Preface to the Third Edition

This new edition remains in step with the goals of earlier editions, namely, to offer a concise treatment of basic topics covered in a post-calculus differential equations course. It is written for students in engineering, biosciences, physics, economics, and mathematics. As such, the text is strongly guided by applications in those areas.

The last twenty-five years witnessed dramatic changes in basic calculus courses and in differential equations. One driver of change has been the availability of technology and its role in a standard course, and another is the level of preparation of students with regard to their ability to perform analytical manipulations. Writing a text for such a diverse audience poses a substantial challenge. Some students need only know what a differential equation means and what it implies qualitatively to understand concepts in their areas; others, who plan on taking advanced courses in engineering or the physical sciences where the mathematics is more intense, require the ability to perform analytic calculations. This text makes an effort to balance these two issues.

Some outstanding textbooks have been written for this course. Many are calculus-like and voluminous, with extensive graphics, marginal notes, and numerous examples and exercises; they cover many more topics than can be discussed in a one-semester course. I have often felt that students become overwhelmed, distracted, and even insecure about skipping material and jumping around in a text of several hundred pages.

An overarching philosophy in this text is that *you can't cover everything.* Therefore, it is more concise and written in a plain, user friendly format that is accessible to science and engineering students. Often these students have limited time and they appreciate a smaller parcel where it is clear what they should know. One success of the text has been that it gives instructors who want

this type of coverage an alternative to existing texts. Another characteristic is that it encourages students to begin developing their analytical thinking for future studies; this includes some formula manipulation and understanding of derivations. Students should slowly advance in their ability to read mathematics in preparation for more advanced, upper level texts in their areas, which require a lot of the reader.

The topics are standard and the table of contents lists them in detail. Briefly, the chapter coverage is as follows.

- **Chapter 1. First-order equations.** Separable, linear, and autonomous equations; equilibrium solutions, stability and bifurcation. Other special types of equations, for example, Bernoulli, exact, and homogeneous equations, are covered in the Exercises with generous guidance. Many applications are discussed from science, engineering, economics, and biology.

- **Chapter 2. Second-order linear equations.** The emphasis is on equations with constant coefficients, both homogeneous and nonhomogeneous, with most examples being spring-mass oscillators and electrical circuits. Other than Cauchy–Euler equations, variable coefficient equations are not examined in detail. There are three optional sections covering reduction of order, higher-order equations, and steady-state heat transfer, which deals with simple boundary value problems.

- **Chapter 3. Laplace transforms.** The treatment is standard, but without overemphasizing partial fraction decompositions for inversion. Use of the enclosed table of transforms is encouraged. This chapter can be covered at any time after Chapter 2.

- **Chapter 4. Linear systems.** This chapter deals only with two-dimensional, or planar, systems. It begins with a discussion of equivalence of linear systems and second-order equations. Linear algebra is kept at a minimum level, with a very short introductory section on notation using vectors and matrices. General solutions are derived using eigenvalues and eigenvectors, and there are applications to chemical reactors (compartmental analysis), circuits, and other topics. There is a thorough introduction to phase plane analysis and simple geometric methods.

- **Chapter 5. Nonlinear systems.** The content of this chapter focuses on applications, e.g., classical dynamics, circuits, epidemics, population ecology, chemical kinetics, malaria, and more.

- **Chapter 6. Computation of solutions.** This brief chapter first discusses the Picard iteration method, and then numerical methods. The latter include the Euler and modified Euler methods, and the Runge–Kutta

method. All or parts of this chapter can be covered or referred to at any time during the course.

A standard, one-semester course can be based on Chapter 1 through most of Chapter 4.

This edition of the text incorporates many changes. Some topics have been rewritten and rearranged. I made the effort to introduce an easier-to-read format and highlight important concepts. There is a increase in the number of routine examples and exercises. A major notational change is that generic functions in differential equations, previously represented by $u = u(t)$, have been changed to the more common $x = x(t)$. The number and variety of applications is substantially increased, and several exercises throughout the book have enough substance to serve as mini-projects for students. Starred sections (*) are optional. Time availability in a one-semester course was an overriding factor, and some topics, such as power series and special functions, are not covered.

Two appendices complement the chapters. There is a new appendix *Review and Exercises* that concisely summarizes methods from Chapters 1 and 2, and is supplemented with several exercises and solutions. It also includes a set of chapter exercises on which students can test their skills. A second appendix includes a MATLAB® supplement that summarizes MATLAB commands and demonstrates simple code writing, as well as use of its built-in programs and symbolic packages to solve problems in differential equations. MATLAB is *not required* for the text. Rather, students are encouraged to use the software available to them. Many exercises can be done with an advanced scientific calculator. Solutions to the even-numbered problems can be found at http://www.springer.com/ and on the author's web site.

Several individuals deserve my heartfelt acknowledgments. User's suggestions have become part of this revision, and I greatly appreciate their interest in making it a better text. Also I thank my many students who, over the last several years, have endured my lectures and exams and have generously given me valuable advice; very often they reminded me who my audience was. My son David, to whom I dedicate this book, was a frequent and meticulous grader who always advocated for students and often altered my own perspective in teaching undergraduates. Elizabeth Loew, my editor at Springer, deserves special recognition for her continuous attentiveness to the project and her expert support. I have found Springer to be an extraordinary partner in this project.

Corrections, comments, and suggestions on the text are greatly appreciated. Contact information is on my web site: www.math.unl.edu/~jlogan1. Additional material, including an errata, will be posted there.

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