Preface

This book is about mathematical models governed by impulsive differential equations.

Impulsive differential equations are used for the mathematical simulation of processes which are subject to impulses during their evolution. Such processes can be observed in numerous fields of science and technology: control theory, population dynamics, biotechnologies, industrial robotics, etc. During the last 20 years the authors' research in the qualitative theory of impulsive differential equations has resulted in a string of extensive results. A systematic account of recent developments in stability, boundedness, and almost periodicity for different classes of impulsive differential equations is given in the books "Stability Analysis of Impulsive Functional Differential Equations" by Stamova [298] and "Almost Periodic Solutions of Impulsive Differential Equations" by Stamov [284]. Both books include applications of the theory to biological models, population modeling, neural networks, and economics. Since the publication of these monographs, many new impulsive mathematical models in science and engineering have been introduced by the authors. The primary aim of this book is to gather most of these recent results under one cover, providing a rich source of mathematical ideas from both a theoretical and a practical point of view. The book presents many applicable techniques, making them available in a single source easily accessible to researchers interested in mathematical models and their applications.

Applied Impulsive Mathematical Models offers a description of recent developments in mathematical modeling by means of impulsive differential equations. The authors provide the basic background from the fundamental theory and give a systematic exposition of recent results related to the qualitative analysis of impulsive mathematical models. The book is dedicated to models which reflect current research in biology, population dynamics, neural networks, and economics. It exhibits different constructive methods, demonstrating how these effective techniques can be applied to investigate qualitative properties of the solutions of impulsive mathematical models. The demonstrated techniques and models will be useful to students of mathematical modeling and will help to instigate the study and development of impulsive models.

The book consists of six chapters.

Chapter 2 provides an introduction to impulsive differential equations as an appropriate tool for modeling and to some methods and concepts necessary to understand the modeling assumptions and methodologies. In it a description of different systems of impulsive differential equations is given, and some central results in the fundamental theory are considered. The classes of piecewise continuous Lyapunov functions and Lyapunov functionals are introduced, which are tools used in the stability and almost periodic theory. Some comparison lemmas and auxiliary assertions, which are used in the remaining four chapters, are exposed. The main definitions of stability, boundedness, and almost periodicity are given.

In Chap. 3 some impulsive biological models are given. We investigate the existence of almost periodic solutions of an impulsive Lasota–Wazewska model and their stability, an impulsive model of hematopoiesis, an impulsive delay logarithmic population model, impulsive models with perturbations in the linear part, and forced perturbed impulsive models. Using vector Lyapunov functions and comparison techniques, sufficient conditions for the conditional stability of a general n-dimensional impulsive biological model are proved. Qualitative properties of different classes of linear and quasilinear impulsive models are studied. Impulsive control models of neutral type are also considered.

Chapter 4 is dedicated to the qualitative properties of impulsive models in population dynamics. We state some existence theorems for almost periodic solutions and some stability and boundedness results for impulsive Lotka–Volterra models, impulsive Lotka–Volterra models with finite and infinite delays, impulsive Lotka–Volterra models with dispersions, impulsive Lotka–Volterra cooperation models with delays, and impulsive models in Banach space. The more general Kolmogorov-type impulsive systems are also investigated. Fundamental to the stability and boundedness results are Lyapunov functions and Lyapunov functional methods. Many examples are included to illustrate the feasibility of the results.

Chapter 5 focuses on impulsive neural network models. We perform qualitative investigations of equilibrium states in neural networks with finite and infinite delays and form neural states that are subject to impulsive state displacements at fixed instants of time. Sufficient conditions for the existence of almost periodic solutions, global asymptotic stability, and global exponential stability of such neural networks are obtained. Results on the impulsive control and impulsive stabilization of neural network systems with delays are included.

Finally, in Chap. 6, we study the stability, stabilization, almost periodic behavior, and impulsive control of the solutions of some models in economics. The impulses are considered either as means of perturbations or as control.

The book is addressed to a wide audience of professionals, including mathematicians, applied researchers, and practitioners.

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