PREFACE

This book is designed to support a one-semester course in numerical methods. It has been written for students who want to learn and apply numerical methods in order to solve problems in engineering and science. As such, the methods are motivated by problems rather than by mathematics. That said, sufficient theory is provided so that students come away with insight into the techniques and their shortcomings.

MATLAB® provides a great environment for such a course. Although other environments (e.g., Excel/VBA, Mathcad) or languages (e.g., Fortran 90, C++) could have been chosen, MATLAB presently offers a nice combination of handy programming features with powerful built-in numerical capabilities. On the one hand, its M-file programming environment allows students to implement moderately complicated algorithms in a structured and coherent fashion. On the other hand, its built-in, numerical capabilities empower students to solve more difficult problems without trying to "reinvent the wheel."

This second edition differs from the first edition in four key ways:

1. **Organization.** The first edition consisted of a series of 20 chapters. For the second edition, I have clustered these chapters into Parts as outlined in Fig. P.1. Aside from organizing the material in a more coherent fashion, this has allowed me to include an introduction/overview at the beginning of each part to orient students to the general topic area.
2. **New Chapters.** As shown in Fig. P.1, I have developed three new chapters. The primary rationale for adding these chapters is to give students a more complete coverage of numerical methods as well as MATLAB'S capabilities. The new chapters deal with the following topics:

    - **Optimization.** This chapter is placed just after the chapters dealing with roots of nonlinear equations. Although standard MATLAB (i.e., excluding Toolboxes) does not have comprehensive optimization capabilities, it has a few built-in functions that can be used to introduce the topic and solve some nice engineering and scientific problems. Although the focus of the chapter is on one-dimensional optimization, a brief introduction to multivariable optimization is included.

PART ONE Modeling, Computers, and Error Analysis	**PART TWO Roots and Optimization**	**PART THREE Linear Systems**	**PART FOUR Curve Fitting**	**PART FIVE Integration and Differentiation**	**PART SIX Ordinary Differential Equations**
CHAPTER 1 Mathematical Modeling, Numerical Methods, and Problem Solving	CHAPTER 5 Roots: Bracketing Methods	CHAPTER 8 Linear Algebraic Equations and Matrices	CHAPTER 13 Linear Regression	CHAPTER 17 Numerical Integration Formulas	CHAPTER 20 Initial-Value Problems
CHAPTER 2 MATLAB Fundamentals	CHAPTER 6 Roots: Open Methods	CHAPTER 9 Gauss Elimination	CHAPTER 14 General Linear Least-Squares and Nonlinear Regression	CHAPTER 18 Numerical Integration of Functions	CHAPTER 21 Adaptive Methods and Stiff Systems
CHAPTER 3 Programming with MATLAB	CHAPTER 7 Optimization	CHAPTER 10 *LU* Factorization	CHAPTER 15 Polynomial Interpolation	CHAPTER 19 Numerical Differentiation	CHAPTER 22 Boundary-Value Problems
CHAPTER 4 Roundoff and Truncation Errors		CHAPTER 11 Matrix Inverse and Condition	CHAPTER 16 Splines and Piecewise Interpolation		
		CHAPTER 12 Iterative Methods			

FIGURE P.1
The shaded areas represent new material. In addition, several of the original chapters have been supplemented with new topics, homework problems, and case studies.

- **Numerical Differentiation.** This chapter is placed after the last chapter on numerical integration. I added it for completeness, as well as to illustrate some of the inherent difficulties of numerical differentiation. It is also included because of the role of finite differences in the solution of boundary-value problems.
- **Boundary-Value Problems.** This chapter is placed at the end of the section on ordinary differential equations. Again, I think that this addition is important for completeness. In addition, it allows me to illustrate the finite-difference approach for solving ODEs. I think that this is important because, although PDEs are not included explicitly in this edition, finite-difference solutions for ODE boundary-value problems provide students with an idea of how PDEs are solved numerically. The subject area also provides nice fodder for more challenging and interesting homework problems.

3. **Case Studies.** These consist of engineering and science applications that are more complex and richer than the standard examples presented in the chapters. They are placed at the ends of selected chapters with the intention of (1) illustrating the nuances of the methods, and (2) showing more realistically how the methods along with MATLAB are used in engineering and science.
4. **New Homework Problems.** Most of the end-of-chapter problems have been modified, and a variety of new problems have been added. In particular, an effort has been made to include several new problems for each chapter that are more challenging and difficult than the problems in the first edition.

Aside from these additions, the second edition is very similar to the first. In particular, I have endeavored to maintain most of the features contributing to its pedagogical effectiveness including extensive use of worked examples and engineering and scientific applications. As with the previous edition, I have made a concerted effort to make this book as "student-friendly" as possible. Thus, I've tried to keep my explanations straightforward and practical.

Although my primary intent is to empower students by providing them with a sound introduction to numerical problem solving, I have the ancillary objective of making this introduction exciting and pleasurable. I believe that motivated students who enjoy engineering and science, problem solving, mathematics—and yes—programming, will ultimately make better professionals. If my book fosters enthusiasm and appreciation for these subjects, I will consider the effort a success.

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The generosity of the Berger family, and in particular Fred Berger, has provided me with the opportunity to work on creative projects such as this book dealing with computing and engineering. In addition, my colleagues in the Civil and Environmental Engineering Department at Tufts, notably Noelle Brooker, Ilse Allen, Jim Limbrunner, and Masoud Sanayei, have been very supportive and helpful.

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It should be stressed that although I received useful advice from the aforementioned individuals, I am responsible for any inaccuracies or mistakes you may find in this book. Please contact me via e-mail if you should detect any errors.

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