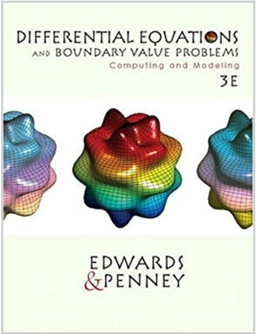

Differential Equations and Boundary Value Problems: Computing and Modeling (3rd Edition)

By C. Henry Edwards, David E. Penney

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This practical book reflects the new technological emphasis that permeates differential equations, including the wide availability of scientific computing environments like *Maple, Mathematica,* and MATLAB; it does not concentrate on traditional manual methods but rather on new computer-based methods that lead to a wider range of more realistic applications. The book starts and ends with discussions of mathematical modeling of real-world phenomena, evident in figures, examples, problems, and applications throughout the book. For mathematicians and those in the field of computer science.

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Differential Equations and Boundary Value Problems: Computing and Modeling (3rd Edition) By C. Henry Edwards, David E. Penney Bibliography

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Editorial Review

From the Publisher
Reflecting the shift in emphasis from traditional methods to new computer-based methods, this text -- in classic Edwards and Penney style -- focuses on the mathematical modeling of real-world phenomena as the goal and constant motivation for the study of differential equations. It offers a fresh computational flavor in figures, examples, problems, and projects throughout, and features a broad range of real-world applications. The book also covers topics not found in other similar texts.

From the Back Cover
This practical book reflects the new technological emphasis that permeates differential equations, including the wide availability of scientific computing environments like Maple, Mathematica, and MATLAB; it does not concentrate on traditional manual methods but rather on new computer-based methods that lead to a wider range of more realistic applications. The book starts and ends with discussions of mathematical modeling of real-world phenomena, evident in figures, examples, problems, and applications throughout the book. For mathematicians and those in the field of computer science.

Many introductory differential equations courses in the recent past have emphasized the formal solution of standard types of differential equations using a (seeming) grab-bag of systematic solution techniques. Many students have concentrated on learning to match memorized methods with memorized equations. The evolution of the present text is based on experience teaching a course with a greater emphasis on conceptual ideas and the use of applications and computing projects to involve students in more intense and sustained problem-solving experiences.

The availability of technical computing environments like *Maple*, *Mathematica*, and MATLAB is reshaping the role and applications of differential equations in science and engineering and has shaped our approach in this text. New technology motivates a shift in emphasis from traditional manual methods to both qualitative and computer-based methods that

- render accessible a wider range of more realistic applications;
- permit the use of both numerical computation and graphical visualization to develop greater conceptual understanding; and
- encourage empirical investigations that involve deeper thought and analysis than standard textbook problems.

Major Features

The following features of this text are intended to support a contemporary differential equations course that augments traditional core skills with conceptual perspectives that students will need for the effective use of differential equations in their subsequent work and study:

- Coverage of seldom-used topics has been trimmed and new topics added to place a greater emphasis on core techniques as well as qualitative aspects of the subject associated with direction fields, solution curves, phase plane portraits, and dynamical systems. We combine symbolic, graphic, and numeric solution methods wherever it seems advantageous. A fresh computational flavor should be evident in figures, examples, problems, and applications throughout the text. About 15% of the examples in the text are new or newly revised for this edition.

- The organization of the book places an increased emphasis on linear systems of differential equations, which are covered in Chapters 4 and 5 (together with the necessary linear algebra), followed by a substantial treatment in Chapter 6 of nonlinear systems and phenomena (including chaos in dynamical systems).
- This book begins and ends with discussions and examples of the mathematical modeling of real-world phenomena. Students learn through mathematical modeling and empirical investigation to balance the questions of what equation to formulate, how to solve it, and whether a solution will yield useful information.,/li>
- The first course in differential equations should also be a window on the world of mathematics. While it is neither feasible nor desirable to include proofs of the fundamental existence and uniqueness theorems along the way in an elementary course, students need to see precise and clear-cut statements of these theorems and to understand their role in the subject. We include appropriate existence and uniqueness proofs in the Appendix and occasionally refer to them in the main body of the text.
- While our approach reflects the widespread use of new computer methods for the solution of differential equations, certain elementary analytical methods of solution (as in Chapters 1 and 3) are important for students to learn. Effective and reliable use of numerical methods often requires preliminary analysis using standard elementary techniques; the construction of a realistic numerical model often is based on the study of a simpler analytical model. We therefore continue to stress the mastery of traditional solution techniques (especially through the inclusion of extensive problem sets).

Computing Features

The following features highlight the flavor of computing technology that distinguishes much of our exposition.

- Almost 700 *computer-generated figures*—over half of them new for this edition and most constructed using Mathematica or MATLAB—show students vivid pictures of direction fields, solution curves, and phase plane portraits that bring symbolic solutions of differential equations to life. For instance, the cover graphic shows an eigenfunction of the three-dimensional wave equation that illustrates surface waves on a spherical planet and was constructed using associated Legendre functions (see Section 10.5).
- About 45 *application modules* follow key sections throughout the text. Most of these applications outline "technology neutral" investigations illustrating the use of technical computing systems and seek to actively engage students in the application of new technology.
- A fresh *numerical emphasis* that is afforded by the early introduction of numerical solution techniques in Chapter 2 (on mathematical models and numerical methods). Here and in Chapter 4, where numerical techniques for systems are treated, a concrete and tangible flavor is achieved by the inclusion of numerical algorithms presented in parallel fashion for systems ranging from graphing calculators to MATLAB.
- A *conceptual perspective* shaped by the availability of computational aids, which permits a leaner and more streamlined coverage of certain traditional manual topics (like exact equations arid variation of parameters) in Chapters 1, 3, and 5.

Modeling Features

Mathematical modeling is a goal and constant motivation for the study of differential equations. To sample the range of applications in this text, take a look at the following questions:

- What explains the commonly observed time lag between indoor and outdoor daily temperature oscillations? (Section 1.5)

- What makes the difference between doomsday and extinction in alligator populations? (Section 2.1)
- How do a unicycle and a two-axle car react differently to road bumps? (Sections 3.7 and 5.3)
- How can you predict the time of next perihelion passage of a newly observed comet? (Section 4.3)
- Why might an earthquake demolish one building and leave standing the one next door? (Section 5.3)
- What determines whether two species will live harmoniously together, or whether competition will result in the extinction of one of them and the survival of the other? (Section 6.3)
- Why and when does nonlinearity lead to chaos in biological and mechanical systems? (Section 6.5)
- If a mass on a spring is periodically struck with a hammer, how does the behavior of the mass depend on the frequency of the hammer blows? (Section 7.6)
- Why are flagpoles hollow instead of solid? (Section 8.6)
- What explains the difference in the sounds of a guitar, a xylophone, and drum? (Sections 9.6, 10.2, and 10.4)

Organization and Content

We have reshaped the usual approach and sequence of topics to accommodate new technology and new perspectives. For instance,

- After a precis of first-order equations in Chapter 1 (though with the coverage of certain traditional symbolic methods streamlined a bit), Chapter 2 offers an, early introduction to mathematical modeling, stability and qualitative properties of differential equations, and numerical methods—a combination of topics that frequently are dispersed later in an introductory course.
- Chapters 4 and 5 provide a flexible treatment of linear systems. Motivated by current trends in science and engineering education and practice, Chapter 4 offers an early, intuitive introduction to first-order systems, models, and numerical approximation techniques. Chapter 5 begins with a self-contained treatment of the linear algebra that is needed and then presents the eigenvalue approach to linear systems. It includes a wide range of applications (ranging from railway cars to earthquakes) of all the various cases of the eigenvalue method. Section 5.5 includes a fairly extensive treatment of matrix exponentials, which are exploited in Section 5.6 on nonhomogeneous linear systems.
- Chapter 6 on nonlinear systems and phenomena ranges from phase plane analysis to ecological and mechanical systems to a concluding section on chaos and bifurcation in dynamical systems. Section 6.5 presents an elementary introduction to such contemporary topics as period doubling in biological and mechanical systems, the pitchfork diagram, and the Lorenz strange attractor (all illustrated with vivid computer graphics).
- Laplace transform methods (Chapter 7) and power series methods (Chapter 8) follow the material on linear and nonlinear systems but can be covered at any earlier point (after Chapter 3) the instructor desires.
- Chapters 9 and 10 treat the applications of Fourier series, separation of variables, and Sturm-Liouville theory to partial differential equations and boundary value problems. After the introduction of Fourier series, the three classical equations—the wave and heat equations and Laplace's equation—are discussed in the last three sections of Chapter 9. The Sturm-Liouville methods of Chapter 10 are developed sufficiently to include some rather significant and realistic applications.

This book includes enough material appropriately arranged for different courses varying in length from one quarter to two semesters. The briefer version, *Differential Equations: Computing and Modeling,* ends with Chapter 7 on Laplace transform methods (and thus omits the material on power series methods, Fourier series, separation of variables and partial differential equations).

Problems, Applications, and Solutions Manuals

Almost 20% of the text's over 1900 problems are new for this edition or are newly revised to include graphic or qualitative content. Accordingly, the answer section now includes almost 300 new computer-generated figures illustrating those which students are expected to construct.

The answer section for this revision has bee...

Users Review

From reader reviews:

Arthur Haynes:

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Ian Sharpless:

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