Preface

This book is intended for an introductory, one-year course in numerical analysis for students in mathematics, engineering, and the physical sciences. Historically, such a course has been offered by mathematics departments mostly to junior and senior level students. In recent years a more elementary course has achieved some popularity. This course is often taught in engineering or computer science departments and has an audience of freshmen and sophomores. These two groups have different skill levels and different needs, but there is a great deal that they have in common. It is our view that their separate needs can be addressed effectively in combination, and that the subject matter can indeed profit from such a combination.

To serve the needs of these two different audiences, each topic is carefully developed in a graduated manner. The first few sections of each chapter present motivation and simple algorithms in an intuitive fashion. Later sections show the underlying theory and introduce the more complicated, less common methods. These later sections are starred to indicate their more advanced nature. The unstarred sections are independent of the starred ones, so the elementary course can be taught relying only on the simple material. For a more challenging course, much of the material will come from the starred sections, with the elementary part providing insight and motivation.

The material selected for the book is, for the most part, standard and traditional. Only in the last three chapters were some choices and compromises made. What to do about partial differential equations is not clear-cut for any author of an introductory text, since any reasonable treatment presumes more theoretical knowledge than the prospective audience can be expected to have. Additionally, there are many practical complications that make it impossible to do justice to the topic at the undergraduate level. But partial differential equations are so important in practice that one cannot see what numerical analysis is all about without some exposure to the main issues. Our way of dealing with this dilemma is to present some simple prototype partial differential equations, with a quick and intuitive overview of the difficulties of implementation and the more theoretical question of stability. While this does not prepare students to solve real-life partial differential equations, it does present them with the flavor of the subject matter in preparation for more advanced courses.

One quite nontraditional topic is in the last chapter: The solution of inverse and ill-posed problems. This inclusion not only reflects the author's special interests, but also gives an introduction to an increasingly more important topic. The matter is an advanced subject, so only the more intuitive aspects are presented. It shows that applying numerical methods arbitrarily does not always work.

This book discusses the most important numerical algorithms, but it does not attempt to be a reference work. Instead, it concentrates on the limited subject matter that is most commonly presented to undergraduate students and stresses pedagogical issues rather than completeness. This book emphasizes:

- providing insight and motivation for the construction of numerical methods
- understanding the strengths and limitations of such methods
- evaluating the effectiveness of available numerical software
- modifying existing software for specific purposes
- gaining experience in choosing between alternative approaches
- experimenting with numerical software in settings that mirror real-world situations, and
- building a strong experiential base for continuing study and more specialized courses.

These aims are greatly aided by the close connection between the discussion of methods and algorithms and their implementation in MATLAB. While the MATLAB library is much less extensive than many industrial libraries (such as IMSL), it does give the student experience working with ready-made software whose internal structure may not always be entirely clear. MATLAB's numerical analysis functions are well constructed but are quite automatic and are used essentially as black boxes. Since most libraries have similar characteristics, students learn how to use numerical methods libraries effectively.

To complement the standard MATLAB functions, we provide an extension: NASOFT. This set of functions does two things. First, it extends the MATLAB functionality to problems such as two-point boundary value problems and some prototype partial differential equations, allowing the student to experiment with fairly complex algorithms. Second, NASOFT functions are coded in a straightforward manner and the MATLAB source is available. This gives the student the opportunity to critique the implementation and modify to improve or adapt it to different purposes. The source code for the NASOFT functions and example scripts are available online at: http://math.jbpub.com/numericalmethods.

Many traditional numerical analysis courses are primarily lecture courses, with perhaps a lab of secondary importance. This book envisions a different emphasis in which lab work is at least as important as the lectures. For this purpose, we have added a chapter called "Explorations." The problems in this exploration section deal with the very practical issues of software evaluation, selection, modification and the solution of not-entirely-specified, open-ended problems. Students should conduct investigations using their own methodology, and should be expected to write informative reports on their observations and conclusions. This is the part of the course that most closely models real life situations and should therefore be considered the heart of the course.

This book is designed for an undergraduate numerical analysis course that stresses insight and hands-on experience over detailed knowledge of a host of numerical methods and their mathematical justification.

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