

Preface

This book is the outcome of my teaching and research on dynamical systems, chaos, fractals, and fluid dynamics for the past two decades in the Department of Mathematics, University of Burdwan, India. There are a number of excellent books on dynamical systems that cover different aspects and approaches to nonlinear dynamical systems and chaos theory. However, there lies a gap among mathematical theories, intuitions, and perceptions of nonlinear science and chaos. There is a need for amalgamation among theories, intuitions, and perceptions of the subject and it is also necessary for systematic, sequential, and logical developments in the subject, which helps students at the undergraduate and postgraduate levels. Teachers and researchers in this discipline will be benefitted from this book. Readers are presumed to have a basic knowledge in linear algebra, mathematical analysis, topology, and differential equations.

Over the past few decades an unprecedented interest and progress in nonlinear systems, chaos theory, and fractals have been noticed, which are reflected in the undergraduate and postgraduate curriculum of science and engineering. The essence of writing this book is to provide the basic ideas and the recent developments in the field of nonlinear dynamical systems and chaos theory; their mathematical theories and physical examples. Nonlinearity is a driving mechanism in most physical and biological phenomena. Scientists are trying to understand the inherent laws underlying these phenomena over the centuries through mathematical modeling. We know nonlinear equations are harder to solve analytically, except for a few special equations. The superposition principle does not hold for nonlinear equations. Scientists are now convinced about the power of geometric and qualitative approaches in analyzing the dynamics of a system that governs nonlinearly. Using these techniques, some nonlinear intractable problems had been analyzed from an analytical point of view and the results were found to be quite interesting. Solutions of nonlinear system may have extremely complicated geometric structure. Historically, these types of solutions were known to both Henri Poincaré (1854–1912), father of nonlinear dynamics, and George David Birkhoff (1884–1944) in the late nineteenth and early twentieth centuries. In the year 1963,

Edward Lorenz published a paper entitled “Deterministic Nonperiodic Flow” that described numerical results obtained by integrating third-order nonlinear ordinary differential equations, which was nothing but a simplified version of convection rolls in atmosphere. This work was most influential and the study of chaotic systems began. Throughout the book, emphasis has been given to understanding the subject mathematically and then explaining the dynamics of systems physically. Some mathematical theorems are given so that the reader can follow the logical steps easily and, also, for further developments in the subject. In this book, continuous and discrete time systems are presented separately, which will help beginners. Discrete-time systems and chaotic maps are given more emphasis. Conjugacy/semi-conjugacy relations among maps and their properties are also described. Mathematical theories for chaos are needed for proper understanding of chaotic motion. The concept and theories are lucidly explained with many worked-out examples, including exercises.

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