PREFACE

Differential equations is one of the oldest subjects in modern mathematics. It was not long after Newton and Leibniz invented calculus that Bernoulli and Euler and others began to consider the heat equation and the wave equation of mathematical physics. Newton himself solved differential equations both in the study of planetary motion and also in his consideration of optics.

Today differential equations is the centerpiece of much of engineering, of physics, of significant parts of the life sciences, and in many areas of mathematical modeling. The audience for a sophomore course in ordinary differential equations is substantial—second only perhaps to that for calculus. There is a need for a definitive text that both describes classical ideas and provides an entrée to the newer ones. Such a text should pay careful attention to advanced topics like the Laplace transform, Sturm-Liouville theory, and boundary value problems (on the traditional side) but should also pay due homage to nonlinear theory, to dynamics, to modeling, and to computing (on the modern side).

George Simmons's fine text is a traditional book written in the classical style. It provides a cogent and accessible introduction to all the traditional topics. It is a pleasure to have this opportunity to bring this text up to date and to add some more timely material. We have streamlined some of the exposition and augmented other parts. There is now computer work based not only on number crunching but also on computer algebra systems such as `Maple`, `Mathematica`, and `MATLAB`. Certainly a study of flows and vector fields, and of the beautiful Poincaré-Bendixson theory built thereon, is essential for any modern treatment. One can introduce some of the modern ideas from the theory of dynamics to obtain qualitative information about nonlinear differential equations and systems.

And all of the above is a basis for *modeling*. Modeling is what brings the subject to life and makes the ideas real for the students. Differential equations can model real-life *questions*, and computer calculations and graphics can then provide real-life *answers*. The symbiosis of the synthetic and the calculational provides a rich educational experience for students, and it prepares them for more concrete, applied work in future courses. The new *Anatomy of an Application* sections in this edition showcase some rich applications from engineering, physics, and applied science.

There are a number of good ordinary differential equations books available today. Popular standards include Boyce & DiPrima; Nagle, Saff, & Snider; Edwards & Penney; Derrick & Grossman; and Polking, Boggess & Arnold. Books for a more specialized audience include Arnol'd; Hubbard & Hubbard; Borrelli & Coleman; and Blanchard, Devaney, & Hall. Classical books, still in use at some schools, include Coddington & Levinson and Birkhoff & Rota. Each of these books has some strengths, but not the combination of features that we have planned for Simmons & Krantz. None has the crystal clear and elegant quality of writing for which George Simmons is so well known. Steven G. Krantz is also a mathematical writer of some repute (50 books and 140 papers), and can sustain the model set by Simmons in this new edition. No book will have the well-developed treatment of modeling and computing (done in a manner so that these two activities speak to each other) that will be rendered in Simmons & Krantz. None will have the quality of exercises.

We look forward to setting a new standard for the modern textbook on ordinary differential equations, a standard to which other texts may aspire. This will be a book that students read, and internalize, and in the end apply to other subjects and disciplines. It will lay the foundation for

future studies in analytical thinking. It will be a touchstone for in-depth studies of growth and change.

Key Features

- **Anatomy of An Application** – Occurring at the end of each chapter, these in-depth examinations of particular applications of ordinary differential equations motivate students to use critical thinking skills to solve practical problems in engineering, physics, and the sciences. After the application is introduced in context, the key concepts and procedures needed to model its associated problems are presented and discussed in detail.
- **Exercises** – The text contains a wide variety of section-level exercises covering varying levels of difficulty. Hints are given when appropriate to assist students with difficult problems and crucial concepts. Special technology exercises are included in nearly every section which harness the power of computer algebra systems such as `Maple`, `Mathematica`, and `MATLAB` for solving ordinary differential equations. Answers to the odd-numbered exercises in the text are included in the Answer Key at the back of the book.
- **Problems for Review and Discovery** – Each chapter is concluded with three sets of review exercises. **Drill Exercises** test students' basic understanding of key concepts from the chapter. **Challenge Problems** take that review a step further by presenting students with more complex problems requiring greater degree of critical thinking. And **Problems for Discussion and Exploration** offer students open-ended opportunities to explore topics from the chapter and develop their intuition and command of the material.
- **Historical Notes** – These biographies, occurring at the end of chapters, offer fascinating insight into the lives and accomplishments of some of the great mathematicians who contributed to the development of differential equations. A longtime hallmark of George Simmons' writings, the Historical Notes show how mathematics is at its heart a human endeavor developed to meet human needs.
- **Math Nuggets** – These brief asides, appearing throughout the text, offer quick historical context and interesting anecdotes tied to the specific topic under discussion. They serve to underscore the human element behind the development of ordinary differential equations in shorter and more context-sensitive form than the end-of-chapter Historical Notes.

Supplements

Student's Solutions Manual, by Donald Hartig (ISBN-10: 0-07-286316-1, ISBN-13: 978-0-07-286316-1) – Contains complete worked solutions to odd-numbered exercises from the text.

Instructor's Solutions Manual, by Donald Hartig (ISBN-10: 0-07-323091-X, ISBN-13: 978-0-07-323091-7) – Contains complete worked solutions to even-numbered exercises from the text.

Companion Website, http://www.mhhe.com/simmons – Contains free online resources for students and instructors to accompany the text. The website features online technology manuals for computer algebra systems such as Maple and Mathematica. These technology manuals give a general overview of these systems and how to use them to solve and explore ordinary differential equations, and provide additional problems and worksheets for further practice with these computational tools.

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The previous incarnation of this classic text was written by George F. Simmons. His book has served as an inspiration to several generations of differential equations students. It has been a pleasure to prepare this new version for a new body of students. George Simmons has played a proactive role at every stage of the writing process, contributing many ideas, edits, and corrections. His wisdom pervades the entire text.

For Hope and Nancy
my wife and daughter
who still make it all worthwhile

For Randi and Hypatia
my wife and daughter
who know why I dedicate my books to them

Steven G. Krantz