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## Preface to the Third Edition

*A teacher can never truly teach unless he is still learning himself. A lamp can never light another lamp unless it continues to burn its own flame. The teacher who has come to the end of his subject, who has no living traffic with his knowledge but merely repeats his lessons to his students, can only load their minds; he cannot quicken them.*

*Rabindranath Tagore  
An Indian Poet  
1913 Nobel Prize Winner for Literature*

The previous two editions of my book were very well received and used as a senior undergraduate or graduate-level text and research reference in the United States and abroad for many years. We received many comments and suggestions from many students, faculty, and researchers around the world. These comments and criticisms have been very helpful, beneficial, and encouraging. This third edition is the result of the input.

Another reason for adding this third edition to the literature is the fact that there have been major discoveries of new ideas, results and methods for the solutions of nonlinear partial differential equations in the second half of the twentieth century. It is becoming even more desirable for mathematicians, scientists, and engineers to pursue study and research on these topics. So what has changed, and will continue to change, is the nature of the topics that are of interest in mathematics, applied mathematics, physics, and engineering, the evolution of books such as this one is a history of these shifting concerns.

This new and revised edition preserves the basic content and style of the second edition published in 2005. As with the previous editions, this book has been revised primarily as a comprehensive text for senior undergraduates or beginning graduate students and a research reference for professionals in mathematics, engineering, and other applied sciences. The main goal of the book is to develop required analytical skills on the part of the reader, rather than to focus on the importance of more abstract formulation, with full mathematical rigor. Indeed, our major emphasis is to

provide an accessible working knowledge of the analytical and numerical methods with proofs required in mathematics, applied mathematics, physics, and engineering.

In general, changes have been made to modernize the contents and to improve the exposition and clarity of the previous edition, to include additional topics, comments, and observations, to add many examples of applications and exercises, and in some cases to entirely rewrite and reorganize many sections. There is plenty of material in the book for a year-long course or seminar. Some of the material need not be covered in a course work and can be left for the readers to study on their own in order to prepare them for further study and research. This edition contains a collection of over 1000 worked examples and exercises with answers and hints to selected exercises. Some of the major changes and additions include the following:

1. Many sections of almost all chapters have been revised and expanded to modernize the contents. We have also taken advantage of this new edition to correct typographical errors and to include several new figures for a clear understanding of physical explanations.
2. Several nonlinear models including the Camassa–Holm (CH) equation, the Degasperis–Procesi (DP) equation, and the Toda lattice equation (TLE) have been presented with their physical significance in Chapter 2. Included are also new sections on the small-amplitude gravity-capillary waves on water of finite and infinite depth, the energy equation and energy flux.
3. A new section on the Lorenz nonlinear system, the Lorenz attractor, and deterministic chaos has been added in Chapter 6.
4. Included is a new section on the Camassa–Holm equation, the Degasperis–Procesi equation, and the Euler–Poincaré (EP) equation in Chapter 9 to describe the wave breaking (singular) phenomena. A new section on the derivation of the KdV equation for the gravity-capillary wave, the gravity-capillary solitary wave solutions, and the two-dimensional periodic flow in an inviscid, incompressible fluid with constant vorticity has been added. Special attention is given to both analytical and computational solutions of these problems with physical significance.
5. A new example describing nonlinear quasi-harmonic waves and modulational instability has been added in Chapter 10.
6. The nonlinear lattices and the Toda lattice equation have been treated in some detail at the end of Chapter 11.
7. All tables of Fourier transforms, Fourier sine and cosine transforms, Laplace transforms, Hankel transforms, and finite Hankel transforms have been revised and expanded so that they become more useful for the study of partial differential equations.
8. In order to make the book self-contained, two new appendices on some special functions and their basic properties, Fourier series, generalized functions, Fourier and Laplace transforms have been added. Special attention has been given to algebraic and analytical properties of the Fourier and Laplace convolutions with applications.

9. The whole section on Answers and Hints to Selected Exercises has been revised and expanded to provide additional help to students.
10. The entire bibliography has been revised and expanded to include new and current research papers and books so that it can stimulate new interest in future study and research.
11. The Index has been revised and reorganized to make it more useful for the reader.

Some of the highlights in this edition include the following:

- The book offers a detailed and clear explanation of every concept and method that is introduced, accompanied by carefully selected worked examples, with special emphasis given to those topics in which students experience difficulty.
- A wide variety of modern examples of applications has been selected from areas of partial differential equations, quantum mechanics, fluid dynamics, solid mechanics, calculus of variations, linear and nonlinear wave propagation, telecommunication, soliton dynamics, and nonlinear stability analysis.
- The book is organized with sufficient flexibility to enable instructors to select chapters appropriate for courses of differing lengths, emphases, and levels of difficulty as chapters are significantly independent of each other.
- A wide spectrum of exercises has been carefully chosen and included at the end of each chapter so the reader may further develop both rigorous skills in the theory and applications of partial differential equations and a deeper insight into the subject.
- Many new research papers and standard books have been added to the bibliography to stimulate new interest in future study and research. The Index of the book has also been completely revised in order to include a wide variety of topics.
- The book provides information that puts the reader at the forefront of current research.

With the improvements and many challenging worked out problems and exercises, we hope this edition will continue to be a useful textbook for students as well as a research reference for professionals in mathematics, applied mathematics, physics, and engineering.

It is my pleasure to express our grateful thanks to many friends, colleagues, and students around the world who offered their suggestions and help at various stages of the preparation of the book. Special thanks to Mrs. Veronica Chavarria for drawing some figures, typing the manuscript with constant changes and revisions. In spite of the best efforts of everyone involved, some typographical errors doubtless remain. Finally, we wish to express our special thanks to Mr. Tom Grasso, Senior Editor, and the staff of Birkhäuser, Boston, for their help and cooperation. I also wish to thank Mr. Donatas Akmanavičius and his staff for their meticulous job in preparing the final revised manuscript for printing the third edition. I am indebted to my wife, Sadhana, for her understanding and tolerance while the third edition was being written.



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