Preface

When Ed Lorenz discovered chaos in a simple system of ordinary differential equations in 1959, he unleashed on the world a new field of science that has grown ever larger with each passing year. The fact that simple equations can have solutions of incredible complexity continues to enthrall scientists and raises the hope that phenomena previously thought too complicated to be understood might be adequately described by very simple models. By now, many such models have been developed and studied in great detail, but they continue to present surprises and raise questions, not the least of which is why they had not already been widely known.

From the start of my interest in the field some twenty years ago, I have been intrigued by the quest for the mathematically simplest systems of various types that can exhibit chaos. I was proud to discover some new systems that are in some sense simpler than those previously known or are otherwise more 'elegant' by virtue of the number of parameters or their values or of some special symmetry or economy of notation. This book is an attempt to share those discoveries and to catalog other simple examples that were previously known or recently discovered by others, as well as many cases that are published here for the first time and are thus ripe for further study.

I have also included a chapter at the end on chaotic electrical circuits since the quest for simple chaotic circuits is closely related to the quest for simple equations that exhibit chaos. Some of these circuits are new and provide an opportunity for study and exploration if your inclinations are more toward building things than sitting in front of a computer.

This book should be of interest to chaos researchers looking for simple systems and circuits to use in their studies or for further exploration, to instructors who want examples to teach and motivate students, and to students doing independent study. The book assumes only an elementary knowledge of calculus. The systems are initial-value ordinary differential equations (ODEs), as well as some partial differential equations (PDEs) and delay differential equations (DDEs), but they must be solved numerically, and so a formal course in differential equations is of limited use.

You will get the most out of this book if you can write simple computer programs in the language of your choice or have access to software that allows you to solve systems of coupled ODEs and to display the results graphically. All the calculations and figures in this book were done with the PowerBASIC console compiler (`http://www.powerbasic.com/`), which I highly recommend. There is no substitute for the thrill and insight of seeing the solution of a simple equation unfold as the trajectory wanders in real time across your computer screen using a program of your own making. A goal of this book is to inspire and delight as well as to teach. I hope you will enjoy reading and studying it as much as I did writing it.

Many people have contributed to the ideas in this book. My greatest debt is to George Rowlands who lured me away from plasma physics when he got me interested in chaos in the late 1980s and who continues to be a valued colleague and mentor. I am also grateful to other collaborators with whom I have coauthored papers on these topics including Cliff Pickover, Dee Dechert, Stefan Linz, Wendell Horton, Karl Lonngren, Hans Gottlieb, Ken Kiers, Wajdi Ahmad, Jim Crutchfield, John Vano, Konstantinos Chlouverakis, Zeraoulia Elhadj, Kehui Sun, and Del Marshall. Working with such interesting and talented people is one of my greatest delights. I am also thankful to the students with whom I have worked over the years, especially those who were able to publish their results including Christopher Watts, David Newman, Brian Meloon, Kevin Mirus, David Albers, Joe Wildenberg, Mike Anderson, Jeff Noel, Joseph Azizi, Charles Brummitt, Adam Maus and Vladimir Zhdankin. They have challenged me with difficult questions and helped study some of the systems in this book. Finally, I would like to thank Jessica Piper for proofreading an early version of the manuscript and for constructing and testing some of the new chaotic circuits in the final chapter.

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