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Book review

An Introduction to Computational Fluid Mechanics by Chuen-Yen Chow, 1979; 396 pages. (*John Wiley*, £11·50)

Any book with the words computational fluid mechanics in its title can be expected to contain elements of fluid dynamics, numerical methods and computational techniques. The aspect which is stressed will vary according to the inclinations of the author. This book concentrates on the discussion of the fluid dynamics of a number of varied problems. Numerical methods which can be used to achieve the solution of these problems are described, the solutions being obtained by means of thirty FORTRAN IV programs which are listed at appropriate points in the text.

In the preface to his book, Professor Chow stresses that this is a book on fluid mechanics, not numerical computation. He makes the assumption that his readers have a fair knowledge of the fundamentals of fluid mechanics and of FORTRAN IV. He also implicitly assumes considerable mathematical knowledge. For example, some parts of the text would be difficult for anyone without a good working knowledge of vector calculus to follow. The author does not, however, assume any familiarity with numerical methods. Derivations are given for the various formulae used—even for the Newton-Raphson iterative formula. In British terms, this book is aimed at final year undergraduate or first year postgraduate students. It contains four chapters which are on the motion of a body through a fluid; on inviscid flows; on viscous flows; and on secondary flows. As an appendix, there is a list of the main subprograms used with a brief description of what they do. There is also a bibliography containing over seventy references, both to other books and to original papers; and two indices, one of authors and the other of subjects. Each chapter contains a number of problems for the reader to attempt using the techniques described in the chapter. No solutions are given, but there is some discussion of the problems in the text. Most of the problems require the writing of a computer program to achieve a solution.

In the first chapter, which is 68 pages long, fluids problems are discussed which reduce to the solution of initial value ordinary differential equations. These are solved using a fourth order Runge Kutta formula. In the second chapter, which is 146 pages long and which would have been better broken down into shorter chapters, a number of classes of fluids problems are discussed. The first class reduce to the solution of boundary value linear second order ordinary differential equations, which are solved by a finite difference scheme, the resulting tridiagonal equations being solved by Gauss elimination. The second class of problems are the source-sink methods for potential flows past various bodies, the resulting set of linear equations being solved (rather surprisingly) by Cramer's rule, the determinants being evaluated by pivotal condensation. The next topic discussed in this chapter is the classification of partial differential equations. A class of fluid problems which reduce to the solution of a linear elliptic equation is discussed, the solution of the

equation being achieved by finite differences with the resultant algebraic equations being solved by successive over-relaxation. Finally, a class of problems which reduce to the solution of a linear hyperbolic equation is discussed, the solution being by an explicit finite difference scheme. In the third chapter, which is 74 pages long, the solution of parabolic partial differential equations by both explicit and implicit methods is described. There is discussion of the stability of these methods. A number of other fluids problems are discussed which use techniques or modifications of techniques from earlier chapters. In the final chapter, which is 92 pages long, nonlinear flows are discussed. The Galerkin method for flow past a sphere is described, the nonlinear algebraic equations which result from this being solved by Newton-Raphson iteration. Problems in fluid stability are also discussed.

While this text has many good points, I would not be able to recommend it for anyone who does not have a strong grounding in numerical and computing techniques. The numerical methods used are in some cases inappropriate, but they are presented with no critical assessment of their value. In a real situation, the normal procedure would be to plug a numerical routine from a subprogram library into a program. There is no help in this book for a person who has a choice to make between library subprograms. Another failing is that there is little or no indication in the text of what to do if a numerical method breaks down. It would be helpful if a reader was told the sort of conditions which cause breakdown and at least given an indication of what alternatives (if any) are available.

The computer programs given in the text are not as polished as they might be. In a number of cases, control leaps around a routine like a grasshopper on hot bricks. This does not give the reader an easy task in following the program, and it can easily be avoided at the cost of a few minutes thought. Few checks are built into the routines to guard against breakdown: to take a trivial example, there is no check on dividing by a small number in the Cramer's rule subprogram. This should have been mentioned in the commentary on the program if it was not built into the program itself. The results from the programs appear to be taken as correct. There is no indication in the text of carrying out analytic checks on the results: for example, close to bodies or far from bodies in a stream. This is, after all, an important part of computational fluids and one feels that some mention at least should be made of it.

In spite of these criticisms, I feel that there is the basis of a good book here. Time would be well spent on bringing out a revised edition. In my opinion, the text could usefully be rearranged in a more systematic way so that each chapter deals with a class of problems which can be solved by a particular method. With more critical evaluation of the numerical methods used and a general tidying up of the programs (preferably so that they conform to an ANSI standard) together with an improved commentary on the programs, the book could become valuable as a class text.

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