**Numerical Methods in Engineering with MATLAB®**
***Third Edition***

The third edition of this successful text describes and evaluates a range of widely used numerical methods, with an emphasis on problem solving. Every method is discussed thoroughly and illustrated with problems involving both hand computation and programming. MATLAB® M-files accompany each method and are available on the book's web page. Code is made simple and easy to understand by avoiding complex bookkeeping schemes, while maintaining the essential features of the method. The third edition features a new chapter on Euler's method, a number of new and improved examples and exercises, and programs that appear as function M-files. *Numerical Methods in Engineering with MATLAB®*, third edition, is a useful resource for both graduate students and practicing engineers.

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# Numerical Methods in Engineering with MATLAB®

## *Third Edition*

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# Contents

# Preface

This book is targeted primarily toward engineers and engineering students of advanced standing (sophomores, seniors, and graduate students). Familiarity with a computer language is required; knowledge of engineering mechanics (statics, dynamics, and mechanics of materials) is useful but not essential.

The text places emphasis on numerical methods, not programming. Most engineers are not programmers but rather problem solvers. They want to know what methods can be applied to a given problem, their strengths and pitfalls, and how to implement them. Engineers are not expected to write computer code for basic tasks from scratch; they are more likely to utilize functions and subroutines that have already been written and tested. Thus programming by engineers is largely confined to assembling existing bits of code into a coherent package that solves the problem at hand.

The "bit" of code is usually a function that implements a specific task. For the user, the details of the code are of secondary importance. What matters is the interface (what goes in and what comes out) and an understanding of the method on which the algorithm is based. Because no numerical algorithm is infallible, the importance of understanding the underlying method cannot be overemphasized; it is, in fact, the rationale behind learning numerical methods.

This book attempts to conform to these views. Each numerical method is explained in detail, and its shortcomings are pointed out. The examples that follow individual topics fall into two categories: hand computations that illustrate the inner workings of the method and small programs that show how the computer code is utilized in solving a problem. Problems that require programming are marked with ■.

The material consists of the usual topics covered in an engineering course on numerical methods: solution of equations, interpolation and data fitting, numerical differentiation and integration, solution of ordinary differential equations, and eigenvalue problems. The choice of methods within each topic is tilted toward relevance to engineering problems. For example, there is an extensive discussion of symmetric, sparsely populated coefficient matrices in the solution of simultaneous equations. In the same vein, the solution of eigenvalue problems concentrates on methods that efficiently extract specific eigenvalues from banded matrices.

An important criterion used in the selection of methods was clarity. Algorithms requiring overly complex bookkeeping were rejected regardless of their efficiency and robustness. This decision, which was taken with great reluctance, is in keeping with the intent to avoid emphasis on programming.

The selection of algorithms was also influenced by current practice. This disqualified several well-known historical methods that have been overtaken by more recent developments. For example, the secant method for finding roots of equations was omitted as having no advantages over Ridder's method. For the same reason, the multistep methods used to solve differential equations (e.g., Milne and Adams methods) were left out in favor of the adaptive Runge-Kutta and Bulirsch-Stoer methods.

Notably absent is a chapter on partial differential equations. It was felt that this topic would best be treated by finite element or boundary element methods, which are outside the scope of this book. The finite difference model, which is commonly introduced in numerical methods texts, is just too impractical in handling curved boundaries.

As usual, the book contains more material than can be covered in a three-credit course. The topics that can be skipped without loss of continuity are tagged with an asterisk.

The programs listed in this book were tested with MATLAB® R2012b under Windows® 7.

# What Is New in the Third Edition

- At the suggestion of reviewers, the Taylor series method of solving initial value problems in Chapter 7 was dropped. It was replaced by Euler's method.
- The Jacobi method for solving eigenvalue problems in Chapter 9 now uses the threshold method in choosing the matrix elements marked for elimination. This change improves the speed of the algorithm.
- The adaptive Runge-Kutta method in Chapter 7 was recoded, and the Cash-Karp coefficients were replaced with the Dormand-Prince coefficients. The result is a more efficient algorithm with tighter error control.
- Twenty-one new problems were introduced, most of them replacing old problems.
- Some example problems in Chapters 4 and 7 were rearranged or replaced with new problems. The result of these changes is better coordination of examples with the text.
- All programs now appear as function M-files rather than as script M-files.