiforakis, Stephen Billett, Alan Dowes, Caroline Lowe, William Speares, Michael Spruce, Ed Boden, Mauricio Cáceres, and many others.

Finally, I thank Springer Verlag for their permanent and positive encouragement and effective support.

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December 2008

http://www.springer.com/978-3-540-25202-3

Riemann Solvers and Numerical Methods for Fluid
Dynamics
A Practical Introduction
Toro, E.F.
2009, XXIV, 724 p. 267 illus., Hardcover
ISBN: 978-3-540-25202-3