FLUID DYNAMICS

Theory, Computation, and Numerical Simulation

Accompanied by the software library *FDLIB*

by

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Preface

Ready access to computers at an institutional and personal level has defined a new era in teaching and learning. The opportunity to extend the subject matter of traditional science and engineering disciplines into the realm of scientific computing has become not only desirable, but also necessary. Thanks to portability and low overhead and operating costs, experimentation by numerical simulation has become a viable substitute, and occasionally the only alternative, to physical experimentation.

The new environment has motivated the writing of texts and monographs with a modern perspective that incorporates numerical and computer programming aspects as an integral part of the curriculum: methods, concepts, and ideas should be presented in a unified fashion that motivates and underlines the urgency of the new elements, but does not compromise the rigor of the classical approach and does not oversimplify.

Interfacing fundamental concepts and practical methods of scientific computing can be done on different levels. In one approach, theory and implementation are kept complementary and presented in a sequential fashion. In a second approach, the coupling involves deriving computational methods and simulation algorithms, and translating equations into computer code instructions immediately following problem formulations. The author of this book is a proponent of the second approach and advocates its adoption as a means of enhancing learning: interjecting methods of scientific computing into the traditional discourse offers a powerful venue for developing analytical skills and obtaining physical insight.

The goal of this book is to offer an introductory course in fluid mechanics, covering traditional topics in a way that unifies theory, computation, computer programming, and numerical simulation. The approach is truly introductory, in the sense that a minimum of prerequisites are required. The intended audience includes not only advanced undergraduate and entry-level graduate students, but also a broad class of scientists and engineers with a general interest in scientific computing.

The discourse is distinguished by two features. First, solution procedures and algorithms are developed immediately after problem formulations. Second, numerical methods are introduced on a need-to-know basis and in increasing order of difficulty: function interpolation, function differentiation, function integration, solution of algebraic equations, finite-difference methods, etc.

A supplement to this book is the FORTRAN software library *FDLIB* whose programs explicitly illustrate how computational algorithms translate into computer code instructions. The codes of *FDLIB* range from introductory to advanced, and the problems considered span a broad range of applications; from laminar channel flows, to vortex flows, to flows in aerodynamics. The input is either entered from the keyboard or read from data files. The output is recorded in output files in numerical form so that it can be read and displayed using independent graphics, visualization, and animation applications on any computer platform. Computer problems at the end of each section ask the student to run the programs for various flow conditions, and thus study the effect of the various parameters characterizing a flow. Instructions for downloading the source code and a description of the library contents are given on page 651.

In concert with the intended usage of this book as a stand-alone text and as a tutorial on numerical fluid dynamics and scientific computing, references are not provided in the text. Instead, a selected compilation of introductory, advanced, and specialized references on fluid dynamics, calculus, numerical methods, and computational fluid dynamics are listed in the bibliography on page 666. The reader who wishes to focus on a particular topic is directed to these resources for further details.

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